PROJECT MANUAL

VOLUME II OF II

DUPONT PUMP STATION AND BASIN IMPROVEMENTS – PHASE 2 (CONTRACT A)

CONTRACT NO. W-12-026-202

MAYOR AND CITY COUNCIL

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November 2019

CDM Smith

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PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. Provide all labor, materials, equipment, and incidentals as shown, specified and required for demolition, removal, and disposal Work.

2. The Work under this Section includes, but is not necessarily limited to:
   a. Demolition and removal of existing materials and equipment as shown or indicated in the Contract Documents. The Work includes demolition of structural concrete, piping, manholes, electrical and mechanical systems and equipment, paving, curbs, sidewalks, gutters, and similar existing facilities.
   b. Demolition and removal of all Underground Facilities underneath, and above-grade piping and utilities in, the building(s) and structures shown or indicated for demolition, unless the Underground Facilities or above-grade facilities are shown or indicated as to remain.
   c. Remove from slabs, foundations, walls, and footings that are to be demolished all utilities and appurtenances embedded in such construction.

3. Demolitions and removals specified under other Sections shall comply with requirements of this Section.

4. Perform demolition Work within areas shown or indicated.

5. Pay all costs associated with transporting and, as applicable, disposing of materials and equipment resulting from demolition.

B. Coordination:

1. Comply with Section 01 14 16, Coordination with Owner's Operations.

2. Review procedures under this and other Sections and coordinate the Work that will be performed with or before demolition and removals.

3. Comply with Section 31 75 01 for deep excavations manholes and structures. Submit detailed plans and shoring details to support earth lateral loads, groundwater pressures and surcharges listed on Engineer's Report Section 4.5.3.5.4. Documentation to be signed and sealed by a TN licensed engineer.

C. Related Sections:

1. Section 31 11 00, Clearing and Grubbing.

1.02 QUALITY ASSURANCE

A. Qualifications:

1. Electrical Removals: Entity and personnel performing electrical removals shall be electrician legally qualified to perform electrical construction and electrical work in the jurisdiction where the Site is located.

B. Regulatory Requirements:

1. Demolition, removal, and disposal Work shall be in accordance with all applicable Laws and Regulations.

2. Comply with requirements of authorities having jurisdiction.

1.03 SUBMITTALS

A. Informational Submittals: Submit the following:

1. Procedure Submittals:
   a. Demolition and Removal Plan: Not less than ten days prior to starting demolition Work, submit acceptable plan for demolition and removal Work, including:
      1) Plan for coordinating shut offs, capping, temporary services, and continuing utility services.
      2) Other proposed procedures as applicable.
      3) Planned demolition operating sequences.

2. Notification of Intended Demolition Start: Submit in accordance with Paragraph 3.1.A of this Section.

3. Qualifications Statements:
   a. Name and qualifications of entity performing electrical removals, including copy of licenses required by authorities having jurisdiction.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PREPARATION

A. Notification:

1. At least 48 hours prior to commencing demolition or removal, notify ENGINEER in writing of planned start of demolition Work. Do not start removals without permission of ENGINEER.

B. Protection of Surrounding Areas and Facilities:

1. Perform demolition and removal Work in manner that prevents damage and injury to property, structures, occupants, the public, and facilities. Do not interfere with use of, and free and safe access to and from, structures and properties.

2. Closing or obstructing of roads, drives, sidewalks, and passageways adjacent to the Work is not allowed unless indicated otherwise in the Contract Documents. Conduct the Work with minimum interference to vehicular and pedestrian traffic.

3. Provide temporary barriers, lighting, sidewalk sheds, and other necessary protection.

4. Repair damage to facilities that are to remain.

C. Existing Utilities: In addition to requirements of the General Conditions, Supplementary Conditions, and Division 01 Specifications, do the following:

1. Should uncharted or incorrectly charted Underground Facilities be encountered, CONTRACTOR responsibilities shall be in accordance with the General Conditions as may be modified by the Supplementary Conditions. Cooperate with utility owners in keeping adjacent services and facilities in operation.

2. Storm Water: Existing storm water system shall remain in place until demolitions of existing building or structure is completed. Upon completing demolition, cut and cap storm sewer laterals at locations shown on the Drawings. Remove existing storm water piping and related structures between points of cutting, and backfill, restore to grade, and stabilize the area over the removed facilities.

3. Shutdown of utility services shall be coordinated by CONTRACTOR, assisted by OWNER as required relative to contacting utility owners.

3.02 DEMOLITION - GENERAL

A. Locate construction equipment used for demolition Work and remove demolished materials and equipment to avoid imposing excessive loading on supporting and adjacent walls, floors, framing, facilities, and Underground Facilities.

B. Pollution Controls:

1. Use water sprinkling, temporary enclosures, and other suitable methods to limit emissions of dust and dirt to lowest practical level. Comply with Section 01 57 05, Temporary Controls, and Laws and Regulations.

2. Do not use water when water may create hazardous or objectionable conditions such as icing, flooding, or pollution.

3. Clean adjacent structures, facilities, properties, and improvements of dust, dirt, and debris caused by demolition Work, in accordance with the General Conditions and Section 01 74 05 Cleaning.

C. Explosives:

1. Do not bring explosives to the Site or use explosives.

D. Comply with Section 01 73 29, Cutting and Patching.

E. Building or Structure Demolition:

1. Unless otherwise approved by ENGINEER, proceed with demolition from top of building or structure to the ground. Complete demolition Work above each floor or tier before disturbing supporting members of lower levels.

2. Demolish concrete and masonry in small sections.

3. Remove structural framing members and lower to ground using hoists, cranes, or other suitable methods. Do not throw or drop to the ground.

4. Break up and remove foundations and slabs-on-grade unless otherwise shown or indicated as remaining in place.

F. Demolition of Site Improvements:

1. Pavement, Sidewalks, Curbs, and Gutters: Demolition of asphalt or concrete pavement, sidewalks, curbs, and gutters, as applicable, shall terminate at cut edges. Edges shall be linear and have a vertical cut face.

2. Fencing, Guardrails, and Bollards: Remove to the limits shown or indicated on the Drawings. Completely remove below-grade posts and concrete.

3. Manholes, Vaults, Chambers, and Handholes: Remove to the limits shown or indicated on the Drawings.

4. Underground Facilities Other than Manholes, Vaults, Chambers, and Handholes: Remove to the extent shown or indicated on the Drawings. Unless otherwise shown or indicated, cap ends of piping to remain in place in accordance with the “Mechanical Removals” Article in this Section.

5. Landscaping: Comply with Section 31 11 00, Clearing and Grubbing.

G. Salvage and Ownership:

1. Refer to Section 01 11 13, Summary of Work, for requirements on salvage, ownership, and handling of equipment and materials removed during demolition and removal Work.

2. Materials and equipment to remain OWNER’s property shall be carefully removed and appropriately handled by CONTRACTOR to avoid damage and

invalidation of warranties in effect and shall be cleaned and stored at the Site (or other site specified in the Contract Documents) at place designated by ENGINEER or OWNER.

3.03 STRUCTURAL REMOVALS

A. Recycling and Reuse of Demolition Materials:

1. All concrete, brick, tile, masonry, roofing materials, reinforcing steel, structural metals, miscellaneous metals, plaster, wire mesh, and other items contained in or upon building or structure to be demolished shall be removed, transported, and disposed of away from the Site, unless otherwise approved by ENGINEER.

2. Do not use demolished materials as fill or backfill adjacent to structures, in pipeline trenches, or as subbase under structures or pavement.

3.04 MECHANICAL REMOVALS

A. Mechanical demolition and removal Work includes dismantling and removing existing piping, tanks, and appurtenances as shown, indicated, and required for completion of the Work. Mechanical removals include cutting and capping as required, except that cutting of existing piping and ductwork to make connections is included under Section 01 12 16, Construction Sequence; Section 01 73 29, Cutting and Patching; and applicable Sections of Division 33, Utilities.

B. Demolition and Removals of Piping, Ductwork, and Similar Items:

1. Purge piping and tanks (as applicable) of chemicals, fuel, water or wastewater (as applicable) and make safe for removal and capping. Existing piping to remain in place shall remain active during abandonment unless otherwise directed by the Engineer. Remove to the extent shown or indicated existing process, water, waste and vent, chemical, gas, fuel, and other piping. Remove piping to the nearest solid piping support and provide caps on ends of remaining piping. Where piping to be demolished passes through existing walls to remain, cut off and cap pipe on each side of the wall.

2. Caps, Closures, Blind Flanges, and Plugs:
   a. Provide closure pieces, such as blind flanges and caps, where shown or required to complete the Work.
   b. Where used in this Section, the term “cap” means the appropriate type closure for the piping or ductwork being closed, including caps, blind flanges, and other closures.
   c. Caps shall be compatible with the piping or ductwork to which the cap is attached, fluid-tight and gastight, and appropriate for the fluid or gas conveyed in the pipe or duct.
   d. Unless otherwise shown or indicated, caps shall be mechanically fastened, fused, or welded to pipe or duct. Plug piping with means other than specified in this Section only when so shown or indicated in the Contractor Documents or when allowed by ENGINEER.

3. When Underground Facilities are altered or removed, properly cut and cap piping left in place, unless otherwise shown or indicated.

4. Remove waste and vent piping, and ductwork to extent shown and cap as required. Where demolished vent piping, stacks, and ductwork passes through existing roofing, patch the roof with the same or similar materials. Completed patch shall be watertight and comply with roofing manufacturer's recommendations.

5. Modifications to potable water piping and other plumbing and heating system work shall comply with Laws and Regulations. All portions of potable water system that have been modified or opened shall be hydrostatically tested and disinfected in accordance with the Contract Documents, and Laws and Regulations. Hydrostatically test other, normally-pressurized, plumbing piping and heating piping.

3.05 ELECTRICAL REMOVALS

A. Electrical demolition Work includes removing existing conduit and raceways, cabling, poles and overhead cabling, and miscellaneous electrical equipment, as shown, specified, or required.

B. Remove existing electrical equipment and fixtures to avoid damaging systems to remain, to keep existing systems in operation, and to maintain integrity of grounding systems.

C. Cables in conduits to be removed shall be removed back to the power source or control panel, unless otherwise shown or indicated. Verify the function of each cable before disconnecting and removing.

D. Conduits in Underground Facilities not scheduled for reuse shall be suitably capped watertight where each enters building or structure to remain.

E. Where shown or indicated, remove direct burial cable. Openings in buildings for entrance of direct burial cable shall be patched with repair mortar or other material approved by ENGINEER for this purpose and made watertight.

F. Existing poles and overhead cables shall be removed or abandoned as shown and specified. Existing substation(s) and poles owned by electric utility will be removed by the electric utility. Completely remove from the Site poles not owned by electric utility and shown or indicated for removal. Make necessary arrangements with electric utility for removal of utility company's transformers and metering equipment after new electrical system has been installed and energized.

3.06 DISPOSAL OF DEMOLITION DEBRIS

A. Remove from the Site all debris, waste, rubbish, and material resulting from demolition operations and equipment used in demolition Work. Comply with the General Conditions, Supplementary Conditions, and Section 01 74 00, Cleaning and Waste Management.

B. Unless otherwise directed by OWNER or ENGINEER, all materials removed under this section shall be removed from the site and disposed of at the CONTRACTOR'S expense. Point of disposal shall be subject to approval of the OWNER and the local jurisdiction responsible for the issuance of dumping permits.

C. Transportation and Disposal:

1. Non-hazardous Material: Properly transport and dispose of non-hazardous demolition debris to a permitted landfill or other suitable location permitted by the Division of Solid Waste Management, in accordance with Laws and Regulations. Non-hazardous material does not contain Asbestos, PCBs, Petroleum, Hazardous Waste, Radioactive Material, or other material designated as hazardous in Laws and Regulations.

2. Hazardous Material: When handling and disposal of hazardous materials is included in the Work, properly transport and dispose of hazardous materials in accordance with the Contract Documents and Laws and Regulations.

D. Submit to ENGINEER information required in this Section on proposed facility(ies) where demolition material will be recycled. Upon request, ENGINEER or OWNER, shall be allowed to visit recycling facility(ies) to verify adequacy and compliance status. During such visits, recycling facility operator shall cooperate and assist ENGINEER and OWNER.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and design, install and remove formwork for cast-in-place concrete complete as shown on the Drawings and as specified herein.

B. Secure to forms or set for embedment all miscellaneous metal items, sleeves, anchor bolts, inserts, waterstops, fiberglass reinforced plastic components, hatches and other items furnished under other Sections and required to be cast into concrete.

1.02 RELATED WORK

A. Concrete reinforcement is included in Section 03 20 00.

B. Concrete joints and joint accessories are included in Section 03 15 00.

C. Cast-in-place concrete is included in Section 03 30 00.

D. Concrete finishes are included in Section 03 35 00.

E. Grout is included in Section 03 60 00.

F. Anchor bolts for structural steel are furnished under Section 05 55 00.

G. Miscellaneous metals are furnished under Sections 05 50 00.

H. Anchor bolts for equipment are furnished under Divisions 23, 33, 35, 40, 43 and 44.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, shop drawings and product data showing materials of construction and details of installation for:

1. Form release agent.

2. Form ties.

3. Location and sequence of concrete placement.

4. Review will be for appearance, performance and strength of the completed structure only. Approval by the Engineer will not relieve the Contractor of responsibility for the strength, safety or correctness of methods used, the adequacy of equipment, or from carrying out the work as shown on the Drawings and as specified herein.

B. Certificates

1. Submit completed PE Certification Form for design of formwork in accordance with Section 01 33 23. The PE Certification Form shall be completed and stamped by a professional engineer registered in the State of Tennessee.

2. Certify that form release agent complies with Federal, State and local VOC limitations.

1.04 REFERENCE STANDARDS

A. American Concrete Institute (ACI)

1. ACI 301 - Specifications for Structural Concrete

2. ACI 318 - Building Code Requirements for Structural Concrete

3. ACI 347 - Guide to Formwork for Concrete

B. APA - The Engineered Wood Association (APA)

1. Material grades and designations as specified

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 SYSTEM DESCRIPTION

A. Structural design responsibility: Contractor shall provide all forms and shoring designed by a professional engineer registered in the State of Tennessee. Design formwork in accordance with the requirements of ACI 301, ACI 318 and ACI 347. Comply with all applicable regulations and codes. Consider any special requirements due to the use of plasticized and/or retarded set concrete.

PART 2 PRODUCTS

2.01 GENERAL

A. The usage of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configurations desired.

2.02 MATERIALS

A. Forms, General

1. Make forms for cast-in-place concrete of wood, steel or other approved materials, except as specified in Paragraphs 2.02B. Construct wood forms of sound lumber or plywood free from knotholes and loose knots. Construct steel forms to produce surfaces equivalent in smoothness and appearance to those produced by new plywood panels. Design and construct all forms to provide a

flat, uniform concrete surface requiring no grinding, repairs, or finishing except as specified in Section 03 35 00.

B. Forms for Exposed Concrete

1. Make forms for all exposed and non-submerged exterior and interior concrete of new and unused Plyform exterior grade plywood panels manufactured in compliance with the APA and bearing the APA trademark. Provide B grade or better veneer with High Density Overlay on all faces to be in contact with concrete. Design and construct all forms to provide a flat, uniform concrete surface requiring no grinding, repairs, or finishing except as specified in Section 03 35 00.

2. Provide rigid forms that will not deflect, move, or leak. Design forms to withstand the high hydraulic pressures resulting from rapid filling of the forms and heavy high frequency vibration of the concrete. Limit deflection to 1/400 of each component span. Lay out form joints in a uniform pattern.

3. Dress and match boards. Sand plywood smooth and fit adjacent panels with tight joints. Tape, gasket, plug, and/or caulk all joints and gaps in forms to provide watertight joints that will withstand placing pressures without exceeding specified deflection limit or creating surface patterns.

4. Provide ¾-inch chamfer on all corners unless otherwise indicated.

C. Provide rustications as indicated. Mill and plane smooth moldings for chamfers and rustications. Provide rustications and chamfer strips of nonabsorbent material, compatible with the form surface and fully sealed on all sides to prevent the loss of paste or water between the two surfaces.

D. Form Release Agent. Coat all form surfaces in contact with concrete with an effective, non-staining, non-residual, water based, bond-breaking form coating unless otherwise indicated or specified.

E. Form Ties

1. Coil and Wire Ties: Provide ties manufactured so that, after removal of the projecting part, no metal remains within 1-1/2-in of the face of the concrete. The part of the tie to be removed shall be at least 1/2-in diameter or be provided with a plastic or wooden cone at least 1/2-in diameter and 1-1/2-in long. Provide cone washer type form ties in concrete exposed to view.

2. Flat Bar Ties for Panel Forms: Provide ties that have plastic or rubber inserts with a minimum depth of 1-1/2-in and manufactured to permit patching of the tie hole.

3. Provide ties for liquid retaining structures that have a steel waterstop tightly attached to each strut or that have a neoprene rubber washer on each strut.

4. Do not use common wire for form ties.

5. Alternate form ties consisting of tapered through-bolts at least 1-in in diameter at smallest end or through-bolts that utilize a removable tapered sleeve of the same minimum size may be used. Install in forms so that large end is, where applicable, on the liquid or backfilled side of the wall. Clean, fill and seal form tie hole with non-shrink cement grout to provide watertight form tie holes and make all repairs needed to make watertight.

PART 3 EXECUTION

3.01 GENERAL

A. Design, furnish, erect, shore, brace, and maintain formwork for all cast-in-place concrete including sides of footings in accordance with ACI 301, ACI 318, and ACI 347. Construct and place forms to provide concrete of the shape, lines, dimensions and appearance indicated.

B. Provide removable panels at the bottom of forms for walls and columns to allow cleaning, inspection and joint surface preparation. Provide closable intermediate inspection ports in forms for walls. Provide tremies and hoppers for placing concrete and to allow concrete sampling, prevent segregation and prevent the accumulation of hardened concrete on the forms and reinforcement above the fresh concrete.

C. Place molding, bevels, or other types of chamfer strips to produce blockouts, rustications, or chamfers as indicated on the Drawings or as specified herein. Provide chamfer strips at horizontal and vertical projecting corners to produce a 3/4-in chamfer. Provide rectangular moldings at locations requiring sealants where shown on the Drawings or specified herein.

D. Provide rigid forms to withstand construction loads and vibration and meeting specified deflection limits and tolerances. Construct forms so that the concrete will not be damaged by form removal.

E. Accessories which remain embedded in the concrete after formwork removal will be subject to the approval of the Engineer. Permanent embedments shall have sufficient concrete cover or be of suitable materials for the exposure condition as approved by the Engineer. Remove unsatisfactory embedded items at no additional cost to the Owner.

3.02 FORM TOLERANCES

A. Design, construct and surface forms in accordance with ACI 347 and meet the following additional requirements for the specified finishes.

B. Forms for Exposed Concrete: Edges of all form panels in contact with concrete flush within 1/8-in and forms for plane surfaces plane within 1/8-in in 4-ft. Maximum deviation of the finished surface at any point not to exceed 1/4-in from the intended surface indicated. Arrange form panels symmetrically and orderly to minimize the number of seams. Provide tight forms to prevent the passage of mortar, water, and grout.

C. Formed Surface Buried or Not Exposed to View: Class "C" Surface per ACI 347.

D. Formed Surface Including Mass Concrete, Pipe Encasement and Other Similar Installations: No minimum requirements for surface irregularities and surface alignment. The overall dimensions of the concrete shall be plus or minus 1-in from the intended surface indicated.

3.03 FORM PREPARATION

A. Clean, repair, remove projecting nails and fill holes, and smooth protrusions on all form surfaces to be in contact with concrete before reuse. Do not reuse forms for exposed concrete unless a "like new" condition of the form is maintained that will produce surfaces equivalent in smoothness and appearance to those produced by new plywood panels.

B. Coat wood forms in contact with concrete using form release agent prior to form installation.

C. Clean steel forms by sandblasting or other method to remove mill scale and other ferrous deposits from the contact surface of all forms. Coat steel forms in contact with concrete using form release agent prior to form installation.

3.04 REMOVAL OF FORMS

A. Be responsible for all damage resulting from removal of forms and make repairs at no additional cost to the Owner. Leave in place forms and shoring for horizontal structural members in accordance with ACI 301 and ACI 347. Conform to the requirements for form removal specified in Section 03 30 00.

3.05 INSPECTION

A. Notify the Engineer when the forms are complete and ready for inspection, at least six working hours prior to the proposed concrete placement. The Engineer will inspect the forms to ensure overall conformance with the contract documents.

B. Failure of the forms to comply with the requirements specified, or to produce concrete complying with requirements specified shall be grounds for rejection of that portion of the concrete work. Repair or replace rejected work as directed by the Engineer at no additional cost to the Owner. Such repair or replacement shall be subject to the requirements of these Specifications and approval of the Engineer.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install accessories for concrete joints complete as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A. Watertightness test for water containing structures is included in Section 01 45 25.

B. Concrete formwork is included in Section 03 10 00.

C. Concrete reinforcement is included in Section 03 20 00.

D. Cast-in-place concrete is included in Section 03 30 00.

E. Concrete finishes are included in Section 03 35 00.

F. Grout is included in Section 03 60 00.

G. Unit Masonry is included in Section 04 20 00.

H. Miscellaneous metals are included in Section 05 50 00.

I. Waterproofing, dampproofing and caulking are included in Section 07 11 13.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, shop drawings and product data for:

1. Plastic Waterstops: Product data including sample, catalogue cut, dimensions, technical data, storage requirements, splicing methods, conformity to CRD standards, detailed drawings and samples of factory fabrications.

2. Premolded joint fillers: Product data including location of use, sample, catalogue cut, technical data, storage requirements, installation instructions, and conformity to ASTM standards.

3. Bond breaker: Product data including location of use, catalogue cut, technical data, storage requirements, and application instructions.

4. Sealant: Product data including location of use, catalogue cut, technical data, storage requirements, mixing and application instructions, and conformity to ASTM standards.

B. Certifications

1. Certify that all materials used within the joint system are compatible with each other.

2. Certify that sealant is made for use in continuous immersion in contact with wastewater.

1.04 REFERENCE STANDARDS

A. ASTM International

1. ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.

2. ASTM C920 - Standard Specification for Elastomeric Joint Sealants.

3. ASTM D1752 - Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.

B. U.S. Army Corps of Engineers (CRD).

1. CRD C572 - Specification for Polyvinylchloride Waterstops.

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Provide services of a manufacturer's field representative of the sealant who has performed at least five projects of similar size and complexity within the last 5 years. The field representative shall be present at the work site prior to any mixing of components to instruct on mixing, application and inspection procedures and to inspect the finish of the prepared surfaces prior to application of the sealant.

B. The manufacturer's field representative shall make at least one additional visit to the site as the work progresses and shall report on each visit to the Contractor and the Engineer, advising as to whether the application is being performed in accordance with this Section and the manufacturer's printed instructions.

1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver products in original, unopened containers displaying the manufacturer's label showing manufacturer name, product identification and batch number.

B. Store products as recommended by the manufacturer.

PART 2 PRODUCTS

2.01 GENERAL

A. All materials used together in a given joint shall be compatible with one another. Coordinate selection of suppliers and products to provide compatibility. Do not use asphaltic bond breakers or asphaltic joint fillers in joints receiving sealant.

2.02 MATERIALS

A. Plastic Waterstops

1. Waterstops for non-expansion joints and other locations shown on the Drawings: 6-in by 3/8-in ribbed type waterstops conforming to CRD C572 and made by extruding elastomeric plastic compound with virgin polyvinylchloride as the basic resins. The compound shall contain no reprocessed materials. Minimum tensile strength of waterstop 1750 psi. Waterstops shall incorporate an integral fastening system, or be provided with grommets or prepunched holes between the outermost ribs at a spacing of 12 inches on center. Waterstops shall be style FR-6380 by Paul Murphy Plastics Co., Roseville, MI; Greenstreak PVC style 679 by Sika Greenstreak, St. Louis, MO; style R6-38 by Vinylex Corp., Knoxville, TN, or equal.

2. Factory fabrications: provide factory fabrications for all waterstop changes of direction, transitions, and intersections (vertical ells, flat ells, vertical tees, flat tees, vertical crosses, flat crosses, and special unusual or complicated intersections including intersections of waterstops of different sizes or configurations, and intersections due to joint offsets). Factory fabrications shall be made and inspected by the waterstop manufacturer. Provide stub ends of sufficient length to leave only straight butt joints for splicing in the field.

B. Premolded Joint Filler

1. Premolded Joint Filler – Structures: Self-expanding cork premolded joint filler conforming to ASTM D1752, Type III. Provide 1-in thickness unless otherwise indicated on the Drawings.

C. Bond Breaker

1. Bond Breaker Tape: Adhesive-backed glazed butyl or polyethylene tape which will adhere to the premolded joint filler or concrete surface. Provide tape the same width as the joint.

2. Bond breaker for concrete other than where tape is indicated on the Drawings or specified: Either bond breaker tape or a non-staining type bond prevention coating such as Crete-Lease Bond Breaker for Tilt-Up by Cresset Chemical Co.; Sure-Lift J-6 WB by Dayton Superior; Silcoseal Select by Nox-Crete, or approved equal.

D. Sealant

1. Provide sealant for joints in horizontal surfaces conforming to ASTM C920, Type S or M, Grade P or NS, Class 25. Provide sealant for joints in sloping and vertical surfaces conforming to ASTM C920, Type S or M, Grade NS, Class 25. Provide Use T sealant in pedestrian and vehicular traffic areas and Use NT in non-traffic areas.

2. Provide sealants made for use in continuous immersion in contact with wastewater. Provide gray colored sealants unless otherwise indicated on the Drawings, specified, or approved.

PART 3 EXECUTION

3.01 INSTALLATION

A. Waterstops - General

1. Install waterstops for all joints as shown on the Drawings. Provide waterstops continuous around all corners and intersections so that a continuous seal is provided.

2. Provide a minimum number of connections or splices. Replace connections or splices that do not meet the specified requirements at no additional cost to the Owner.

3. Secure waterstops in joints before concrete is placed.

4. Install plastic waterstops so that half of the width will be embedded on each side of the joint. Provide waterstops completely embedded in void-free concrete.

5. Terminate waterstops 2-in below the exposed top of walls.

6. Protect waterstops from damage in the intervals between placing waterstops and subsequent placing of concrete. Replace damaged or punctured waterstops at no additional cost to the Owner.

7. Protect plastic waterstops from sunlight when they will be exposed more than 30 days between concrete placements.

8. Provide waterstops free from form release agent, bond breaker, dirt, concrete splatter, ice, mortar, paint, or any other material which could reduce or destroy bond between the waterstop and the concrete to be placed around it.

B. Plastic Waterstops

1. Only straight butt joints are allowed for field splices. Make splices on a bench. Use a power saw and guide to cut straight ends to be spliced. Heat fuse weld splices using a Teflon coated thermostatically controlled waterstop splicing iron

following the manufacturer's recommendations. The finished splices shall provide a cross-section that is dense and free of porosity. Engineer may conduct destructive tests of splices by cutting along one half of the splice length and by cutting perpendicular to the splice at several locations on the remaining half of the splice length. The right of the Engineer to make such tests shall not be construed as creating any obligation to make such tests, and not exercising this right to do so shall not relieve the Contractor from meeting the requirements of these Specifications. Completed splices shall exhibit a continuous and uniform bead of excess melted material. The welded material shall not look noticeably different from the parent material. Splices shall not show misalignment of ribs greater than 1/16-in, lack of fusion, porosity, pinholes, cracks, charred or burnt material, bubbles, or separation of cooled splice when bent by hand. If a splice displays any of these defects, reject the splice, recut back at least 1-in from rejected splice on each side, and reweld.

2. Secure waterstops in wall joints before concrete is placed. If waterstop does not incorporate an integral fastening system, grommets or prepunched holes, drill holes in waterstops between the outermost ribs at each edge. Center the waterstop in the joint. Tie both edges of the waterstop to reinforcing steel with tie wire as specified for tying reinforcing steel. Secure the waterstop centered on and perpendicular to the joint and to maintain this position during concrete placement.

3. Space waterstop ties to match the spacing of the adjacent reinforcing, but ties need not be spaced closer than 12-in on center.

4. Clamp horizontal waterstops in slabs in position with the form bulkhead (unless previously set in concrete). Lift the edge of the waterstop while placing concrete below the waterstop. Manually force the waterstop against and into the placed concrete and cover with fresh concrete, to provide complete encasement of the waterstop in concrete.

C. Construction Joints

1. Make construction joints only at locations shown on the Drawings or as approved by the Engineer. Any additional or relocation of construction joints proposed by the Contractor must be submitted to the Engineer for written approval. Do not eliminate construction joints.

2. Locate additional or relocated joints where they least impair strength of the member. In general, locate joints within the middle third of spans of slabs, beams and girders. However, if a beam intersects a girder at the joint, offset the joint a distance equal to twice the width of the member being connected. Locate joints in walls and columns at the underside of floors, slabs, beams or girders and at tops of footings or floor slabs. Do not locate joints between beams, girders, column capitals, or drop panels and the slabs above them. Do not locate joints between brackets or haunches and walls or columns supporting them.

3. Unless indicated otherwise, provide joints perpendicular to main reinforcement. Continue reinforcing steel through the joint as indicated on the Drawings.

4. Provide waterstops in wall and slab construction joints in liquid retaining structures and at other locations shown on the Drawings.

5. At all construction joints and at concrete joints indicated on the Drawings to be "roughened", uniformly roughen the surface of the concrete to a full amplitude (distance between high and low points and side to side) of 1/4-in with chipping tools to expose a fresh face. Thoroughly clean joint surfaces of loose or weakened materials by waterblasting or sandblasting and prepare for bonding. At least two hours before and again shortly before the new concrete is deposited, saturate the joints with water. After glistening water disappears, coat joints with neat cement slurry mixed to the consistency of very heavy paste. The surfaces shall receive a coating at least 1/8-in thick, scrubbed-in by means of stiff bristle brushes. Deposit new concrete before the neat cement dries.

6. Do not use keyways in construction joints unless specifically shown on the Drawings or approved by the Engineer.

D. Partial Contraction Joints

1. Make partial contraction joints at locations shown on the Drawings. Do not eliminate or relocate partial contraction joints.

2. Provide sealant grooves and sealants in wall and slab partial contraction joints in liquid retaining structures and at other locations shown on the Drawings.

3. Extend every other bar of reinforcing steel through partial contraction joints or as indicated on the Drawings. Coat the concrete surface with a bond breaker prior to placing new concrete against it as shown on the Drawings. Do not coat reinforcement or waterstops with bond breaker. Mask waterstops and reinforcing passing through the joint to prevent bond breaker form running or dripping on to them. Remove masking prior to concrete placement.

E. Sealant

1. Install sealants in clean dry recesses free of frost, oil, grease, form release agent, loose material, laitance, dirt, dust and other materials which will impair bond at the locations shown on the Drawings. Apply sealant conforming to the manufacturer's recommendations including concrete cure, temperature, moisture, mixing, primer, primer cure time, joint and recess preparation, tooling, and curing. Apply masking tape to each side of the joint prior to the installation of the sealant and remove afterwards along with any spillage to leave a sealant installation with neat straight edges.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install all concrete reinforcement complete as shown on the Drawings and as specified herein, including dowels embedded into concrete for masonry.

1.02 RELATED WORK

A. Concrete formwork is included in Section 03 10 00.

B. Concrete joints and joint accessories are included in Section 03 15 00.

C. Cast-in-place concrete is included in Section 03 30 00.

D. Grout is included in Section 03 60 00.

E. Unit Masonry is included in Section 04 20 00.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, shop drawings and product data showing materials of construction and details of installation for:

1. Reinforcing steel. Drawings for fabrication, bending, and placement of concrete reinforcement shall conform to the recommendations of ACI 315 for placement drawings and as specified herein.
    a. Placement drawings. For walls, show elevations from the outside, looking towards the structure, at a minimum scale of 1/4 inch to one foot. For slabs, show top and bottom reinforcement on separate plan views, as needed for clarity. For beams and columns, show schedules with sections and/or elevations and stirrup/tie spacing. Show additional reinforcement around openings, at corners and at other locations indicated, diagrams of bent bars, arrangements and assemblies, all as required for the fabrication and placement of concrete reinforcement. Reference bars to the same identification marks shown on the bar bending details. Identify bars to have special coatings and/or to be of special steel or special yield strength.
    b. Bar bending details. Reference bars to the same identification marks shown on the placement drawings. Identify bars to have special coatings and/or to be of special steel or special yield strength.

2. Fiber reinforcement. Submit manufacturer's data for synthetic reinforcing fibers. Identify all placements that are to contain synthetic reinforcing fibers. The fiber length and amount of fibers per cubic yard to be used for each placement shall be noted. Submit two samples of synthetic reinforcing fibers.

B. Submit, in accordance with Section 01 33 23, Test Reports of each of the following items.

1. Certified copy of mill test on each heat of each steel proposed for use showing the physical properties of the steel and the chemical analysis.

2. Welder's certification in accordance with AWS D1.4 when welding of reinforcement is indicated, specified, or approved.

3. Certified copy of test reports for each foreign manufactured steel proposed for use in the fabrication of reinforcement. The tests shall be specifically made for this project at the expense of the Contractor by a domestic independent testing laboratory certified to perform the tests. The testing shall be for conformity to the applicable ASTM Standard.

1.04 REFERENCE STANDARDS

A. ASTM International (ASTM):

1. ASTM A82 - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.

2. ASTM A184 - Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement.

3. ASTM A496 - Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement.

4. ASTM A497 - Standard Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement.

5. ASTM A615 - Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.

6. ASTM A704 - Standard Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement.

7. ASTM A706 - Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.

8. ASTM A1064 - Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.

B. American Concrete Institute (ACI):

1. ACI 301 - Specifications for Structural Concrete.

2. ACI 315 - Details and Detailing of Concrete Reinforcement.

3. ACI 318 - Building Code Requirements for Structural Concrete.

4. SP-66 (ACI 315) ACI Detailing Manual.

C. Concrete Reinforcing Steel Institute (CRSI):

1. Manual of Standard Practice.

D. American Welding Society (AWS):

1. AWS D1.4 Structural Welding Code - Reinforcing Steel.

E. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Fiber Reinforcement. Provide services of a manufacturer's representative, with at least 2 years' experience in the use of the synthetic reinforcing fibers for a preconstruction meeting and assistance during the first placement of the material.

1.06 DELIVERY, HANDLING AND STORAGE

A. Provide reinforcement free from mill scale, rust, mud, dirt, grease, oil, ice, or other foreign matter.

B. Ship and store reinforcement with bars of the same size and shape fastened in bundles with durable tags, marked in a legible manner with waterproof markings showing the same "mark" designations as those shown on the submitted placement drawings. Tags for ASTM A706 reinforcing and for ASTM A615 reinforcing meeting the requirements of Paragraph 2.01, C.1 shall indicate that the reinforcing is weldable.

C. Store reinforcement off the ground, protect from moisture and keep free from rust, mud, dirt, grease, oil, ice, or other injurious contaminants.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide new materials complying with the following material specifications.

B. Deformed Concrete Reinforcing Bars: ASTM A615, Grade 60 and 75 deformed bars.

C. Deformed Concrete Reinforcing Bars required on the Drawings to be Field Bent or Welded: ASTM A706.

1. ASTM A615, Grade 60 may be substituted for ASTM A706 subject to the following:
   a. The actual yield strength of the reinforcing steel based on mill tests does not exceed the specified yield strength by more than 18,000 psi. Retests not to exceed this value by more than an additional 3,000 psi.

b. The ratio of the actual ultimate tensile strength to the actual tensile yield strength of the reinforcement is not less than 1.25.
c. The carbon equivalency (CE) is 0.55 percent or less.

D. Welded Steel Wire Fabric: ASTM A1064 flat sheets only.

E. Welded Deformed Steel Wire Fabric: ASTM A497.

F. Welded Plain Bar Mats: ASTM A704 and ASTM A615 Grade 60 plain bars.

G. Fabricated Deformed Steel Bar Mats: ASTM A184 and ASTM A615 Grade 60 deformed bars.

H. Reinforcing Steel Accessories:

1. Plastic Protected Wire Bar Supports: CRSI Bar Supports, Class 1 - Maximum Protection.

2. Stainless Steel Protected Wire Bar Supports: CRSI Bar Supports, Class 2 - Moderate Protection with legs made wholly from stainless steel wire.

3. Precast Concrete Bar Supports: CRSI Bar Supports, Precast Concrete Bar Supports. Precast concrete blocks that have equal or greater strength than the surrounding concrete.

I. Tie Wire:

1. Tie Wires for Reinforcement: 16-gauge or heavier black annealed wire.

J. Fiber Reinforcement:

1. Synthetic reinforcing fibers for concrete grout shall be 100 percent polypropylene collated, fibrillated fibers, Fibermesh 300 as manufactured by Propex Concrete Systems Corp, Chattanooga, TN, or equal. Fiber length and quantity for the concrete grout mix shall be in strict compliance with the manufacturer's recommendations as approved by the Engineer.

2.02 FABRICATION

A. Comply with the CRSI Manual of Standard Practice.

B. Bend bars cold. Do not straighten or rebend bars.

C. Bend bars around a revolving collar having a diameter not less than that recommended by the CRSI or ACI 318.

D. Saw cut bar ends that are to be butt spliced, placed through limited diameter holes in metal, or threaded. Terminate saw cut ends in flat surfaces within 1-1/2 degrees of a right angle to the axis of the bar.

PART 3 EXECUTION

3.01 INSTALLATION

A. Comply with the CRSI Manual of Standard Practice for surface condition, bending, spacing and tolerances of placement for reinforcement. Provide the amount of reinforcing indicated at the spacing and clearances indicated on the Drawings.

B. Determine clear concrete cover based on exposure to the environment. Unless indicated otherwise on the Drawings, provide the following minimum clear concrete cover over reinforcement:

1. Concrete cast against and permanently exposed to earth: 3 inches.

2. Concrete exposed to soil, water, sewage, sludge and/or weather:
   a. Slabs (top and bottom cover), walls: 2 inches.
   b. Beams and columns (ties, spirals and stirrups): 2 inches.

C. Coat uncoated reinforcement which will be exposed for more than 60 days after placement with a heavy coat of neat cement slurry.

D. Do not weld reinforcing steel bars either during fabrication or erection unless indicated on the Drawings or as specified herein, or unless prior written approval has been obtained from the Engineer. Remove immediately all bars that have been welded, including tack welds, without such approval. Comply with AWS D1.4 when welding of reinforcement is shown on the Drawings, specified, or approved.

E. Reinforcing steel interfering with the location of other reinforcing steel, piping, conduits or embedded items may be moved within the specified tolerances or one bar diameter, whichever is greater. Obtain the approval of the Engineer if greater displacement of bars to avoid interference is needed. Do not cut reinforcement to install inserts, conduits, mechanical openings or other items without the prior approval of the Engineer.

F. Secure, support and tie reinforcing steel to prevent movement during concrete placement. Secure dowels in place before placing concrete.

G. Do not field bend reinforcing unless indicated or specifically authorized in writing by the Engineer. Cold-bend bars indicated or authorized to be field bent around the standard diameter spool specified in the CRSI. Do not heat bars. Closely inspect the reinforcing steel for breaks. Replace, repair by cutting out damaged bars and splicing new bars using coupling sleeves filled with ferrous material, or otherwise repair damaged reinforcing bars as directed by the Engineer at no additional cost to the Owner. Do not bend reinforcement after it is embedded in concrete unless indicated on the Drawings.

3.02 REINFORCEMENT AROUND OPENINGS

A. Provide additional reinforcing steel on each side of the opening equivalent to one half of the cross-sectional area of the reinforcing steel interrupted by the opening unless indicated otherwise on the Drawings. Extend each end of each bar beyond the edge of the opening or penetration by the tension development length for that bar size.

3.03 SPLICING OF REINFORCEMENT

A. Provide splices as shown on the Drawings and as specified herein.

B. Splices Indicated as Compression Splices: Provide lap splice of 30 bar diameters, but not less than 12 inches unless indicated otherwise on the Drawings. Base the lap splice length for column vertical bars on the bar size in the column above.

C. All Other Splices: Provide tension lap splices in compliance with ACI 318. Stagger splices in adjacent bars where possible. Provide Class B tension lap splices at all locations unless otherwise indicated.

D. Splices in Circumferential Reinforcement in Circular Walls: Provide Class B tension lap splices and stagger as indicated.

E. Lap splices in welded wire fabric in accordance with the requirements of ACI 318 but not less than 12 inches. Tie the spliced fabrics together with wire ties spaced not more than 24 inches on center and lace with wire of the same diameter as the welded wire fabric. Offset splices in adjacent widths to prevent continuous splices.

3.04 ACCESSORIES

A. Determine, provide and install accessories such as chairs, chair bars and the like to support the reinforcement providing the spacing and clearances indicated on the Drawings and prevent its displacement during the erection of the reinforcement and the placement of concrete.

B. Use precast concrete blocks where the reinforcing steel is to be supported over soil.

C. Use plastic protected bar supports or steel supports with plastic tips where the reinforcing steel is to be supported on forms for a concrete surface that will be exposed to weather, high humidity, or liquid (including bottom of slabs over liquid containing areas). Use stainless steel protected bar supports in walls, beams and elevated slabs. Use stainless steel supports or plastic tipped metal supports in all other locations unless otherwise noted on the Drawings or specified herein.

D. Provide #5 minimum size support bars. Do not reposition upper bars in a bar mat for use as support bars.

E. Alternate methods of supporting top steel in slabs, such as steel channels supported on the bottom steel or vertical reinforcing steel fastened to the bottom and top mats, may be used if approved by the Engineer.

3.05 INSPECTION

A. Notify the Engineer when the reinforcing is complete and ready for inspection, at least six working hours prior to the proposed concrete placement. Do not cover reinforcing steel with concrete until the installation of the reinforcement, including the size, spacing and position of the reinforcement has been inspected by the Engineer and the Engineer's release to proceed with the concreting has been obtained. Keep forms open until the Engineer has completed inspection of the reinforcement.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment, and incidentals required and install cast-in-place concrete complete as shown on the Drawings and as specified herein.

B. Furnish, as required to establish concrete mixes, all sampling and laboratory testing of products and materials performed by an independent testing laboratory engaged by and at the expense of the Contractor.

1.02 RELATED WORK

A. Watertightness test for water containing structures is included in Section 01 45 25.

B. Concrete formwork is included in Section 03 10 00.

C. Concrete reinforcement is included in Section 03 20 00.

D. Concrete joints and joint accessories are included in Section 03 15 00.

E. Concrete finishes are included in Section 03 35 00.

F. Grout is included in Section 03 60 00.

G. Unit Masonry is included in Section 04 20 00.

H. Miscellaneous metals are included in Section 05 50 00.

I. Waterproofing, dampproofing, and caulking are included in Section 07 11 13.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, product data for:

1. Sources of cement, fly ash or ground granulated blast furnace slag, aggregates, and batched concrete. Indicate name and address of mill or quarry, as applicable.

2. Air-entraining admixture. Product data including catalogue cut, technical data, storage requirements, product life, recommended dosage, temperature considerations and conformity to ASTM standards.

3. Water reducing admixture. Product data including catalogue cut, technical data, storage requirements, product life, recommended dosage, temperature considerations and conformity to ASTM standards.

4. Sheet curing material. Product data including catalogue cut, technical data and conformity to ASTM standard.

5. Safety Data Sheets (SDS) for all concrete components and admixtures.

6. Cold weather and hot weather concreting plans demonstrating how concrete will meet the requirements of this Section including but not limited to concrete mixes, placement, curing and protection.

7. High-range water-reducing admixture (plasticizer). Product data including catalogue cut, technical data, storage requirements, product life, recommended dosage, temperature considerations, retarding effect, slump range and conformity to ASTM standards. Identify proposed locations of use.

8. Liquid membrane forming curing compound. Product data including catalogue cut, technical data, storage requirements, product life, application rate and conformity to ASTM standards. Identify proposed locations of use.

B. Test Reports

1. Aggregates: Conformance to ASTM standards, including sieve analysis, mechanical properties, deleterious substance content, and mortar bar expansion test results.

2. Cement and fly ash or ground granulated blast furnace slag: Conformance to ASTM standards, including chemical analysis and physical tests.

3. Concrete mixes: For each formulation of concrete proposed for use, submit constituent quantities per cubic yard, water cementitious ratio, air content, concrete slump, type and manufacturer of cement and type and manufacturer of fly ash or ground granulated blast furnace slag. Provide either Paragraph a. or b., below, for each mix proposed.
   a. Standard deviation data for each proposed concrete mix based on statistical records.
   b. Provide the following for each strength data point used in the calculation of the standard deviation for determination of the minimum required average strength:
      1) Date of sampling and name of testing laboratory.
      2) Name of concrete batch plant.
      3) Water cementitious ratio.
      4) Slump of batch.
      5) Air content of batch.
      6) Compressive strengths of all cylinders tested at that age in that batch.
      7) If available, temperature and unit weight of batch.
      8) Provide data from projects not more strictly controlled than outlined in these specifications. Provide summary sheet showing all pertinent data and the computation of the standard deviation.
   c. Water cementitious ratio curve for concrete mixes based on laboratory tests. Provide average cylinder strength test results at 7, 14, and 28 days for laboratory concrete mix designs.

4. Concrete Mixes: shrinkage.

C. Certifications

1. Certify that admixtures used in the same concrete mix are compatible with each other and the aggregates.

2. Certify that the Contractor is not associated with the independent testing laboratory proposed for use by the Contractor nor does the Contractor or officers of the Contractor's organization have a beneficial interest in the laboratory.

3. Certificate of conformance for concrete production facilities from the NRMCA.

1.04 REFERENCE

A. ASTM International

1. ASTM C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field.

2. ASTM C33 - Standard Specification for Concrete Aggregates.

3. ASTM C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

4. ASTM C42 - Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.

5. ASTM C94 - Standard Specification for Ready-Mixed Concrete.

6. ASTM C138 - Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.

7. ASTM C143 - Standard Test Method for Slump of Hydraulic-Cement Concrete

8. ASTM C150 - Standard Specification for Portland Cement

9. ASTM C156 - Standard Test Method for Water Retention by Liquid Membrane-Forming Curing Compound for Concrete

10. ASTM C157 - Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.

11. ASTM C171 - Standard Specification for Sheet Materials for Curing Concrete

12. ASTM C173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method.

13. ASTM C192 - Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.

14. ASTM C231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.

15. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.

16. ASTM C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.

17. ASTM C311 - Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for use in Portland Cement Concrete.

18. ASTM C494 - Standard Specification for Chemical Admixtures for Concrete.

19. ASTM C596 - Standard Test Method for Drying Shrinkage of Mortar Containing Hydraulic Cement.

20. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.

21. ASTM C989 - Standard Specification for Slag Cement for Use in Concrete and Mortars.

22. ASTM C1017 - Standard Specification for Chemical Admixtures for use in Producing Flowing Concrete.

23. ASTM C1077 - Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation.

24. ASTM C1260 - Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).

25. ASTM E329 - Standard Specification for Agencies Engaged in Construction Inspection and/or Testing.

B. American Concrete Institute (ACI).

1. ACI 211.1 - Standard Practice for Selecting Proportions for Normal, Heavyweight and Mass Concrete.

2. ACI 232.2R - Use of Fly Ash in Concrete.

3. ACI 233R - Slag Cement in Concrete and Mortar.

4. ACI 304R - Guide for Measuring, Mixing, Transporting and Placing Concrete.

5. ACI 304.2R - Placing Concrete by Pumping Methods.

6. ACI 305R - Hot Weather Concreting.

7. ACI 306R - Cold Weather Concreting.

8. ACI 350 - Code Requirements for Environmental Engineering Concrete Structures and Commentary.

C. National Ready Mixed Concrete Association (NRMCA)

1. Quality Control Manual, Section 3 - Certification of Ready Mixed Concrete Production Facilities.

D. Truck Mixer Manufacturers Bureau (TMMB)

1. TMMB 100 - Truck Mixer, Agitator and Front Discharge Concrete Carrier Standards.

E. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Comply with ACI 318 and 350 and other stated specifications, codes and standards. Apply the most stringent requirements of other stated specifications, codes, standards, and this Section when conflicts exist.

B. Use only one source of cement and aggregates for the project. Provide concrete uniform in color and appearance.

C. At least ten working days before the first concrete placement hold a preconstruction meeting to review the requirements for concrete placement, waterstop placement, jointing, concrete curing, hot weather concreting, cold weather concreting and finishing. Review, with the attendance of the plasticizer manufacturer, the properties and techniques of batching and placing concrete containing high-range water-reducing admixture. Notify all parties involved, including the Engineer, of the meeting at least ten working days prior to its scheduled date. Prepare an agenda for the meeting. Take meeting minutes and distribute to all attendees.

D. If, during the progress of the work, it is impossible to secure concrete of the specified workability and strength with the materials being furnished, the Engineer may order such changes in proportions or materials, or both, as may be necessary to secure the specified properties. Make all changes so ordered at no additional cost to the Owner.

E. If, during the progress of the work, the materials from the sources originally accepted change in characteristics, make, at no additional cost to the Owner, new acceptance tests of materials and establish new concrete mixes with the assistance of an independent testing laboratory.

F. Provide all field testing and inspection services and related laboratory tests. Methods of testing shall comply with the latest applicable ASTM methods. The following items shall be tested to verify conformity with this Section.

1. Concrete placements - compressive strength (cylinders), compressive strength (cores), temperature, slump, and air content.

2. Other materials that may require field testing.

G. Provide laboratory tests of samples of constituents and of concrete as-placed. All materials incorporated in the work shall conform to accepted samples.

1.06 DELIVERY, STORAGE AND HANDLING

A. Cement: Store in weathertight buildings, bins or silos to provide protection from dampness and contamination and to prevent warehouse set.

B. Aggregate: Arrange and use stockpiles to prevent segregation or contamination with other materials or with other sizes of like aggregates. Build stockpiles in successive horizontal layers not exceeding three feet in thickness. Complete each layer before the next is started. Do not use frozen or partially frozen aggregate.

C. Sand: Arrange and use stockpiles to prevent contamination. Allow sand to drain to a uniform moisture content before using. Do not use frozen or partially frozen sand.

D. Admixtures: Store in closed containers to prevent contamination, evaporation or damage. Provide agitating equipment to uniformly disperse ingredients in admixture solutions which tend to separate. Protect liquid admixtures from freezing and other temperature changes which could adversely affect their characteristics.

E. Fly Ash or Ground Granulated Blast Furnace Slag: Store in weathertight buildings, bins or silos to provide protection from dampness and contamination.

F. Sheet Curing Materials: Store in weathertight buildings or off the ground and under cover.

G. Liquid Membrane Forming Curing Compounds: Store in closed containers.

PART 2 PRODUCTS

2.01 GENERAL

A. The use of manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired.

B. Like items of materials shall be the end products of one manufacturer in order to provide standardization for appearance, maintenance and manufacturer's service.

2.02 MATERIALS

A. Materials shall comply with this Section and any applicable State or local requirements.

B. Cement: Domestic portland cement conforming to ASTM C150. Cement shall be low alkali cement. Do not use air entraining cements. Cement brand must be approved by the Engineer and one brand shall be used throughout the work. Provide the following type(s) of cement:

1. Class A Concrete - Type I with the addition of fly ash or ground granulated blast furnace slag resulting in C3A being below 8 percent of total cementitious content, Type II, Type II (MH) or Type III limited to 8 percent C3A.

2. Class E1, E2 Concrete - Type II, Type II (MH) with the addition of fly ash or ground granulated blast furnace slag resulting in C3A being below 5 percent of total cementitious content, Type III limited to 5 percent C3A or Type V.

C. Aggregates:

1. Fine Aggregate: Washed inert natural sand conforming to ASTM C33.

2. Coarse Aggregate: Well-graded crushed stone or washed gravel conforming to ASTM C33. Grading requirements as listed in ASTM C33, Table 3 for the specified coarse aggregate size number listed in Table 1 herein. Limits of deleterious substances and physical property requirements as listed in ASTM C33, Table 4 for severe weathering regions. Do not use coarse aggregates known to be deleteriously reactive with alkalis in cement.

3. The fine and coarse aggregates used shall not cause expansion of mortar bars greater than 0.1 percent in 16 days when tested in accordance with ASTM C1260 and using the cement proposed for the project. If aggregates proposed for use do not meet this requirement, then satisfy either a. or b. below.
   a. Total equivalent alkali content of the cement used shall not exceed 0.60 percent as provided in the Optional Chemical Requirements of ASTM C150.
   b. The fine and coarse aggregates used shall not cause expansion of mortar bars greater than 0.1 percent in 16 days when tested in accordance with ASTM C1260 and using the cement and fly ash or ground granulated blast furnace slag proposed for the project. The proportions of the cement-fly ash mix or cement-ground granulated blast furnace slag mix shall be the same as those proposed for the project.

D. Water: Potable water free of oil, acid, alkali, salts, chlorides (except those attributable to drinking water), organic matter, or other deleterious substances.

E. Admixtures: Use admixtures free of chlorides and alkalis (except for those attributable to drinking water). The admixtures shall be from the same manufacturer when it is required to use more than one admixture in the same concrete mix. Use admixtures compatible with the concrete mix including other admixtures.

1. Air Entraining Admixture: Conforming to ASTM C260. Proportion and mix in accordance with manufacturer's recommendations.

2. Water Reducing Admixture: Conforming to ASTM C494, Type A. Proportion and mix in accordance with manufacturer's recommendations.

3. High-Range Water-Reducing Admixtures (Plasticizer): Conforming to ASTM C494, Type F resulting in non-segregating plasticized concrete with little bleeding and with the physical properties of low water/cementitious ratio concrete. The treated concrete shall be capable of maintaining its plastic state in excess of 2 hours. Proportion and mix in accordance with manufacturer's recommendations.

4. Do not use admixtures causing retarded or accelerated setting of concrete without written approval from the Engineer. Use retarding or accelerating water reducing admixtures when so approved.

F. Supplementary Cementitious Materials

1. Fly Ash: Class F fly ash complying with ASTM C618, including the requirements of Table 1 but with the Loss on Ignition (LOI) limited to 3 percent maximum and the optional physical requirements of Table 3. Test in compliance with ASTM C311 with a minimum of one sample weighing four pounds taken from each 200 tons of fly ash supplied for the project.

2. Ground Granulated Blast Furnace Slag: Grade 100 or Grade 120 ground granulated blast furnace slag complying with ASTM C989. Ground granulated blast furnace slag shall be from a single source and uniform in color. Mill test reports submitted must be within 6 months of submittal date.

G. Sheet Curing Materials: Waterproof paper, polyethylene film or white burlap-polyethylene sheeting, all conforming to ASTM C171.

H. Liquid Membrane-Forming Curing Compound. Compound conforming to ASTM C309, Type 1-D (clear or translucent with fugitive dye) and containing no wax, paraffin, or oil. Curing compounds shall be non-yellowing and have a unit moisture loss no greater than 0.039 gm/cm2 at 72 hours as measured by ASTM C156. Curing compound shall comply with Federal, State and local VOC limits.

2.03 MIXES

A. An independent testing laboratory engaged by and at the expense of the Contractor shall establish concrete mixes and perform all sampling and laboratory testing of products and materials.

B. Select proportions of ingredients to meet the design strength and materials limits specified in Table 1 and to produce placeable, durable concrete conforming to these specifications. Proportion ingredients to produce a homogenous mixture which will readily work into corners and angles of forms and around reinforcement without permitting materials to segregate or allowing free water to collect on the surface.

C. Base concrete mixes on standard deviation data of prior mixes with essentially the same proportions of the same constituents or, if not available, develop concrete mixes by laboratory tests using the materials proposed for the work.

1. For concrete mixes based on standard deviation data of prior mixes, submit standard deviation data of prior mixes with essentially the same proportions of the same constituents in accordance with ACI 350 and based on the modification factors for standard deviation tests contained in ACI 350.

2. For concrete mixes developed by laboratory testing, base cementitious content of the concrete on curves showing the relation between water cementitious ratio and 7, 14 and 28 day compressive strengths of concrete made using the proposed materials. Determine curves by four or more points, each representing an average value of at least three test specimens and one water-cementitious ratio at each age. Provide curves with a range of values sufficient to yield the desired data, including the compressive strengths specified, without extrapolation. The cementitious content of the concrete mixes to be used, as determined from the curve, shall correspond to the required average compressive strength in Table 5.3.2.2 of ACI 318. The resulting mix shall not conflict with the limiting values for maximum water cementitious ratio and net minimum cementitious content specified in Table 1.

D. Test the fly ash or ground granulated blast furnace slag and concrete mixture to provide test data confirming that the fly ash or ground granulated blast furnace slag in combination with the cement to be used meets all strength requirements and is compatible with the other concrete additives.

E. Test aggregates for potential alkali reactivity in accordance with ASTM C1260. If initial testing indicates aggregates are not potentially reactive repeat test at 3 month intervals.

F. Compression Tests: Provide testing of the proposed concrete mixes to demonstrate compliance with the compression strength requirements in conformity with the provisions of ACI 318.

G. Entrained air, as measured by ASTM C231, shall be as shown in Table 1.

1. If the air entraining agent proposed for use in the mix requires testing methods other than ASTM C231 to accurately determine air content, make special note of this requirement in the admixture submittal specified under Paragraph 1.03.

H. Slump of the concrete as measured by ASTM C143, shall be as shown in Table 1. If a high-range water-reducing admixture (plasticizer) is used, the slump indicated shall be that measured before plasticizer is added. Plasticized concrete shall have a slump ranging from 7 to 10-in.

I. Proportion admixtures according to the manufacturer's recommendations. Two or more admixtures specified may be used in the same mix provided that the admixtures in combination retain full efficiency and have no deleterious effect on the concrete or on the properties of the other admixture(s).

TABLE 1

Class	Design Strength 1	Cement 2	Fine Aggregate 3	Coarse Aggregate 3	Cementitious Content 4
A	2500	Type II	Sand	57 (9)	440
E1	4500	Type II	Sand	467	560
E2	4500	Type II	Sand	57	580

Class	W/C Ratio 5	SCM 6	AE Range 7	WR 8	HRWR 10	Slump Range Inches
A	0.62 max.	Yes	3.5 to 5	Yes	No	1-4
E1	0.42 max.	Yes	3.5 to 5	Yes	No	3-5
E2	0.42 max.	Yes	3.5 to 5	Yes	Optional	3-5

TABLE NOTES:
1. Minimum compressive strength in psi at 28 days
2. ASTM designation in ASTM C150
3. Size Number in ASTM C33
4. Minimum cementitious content in lbs per cubic yard (where fly ash or ground granulated blast furnace slag is used cementitious content is defined as cement content plus fly ash or ground granulated blast furnace slag content)
5. W/C is Maximum Water Cementitious ratio by weight
6. Supplementary Cementitious Material (SCM) fly ash content in the range of 20-25 percent of the total cement content plus fly ash content, by weight. If ground granulated blast furnace slag is used in lieu of fly ash, the content of ground granulated blast furnace slag shall be in the range of 25-45 percent of the total cement plus ground granulated blast furnace slag content, by weight
7. AE is percent air entrainment
8. WR is water reducing admixture
9. Except as specified in Section 03800 for concrete electrical raceway encasement
10. HRWR is high-range water-reducing admixture

J. Shrinkage Tests: Perform shrinkage tests on the design mix for Class E1 and E2 concrete. The tests shall conform to ASTM C157 as modified by ASTM C596 for curing, storage, and comparator readings. Use concrete specimens. Do not use mortar specimens.

1. The average shrinkage at 25 days of air storage shall not exceed 0.036 percent.

PART 3 EXECUTION

3.01 MEASURING MATERIALS

A. Provide concrete composed of portland cement, fly ash or ground granulated blast furnace slag, fine aggregate, coarse aggregate, water and admixtures as specified and produced by a plant complying with ACI 318 and ASTM C94. Batch all constituents, including admixtures, at the plant. High-range water reducing admixtures may be added in the field.

B. Measure materials for batching concrete by weighing in conformity with and within the tolerances given in ASTM C94 except as otherwise specified. Use scales last certified by the local Sealer of Weights and Measures within one year of use.

C. Weigh cement and fly ash or ground granulated blast furnace slag in individual weigh batchers that are separate and distinct from the weigh batchers used for other materials. When cement and fly ash or ground granulated blast furnace slag are weighed in a cumulative weigh batcher, the cement shall be weighed first.

D. Measure the amount of free water in fine aggregates within 0.5 percent with a moisture meter. Compensate for varying moisture contents of fine aggregates. Record the number of gallons of water as-batched on printed batch tickets.

E. Dispense admixtures either manually using calibrated containers or measuring tanks, or by means of an automatic dispenser approved by the manufacturer of the specific admixture.

1. Charge air-entraining and chemical admixtures into the mixer as a solution using an automatic dispenser or similar metering device.

2. Inject multiple admixtures separately during the batching sequence.

3.02 MIXING AND TRANSPORTING

A. Provide ready-mixed concrete produced by equipment complying with ACI 318 and ASTM C94 and produced by a plant certified by the NRMCA. Do not hand-mix. All truck mixers shall carry a rating plate conforming to TMMB 100. Clean each transit mix truck drum and reverse drum rotation before the truck proceeds under the batching plant. Equip each transit-mix truck with a continuous, nonreversible, revolution counter showing the number of revolutions at mixing speeds.

B. Transport ready-mix concrete to the site in watertight agitator or mixer trucks loaded not in excess of their rated capacities as stated on the name plate.

C. Keep the water tank valve on each transit truck locked at all times. Any addition of water must be directed by the Engineer. Incorporate water directed to be added by additional mixing of at least 50 revolutions at mixing speed after the addition of all water. Meter all added water and show the amount of water added on each delivery ticket.

D. Comply with ACI 318 and ASTM C94 for all central plant and rolling stock equipment and methods.

E. Select equipment of size and design to provide continuous flow of concrete at the delivery end. Use metal or metal-lined non-aluminum discharge chutes with slopes not exceeding one vertical to two horizontal and not less than one vertical to three horizontal. Chutes more than 20-ft long and chutes not meeting slope requirements may be used if concrete is discharged into a hopper before distribution.

F. Do not retemper (mix with or without additional cement, aggregate, or water) concrete or mortar which has partially hardened.

G. Handle concrete from mixer to placement providing concrete of specified quality in the placement area and not exceeding the maximum time interval specified in Paragraph 3.02 I.4. Dispatch trucks from the batching plant so they arrive at the work site just before the concrete is required to avoid excessive mixing of concrete while waiting or delays in placing successive layers of concrete in the forms. Remix for a minimum of 5 minutes prior to discharge or testing.

H. Furnish a delivery ticket for ready mixed concrete to the Engineer as each truck arrives. Provide a printed record of the weight of cement and each aggregate as batched individually on each ticket. Use the type of indicator that returns for zero punch or returns to zero after a batch is discharged. Indicate for each batch the weight of fine and coarse aggregate, cement, fly ash or ground granulated blast furnace slag, and water, moisture content of fine and coarse aggregate at time of batching, and types, brand and quantity of each admixture, the quantity of concrete delivered, the time any water is added and the amount, and the numerical sequence of the delivery. Show the time of day batched and time of discharge from the truck. Indicate the number of revolutions of transit mix truck.

I. Temperature and Mixing Time Control

1. In cold weather (see Paragraph 3.07D) maintain the as-mixed temperature of the concrete and concrete temperatures at the time of placement in the forms as indicated in Table 3.

2. If water or aggregate has been heated, combine water with aggregate in the mixer before cement is added. Do not add cement to mixtures of water and aggregate when the temperature of the mixture is greater than 90 degrees F.

3. In hot weather (see Paragraph 3.07E), cool ingredients before mixing to maintain temperature of the concrete below the maximum placing temperature of 90 degrees F. Well-crushed ice may be substituted for all or part of the mixing water.

4. The maximum time interval between the addition of mixing water and/or cement to the batch and the final placing of concrete in the forms shall not exceed the values shown in the following TABLE 2:

TABLE 2

AIR OR CONCRETE TEMPERATURE (WHICHEVER IS HIGHER)	MAXIMUM TIME
(27 Degree C) 80 Degree F to 90 Degree F (32 Degree C)	45 minutes
(21 Degree C) 70 Degree F to 79 Degree F (26 Degree C)	60 minutes
(5 Degree C) 40 Degree F to 69 Degree F (20 Degree C)	90 minutes

5. If an approved high-range water-reducing admixture (plasticizer) is used to produce plasticized concrete, the maximum time interval between the addition of mixing water and/or cement to the batch and the final placing of concrete in the forms shall not exceed 90 minutes.

3.03 INSPECTION AND COORDINATION

A. Batching, mixing, transporting, placing and curing of concrete shall be subject to the inspection of the Engineer at all times. Advise the Engineer of readiness to proceed at least six working hours prior to each concrete placement. The Engineer will inspect the preparations for concreting including the preparation of previously placed concrete, the reinforcing and the alignment, cleanliness and tightness of formwork. Do not place concrete without the inspection and acceptance of the Engineer.

3.04 EMBEDDED ITEMS

A. Secure to forms as required or set for embedment as required, all miscellaneous metal items, sleeves, reglets, anchor bolts, anchors, inserts and other items furnished under other Sections and required to be embedded into concrete. Set and secure such items in the locations and alignments needed so they are not displaced by concrete placement.

B. Clean embedded items free of rust, mud, dirt, grease, oil, ice, or other contaminants which would reduce or prevent bonding with concrete.

C. Coat or isolate all aluminum embedments to prevent aluminum-concrete reaction or electrolytic action between aluminum and steel.

D. Do not embed piping in concrete unless shown on the Drawings.

E. Do not embed electrical conduits in concrete unless shown on the Drawings.

F. Fabricate piping and conduit such that the cutting, bending, or relocation of reinforcing steel is not required. Pipes and conduits embedded within a slab or wall (other than those merely passing through) shall satisfy the following, unless otherwise shown on the Drawings or approved:

1. Maximum outside dimension of pipe or conduit shall not be greater than one third the overall thickness of the slab or wall.

2. Spacing of pipes or conduits shall be greater than or equal to three diameters or widths on center.

G. Close open ends of piping, conduits, and sleeves embedded in concrete with caps or plugs prior to placing concrete.

H. Ensure all specified tests and inspections on embedded piping are completed and satisfactory before starting concrete placement. Ensure all mechanical or electrical tests and inspections are completed and satisfactory prior to starting concrete placement. Do not place concrete until unsatisfactory items and conditions have been corrected.

I. Position embedded anchor bolts using templates.

J. Check location, alignment, and support of anchor bolts, piping, electrical conduits, and other items which will be fully or partially embedded in concrete before depositing concrete. Correct mislocated and misaligned items and secure items which have become loose before depositing concrete.

K. Correct all embedded items not installed in the location or alignment needed or displaced by concrete placement at no additional cost to the Owner.

3.05 CONCRETE APPEARANCE

A. Remix concrete showing either poor cohesion or poor coating of the coarse aggregate with paste. Reject remixed concrete showing either poor cohesion or poor coating of the coarse aggregate with paste. Make, at no additional cost to the Owner, changes in the concrete mix design for future deliveries only by adjusting one or more of the following if the slump is within the allowable limit, but excessive bleeding, poor workability, or poor finishability are observed:

1. The gradation of aggregate.

2. The proportion of fine and coarse aggregate.

3. The percentage of entrained air, within the allowable limits.

B. Provide concrete having a homogeneous structure which, when hardened, will have the specified strength, durability and appearance. Provide mixtures and workmanship such that concrete surfaces, when exposed, will require no finishing except as specified in Section 03 35 00.

3.06 PLACING AND COMPACTING

A. Placing

1. Verify that all formwork completely encloses concrete to be placed and is securely braced prior to concrete placement. Remove ice, standing water, dirt, debris, and other foreign materials from forms and exposed joint surfaces. Confirm that reinforcement and other embedded items are securely in place.

Have a worker at the location of the placement who can check that reinforcement and embedded items remain in designated locations and alignments while concrete is being placed. Sprinkle semi-porous subgrades or forms to eliminate suction of water from the mix. Do not place concrete on frozen subgrade, snow, or ice.

2. Deposit concrete as near its final position as possible to prevent segregation due to rehandling or flowing. Place concrete continuously at a rate that allows the concrete previously placed to be integrated with fresh plastic concrete. Do not deposit concrete which has partially hardened or has been contaminated by foreign materials or on concrete which has hardened sufficiently to cause formation of seams or planes of weakness within the section. If the section cannot be placed continuously, place construction joints as specified or as approved.

3. Pumping of concrete will be permitted. Use a mix design and aggregate sizes chosen for pumping and submit for approval. Do not use pipelines made of aluminum or aluminum alloy. When concrete is pumped, slump will be determined at point of truck discharge and air content will be determined at point of placement.

4. Remove temporary spreaders from forms when the spreader is no longer needed. Temporary spreaders may remain embedded in concrete only when made of galvanized steel or concrete and if prior approval has been obtained.

5. Do not place concrete for supported elements until concrete previously placed in the supporting element has attained design strength.

6. Where surface mortar is to form the base of a finish, especially surfaces designated to be painted, work coarse aggregate back from forms to bring the full surface of the mortar against the form. Prevent the formation of surface voids.

7. Slabs
   a. After bulkheads, screeds and jointing materials have been positioned, place concrete continuously between joints beginning at a bulkhead, edgeform, or corner. Place each batch into the edge of the previously placed concrete to avoid stone pockets and segregation.
   b. Avoid delays in placement. If there is a delay in placement, spade and consolidate the concrete placed after the delay at the edge of the previously placed concrete to avoid cold joints. Bring concrete to correct level and strike off with a straightedge. Use bullfloats or darbies to smooth the surface, leaving it free of humps or hollows.
   c. Where slabs are to be placed integrally with the walls below them, place the walls and compact as specified. Allow one hour to pass between placement of the wall and the overlying slab to permit consolidation of the wall concrete. Keep the top surface of the wall moist to prevent cold joints.

8. Formed Concrete
   a. Place concrete in forms using tremie tubes taking care to prevent segregation. Maintain bottom of tremie tubes in contact with the concrete already placed. Do not permit concrete to drop freely more than 4-ft. Place concrete for walls in 12-in to 24-in lifts, keeping the surface horizontal. If a high-range water-reducing admixture is used do not permit concrete to drop freely more than 15-ft; maximum lift thickness not to exceed 7-ft.

9. Bollards
   a. Conform to requirements specified above for formed concrete and completely fill pipe with concrete as indicated.

10. Do not place concrete underwater unless approved in writing by the Engineer.

B. Compacting

1. Consolidate concrete by vibration and puddling, spading, rodding or forking so that concrete is completely worked around reinforcement, embedded items and openings and into corners of forms. Continuously perform puddling, spading, rodding and forking along with vibration of the placement to eliminate air or stone pockets which may cause honeycombing, pitting or planes of weakness.

2. Compact all concrete with mechanical vibrators. Do not order concrete until vibrators (including standby units in working order) are on the job.

3. Use mechanical vibrators having a minimum frequency of 8000 vibrations per minute. Insert vibrators and withdraw at points from 18-in to 30-in apart. Vibrate sufficiently at each insertion to consolidate concrete, generally from 5 to 15 seconds. Do not over vibrate so as to segregate. Keep standby vibrators on the site during concrete placing operations.

4. Concrete Slabs: Vibration for concrete slabs less than 8-in thick shall be by vibrating screeds. Vibration for concrete slabs 8-in and thicker shall be by internal vibrators and (optionally) with vibrating screeds. Place vibrators into concrete vertically. Do not lay vibrators horizontally or lay over.

5. Walls and Columns: Use internal vibrators (rather than form vibrators) unless otherwise approved by the Engineer. In general, for each vibrator needed to melt down (level) the batch at the point of discharge, one or more additional vibrators must be used to densify, homogenize and perfect the surface. Insert vibrators vertically at regular intervals, through the fresh concrete and slightly into the previous lift, if any.

6. Amount of Vibration: Use vibrators to consolidate properly placed concrete. Do not use vibrators to move or transport concrete in the forms. Continue vibration until:
   a. Frequency of vibrator returns to normal.
   b. Surface appears liquefied, flattened and glistening.
   c. Trapped air ceases to rise.
   d. Coarse aggregate has blended into surface, but has not disappeared.

3.07 CURING AND PROTECTION

A. Protect all concrete work against injury from the elements and defacements of any nature during construction operations.

B. Curing Methods

1. Curing Methods for Concrete Surfaces: Cure concrete to retain moisture and maintain a temperature of at least 50 Degrees F at the concrete surface for a minimum of seven days after placement. Use the following curing methods as specified:
   a. Water Curing: Keep entire concrete surface wet by ponding, continuous sprinkling or covered with saturated burlap. Begin water curing as soon as concrete attains an initial set and maintain water curing 24 hours a day. Do not permit the surface of the concrete to dry out at any time during the curing period. Temperature of curing water shall be within 20 Degrees F of the concrete temperature.
   b. Sheet Material Curing: Cover entire surface with sheet material. Anchor sheeting to prevent wind and air from lifting the sheeting or entrapping air under the sheet. Place and secure sheet as soon as initial concrete set occurs.
   c. Liquid Membrane Curing: Apply over the entire concrete surface except as follows. Curing compound shall NOT be placed on any concrete surface where additional concrete or grout is to be placed, where concrete sealers or surface coatings are to be used, or where the concrete finish requires an integral floor product. Apply curing compound as soon as the free water on the surface has disappeared and no water sheen is visible, but not after the concrete is dry or when the curing compound can be absorbed into the concrete. Apply in compliance with the manufacturer's recommendations.

2. Specified applications of curing methods:
   a. Slabs for Liquid Retaining Structures: Water curing only.
   b. Slabs on Grade and Footings (not used to retain liquids): Water curing, sheet material curing or liquid membrane curing.
   c. Structural Slabs (other than Liquid Retaining Structures): Water curing or liquid membrane curing.
   d. Horizontal Surfaces which will Receive Additional Concrete, Coatings, Grout or Other Material that Requires Bond to the substrate: Water curing.
   e. Formed Surfaces: None if nonabsorbent forms are left in place seven days. Water curing if absorbent forms are used. Water curing if forms are removed prior to seven days. Sheet cure or liquid membrane cure if forms are removed prior to seven days. Exposed horizontal surfaces of formed walls or columns shall be water cured for seven days or until next placement of concrete is made.
   f. Surfaces of Concrete Joints: Water curing or sheet material curing.

C. Protect finished surfaces and slabs from the direct rays of the sun to prevent checking and crazing.

D. Cold Weather Concreting

1. For this Specification, "cold weather" is defined as a period when for more than three successive days, the average daily outdoor temperature drops below 40 degrees F. Calculate average daily temperature as the average of the highest and the lowest temperature during the period from midnight to midnight.

2. Batch, deliver, place, cure and protect concrete during cold weather in compliance with the recommendations of ACI 306R and the additional requirements of this Section.

3. Review the cold weather concreting plan at the preconstruction meeting. Include the methods and procedures for use during cold weather including the production, transportation, placement, protection, curing and temperature monitoring of the concrete and the procedures to be implemented upon abrupt changes in weather conditions or equipment failures.

4. The minimum temperature of concrete immediately after placement and during the protection period shall be as indicated in Table 3. The temperature of the concrete in place and during the protection period shall not exceed these values by more than 20 degrees F. Prevent overheating and non-uniform heating of the concrete.

TABLE 3

Concrete Temperatures Minimum
Dimension of Section

	< 12-in	12 to 36-in
Min. conc temp:	55 Degree F	50 Degree F

5. Protect concrete during periods of cold weather to provide continuous warm, moist curing (with supplementary heat when required by weather conditions) for a total of at least 350 degree-days of curing.
   a. Degree-days are defined as the total number of 24 hour periods multiplied by the weighted average daily air temperature at the surface of the concrete (e.g., 7 days at an average 50 degrees F = 350 degree-days).
   b. To calculate the weighted average daily air temperature, sum hourly measurements of the air temperature in the shade at the surface of the concrete taking any measurement less than 50 degrees F as 0 degrees F. Divide the sum thus calculated by 24 to obtain the weighted average temperature for that day.

6. Do not use salt, manure or other chemicals for protection.

7. At the end of the protection period, allow the concrete to cool gradually to the ambient temperature. If water curing has been used, do not expose concrete to temperatures below those shown in Table 3 until at least 24 hours after water curing has been terminated and air dry concrete for at least 3 days prior to first exposure to freezing temperatures.

8. During periods not defined as cold weather, but when freezing temperatures are expected or occur, protect concrete surfaces from freezing for the first 24 hours after placing.

E. Hot Weather Concreting

1. For this Specification, "hot weather" is defined as any combination of high air temperatures, low relative humidity and wind velocity which produces a rate of evaporation as estimated in ACI 305R, approaching or exceeding 0.2 pounds per square foot per hour (lb/sq ft/hr).

2. Batch, deliver, place, cure and protect concrete during hot weather in compliance with the recommendations of ACI 305R and the additional requirements of this Section.
   a. Temperature of concrete being placed shall not exceed 90 degrees F. Maintain a uniform concrete mix temperature below this level. The temperature of the concrete shall not cause loss of slump, flash set or cold joints.
   b. Promptly deliver concrete to the site and promptly place the concrete upon its arrival at the site, not exceeding the maximum time interval specified in Paragraph 3.02I.4. Provide vibration immediately after placement.
   c. The Engineer may direct the Contractor to immediately cover concrete with sheet curing material.

3. Review the hot weather concreting plan at the preconstruction meeting. Include the methods and procedures for use during hot weather including production, placement, and curing.

3.08 REMOVAL OF FORMS

A. Do not remove forms before the concrete has attained a strength of at least 70 percent of its specified design strength for beams and slabs and at least 30 percent of its specified design strength for walls and vertical surfaces, nor before reaching the following number of day-degrees of curing (whichever is the longer):

TABLE 4

Forms for	Degree Days
Beams and slabs	500
Walls and vertical surfaces	100

(See definition of degree-days in Paragraph 3.07D).

B. Do not remove shores until the concrete has attained at least 70 percent of its specified design strength and also sufficient strength to support safely its own weight and the construction live loads upon it.

C. In cold weather, when temperature of concrete exceeds ambient air temperature by 20 Degrees F at the end of the protection period, loosen forms and leave in place for at least 24 hours to allow concrete to cool gradually to ambient air temperature.

3.09 FIELD AND LABORATORY TESTS

A. Take field control cylinder specimens during the progress of the work, in compliance with ASTM C31. The number of sets of concrete test cylinders taken of each class of concrete placed each day shall not be less than one set per day, nor less than one set for each 100 cu yds of concrete nor less than one set for each 5,000 sq ft of surface area for slabs or walls. Specimens shall be formed in 6-in diameter by 12-in long non-absorbent cylindrical molds.

1. A "set" of test cylinders shall consist of five cylinders: one to be tested at seven days, one to be tested at 14 days, and two to be tested and their strengths averaged at 28 days. The fifth may be used for a special test at 3 days or to verify strength after 28 days if 28 day test results are low.

2. When the average 28 day compressive strength of the cylinders in any set falls below the required compressive strength or below proportional minimum seven-day or 14-day strengths (where proper relation between seven, 14 and 28 day strengths have been established by tests), change proportions, cementitious content, or temperature conditions to achieve the required strengths at no additional cost to the Owner.

B. Provide four firmly braced, insulated, heated, closed wooden curing boxes, each sized to hold ten specimens, complete with cold weather temperature and hot weather temperature control thermostat for initial curing and storage from time of fabrication until shipment to testing lab. Protect the specimens against injury or loss through construction operations.

C. Test slump immediately prior to placing the concrete. Test shall be made in accordance with ASTM C143. When concrete is pumped, slump will be determined at point of truck discharge. If the slump is outside the specified range, the concrete will be rejected.

D. Test for air content shall be conducted on a fresh concrete sample. Air content for concrete made of ordinary aggregates having low absorption shall be made in compliance with either the pressure method complying with ASTM C231 or by the volumetric method complying with ASTM C173. If aggregates with high absorptions are used, the latter test method shall be used. When concrete is pumped, air content will be determined at point of placement.

3.10 FIELD CONTROL

A. The Engineer may have cores taken from any questionable area in the concrete work such as construction joints and other locations as required for determination of concrete quality. The results of tests on such cores shall be the basis for acceptance, rejection or determining the continuation of concrete work. The right of the Engineer to take such cores shall not be construed as creating any obligation to take such

cores, and not exercising this right to do so shall not relieve the Contractor from meeting the requirements of these Specifications.

B. Cooperate in obtaining cores by allowing free access to the work and permitting the use of ladders, scaffolding and such incidental equipment as may be required. Repair all core holes with non-shrink grout as specified in Section 03 60 00. The work of cutting, testing and repairing the cores will be at the expense of the Contractor if defective work is uncovered. If no defective work is found, such cost will be at the expense of the Owner.

3.11 FAILURE TO MEET REQUIREMENTS

A. Should the strengths shown by the test specimens made and tested in compliance with the previous provisions fall below the values given in Table 1, the Engineer may require changes in proportions or materials, or both, to apply to the remainder of the work in accordance with Paragraph 1.05E. Furthermore, the Engineer may require additional curing on those portions of the structure represented by the test specimens which fall below the values given in Table 1. The cost of such additional curing shall be at no additional cost to the Owner. In the event that such additional curing does not give the strength required, as evidenced by core and/or load tests, the Engineer may require strengthening or replacement of those portions of the structure which fail to develop the required strength. Coring and testing and/or load tests and any strengthening or concrete replacement required because strengths of test specimens are below that specified, shall be at no additional cost to the Owner. In such cases of failure to meet strength requirements the Contractor and Owner shall confer to determine what adjustment, if any, can be made in compliance with Sections titled "Strength" and "Failure to Meet Strength Requirements" of ASTM C94. The "purchaser" referred to in C94 is the Contractor.

B. When the tests on control specimens of concrete fall below the required strength, the Engineer will permit check tests for strengths to be made by means of typical cores drilled from the structure in compliance with ASTM C42 and C39. In cases where tests of cores fall below the values given in Table 1, the Engineer, in addition to other recourses, may require load tests on any one of the slabs and walls in which such concrete was used. Test need not be made until concrete has aged 60 days. The Engineer may require strengthening or replacement of those portions of the structure which fail to develop the required strength. All coring and testing and/or load tests and any strengthening or concrete replacement required because strengths of test specimens are below that specified, shall be at no additional cost to the Owner.

C. Should the strength of test cylinders fall below 60 percent of the required minimum 28 day strength, the concrete shall be rejected and shall be removed and replaced at no additional cost to the Owner.

3.12 PATCHING AND REPAIRS

A. It is the intent of these Specifications to require quality work including forming, mixture and placement of concrete and curing so completed concrete surfaces will require no patching or repairs.

B. As soon as the forms have been stripped and the concrete surfaces exposed: remove fins and other projections; fill recesses left by the removal of form ties; and repair surface defects which do not impair structural strength. Clean all exposed concrete surfaces and adjoining work stained by leakage of concrete.

C. Immediately after removal of forms remove tie cones and metal portions of ties as specified in Section 03 10 00. Fill holes promptly upon stripping as follows: Moisten the hole with water, followed by a 1/16-in brush coat of neat cement slurry mixed to the consistency of a heavy paste. Immediately plug the hole with a 1 to 1.5 mixture of cement and concrete sand mixed slightly damp to the touch (just short of "balling"). Hammer the grout into the hole until dense, and an excess of paste appears on the surface in the form of a spider web. Trowel smooth with heavy pressure. Avoid burnishing.

D. When filling tie cone holes and patching or repairing exposed surfaces use the same source of cement and sand as used in the parent concrete. Adjust color to match by addition of white cement. Rub lightly with a fine carborundum stone at an age of one to five days if necessary to bring the surface down with the parent concrete. Do not damage or stain the virgin skin of the surrounding parent concrete. Wash thoroughly to remove all rubbed matter.

E. Defective concrete and honeycombed areas: Chip down square and at least 1-in deep to sound concrete with hand chisels or pneumatic chipping hammers. Irregular voids or surface stones need not be removed if they are sound, free of laitance, and firmly embedded in the parent concrete. If honeycomb exists around reinforcement, chip to provide a clear space at least 3/8-in wide all around the steel. For areas less than 1-1/2-in deep, the patch may be made in the same manner as described above for filling form tie holes, care being exercised to use adequately dry (non-trowelable) mixtures and to avoid sagging. Thicker repairs will require build-up in successive 1-1/2-in layers on successive days, each layer being applied (with slurry, etc.) as described above. For deep repairs the Engineer may require an alternate repair method. Submit repair method for defective concrete to the Engineer for Approval prior to starting work.

F. For very heavy (generally formed) patches, the Engineer may order the addition of pea gravel to the mixture and the proportions modified as follows:

Material	Volumes	Weights
Cement	1.0	1.0
Sand	1.0	1.0
Pea Gravel	1.5	1.5

G. The Contractor may use a pre-packaged patching compound, such as: Poly-Patch by Euclid Chemical Company; Sikatop 122 Plus by Sika Chemical Corporation or equal only if approved by the Engineer for use and for color match.

3.13 SCHEDULE

A. The following (Table 5) are the general applications for the various concrete classes and design strengths:

TABLE 5

Class	Design Strength (psi)	Description
A	2,500	Concrete fill, concrete fill for bollards and pipe encasement.
E1	4,500	Structural concrete foundation mats and slabs, walls, and footings 16-in and greater in thickness.
E2	4,500	Except as noted above for Class E1 concrete: Structural concrete greater than 10-in in thickness including walls, slabs on grade, elevated slab and beam systems, grade beams, piles, pile caps and all other structural concrete greater than 10-in in thickness.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and design and deliver under-slab vapor retarders for the Project as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A. Cast-In-Place Concrete is included in Section 03 30 00.

1.03 SUBMITTALS

A. Submit in accordance with Section 01 33 23.

B. Product Data: For each type of product indicated.

C. Material Certificates: For under-slab vapor retarders.

1.04 REFERENCE STANDARDS

A. ASTM International

1. ASTM C 33 - Specification for Concrete Aggregates

2. ASTM D 448 - Classification for Sizes of Aggregate for Road and Bridge Construction

3. ASTM E 1643 - Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs

4. ASTM E 1745 - Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs

B. Where reference is made to one of the above or other referenced standards, the revisions in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Source Limitations: Obtain under-slab vapor retarders from single source and obtain admixtures from single source from single manufacturer.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle under-slab vapor retarders to prevent bending and damage.

PART 2 PRODUCTS

2.01 UNDER-SLAB VAPOR RETARDERS

A. Under-Slab Vapor Retarders: ASTM E 1745, Class A, except with maximum perm rating of 0.01. Include manufacturer's recommended adhesive or pressure-sensitive tape.

1. Products: Subject to compliance with requirements, provide one of the following:
   a. Carlisle Coatings & Waterproofing, Inc.; Blackline 400.
   b. Fortifiber Building Systems Group; Moistop Ultra 15.
   c. Grace Construction Products, W. R. Grace & Co.; Florprufe 120.
   d. Meadows, W. R., Inc.; Perminator 15 mil.
   e. Raven Industries Inc.; Vapor Block 15.
   f. Stego Industries, LLC; Stego Wrap 15 mil Class A.
   g. Or equal.

2. Thickness: Minimum 15 mils.

B. Accessories: Seam tape and mastic materials approved in writing by the manufacturer for use with under-slab vapor retarder.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of work.

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

3.02 UNDER-SLAB VAPOR RETARDERS

A. Under-Slab Vapor Retarders: Place, protect, and repair sheet vapor retarder according to ASTM E 1643 and manufacturer's written instructions.

1. Lap joints 6 inches and seal with manufacturers recommended tape.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and finish cast-in-place concrete surfaces as specified herein.

1.02 RELATED WORK

A. Concrete and finishing for walkway and pavements is included in Division 32.

B. Concrete formwork is included in Section 03 10 00.

C. Patching and repair of defective and honeycombed concrete is included in Section 03 30 00.

D. Grout is included in Section 03 60 00.

E. Waterproofing, dampproofing and caulking are included in Section 07 11 13.

F. Painting, toppings and special surfaces are included in Division 09.

1.03 REFERENCE STANDARDS

A. ASTM International

1. ASTM C144 - Standard Specification for Aggregate for Masonry Mortar

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.04 RESPONSIBILITY FOR CHANGING FINISHES

A. The surface finishes specified for concrete to receive coatings or other finish materials are those required for the proper application of the products specified under other Sections. Where products different from those specified are approved for use determine if changes in finishes are required and provide the proper finishes to receive these products.

B. Perform changes in finishes made to accommodate products different from those specified at no additional cost to the Owner. Submit the proposed new finishes to the Engineer for approval.

PART 2 PRODUCTS

2.01 MATERIALS

A. Cementitious and component materials required for finishing concrete surfaces: As specified in Section 03 30 00.

PART 3 EXECUTION

3.01 FORMED SURFACES

A. Form removal: Conform to Sections 03 10 00 and 03 30 00.

B. Do not damage edges or obliterate the lines of chamfers, rustications or corners when removing the forms or doing any other work adjacent thereto.

C. Clean all exposed concrete surfaces and adjoining work stained by leakage of concrete.

D. Off-Form Finish

1. Remove fins and other projections and fill tie cones and defects as specified in Section 03 30 00.

E. Rubbed Finish

1. Immediately upon stripping forms and before concrete changes color, carefully remove all fins with a hammer. While the surface is still damp apply a thin coat of medium consistency neat cement slurry using bristle brushes to provide a bonding coat within all pits, air holes or blemishes in the parent concrete. Do not coat large areas of the surface with this slurry.

2. Before the slurry dries or changes color, apply a dry (almost crumbly) grout consisting of one volume cement to 1-1/2 volumes of clean masonry sand having a fineness modulus of approximately 2.25 and complying with the gradation requirements of ASTM C144. Apply grout uniformly using damp (neither dripping wet nor dry) pads of coarse burlap approximately 6-in square used as a float. Scrub grout into the pits and air holes to provide a dense mortar in the imperfections to be patched.

3. Allow the mortar to partially harden for one or two hours depending upon the weather. If the air is hot and dry, keep the surface damp during this period using a fine, fog spray. When the grout has hardened sufficiently so it can be scraped from the surface with the perpendicular edge of a steel trowel without damaging the grout in the small pits or holes, cut off all grout that can be removed with a trowel. Grout allowed to remain on the surface too long will get too hard and will be difficult to remove.

4. Allow the surface to dry and rub it vigorously with clean dry burlap to completely remove any dried grout. No visible film of grout should remain after this rubbing. The entire cleaning operation for any area must be completed the day it is started. Do not leave grout on surfaces overnight. Allow grout to dry after it has been cut off with the trowel so it can be wiped off clean with the burlap.

5. On the day following the repair of pits, air holes and blemishes, the surfaces again shall be wiped off clean with dry, used pieces of burlap containing old hardened mortar which will act as a mild abrasive. After this treatment, there shall be no built-up film remaining on the parent surface. If, however, a built-up film remains, use a fine abrasive stone to remove all such material without breaking through the surface film of the original concrete. Scrub lightly to remove excess material without working up a lather or mortar or changing the texture of the concrete.

6. Follow the final bagging or stoning operation with a thorough wash-down with stiff bristle brushes to remove extraneous materials from the surface. Spray the surface with a fine fog spray periodically to maintain a continually damp condition for at least 3 days after the application of the repair grout.

7. The Rubbed Finish application may be deleted by the Engineer if the unfinished concrete surface is of superior quality and without surface voids.

3.02 FLOORS AND SLABS

A. Consider the potential for longer setting time in concrete containing fly ash or ground granulated blast furnace slag.

B. Compact with internal vibrators as specified in Section 03 30 00 and screed to the established grades. Provide floors and slabs level with a tolerance of 1/8-in when checked with a 12-ft straightedge, except where drains occur, in which case pitch floors to drains as indicated. Failure to meet either of above shall be cause for removal, grinding, or other correction as directed by the Engineer, at no additional cost to the Owner.

C. Following screeding as specified above, float the slabs as approved by the Engineer. Continue floating operation until sufficient mortar is brought to the surface to fill all voids. Test the surfaces with a straightedge to detect high and low spots which shall be eliminated. Do not overwork the concrete as evidenced by excess water and fine material on the surface.

D. Do not use "jitterbugs" or other special tools designed for the purpose of forcing the coarse aggregate away from the surface and allowing a layer of mortar to accumulate on any slab finish. Do not dust surfaces with dry materials. Round off all edges of slabs and tops of walls with a steel edging tool. Use steel edging tool with radius of 1/4-in for all slabs subject to wheeled traffic.

E. Measure floor flatness the day after a concrete floor is finished and before the shoring is removed, in order to eliminate any effects of shrinkage, curling and deflection. A 12-ft long straightedge shall be supported at each end with steel gauge blocks whose

thickness are equal to tolerance specified. Floor surface shall not have crowns so high as to prevent 12-ft straightedge from resting on the two end blocks, nor low spots so low that a third block of twice the tolerance in thickness can pass under the supported straightedge. Compliance with the designated limits in four of five consecutive measurements will confirm compliance, unless obvious faults are observed. A check for adequate slope and drainage will also be made to confirm compliance.

F. Descriptions

1. Steel Trowel Finish. Finish by screeding and floating with straightedges to bring the surfaces to the elevations indicated. While the concrete is still green, but sufficiently hardened to bear a person's weight without deep imprint, the surface shall be wood floated to a true, even plane with no coarse aggregate visible. Apply sufficient pressure on the wood floats to bring moisture to the surface. After surface moisture has disappeared, hand steel trowel to produce a smooth, impervious surface, free from trowel marks. Trowel the surface again for the purpose of burnishing. The final troweling shall produce a ringing sound from the trowel. Do not use dry cement or additional water in troweling.

2. Wood Float Finish. Finish by screeding with straightedges to bring the surfaces to the elevations indicated. Use a wood float to compact and seal surface. Remove all laitance and leave a clean surface.

3. Light Broomed Finish. Steel trowel finish the concrete, as specified above but omit the final troweling and finish the surface by drawing a fine-hair broom lightly across the surface. Broom in the same direction and parallel to expansion joints, or in the case of inclined slabs, perpendicular to the slope, or except as directed otherwise.

4. Broomed Finish. Steel trowel finish the concrete, as specified above but omit the final troweling. While the concrete is still soft enough, finish the surface with a stiff coarse fiber broom to produce the pattern and depth of scoring as approved by the Engineer.

5. Power Machine Finish. In lieu of hand steel trowel finishing, an approved power machine for finishing concrete floors and slabs may be used in accordance with the directions of the machine manufacturer and as approved by the Engineer. Do not use a power machine until the concrete has attained the necessary set to allow finishing without introducing high and low spots in the slab. Hand steel trowel the areas of slabs not accessible to power equipment. Provide a final steel troweling done by hand over all areas.

3.03 APPROVAL OF FINISHES

A. All concrete surfaces, when finished, will be inspected by the Engineer.

B. Refinish or rework unsatisfactory finishes until approved by the Engineer, at no additional cost to the Owner.

C. Hardened unsatisfactory finishes will require removal, grinding, or other appropriate correction approved by the Engineer, at no additional cost to the Owner.

3.04 SCHEDULE OF FINISHES

A. Finish concrete in the various specified manners either to remain as natural concrete or to receive an additional applied finish or material under another Section. Where products different from those specified are approved for use comply with the requirements of Paragraphs 1.06A and1.06B.

B. Finishes to the base concrete for the following conditions shall be as scheduled below and as further specified herein:

1. Exposed exterior concrete excluding slabs and walking surfaces - Rubbed finish. (Rub open tank walls above and to 1-ft below normal water line).

2. Concrete for exterior on stairs and other horizontal areas - Broomed finish, non-slip.

3. Exposed interior concrete including underside slabs, beams and stairs and sides of openings, beams and stairs - Rubbed finish.

4. Walls of open topped tanks - Rubbed finish above and to 1-ft below normal water line. Off-form finish from 1-ft below normal water line to base of wall.

5. Tops of curbs and pads - Steel trowel finish.

6. Concrete on which liquids flow or are contained - Steel troweled finish.

7. Concrete not exposed in the finished work and not scheduled to receive an additional applied finish or material - Off-form finish at vertical surfaces, consolidate and screed to grade at horizontal surfaces.

8. Concrete tank bottoms to be covered with grout - Broom finish as approved. See Section 03 60 00 for additional requirements.

9. Concrete to receive dampproofing - Off-form finish.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install grout complete as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A. Grout for mini-piles, is included in Division 31.

B. Demolition and removals are included in Section 02 41 00.

C. Concrete formwork is included in Section 03 10 00.

D. Concrete reinforcement is included in Section 03 20 00.

E. Concrete joints and joint accessories are included in Section 03 15 00.

F. Cast-in-place concrete is included in Section 03 30 00.

G. Masonry grout is included in Section 04 20 00.

H. Miscellaneous metals are included in Section 05 50 00.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, shop drawings and product data showing materials of construction and details of surface preparation, mixing and installation for:

1. Commercially manufactured non-shrink cementitious grout. Include catalog cuts, technical data, storage requirements, product life, working time after mixing, temperature considerations, conformity to the specified ASTM standards, and Material Safety Data Sheet.

2. Cement grout. Include the type and brand of cement, the gradation of fine aggregate, product data on any proposed admixtures and the proposed grout mix.

3. Concrete grout. Include data as required for concrete as delineated in Section 03 30 00 and for fiber reinforcement as delineated in Section 03 20 00.

B. Laboratory Test Reports

1. For concrete grout, submit laboratory test data as required for concrete as delineated in Section 03 30 00.

C. Qualifications

1. Submit documentation that grout manufacturers have a minimum of 10 years experience in the production and use of the grouts proposed.

1.04 REFERENCE STANDARD

A. ASTM International

1. ASTM C33 - Standard Specification for Concrete Aggregates

2. ASTM C150 - Standard Specification for Portland Cement

3. ASTM C827 - Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures

4. ASTM C1077 - Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation

5. ASTM C1107 - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink)

6. ASTM E329 - Standard specification for agencies engaged in the testing and/or inspection of materials used in construction

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Qualifications

1. Grout manufacturers shall have a minimum of 10 years' experience in the production and use of the type of grout proposed.

B. Field Testing

1. All field testing and inspection services will be provided by the Owner. Assist in the sampling of materials, and cooperate by allowing free access to the work and permitting the use of ladders, scaffolding, and such incidental equipment as may be required. Methods of testing will comply with the applicable ASTM Standards.

2. Field testing of concrete grout will be as specified for concrete in Section 03 30 00.

1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver materials to the jobsite in original, unopened packages, clearly labeled with the manufacturer's name, product identification, batch numbers and printed instructions.

B. Store materials in full compliance with the manufacturer's recommendations. Limit total storage time from date of manufacture to date of installation to six months or the manufacturer's recommended storage time, whichever is less.

C. Remove immediately from the site material which becomes damp, contains lumps, or is hardened and replace with acceptable material at no additional cost to the Owner.

D. Deliver non-shrink cementitious grout as a pre-portioned blend in prepackaged mixes requiring only the addition of water.

1.07 DEFINITIONS

A. Non-shrink Grout: A commercially manufactured product that does not shrink in either the plastic or hardened state, is dimensionally stable in the hardened state and bonds to a clean base plate.

PART 2 PRODUCTS

2.01 GENERAL

A. The use of a manufacturer's name and product or catalog number is for the purpose of establishing the standard of quality desired.

B. Like materials shall be the products of one manufacturer or supplier in order to provide standardization of appearance.

2.02 MATERIALS

A. Non-shrink Cementitious Grout

1. Non-shrink cementitious grouts: Conform to ASTM C1107. Grouts shall be portland cement based, contain a pre-proportioned blend of selected aggregates and shrinkage compensating agents and require only the addition of water. Non-shrink cementitious grouts shall not contain expansive cement or metallic particles. The grouts shall exhibit no shrinkage when tested in conformity with ASTM C827.
    a. General purpose non-shrink cementitious grout: Conform to the standards stated above. SikaGrout 212 by Sika Corp.; Set Grout by BASF Building Systems; NS Grout by The Euclid Chemical Co.; Five Star Grout by Five Star Products, Inc., or equal.
    b. Flowable (Precision) non-shrink cementitious grout: Conform to the standards stated above. Masterflow 928 by BASF Building Systems; Hi-

Flow Grout by The Euclid Chemical Co.; SikaGrout 212 by Sika Corp.; Five Star Grout by Five Star Products, Inc., or equal.

B. Cement Grout

1. A mixture of one part portland cement conforming to ASTM C150, Type I, II, or III and one to two parts sand conforming to ASTM C33 with sufficient water to place the grout. The water content shall be sufficient to impart workability to the grout but not to the degree that it will allow the grout to flow.

C. Concrete Grout

1. Conform to the requirements of Section 03 30 00 except as specified herein. Proportion with Type II cement, coarse and fine aggregates, water, water reducing admixture and air entraining agent to produce a mix having an average strength of 3500 psi at 28 days (2500 psi nominal strength). Coarse aggregate size shall be 3/8-in maximum. Slump shall not exceed 5-in. Minimum cement content shall be 540 lbs per cubic yard and maximum water to cement ratio shall be 0.45.

2. Add synthetic reinforcing fibers as specified in Section 03 20 00 to the concrete grout mix at the rate of 1.5 lbs of fibers per cubic yard of grout. Add fibers from the manufacturer's pre-measured bags and according to the manufacturer's recommendations to ensure complete dispersion of the fiber bundles as single monofilaments within the concrete grout.

D. Self-Leveling Cementitious Underlayment Grout

1. Grout shall be portland cement based, non-shrinking, self-leveling underlayment, factory prepared and packaged. Underlayment Self-Leveling by BASF Building Systems, LeveLayer by Dayton Superior, Flo-Top by the Euclid Chemical Company, or equal providing a one day compressive strength of 1200 psi minimum and a 28 day value of 3000 psi minimum.

2. Provide polymer emulsion, system primer for substrate preparation, Primer 800 by BASF Building Systems, Level Primer J42 by Dayton Superior, Tammsweld by the Euclid Chemical Company, or equal for the specific product proposed.

3. Provide clean, dry and sound pea gravel, 1/4-in maximum and 1/8-in minimum size and conforming to ASTM C33 (Provide 1/8-in maximum size, clean, dry and sound sand conforming to ASTM C33 for the equal specific product.

E. Water

1. Potable water free of oil, acid, alkali, salts, chlorides (except those attributable to drinking water), organic matter, or other deleterious substances.

PART 3 EXECUTION

3.01 PREPARATION

A. Place grout where indicated or specified over cured concrete which has attained its specified design strength unless otherwise approved by the Engineer.

B. Concrete surfaces to receive grout shall be clean and sound; free of ice, frost, dirt, dust, grease, oil, form release agent, laitance and paints and free of all loose material or foreign matter which may affect the bond or performance of the grout.

C. Roughen concrete surfaces by chipping, sandblasting, or other dry mechanical means to bond the grout to the concrete. Remove loose or broken concrete. Irregular voids or projecting coarse aggregate need not be removed if they are sound, free of laitance and firmly embedded into the parent concrete.

1. Air compressors used to clean surfaces in contact with grout shall be the oilless type or equipped with an oil trap in the airline to prevent oil from being blown onto the surface.

D. Remove all loose rust, oil or other deleterious substances which may affect the bond or performance of the grout from metal embedments or bottom of baseplates prior to the installation of the grout.

E. Wash concrete surfaces clean and then keep moist for at least 24 hours prior to the placement of non-shrink cementitious or cement grout. Saturation may be achieved by covering the concrete with saturated burlap bags, use of a soaker hose, or flooding the surface or other method acceptable to the Engineer. Upon completion of the 24-hour period, remove visible water from the surface prior to grouting.

F. Provide forms for grout. Line or coat forms with release agents recommended by the grout manufacturer. Provide forms anchored in place and shored to resist the forces imposed by the grout and its placement.

1. Forms for all grout other than concrete grout shall be designed to allow the formation of a hydraulic head and shall have chamfer strips built into forms.

G. Level and align the structural or equipment bearing plates in accordance with the structural requirements or the recommendations of the equipment manufacturer, as applicable.

H. Support equipment during alignment and installation of grout by shims, wedges, blocks or other approved means. The shims, wedges and blocking devices shall be prevented from bonding to the grout by bond breaking coatings and removed after grouting unless otherwise approved by the Engineer. Grout voids created by the removal of shims, wedges and blocks.

3.02 INSTALLATION - GENERAL

A. Mix, apply and cure products in strict compliance with the manufacturer's recommendations and these specifications.

B. Provide staffing and equipment available for rapid and continuous mixing and placing. Keep all necessary tools and materials ready and close at hand.

C. Maintain temperatures of the base plate, supporting concrete, and grout between 40 and 90 degrees F during grouting and for at least 24 hours after placement, until grout compressive strength reaches 1000 psi or as recommended by the grout manufacturer, whichever is longer. Do not allow differential heating or cooling of baseplates and grout during the curing period.

D. Take special precautions for hot weather or cold weather grouting as recommended by the manufacturer when ambient temperatures and/or the temperature of the materials in contact with the grout are outside of the 40 to 90 degrees F range.

E. Install grout to preserve the isolation between the elements on either side of the joint where grout is placed in the vicinity of an expansion or partial contraction joint.

F. Reflect all existing underlying expansion, partial contraction and construction joints through the grout.

3.03 INSTALLATION – NON-SHRINK CEMENTITIOUS GROUTS AND CEMENT GROUTS

A. Mix in accordance with manufacturer's recommendations. Do not add cement, sand, pea gravel or admixtures without prior approval by the Engineer.

B. Do not mix by hand. Mix in a mortar mixer with moving blades. Pre-wet the mixer and empty excess water. Add pre-measured amount of water for mixing, followed by the grout. Begin with the minimum amount of water recommended by the manufacturer and then add the minimum additional water required to obtain workability. Do not exceed the manufacturer's maximum recommended water content.

C. Placements greater than 3-in in depth shall include the addition of clean, washed pea gravel to the grout mix when approved by the manufacturer. Comply with the manufacturer's recommendations for the size and amount of aggregate to be added.

D. Provide forms as specified in Paragraph 3.01G. Place grout into the designated areas and prevent segregation and entrapment of air. Do not vibrate grout to release air or to consolidate the material. Fill all spaces and provide full contact between the grout and adjoining surfaces. Provide grout holes and vent holes as necessary.

E. Place grout rapidly and continuously to avoid cold joints. Do not place grout in layers. Do not add additional water to the mix (retemper) after initial stiffening.

F. Just before the grout reaches its final set, cut back the grout to the substrate at a 45-degree angle from the lower edge of bearing plate unless otherwise ordered and approved by the Engineer. Finish this surface with a wood float or brush finish.

G. Begin curing immediately after form removal, cutback, and finishing. Keep grout moist and within its recommended placement temperature range for at least 24 hours after placement, until grout compressive strength reaches 1000 psi or as recommended by the manufacturer, whichever is longer. Saturate the grout surface by use of saturated burlap bags, soaker hoses or ponding. Provide sunshades. If drying winds inhibit the ability of a given curing method to keep grout moist, erect wind breaks until wind is no longer a problem or curing is finished.

3.04 INSTALLATION – CONCRETE GROUT

A. Inspect slabs finished under Section 03 35 00 and scheduled to receive concrete grout. Protect and keep the surface clean until placement of concrete grout.

B. Remove debris and clean the surface by sweeping and vacuuming of all dirt and other foreign materials. Pressure wash the surface. Do not flush debris into tank drain lines.

C. Saturate the concrete surface for at least 24 hours prior to placement of the concrete grout by use of saturated burlap bags, soaker hoses or ponding. Remove excess water just prior to placement of the concrete grout. Place a cement slurry immediately ahead of the concrete grout so that the slurry is moist when the grout is placed. Work the slurry over the surface with a broom until it is coated with approximately 1/16 to 1/8-in thick cement paste.

D. Place concrete grout to final grade using the scrapers of the installed mechanical equipment as a guide for surface elevation and to eliminate high and low spots. Unless specifically approved by the equipment manufacturer, mechanical scraper mechanisms powered by their motors shall not be used as a finishing machine or screed to push grout.

E. Provide grout control joints as indicated on the Drawings.

F. Steel trowel finish as specified in Section 03 35 00. Cure the concrete grout as specified for cast-in-place concrete in Section 03 30 00.

3.05 INSTALLATION – SELF-LEVELING CEMENTITIOUS UNDERLAYMENT GROUT

A. Perform work generally as follows but conform to installation procedures as submitted and approved.

B. Removal of flooring and underlying fill concrete material are included under Division 02. Provide additional substrate preparation as required to ensure proper bond of the grout system.

C. Prime the prepared substrate with the system primer and remove all puddles. Allow to dry completely.

D. Mix underlayment grout with water and the approved aggregate only and in the approved proportions to be flowable and self-leveling.

E. Install in one lift for all locations and allow to level. Completely fill the required areas allowing no voids in the grout thickness. Slope to floor drains as required.

F. Cure in conformance with manufacturer's instructions. Do not allow conditions which would permit premature drying.

G. Protect the grouted areas as approved until finish material is applied under Division 09 9.

3.06 SCHEDULE

A. The following list indicates where the particular types of grout are to be used:

1. General purpose non-shrink cementitious grout: Use at all locations where non-shrink grout is indicated on the Drawings, except for base plates greater in area than 3-ft wide by 3-ft long.

2. Flowable (precision) non-shrink cementitious grout: Use under all base plates greater in area than 3-ft wide by 3-ft long. Use at all locations indicated on the Drawings to receive flowable (precision) non-shrink grout. Flowable (precision), non-shrink, cementitious grout may be substituted for general purpose non-shrink cementitious grout.

3. Cement grout: Use where indicated on the Drawings.

4. Concrete grout: Use for concrete grout fill within liquid retaining structures and other locations where specifically indicated on the Drawings.

5. Self-leveling cementitious underlayment grout: Use over existing slab as shown and required to provide substrate for tile work.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install unit masonry complete as shown on the Drawings and as specified herein.

B. Sections includes, but is not limited to the following:

1. Concrete masonry units (CMUs).
2. Decorative concrete masonry units.
3. Mortar and grout.
4. Masonry joint reinforcement.
5. Ties and anchors.
6. Embedded flashing.
7. Miscellaneous masonry accessories.
8. Masonry-cell insulation.
9. Cavity-wall insulation.

1.02 RELATED WORK

A. Reinforcing steel is included in Section 03 20 00.

B. Steel lintels and shelf angles is included in Section 05 50 00.

C. Dampproofing applied to cavity face of backup wythes of cavity walls is included in Section 07 11 13.

D. Sealing control and expansion joints in unit masonry Section 07 92 00.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, detailed information on materials proposed and installation methods.

B. Product Data: For each type of product indicated.

C. Shop Drawings: For the following:

1. Masonry Units: Show sizes, profiles, coursing, and locations of special shapes.

2. Fabricated Flashing: Detail corner units, end-dam units, and other special applications.

D. Samples: For the following:

1. Colored mortar.

2. Weep holes/vents.

3. Pigmented mortar. Make Samples using same sand and mortar ingredients to be used on Project. Label Samples to indicate types and amounts of pigments used.

4. Accessories embedded in masonry.

E. Qualification Data: For testing agency.

F. Material Certificates: Include statements of material properties indicating compliance with requirements including compliance with standards and type designations within standards. Provide for each type and size of the following:

1. Masonry units.
   a. Include data on material properties and material test reports substantiating compliance with requirements.
   b. For masonry units used in structural masonry, include data and calculations establishing average net-area compressive strength of units.

2. Cementitious materials. Include brand, type, and name of manufacturer.

3. Pre-blended, dry mortar mixes. Include description of type and proportions of ingredients.

4. Grout mixes. Include description of type and proportions of ingredients.

5. Joint reinforcement.

6. Anchors, ties, and metal accessories.

G. Mix Designs: For each type of mortar and grout. Include description of type and proportions of ingredients.

1. Include test reports, per ASTM C 780, for mortar mixes required to comply with property specification.

2. Include test reports, per ASTM C 1019, for grout mixes required to comply with compressive strength requirement.

H. Statement of Compressive Strength of Masonry: For each combination of masonry unit type and mortar type, provide statement of average net-area compressive strength of masonry units, mortar type, and resulting net-area compressive strength of masonry determined according to Tables 1 and 2 in ACI 530.1/ASCE 6/TMS 602.

I. Cold-Weather and Hot-Weather Procedures: Detailed description of methods, materials, and equipment to be used to comply with cold-weather requirements.

1.04 REFERENCES

A. American Concrete Institute/American Concrete Institute

1. ACI 315 - Details and Detailing of Concrete Reinforcement

B. American Concrete Institute/American Concrete Institute; American Society of Civil Engineers; and The Masonry Society

1. ACI 530.1/ASCE 6/TMS 602 - Specification for Masonry Structures

C. ASTM International

1. ASTM A 153/A 153M - Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

2. ASTM A 240/A 240M - Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

3. ASTM A 580/A 580M - Specification for Stainless Steel Wire

4. ASTM A 653/A 653M - Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

5. ASTM A 666 - Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar

6. ASTM A 951/A 951M - Specification for Masonry Joint Reinforcement

7. ASTM A 1008/A 1008M - Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability

8. ASTM B 32 - Specification for Solder Metal

9. ASTM B 117 - Practice for Operating Salt Spray (Fog) Apparatus

10. ASTM B 370 - Specification for Copper Sheet and Strip for Building Construction

11. ASTM B 633 - Specification for Electrodeposited Coatings of Zinc on Iron and Steel

12. ASTM C 90 - Specification for Loadbearing Concrete Masonry Units

13. ASTM C 140 - Test Methods for Sampling and Testing Concrete Masonry Units and Related Units

14. ASTM C 143/C 143M - Test Method for Slump of Hydraulic Cement Concrete

15. ASTM C 144 - Specification for Aggregate for Masonry Mortar
16. ASTM C 150 - Specification for Portland Cement
17. ASTM C 199 - Test Method for Pier Test for Refractory Mortars
18. ASTM C 207 - Specification for Hydrated Lime for Masonry Purposes
19. ASTM C 270 - Specification for Mortar for Unit Masonry
20. ASTM C 404 - Specification for Aggregates for Masonry Grout
21. ASTM C 476 - Specification for Grout for Masonry
22. ASTM C 494/C 494M - Specification for Chemical Admixtures for Concrete
23. ASTM C 578 - Specification for Rigid, Cellular Polystyrene Thermal Insulation
24. ASTM C 780 - Test Method for Preconstruction and Construction Evaluation of Mortars for Plain and Reinforced Unit Masonry
25. ASTM C 920 - Specification for Elastomeric Joint Sealants
26. ASTM C 1019 - Test Method for Sampling and Testing Grout
27. ASTM C 1093 - Practice for Accreditation of Testing Agencies for Unit Masonry
28. ASTM C 1289 - Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board
29. ASTM C 1314 - Test Method for Compressive Strength of Masonry Prisms
30. ASTM C 1329 - Specification for Mortar Cement
31. ASTM C 1506 - Test Method for Water Retention of Hydraulic Cement-Based Mortars and Plasters
32. ASTM D 1056 - Specification for Flexible Cellular Materials - Sponge or Expanded Rubber
33. ASTM E 119 - Test Methods for Fire Tests of Building Construction and Materials
34. ASTM E 488 - Test Methods for Strength of Anchors in Concrete and Masonry Elements
35. ASTM E 514 - Test Method for Water Penetration and Leakage Through Masonry

D. National Concrete Masonry Association

1. NCMA TEK 8 - Removal of Stains from Concrete Masonry Walls

E. Sheet Metal and Air Conditioning Contractors' National Association

1. Architectural Sheet Metal Manual.

F. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 DEFINITIONS

A. Reinforced Masonry: Masonry containing reinforcing steel in grouted cells.

B. CMU(s): Concrete masonry unit(s).

1.06 PERFORMANCE REQUIREMENTS

A. Provide structural unit masonry that develops indicated net-area compressive strengths (f'm) at 28 days.

B. Determine net-area compressive strength (f'm) of masonry from average net-area compressive strengths of masonry units and mortar types (unit-strength method) according to Tables 1 and 2 in ACI 530.1/ASCE 6/TMS 602.

1. For concrete masonry unit construction: f 'm = 1900 psi.

C. Determine net-area compressive strength (f'm) of masonry by testing masonry prisms according to ASTM C 1314.

1.07 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM C 1093 for testing indicated.

B. Source Limitations for Masonry Units: Obtain exposed masonry units of a uniform texture and color, or a uniform blend within the ranges accepted for these characteristics, through one source from a single manufacturer for each product required.

C. Source Limitations for Mortar Materials: Obtain mortar ingredients of a uniform quality, including color for exposed masonry, from a single manufacturer for each cementitious component and from one source or producer for each aggregate.

D. Masonry Standard: Comply with ACI 530.1/ASCE 6/TMS 602 unless modified by requirements in the Contract Documents.

E. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

1. Build mockups for typical exterior wall in sizes approximately 60 inches long by 48 inches high by full thickness, including face and backup wythes and accessories.
   a. Include a sealant-filled joint at least 16 inches (400 mm) long in exterior wall mockup.

b. Include through-wall flashing installed for a 24-inch (600-mm) length in corner of exterior wall mockup approximately 16 inches (400 mm) down from top of mockup, with a 12-inch (300-mm) length of flashing left exposed to view (omit masonry above half of flashing).
c. Include flashing, and weep holes in exterior masonry-veneer wall mockup.

2. Masonry is to match existing nearby Tennis Center.

3. Clean one-half of exposed faces of mockups with masonry cleaner as indicated.

4. Protect accepted mockups from the elements with weather-resistant membrane.

5. Approval of mockups is for color, texture, and blending of masonry units; relationship of mortar and sealant colors to masonry unit colors; tooling of joints; and aesthetic qualities of workmanship.
   a. Approval of mockups is also for other material and construction qualities specifically approved by Engineer in writing.
   b. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless such deviations are specifically approved by Engineer in writing.

6. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Store masonry units on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied. If units become wet, do not install until they are dry.

B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.

C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

D. Deliver pre-blended, dry mortar mix in moisture-resistant containers designed for lifting and emptying into dispensing silo. Store pre-blended, dry mortar mix in delivery containers on elevated platforms, under cover, and in a dry location or in a metal dispensing silo with weatherproof cover.

E. Store masonry accessories, including metal items, to prevent corrosion and accumulation of dirt and oil.

1.09 PROJECT CONDITIONS

A. Protection of Masonry: During construction, cover tops of walls, projections, and sills with waterproof sheeting at end of each day's work. Cover partially completed masonry when construction is not in progress.

1. Extend cover a minimum of 24 inches down both sides of walls and hold cover securely in place.

2. Where one wythe of multi-wythe masonry walls is completed in advance of other wythes, secure cover a minimum of 24 inches down face next to unconstructed wythe and hold cover in place.

B. Do not apply uniform floor or roof loads for at least 12 hours and concentrated loads for at least 3 days after building masonry walls or columns.

C. Stain Prevention: Prevent grout, mortar, and soil from staining the face of masonry to be left exposed or painted. Immediately remove grout, mortar, and soil that come in contact with such masonry.

1. Protect base of walls from rain-splashed mud and from mortar splatter by spreading coverings on ground and over wall surface.

2. Protect sills, ledges, and projections from mortar droppings.

3. Protect surfaces of window and door frames, as well as similar products with painted and integral finishes, from mortar droppings.

4. Turn scaffold boards near the wall on edge at the end of each day to prevent rain from splashing mortar and dirt onto completed masonry.

D. Cold-Weather Requirements: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen substrates. Remove and replace unit masonry damaged by frost or by freezing conditions. Comply with cold-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602.

1. Cold-Weather Cleaning: Use liquid cleaning methods only when air temperature is 40 deg F (4 deg C) and higher and will remain so until masonry has dried, but not less than seven days after completing cleaning.

E. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602.

PART 2 PRODUCTS

2.01 MASONRY UNITS, GENERAL

A. Defective Units: Referenced masonry unit standards may allow a certain percentage of units to contain chips, cracks, or other defects exceeding limits stated in the standard. Do not use units where such defects will be exposed in the completed Work.

2.02 CONCRETE MASONRY UNITS (CMUS)

A. Shapes: Provide shapes indicated and as follows:

1. Provide special shapes for lintels, corners, jambs, sashes, movement joints, headers, bonding, and other special conditions.

2. Provide square-edged units for outside corners, unless otherwise indicated.

B. Integral Water Repellent: Provide units made with integral water repellent for exposed units.

1. Integral Water Repellent: Liquid polymeric, integral water-repellent admixture that does not reduce flexural bond strength. Units made with integral water repellent, when tested as a wall assembly made with mortar containing integral water-repellent manufacturer's mortar additive according to ASTM E 514, with test period extended to 24 hours, show no visible water or leaks on the back of test specimen.
   a. Products:
      1) ACM Chemistries; RainBloc.
      2) BASF Aktiengesellschaft; Rheopel Plus.
      3) Grace Construction Products, W. R. Grace & Co. - Conn.; Dry-Block.
      4) Or equal.

C. CMU's: ASTM C 90.

1. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of1900 psi.

2. Density Classification: Normal weightunless otherwise indicated.

3. Size (Width): Manufactured to dimensions 3/8 inch less than nominal dimensions.

D. Decorative CMU's: ASTM C 90.

1. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of 2150 psi.

2. Density Classification: Normal weight.

3. Size (Width): As noted on Drawings and manufactured to dimensions specified in "Concrete Masonry Units" Paragraph above.

4. Pattern and Texture:
   a. Standard pattern, ground finish.
   b. Double scored vertically so units laid in running bond appear as square units laid in stacked bond, ground finish.

5. Colors: Custom color to match tennis center.

2.03 CONCRETE LINTELS

A. General: Provide either concrete or masonry lintels, at Contractor's option, complying with requirements below.

B. Precast or formed-in-place concrete lintels complying with requirements in Section 03 30 00 and with reinforcing bars indicated.

2.04 MORTAR AND GROUT MATERIALS

A. Portland Cement: ASTM C 150, Type I or II, except Type III may be used for cold-weather construction. Provide natural color or white cement as required to produce mortar color indicated.

B. Hydrated Lime: ASTM C 207, Type S.

C. Portland Cement-Lime Mix: Packaged blend of portland cement complying with ASTM C 150, Type I or Type III, and hydrated lime complying with ASTM C 207, Type S.

D. Colored Cement Product: Packaged blend made from portland cement and lime and mortar pigments, all complying with specified requirements, and containing no other ingredients. Do not use mortar cement or masonry cement in blend.

1. Formulate blend as required to produce color indicated or, if not indicated, as selected from manufacturer's standard colors.

2. Pigments shall not exceed 10 percent of portland cement by weight.

3. Pigments shall not exceed 5 percent of masonry cement by weight.

4. Products: Colored Portland Cement-Lime Mix: Provide one of the following:
   a. Capital Materials Corporation; Riverton Portland Cement Lime Custom Color.
   b. Holcim (US) Inc.; Rainbow Mortamix Custom Color Cement/Lime.
   c. Lafarge North America Inc.; Eaglebond.
   d. Lehigh Cement Company; Lehigh Custom Color Portland/Lime Cement.
   e. Or equal.

E. Aggregate for Mortar: ASTM C 144.

1. For mortar that is exposed to view, use washed aggregate consisting of natural sand or crushed stone.

2. For joints less than 1/4 inch thick, use aggregate graded with 100 percent passing the No. 16 sieve.

3. White-Mortar Aggregates: Natural white sand or crushed white stone.

4. Colored-Mortar Aggregates: Natural sand or crushed stone of color necessary to produce required mortar color.

F. Aggregate for Grout: ASTM C 404.

G. Cold-Weather Admixture: Nonchloride, noncorrosive, accelerating admixture complying with ASTM C 494/C 494M, Type C, and recommended by manufacturer for use in masonry mortar of composition indicated.

1. Products:
   a. Euclid Chemical Company (The); Accelguard 80.
   b. Grace Construction Products, a unit of W. R. Grace & Co. - Conn.; Morset.
   c. Sonneborn Products, BASF Aktiengesellschaft; Trimix-NCA.
   d. Or equal.

H. Water-Repellent Admixture: Liquid water-repellent mortar admixture intended for use with concrete masonry units, containing integral water repellent by same manufacturer.

1. Products:
   a. ACM Chemistries; RainBloc for Mortar.
   b. BASF Aktiengesellschaft; Rheopel Mortar Admixture.
   c. Grace Construction Products, W. R. Grace & Co. - Conn.; Dry-Block Mortar Admixture.
   d. Or equal.

I. Water: Potable.

2.05 REINFORCEMENT

A. Steel reinforcing bars are specified in Section 03 20 00.

B. Masonry Joint Reinforcement, General: ASTM A 951/A 951M.

1. Interior Walls: Hot-dip galvanized, carbon steel.

2. Exterior Walls: Hot-dip galvanized, carbon steel.

3. Wire Size for Side Rods: 0.187-inch (4.76-mm) diameter.

4. Wire Size for Cross Rods: 0.187-inch (4.76-mm) diameter.

5. Wire Size for Veneer Ties: 0.187-inch (4.76-mm) diameter.

6. Spacing of Cross Rods, Tabs, and Cross Ties: Not more than 16 inches (407 mm) o.c.

7. Provide in lengths of not less than 10 feet (3 m), with prefabricated corner and tee units.

C. Masonry Joint Reinforcement for Single-Wythe Masonry: Either ladder or truss type with single pair of side rods.

D. Masonry Joint Reinforcement for Multi-wythe Masonry:

1. Adjustable (two-piece) type, either ladder or truss design, with one side rod at each face shell of backing wythe and with separate adjustable ties with pintle-and-eye connections having a maximum adjustment of 1-1/4 inches (32 mm). Size ties to extend at least halfway through facing wythe but with at least 5/8-inch (16-mm) cover on outside face. Ties have hooks or clips to engage a continuous horizontal wire in the facing wythe.

2.06 TIES AND ANCHORS

A. Materials: Provide ties and anchors specified in subsequent paragraphs that are made from materials that comply with eight subparagraphs below, unless otherwise indicated.

1. Hot-Dip Galvanized, Carbon-Steel Wire: ASTM A 82; with ASTM A 153/A 153M, Class B-2 coating.

2. Galvanized Steel Sheet: ASTM A 653/A 653M, Commercial Steel, G60 (Z180) zinc coating.

3. Steel Sheet, Galvanized after Fabrication: ASTM A 1008/A 1008M, Commercial Steel, with ASTM A 153/A 153M, Class B coating.

2.07 MISCELLANEOUS ANCHORS

A. Unit Type Inserts in Concrete: Cast-iron or malleable-iron wedge-type inserts.

B. Anchor Bolts: Headed or L-shaped steel bolts complying with ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6); with ASTM A 563 (ASTM A 563M) hex nuts and, where indicated, flat washers; hot-dip galvanized to comply with ASTM A 153/A 153M, Class C; of dimensions indicated.

C. Postinstalled Anchors: Torque-controlled expansion anchors or chemical anchors.

1. Load Capacity: Capable of sustaining, without failure, a load equal to six times the load imposed when installed in unit masonry and four times the load imposed when installed in concrete, as determined by testing according to ASTM E 488, conducted by a qualified independent testing agency.

2. Material for Interior Locations: Carbon-steel components zinc plated to comply with ASTM B 633 or ASTM F 1941 (ASTM F 1941M), Class Fe/Zn 5 unless otherwise indicated.

2.08 EMBEDDED FLASHING MATERIALS

A. Metal Flashing: Provide metal flashing, where flashing is exposed or partly exposed and where indicated, complying with SMACNA's "Architectural Sheet Metal Manual and as follows:

1. Stainless Steel: ASTM A 240/A 240M, Type 304, 0.016 inch (0.40 mm) thick.

2. Fabricate through-wall metal flashing embedded in masonry from stainless steel, with ribs at 3-inch (76-mm) intervals along length of flashing to provide an integral mortar bond.
   a. Products:
      1) Cheney Flashing Company; Cheney Flashing (Dovetail) or Cheney 3-Way Flashing (Sawtooth).

2) Keystone Flashing Company, Inc.; Keystone 3-Way Interlocking Thruwall Flashing.
3) Sandell Manufacturing Co., Inc.; Mechanically Keyed Flashing
4) Or equal.

3. Fabricate through-wall flashing with drip edge, unless otherwise indicated. Fabricate by extending flashing 1/2 inch (13 mm) out from wall, with outer edge bent down 30 degrees and hemmed.

4. Metal Drip Edges: Fabricate from stainless steel. Extend at least 3 inches (76 mm) into wall and 1/2 inch (13 mm) out from wall, with outer edge bent down 30 degrees and hemmed.

5. Metal Flashing Terminations: Fabricate from stainless steel. Extend at least 3 inches (76 mm) into wall and out to exterior face of wall. At exterior face of wall, bend metal back on itself for 3/4 inch (19 mm) and down into joint 1/4 inch (6 mm) to form a stop for retaining sealant backer rod.

B. Flexible Flashing: For flashing not exposed to the exterior, use one of the following, unless otherwise indicated:

1. Rubberized-Asphalt Flashing: Composite flashing product consisting of a pliable, adhesive rubberized-asphalt compound, bonded to a high-density, cross-laminated polyethylene film to produce an overall thickness of not less than 0.030 inch (0.76 mm).
   a. Products: Provide one of the following:
      1) Advanced Building Products Inc.; Peel-N-Seal.
      2) Carlisle Coatings & Waterproofing; CCW-705-TWF Thru-Wall Flashing.
      3) Dayton Superior Corporation, Dur-O-Wal Division; Dur-O-Barrier Thru-Wall Flashing.
      4) Fiberweb, Clark Hammerbeam Corp.; Aquaflash 500.
      5) Grace Construction Products, W. R. Grace & Co. - Conn.; Perm-A-Barrier Wall Flashing.
      6) Heckmann Building Products Inc.; No. 82 Rubberized-Asphalt Thru-Wall Flashing.
      7) Hohmann & Barnard, Inc.; Textroflash.
      8) W. R. Meadows, Inc.; Air-Shield Thru-Wall Flashing.
      9) Polyguard Products, Inc.; Polyguard 300.
      10) Sandell Manufacturing Co., Inc.; Sando-Seal.
      11) Williams Products, Inc.; Everlastic MF-40.
      12) Or equal.

C. Application: Unless otherwise indicated, use the following:

1. Where flashing is indicated to receive counterflashing, use metal flashing.

2. Where flashing is indicated to be turned down at or beyond the wall face, use metal flashing.

3. Where flashing is partly exposed and is indicated to terminate at the wall face, use metal flashing or flexible flashing with a metal drip edge or elastomeric thermoplastic flashing with drip edge.

4. Where flashing is fully concealed, use flexible flashing.

D. Adhesives, Primers, and Seam Tapes for Flashings: Flashing manufacturer's standard products or products recommended by flashing manufacturer for bonding flashing sheets to each other and to substrates.

2.09 MISCELLANEOUS MASONRY ACCESSORIES

A. Compressible Filler: Premolded filler strips complying with ASTM D 1056, Grade 2A1; compressible up to 35 percent; of width and thickness indicated; formulated from neoprene.

B. Preformed Control-Joint Gaskets: Made from styrene-butadiene-rubber compound, complying with ASTM D 2000, Designation M2AA-805 and designed to fit standard sash block and to maintain lateral stability in masonry wall; size and configuration as indicated.

C. Bond-Breaker Strips: Asphalt-saturated, organic roofing felt complying with ASTM D 226, Type I (No. 15 asphalt felt).

D. Weep/Vent Products: Use the following, unless otherwise indicated:

1. Cellular Plastic Weep/Vent: One-piece, flexible extrusion made from UV-resistant polypropylene copolymer, full height and width of head joint and depth 1/8 inch (3 mm) less than depth of outer wythe, in color selected from manufacturer's standard.
   a. Products:
      1) Advanced Building Products Inc.; Mortar Maze weep vent.
      2) Blok-Lok Limited; Cell-Vent.
      3) Dayton Superior Corporation, Dur-O-Wal Division; Cell Vents.
      4) Heckmann Building Products Inc.; No. 85 Cell Vent.
      5) Hohmann & Barnard, Inc.; Quadro-Vent.
      6) Wire-Bond; Cell Vent.
      7) Or equal.

E. Cavity Drainage Material: Free-draining mesh, made from polymer strands that will not degrade within the wall cavity.

1. Provide one of the following configurations:
   a. Strips, full-depth of cavity and 10 inches (250 mm) wide, with dovetail shaped notches 7 inches (175 mm) deep that prevent mesh from being clogged with mortar droppings.
   b. Strips, not less than 3/4 inch (19 mm) thick and 10 inches (250 mm) wide, with dimpled surface designed to catch mortar droppings and prevent weep holes from being clogged with mortar.
   c. Sheets or strips full depth of cavity and installed to full height of cavity.

d. Sheets or strips not less than 3/4 inch (19 mm) thick and installed to full height of cavity with additional strips 4 inches high at weep holes and thick enough to fill entire depth of cavity and prevent weep holes from being clogged with mortar.

2. Products:
   a. Advanced Building Products Inc.; Mortar Break.
   b. Archovations, Inc.; CavClear Masonry Mat.
   c. Dayton Superior Corporation, Dur-O-Wal Division; Polytite MortarStop.
   d. Mortar Net USA, Ltd.; Mortar Net.
   e. Or equal.

F. Reinforcing Bar Positioners: Wire units designed to fit into mortar bed joints spanning masonry unit cells with loops for holding reinforcing bars in center of cells. Units are formed from 0.142-inch (3.77-mm) steel wire, hot-dip galvanized after fabrication. Provide units with either two loops or four loops as needed for number of bars indicated.

1. Products:
   a. Dayton Superior Corporation, Dur-O-Wal Division; D/A 810, D/A 812 or D/A 817.
   b. Heckmann Building Products Inc.; No. 376 Rebar Positioner.
   c. Hohmann & Barnard, Inc.; #RB or #RB-Twin Rebar Positioner.
   d. Wire-Bond; O-Ring or Double O-Ring Rebar Positioner.
   e. Or equal.

2.10 MASONRY-CELL INSULATION

A. Molded-Polystyrene Insulation Units: Rigid, cellular thermal insulation formed by the expansion of polystyrene-resin beads or granules in a closed mold to comply with ASTM C 578, Type I. Provide specially shaped units designed for installing in cores of masonry units.

1. Products:
   a. Concrete Block Insulating Systems; Korfil.
   b. Shelter Enterprises Inc.; Omni Core.
   c. Or equal.

2.11 CAVITY-WALL INSULATION

A. Extruded-Polystyrene Board Insulation with Increased R-Value: ASTM C 578, Type IV, but with an aged thermal resistance (R-value) for 1-inch (25-mm) thickness of 5.6 deg F x h x sq. ft./Btu at 75 deg F (1.0 K x sq. m/W at 24 deg C) at 5 years; closed-cell product with a carbon-black filler and extruded with an integral skin.

B. Adhesive: Type recommended by insulation board manufacturer for application indicated.

2.12 MASONRY CLEANERS

A. Proprietary Acidic Cleaner: Manufacturer's standard-strength cleaner designed for removing mortar/grout stains, efflorescence, and other new construction stains from new masonry without discoloring or damaging masonry surfaces. Use product expressly approved for intended use by cleaner manufacturer and manufacturer of masonry units being cleaned.

1. Manufacturers:
   a. Diedrich Technologies, Inc.
   b. EaCo Chem, Inc.
   c. ProSoCo, Inc.
   d. Or equal.

2.13 MORTAR AND GROUT MIXES

A. General: Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures, unless otherwise indicated.

1. Do not use calcium chloride in mortar or grout.

2. Limit cementitious materials in mortar to portland cement and lime.

3. Add cold-weather admixture (if used) at same rate for all mortar that will be exposed to view, regardless of weather conditions, to ensure that mortar color is consistent.

B. Preblended, Dry Mortar Mix: Furnish dry mortar ingredients in form of a preblended mix. Measure quantities by weight to ensure accurate proportions, and thoroughly blend ingredients before delivering to Project site.

C. Mortar for Unit Masonry: Comply with ASTM C 270, Proportion Specification. Provide the following types of mortar for applications stated unless another type is indicated or needed to provide required compressive strength of masonry.

1. For reinforced masonry, use Type S.

2. For interior non-load-bearing partitions, Type O may be used instead of Type N.

D. Colored-Aggregate Mortar: Produce required mortar color by using colored aggregates and natural color or white cement as necessary to produce required mortar color.

1. Mix to match Engineer's sample.

2. Application: Use pigmented mortar for exposed mortar joints with the following units:
   a. Decorative CMUs.

E. Grout for Unit Masonry: Comply with ASTM C 476.

1. Use grout of type indicated or, if not otherwise indicated, of type (fine or coarse) that will comply with Table 1.15.1 in ACI 530.1/ASCE 6/TMS 602 for dimensions of grout spaces and pour height.

2. Proportion grout in accordance with ASTM C 476, Table 1 or paragraph 4.2.2 for specified 28-day compressive strength indicated, but not less than 2000 psi (14 MPa).

3. Provide grout with a slump of 8 to 11 inches (203 to 279 mm) as measured according to ASTM C 143/C 143M.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of work.

1. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of work.

2. Verify that foundations are within tolerances specified.

3. Verify that reinforcing dowels are properly placed.

B. Before installation, examine rough-in and built-in construction for piping systems to verify actual locations of piping connections.

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

3.02 INSTALLATION, GENERAL

A. Thickness: Build cavity and composite walls and other masonry construction to full thickness shown. Build single-wythe walls to actual widths of masonry units, using units of widths indicated.

B. Build chases and recesses to accommodate items specified in this and other Sections.

C. Leave openings for equipment to be installed before completing masonry. After installing equipment, complete masonry to match the construction immediately adjacent to opening.

D. Use full-size units without cutting if possible. If cutting is required to provide a continuous pattern or to fit adjoining construction, cut units with motor-driven saws; provide clean, sharp, unchipped edges. Allow units to dry before laying unless wetting of units is specified. Install cut units with cut surfaces and, where possible, cut edges concealed.

E. Select and arrange units for exposed unit masonry to produce a uniform blend of colors and textures.

1. Mix units from several pallets or cubes as they are placed.

3.03 TOLERANCES

A. Dimensions and Locations of Elements:

1. For dimensions in cross section or elevation do not vary by more than plus 1/2 inch or minus 1/4 inch (6 mm).

2. For location of elements in plan do not vary from that indicated by more than plus or minus 1/2 inch.

3. For location of elements in elevation do not vary from that indicated by more than plus or minus 1/4 inch (6 mm) in a story height or 1/2 inch total.

B. Lines and Levels:

1. For bed joints and top surfaces of bearing walls do not vary from level by more than 1/4 inch in 10 feet, or 1/2 inch maximum.

2. For conspicuous horizontal lines, such as lintels, sills, parapets, and reveals, do not vary from level by more than 1/8 inch in 10 feet, 1/4 inch in 20 feet, or 1/2 inch maximum.

3. For vertical lines and surfaces do not vary from plumb by more than 1/4 inch in 10 feet (6 mm in 3 m), 3/8 inch in 20 feet (9 mm in 6 m), or 1/2 inch (12 mm) maximum.

4. For conspicuous vertical lines, such as external corners, door jambs, reveals, and expansion and control joints, do not vary from plumb by more than 1/8 inch in 10 feet (3 mm in 3 m), 1/4 inch in 20 feet (6 mm in 6 m), or 1/2 inch (12 mm) maximum.

5. For lines and surfaces do not vary from straight by more than 1/4 inch in 10 feet (6 mm in 3 m), 3/8 inch in 20 feet (9 mm in 6 m), or 1/2 inch (12 mm) maximum.

6. For vertical alignment of exposed head joints, do not vary from plumb by more than 1/4 inch in 10 feet (6 mm in 3 m), or 1/2 inch (12 mm) maximum.

7. For faces of adjacent exposed masonry units, do not vary from flush alignment by more than 1/16 inch (1.5 mm) except due to warpage of masonry units within tolerances specified for warpage of units.

C. Joints:

1. For bed joints, do not vary from thickness indicated by more than plus or minus 1/8 inch (3 mm), with a maximum thickness limited to 1/2 inch (12 mm).

2. For exposed bed joints, do not vary from bed-joint thickness of adjacent courses by more than 1/8 inch (3 mm).

3. For head and collar joints, do not vary from thickness indicated by more than plus 3/8 inch (9 mm) or minus 1/4 inch (6 mm).

4. For exposed head joints, do not vary from thickness indicated by more than plus or minus 1/8 inch (3 mm). Do not vary from adjacent bed-joint and head-joint thicknesses by more than 1/8 inch (3 mm).

5. For exposed bed joints and head joints of stacked bond, do not vary from a straight line by more than 1/16 inch (1.5 mm) from one masonry unit to the next.

3.04 LAYING MASONRY WALLS

A. Lay out walls in advance for accurate spacing of surface bond patterns with uniform joint thicknesses and for accurate location of openings, movement-type joints, returns, and offsets. Avoid using less-than-half-size units, particularly at corners, jambs, and, where possible, at other locations.

B. Bond Pattern for Exposed Masonry: Unless otherwise indicated, lay exposed masonry in running bond; do not use units with less than nominal 4-inch (100-mm) horizontal face dimensions at corners or jambs.

C. Lay concealed masonry with all units in a wythe in running bond or bonded by lapping not less than 4-inches (100-mm). Bond and interlock each course of each wythe at corners. Do not use units with less than nominal 4-inch (100-mm) horizontal face dimensions at corners or jambs.

D. Stopping and Resuming Work: Stop work by racking back units in each course from those in course below; do not tooth. When resuming work, clean masonry surfaces that are to receive mortar, remove loose masonry units and mortar, before laying fresh masonry.

E. Built-in Work: As construction progresses, build in items specified in this and other Sections. Fill in solidly with masonry around built-in items.

F. Fill space between steel frames and masonry solidly with mortar, unless otherwise indicated.

G. Where built-in items are to be embedded in cores of hollow masonry units, place a layer of metal lath, wire mesh, or plastic mesh in the joint below and rod mortar or grout into core.

H. Fill cores in hollow concrete masonry units with grout 24 inches (600 mm) under bearing plates, beams, lintels, posts, and similar items, unless otherwise indicated.

I. Build non-load-bearing interior partitions full height of story to underside of solid floor or roof structure above, unless otherwise indicated.

1. Install compressible filler in joint between top of partition and underside of structure above.

2. Fasten partition top anchors to structure above and build into top of partition. Grout cells of CMUs solidly around plastic tubes of anchors and push tubes down into grout to provide 1/2-inch (13-mm) clearance between end of anchor rod and end of tube. Space anchors 48 inches (1200 mm) o.c., unless otherwise indicated.

3.05 MORTAR BEDDING AND JOINTING

A. Lay hollow concrete masonry units as follows:

1. With face shells fully bedded in mortar and with head joints of depth equal to bed joints.

2. With webs fully bedded in mortar in all courses of piers, columns, and pilasters.

3. With webs fully bedded in mortar in grouted masonry, including starting course on footings.

4. With entire units, including areas under cells, fully bedded in mortar at starting course on footings where cells are not grouted.

B. 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 deeply furrow bed joints or slush head joints.

C. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness, unless otherwise indicated.

D. Cut joints flush for masonry walls to receive plaster or other direct-applied finishes (other than paint), unless otherwise indicated.

3.06 CAVITY WALLS

A. Bond wythes of cavity walls together using bonding system indicated on Drawings.

B. Keep cavities clean of mortar droppings and other materials during construction. Bevel beds away from cavity, to minimize mortar protrusions into cavity. Do not attempt to trowel or remove mortar fins protruding into cavity.

C. Coat cavity face of backup wythe to comply with Section 07 05 00.

D. Installing Cavity-Wall Insulation: Place small dabs of adhesive, spaced approximately 12 inches (300 mm) o.c. both ways, on inside face of insulation boards, or attach with plastic fasteners designed for this purpose. Fit courses of insulation between wall ties and other confining obstructions in cavity, with edges butted tightly both ways. Press units firmly against inside wythe of masonry or other construction as shown.

1. Fill cracks and open gaps in insulation with crack sealer compatible with insulation and masonry.

3.07 MASONRY-CELL INSULATION

A. Install molded-polystyrene insulation units into masonry unit cells before laying units.

3.08 MASONRY JOINT REINFORCEMENT

A. General: Install entire length of longitudinal side rods in mortar with a minimum cover of 5/8 inch (16 mm) on exterior side of walls, 1/2 inch (13 mm) elsewhere. Lap reinforcement a minimum of 6 inches (150 mm).

1. Space reinforcement not more than 16 inches (406 mm) o.c.

2. Space reinforcement not more than 8 inches (203 mm) o.c. in foundation walls and parapet walls.

3. Provide reinforcement not more than 8 inches (203 mm) above and below wall openings and extending 12 inches (305 mm) beyond openings in addition to continuous reinforcement.

B. Interrupt joint reinforcement at control and expansion joints, unless otherwise indicated.

C. Provide continuity at wall intersections by using prefabricated T-shaped units.

D. Provide continuity at corners by using prefabricated L-shaped units.

E. Cut and bend reinforcing units as directed by manufacturer for continuity at corners, returns, offsets, column fireproofing, pipe enclosures, and other special conditions.

3.09 ANCHORING MASONRY VENEERS

A. Anchor masonry veneers to concrete and masonry backup with masonry-veneer anchors to comply with the following requirements:

1. Insert slip-in anchors in metal studs as sheathing is installed. Provide one anchor at each stud in each horizontal joint between sheathing boards.

2. Embed connector sections and continuous wire in masonry joints. Provide not less than 2 inches (50 mm) of air space between back of masonry veneer and face of sheathing.

3. Locate anchor sections to allow maximum vertical differential movement of ties up and down.

4. Space anchors as indicated, but not more than 18 inches (458 mm) o.c. vertically and 24 inches (610 mm) o.c. horizontally, with not less than 1 anchor for each 2 sq. ft. (0.2 sq. m) of wall area. Install additional anchors within 12 inches (305 mm) of openings and at intervals, not exceeding 8 inches (203 mm), around perimeter.

3.10 CONTROL AND EXPANSION JOINTS

A. General: Install control and expansion joint materials in unit masonry as masonry progresses. Do not allow materials to span control and expansion joints without provision to allow for in-plane wall or partition movement.

B. Form control joints in concrete masonry as follows:

1. Install preformed control-joint gaskets designed to fit standard sash block.

C. Provide horizontal, pressure-relieving joints by either leaving an air space or inserting a compressible filler of width required for installing sealant and backer rod specified in Section 07 92 00, but not less than 3/8 inch (10 mm).

1. Locate horizontal, pressure-relieving joints beneath shelf angles supporting masonry.

3.11 LINTELS

A. Install steel lintels where indicated.

B. Provide concrete or masonry lintels where shown and where openings of more than 12-inches (305 mm) for brick-size units and 24 inches (610 mm) for block-size units are shown without structural steel or other supporting lintels.

C. Provide minimum bearing of 8 inches (200 mm) at each jamb, unless otherwise indicated.

3.12 FLASHING, WEEP HOLES, CAVITY DRAINAGE, AND VENTS

A. General: Install embedded flashing and weep holes in masonry at shelf angles, lintels, ledges, other obstructions to downward flow of water in wall, and where indicated. Install vents at shelf angles, ledges, and other obstructions to upward flow of air in cavities, and where indicated.

B. Install flashing as follows, unless otherwise indicated:

1. Prepare masonry surfaces so they are smooth and free from projections that could puncture flashing. Where flashing is within mortar joint, place through-wall flashing on sloping bed of mortar and cover with mortar. Before covering with mortar, seal penetrations in flashing with adhesive, sealant, or tape as recommended by flashing manufacturer.

2. At masonry-veneer walls, extend flashing through veneer, across air space behind veneer, and up face of sheathing at least 8 inches (200 mm); with upper edge tucked under building paper or building wrap, lapping at least 4 inches (100 mm).

3. At lintels and shelf angles, extend flashing a minimum of 6 inches (150 mm) into masonry at each end. At heads and sills, extend flashing 6 inches (150 mm) at ends and turn up not less than 2 inches (50 mm) to form end dams.

4. Interlock end joints of ribbed sheet metal flashing by overlapping ribs not less than 1-1/2 inches (38 mm) or as recommended by flashing manufacturer, and seal lap with elastomeric sealant complying with requirements in Section 07 92 00 for application indicated.

5. Install metal drip edges and sealant stops with ribbed sheet metal flashing by interlocking hemmed edges to form hooked seam. Seal seam with elastomeric sealant complying with requirements in Section 07 92 00 for application indicated.

6. Install metal flashing termination beneath flexible flashing at exterior face of wall. Stop flexible flashing 1/2 inch (13 mm) back from outside face of wall and adhere flexible flashing to top of metal flashing termination.

7. Cut flexible flashing off flush with face of wall after masonry wall construction is completed.

C. Install reglets and nailers for flashing and other related construction where they are shown to be built into masonry.

D. Install weep holes in head joints in exterior wythes of first course of masonry immediately above embedded flashing and as follows:

1. Use specified weep/vent products to form weep holes.

2. Use wicking material to form weep holes above flashing under brick sills. Turn wicking down at lip of sill to be as inconspicuous as possible.

3. Space weep holes 24 inches (600 mm) o.c., unless otherwise indicated.

4. Space weep holes formed from plastic tubing or wicking material 16 inches o.c.

5. Cover cavity side of weep holes with plastic insect screening at cavities insulated with loose-fill insulation.

6. Trim wicking material flush with outside face of wall after mortar has set.

E. Place pea gravel in cavities as soon as practical to a height equal to height of first course above top of flashing, but not less than 2 inches (50 mm), to maintain drainage.

1. Fill cavities full height by placing pea gravel in cavities as masonry is laid so that at any point masonry does not extend more than 24 inches (600 mm) above top of pea gravel.

F. Place cavity drainage material in cavities to comply with configuration requirements for cavity drainage material in Part 2 "Miscellaneous Masonry Accessories" Article.

3.13 REINFORCED UNIT MASONRY INSTALLATION

A. Temporary Formwork and Shores: Construct formwork and shores as needed to support reinforced masonry elements during construction.

1. Construct formwork to provide shape, line, and dimensions of completed masonry as indicated. Make forms sufficiently tight to prevent leakage of mortar and grout. Brace, tie, and support forms to maintain position and shape during construction and curing of reinforced masonry.

2. Do not remove forms and shores until reinforced masonry members have hardened sufficiently to carry their own weight and other temporary loads that may be placed on them during construction.

B. Placing Reinforcement: Comply with requirements in ACI 530.1/ASCE 6/TMS 602.

C. Grouting: Do not place grout until entire height of masonry to be grouted has attained enough strength to resist grout pressure.

1. Comply with requirements in ACI 530.1/ASCE 6/TMS 602 for cleanouts and for grout placement, including minimum grout space and maximum pour height.

2. Limit height of vertical grout pours to not more than 60 inches (1520 mm).

3.14 FIELD QUALITY CONTROL

A. Testing and Inspecting: Owner will engage special inspectors to perform tests and inspections and prepare reports. Allow inspectors access to scaffolding and work areas, as needed to perform tests and inspections. Retesting of materials that fail to comply with specified requirements shall be done at Contractor's expense.

B. Testing Prior to Construction: One set of tests.

C. Testing Frequency: One set of tests for each 5000 sq. ft. (464 sq. m) of wall area or portion thereof.

D. Concrete Masonry Unit Test: For each type of unit provided, according to ASTM C 140 for compressive strength.

E. Mortar Aggregate Ratio Test (Proportion Specification): For each mix provided, according to ASTM C 780.

F. Mortar Test (Property Specification): For each mix provided, according to ASTM C 780. Test mortar for mortar air content and compressive strength.

G. Grout Test (Compressive Strength): For each mix provided, according to ASTM C 1019.

H. Prism Test: For each type of construction provided, according to ASTM C 1314 at 7 days and at 28 days.

3.15 REPAIRING, POINTING, AND CLEANING

A. Remove and replace masonry units that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Install new units to match adjoining units; install in fresh mortar, pointed to eliminate evidence of replacement.

B. Pointing: During the tooling of joints, enlarge voids and holes, except weep holes, and completely fill with mortar. Point up joints, including corners, openings, and adjacent construction, to provide a neat, uniform appearance. Prepare joints for sealant application, where indicated.

C. In-Progress Cleaning: Clean unit masonry as work progresses by dry brushing to remove mortar fins and smears before tooling joints.

D. Final Cleaning: After mortar is thoroughly set and cured, clean exposed masonry as follows:

1. Remove large mortar particles by hand with wooden paddles and nonmetallic scrape hoes or chisels.

2. Test cleaning methods on sample wall panel; leave one-half of panel uncleaned for comparison purposes. Obtain Engineer's approval of sample cleaning before proceeding with cleaning of masonry.

3. Protect adjacent stone and non-masonry surfaces from contact with cleaner by covering them with liquid strippable masking agent or polyethylene film and waterproof masking tape.

4. Wet wall surfaces with water before applying cleaners; remove cleaners promptly by rinsing surfaces thoroughly with clear water.

5. Clean brick by bucket-and-brush hand-cleaning method described in BIA Technical Notes 20.

6. Clean masonry with a proprietary acidic cleaner applied according to manufacturer's written instructions.

7. Clean concrete masonry by cleaning method indicated in NCMA TEK 8-2A applicable to type of stain on exposed surfaces.

8. Clean stone trim to comply with stone supplier's written instructions.

9. Clean limestone units to comply with recommendations in ILI's "Indiana Limestone Handbook."

3.16 MASONRY WASTE DISPOSAL

A. Salvageable Materials: Unless otherwise indicated, excess masonry materials are Contractor's property. At completion of unit masonry work, remove from Project site.

B. Waste Disposal as Fill Material: Dispose of clean masonry waste, including excess or soil-contaminated sand, waste mortar, and broken masonry units, by crushing and mixing with fill material as fill is placed.

1. Crush masonry waste to less than 4 inches in each dimension.

2. Mix masonry waste with at least two parts of specified fill material for each part of masonry waste. Fill material is specified in Division 31.

3. Do not dispose of masonry waste as fill within 18 inches (450 mm) of finished grade.

C. Excess Masonry Waste: Remove excess clean masonry waste that cannot be used as fill, as described above, and other masonry waste, and legally dispose of off Owner's property.

3.17 SITE ENVIRONMENTAL PROCEDURES

A. Mixing equipment: Minimize water used to wash equipment.

B. Coordinate with manufacturer for take-back program. Set aside scrap and packaging to be returned to manufacturer for recycling into new product.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals and install steel joists, bridging, and accessories complete as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A. Steel roof deck is included in Section 05 31 23.

B. Miscellaneous metal is included in Section 05 50 00.

C. Bearing plates are furnished under Section 05 50 00 and installed under Section 04 20 00.

D. Shop painting is included in Section 09 91 10.

E. Field painting, except as specified herein, is included in Section 09 91 00.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, design calculations for special joists, shop drawings and product data, showing:

1. Location and size of all joists, bridging (including erection bridging), and accessories.

2. Materials and details of construction of all members, including camber.

3. Details of installation of all members.

4. Size and length of all field welds to supports.

5. Erection marks. Mark each field piece to correspond to the shop drawings.

6. Uniform, concentrated and varying loads used to design the special joists indicated on the Drawings.

7. Product data for shop primer. Certify compatibility with additional coatings specified in Sections 09 91 10 and 09 91 00.

B. Certificates

1. Certification from the Steel Joist Institute showing that the manufacturer's products conform to the Institute's standards and load tables for the type of member provided.

2. Certification for welders.

C. Weld Procedure Qualifications

1. Written Welding Procedure Specifications (WPS's) in accordance with AWS D1.1 for each different welded joint proposed for use whether prequalified or qualified by testing. WPS's shall identify actual electrodes to be used, not just electrode classification.

2. Electrode manufacturer's data for actual electrodes proposed. Data shall include manufacturer's recommended welding parameters for each electrode to be used.

1.04 REFERENCE STANDARDS

A. Steel Joist Institute (SJI):

1. Standard Specifications for Open Web Steel Joists, K-Series.

2. Standard Specifications for Longspan Steel Joists, LH-Series and Deep Longspan Steel Joists, DLH-Series.

B. ASTM International (ASTM):

1. ASTM A325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.

2. ASTM B695 - Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.

C. American Welding Society (AWS):

1. AWS D1.1 - Structural Welding Code - Steel.

D. Steel Structures Painting Council (SSPC):

1. SSPC-Paint 15 - Paint Specification No. 15 Steel Joist Shop Paint.

E. Where reference is made to one of the above standards, the revision in effect at the time of Bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Steel joists, bridging and accessories shall be fabricated in accordance with the standards of the Steel Joist Institute by a manufacturer certified by the Steel Joist Institute. Steel joists shall be of welded construction and top and bottom chords shall be constructed of hot rolled shapes. Rods, reinforcing bars, or cold formed shapes will not be allowed for top and bottom chords.

B. Field welding shall be done by certified welders in accordance with AWS D1.1.

1. Qualify welders in accordance with AWS D1.1 for each process and joint configuration.

2. WPS's for each joint type shall indicate proper AWS qualification and be available where welding is performed.

1.06 DELIVERY, STORAGE AND HANDLING

A. Handle material with cranes and derricks. Do not dump material off cars or trucks, or handle in any way likely to cause damage.

B. Store material on skids and not on the ground. Pile and block stored material to prevent bending or other damage.

C. Materials with excessive damage, in the opinion of the Engineer, shall not be incorporated in the work. Remove and replace them with new undamaged materials at no additional cost to the Owner.

1.07 PROJECT/SITE REQUIREMENTS

A. Verify at the site both the dimensions and work of other trades adjoining the work of this Section before installation of the items specified.

B. Coordinate locations of openings and weight of equipment mounted on steel joists.

C. Provide steel framing around openings and miscellaneous steel as required to erect the joists.

D. Provide additional web members at all concentrated loads not occurring at panel points.

E. See Drawings for loads applied to special joists. Locations and loads shown on the Drawings for equipment and appurtenances supported by special joists are approximate. Coordinate with the manufacturer(s) of the approved equipment and appurtenances to obtain the actual locations and operating loads for the design of special joists. Design joists using load combinations prescribed in the design code specified on the Drawings.

PART 2 PRODUCTS

2.01 MATERIALS

A. Open web steel joists shall conform to SJI Standard for Open Web Steel Joists, K-Series, size and location as shown on the Drawings.

B. Longspan steel joists shall conform to SJI Standard for Longspan Steel Joists, LH-Series, size and location as shown on the Drawings.

C. Provide top chord extensions anddeep bearings where shown on the Drawings.

D. Bridging:

1. Provide diagonal and/or horizontal bridging designed and installed in compliance with the requirements of the SJI Standard Specifications for the particular series used.

2. Connect all bridging to end walls unless otherwise shown on the Drawings.

3. Provide bridging as required to adequately brace bottom chords against lateral movement under a net uplift pressure indicated on the Drawings.

4. In no case shall the spacing between rows of bridging exceed that noted in the SJI Standard Specifications. Spacing between rows of bridging shall be approximately equal.

E. High strength steel bolts shall conform to ASTM A325 and shall be mechanically galvanized in accordance with ASTM B695, Class 50, Type II.

2.02 FINISHES

A. Apply shop primer in accordance with SSPC Paint Specification No.15.

2.03 SURFACE PREPARATION AND SHOP COATINGS/PAINTING

A. Prepare surfaces and apply shop paint in accordance with Section 09 91 10.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install steel joists in accordance with the SJI Standard Specifications, approved shop drawings and the Drawings. Weld joists to supports as shown on the Drawings.

B. Weld or bolt bridging to joists as shown on the Drawings. Bridging and bridging anchors shall be completely installed before construction loads are placed on the steel joists.

C. Do not attach supports or braces for equipment, piping, conduits, ductwork, or other utilities to steel joists, bridging, or accessories unless the steel joists have been designed and fabricated to support all loads due to the equipment, piping, conduits, ductwork, or other utilities.

3.02 FIELD PAINTING

A. Field Painting:

1. After erection, prepare shop primed surfaces as approved and touch-up all steel surfaces which have become abraded or where paint has been omitted or removed due to welding or other erection procedure with the shop primer used.

3.03 INSPECTION

A. The Engineer reserves the right to inspect joists, bridging, and accessories in the field for compliance with the Steel Joist Institute standards, this Section, and the approved shop drawings. The Engineer may reject or require repair or refabrication of any joists, bridging or accessories not meeting these requirements.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install steel roof deck complete as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A. Structural steel is included in Section 05 12 00.

B. Steel joists are included in Section 05 21 00.

C. Miscellaneous metal is included in Section 05 50 00.

D. Roofing, flashing and insulation are included in Division 07.

E. Field painting, except as specified herein, is included in Section 09 91 00.

1.03 SUBMITTALS

A. Shop Drawings: Submit, in accordance with Section 01 33 23, shop drawings showing:

1. Location and size of all members

2. Projections and openings.

3. Fastener types and layout patterns.

4. Erection marks. Mark each bundle to correspond to the shop drawings.

B. Product Data: Submit, in accordance with Section 01 33 23, product data showing:

1. Materials, finishes and details of construction of all members.

2. Manufacturer's load table including design thickness in inches and section properties, gravity load carrying capability at the span used, diaphragm shear capacity and ICC Evaluation Report.

C. Quality Assurance/Control:

1. Certification from the Steel Deck Institute (SDI) that the steel roof deck is designed in accordance with the SDI.

1.04 REFERENCE STANDARDS

A. Steel Deck Institute (SDI)

1. SDI Specifications and Commentary for Steel Roof Deck.

B. ASTM International

1. ASTM A653 - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron, Alloy-Coated (Galvannealed) by the Hot-Dip Process.

2. ASTM A780 - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.

C. American Iron and Steel Institute (AISI)

1. AISI SG-67303-3 – North American Specification for the Design of Cold-Formed Steel Structural Members

D. International Code Council (ICC)

E. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Steel roof deck shall conform to the requirements of the SDI.

1.06 DELIVERY, STORAGE AND HANDLING

A. Handle material with cranes and derricks. Do not dump material off cars or trucks, or handle in any way likely to cause damage.

B. Store material off the ground with one end elevated to provide drainage. Protect from the elements with a waterproof covering, ventilated to avoid condensation.

C. Material with excessive damage, in the opinion of the Engineer, shall not be incorporated in the work. Remove and replace them with new undamaged material at no additional cost to the Owner.

1.07 PROJECT/SITE REQUIREMENTS

A. Notify the Engineer in writing of any inaccuracies in alignment or level of steel joists. Correct inaccuracies before the deck is placed at no additional cost to the Owner.

B. Coordinate sizes and locations of HVAC openings with architectural, structural, or HVAC drawings, using the approved curb and equipment details.

C. Coordinate size, location and details of all penetrations with the Drawings, other trades and details of approved equipment.

D. Provide reinforcement and miscellaneous framing for all penetrations as shown on the Drawings and as specified herein.

1.08 DEFINITIONS

A. Transverse supports - supports which are perpendicular to the direction of the deck ribs.

B. Longitudinal support - supports which are parallel to the direction of the deck ribs.

PART 2 PRODUCTS

2.01 MATERIALS

A. Steel roof deck shall conform to the SDI Specifications for Steel Roof Deck and to the AISI.

B. North American Specification for the Design of Cold-Formed Steel Structural Members.

C. The depth, type and gauge of steel roof deck shall be as shown on the Drawings. Unless otherwise noted, steel roof deck shall be 1-1/2-in deep, 36-in wide, Type WR with nestable side laps.

D. Steel deck shall be as manufactured by Verco Manufacturing Company or approved equal. For a proposed deck to be considered equal, the deck gauge, fastening pattern to supports, and side lap connections must be sufficient to provide diaphragm shears greater than or equal to those published in ICC Evaluation Report 2078P for the deck specified using the same spans, welding pattern, and type and spacing of side lap connections shown on the Drawings. An ICC Evaluation Report will be required to substantiate all values.

E. Steel roof deck and accessories shall be manufactured from steel conforming to ASTM A653, designation SS, Grade 33 or higher.

F. Steel roof deck and accessories shall be galvanized in accordance with ASTM A653, coating designation G90.

G. Provide minimum 18 gauge closure strips, eave plates, ridge plates valley plates cant strips butt plates as shown on the Drawings and as specified herein. Provide reinforcing plates same gauge as deck for openings 6-in and larger but less than 12-in in greatest dimension.

H. Provide galvanized touch-up to repair damaged surfaces. Use Endupor, zinc-rich coating by Dampney Manufacturing Co., Everett, MA; ZiRP, zinc-rich coating by Duncan Galvanizing Corp., Everett, MA; ZRC Cold Galvanizing Compound by ZRC Chemical Products Co., Division of Norfolk Corp., Quincy, MA, or equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install steel roof deck as shown on the Drawings, in accordance with manufacturer's instructions and in accordance with approved shop drawings. Where possible, extend deck sheets over a minimum of three spans.

B. End laps of steel roof deck shall be at least 2-in long and shall occur over transverse supporting members.

C. Fasten steel roof deck to all interior and exterior transverse supports and at side laps and longitudinal supports. Deck fasteners and fastener spacings shall be as noted in the Roof Framing Drawing.

D. Maintain contact between deck sheets and deck sheets and steel supports while fastening steel roof deck to eliminate eccentricities between the connected parts at screwed connections.

E. Coordinate size, location and details of all penetrations with the Drawings, other trades and details of approved equipment. Pipe and conduit openings in the steel roof deck shall be reinforced as shown on the Drawings.

1. Cutting and Fitting
    a. Cut and fit steel roof deck units and accessories around projections through steel roof deck.
    b. Cut openings in steel roof deck true to dimensions using metal saws or drills. Do not use cutting torches.
    c. Make cuts neat, square and trim. Make cuts free of burrs.
    d. Reinforce openings 6-in and larger but less than 12-in in greatest dimension with a flat plate same thickness as deck, centered on the opening as shown on the Drawings.

F. Weld closure strips, eave plates, ridge plates, valley plates, cant strips, butt plates, roof sump pans, and reinforcing platesdirectly to steel deck to provide a finished surface.

1. Roof Sump Pans and Reinforcing Plates
    a. Place roof sump pans and reinforcing plates over openings in steel roof deck and weld to top surface of steel roof deck.
    b. Space welds not more than 6-in on center with at least one weld at each corner.
    c. Cut opening in roof sump pan or reinforcing plate to accommodate drain or other fixture.

2. Ridge Plates, Valley Plates, Cant Strips, Butt Plates
    a. Weld to top surface of steel roof deck at no more than 12-in on center.
    b. Lap end joints not less than 3-in.

3. Closure Strips, Eave Plates
   a. Install closure strips at all open uncovered ends and edges of steel roof deck and in voids between deck and other construction.
   b. Weld to top surface of steel roof deck at not more than 12-in on center and into position to provide complete deck installation for support of roof insulation.

G. Do not attach suspended ceilings, light fixtures, ducts, piping, conduits or other utilities to steel roof deck.

H. Do not use deck for storage or work platforms until permanently secured into position.

I. Construction loads shall not exceed safe capacity of deck and supporting construction.

3.02 FIELD PAINTING

A. Clean and repair all steel surfaces which have become abraded or where galvanizing has been damaged due to welding and/or erection procedures.

B. Repair abraded or damaged galvanized areas using the touch-up material specified above to produce a dry film thickness of not less than 6 mils. Conduct all repairs of galvanizing in accordance with ASTM A780.

3.03 INSPECTION

A. Field welding will be inspected visually and by non-destructive testing by AWS certified welding inspectors provided by the Owner.

B. The Engineer and the certified welding inspector will inspect steel roof deck in the field for compliance with this Section and the approved shop drawings. The Engineer and the certified welding inspector may reject or require repair or refabrication of any steel roof deck or accessories not meeting these requirements.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install all miscellaneous metal complete as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A. Structural steel, steel joists and steel roof deck are included in Division 05.

B. Painting is included in Division 09.

C. Sluice gates, slide gates, operators and appurtenances, including wall thimbles, are included in Division 35.

D. Pipe hangers and sleeves are included in Division 40.

E. Equipment anchor bolts are included in the respective Sections of Divisions 11 and 15.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, shop drawings and product data showing materials of construction and details of installation for:

1. Shop drawings, showing sizes of members, method of assembly, anchorage and connection to other members.

B. Test Reports:

1. Certified copy of mill test reports on each steel, stainless steel and aluminum proposed for use showing the physical properties and chemical analysis.

C. Certificates:

1. Certify that welders have been qualified under AWS, within the previous 12 months, to perform the welds required under this Section.

1.04 REFERENCE STANDARDS

A. Aluminum Association (AA):

1. AA M31C22A41:
   a. M31: Mechanical Finish, Fine Satin.
   b. C22: Finish, Medium Matte.
   c. A41: Clear Anodic Coating, Class I.

B. ASTM International (ASTM):

1. ASTM A36 - Standard Specification for Carbon Structural Steel.

2. ASTM A48 - Standard Specification for Gray Iron Castings.

3. ASTM A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

4. ASTM A108 - Standard Specification for Steel Bars, Carbon, Cold Finished, Standard Quality.

5. ASTM A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

6. ASTM A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

7. ASTM A240 - Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Plate, Sheet, and Strip Pressure Vessels.

8. ASTM A276 - Standard Specification for Stainless Steel Bars and Shapes.

9. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 Psi Tensile Strength.

10. ASTM A325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.

11. ASTM A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.

12. ASTM A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.

13. ASTM A536 - Standard Specification for Ductile Iron Castings.

14. ASTM A570 - Standard Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality.

15. ASTM A1008 - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.

16. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

17. ASTM B221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles and Tubes.

18. ASTM B429 - Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.

19. ASTM F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.

20. ASTM F594 - Standard Specification for Stainless Steel Nuts.

21. ASTM F1554 -Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.

22. ASTM F2329 - Specification for Zinc Coating, Hot-Dip, Requirements for Application to Carbon Screws, Washers, Nuts, and Special Threaded Fasteners.

C. American Institute of Steel Construction (AISC):

1. Specification for Structural Steel Buildings – Allowable Stress Design and Plastic Design.

D. American Welding Society (AWS):

1. AWS D1.1 - Structural Welding Code - Steel.

2. AWS D1.2 - Structural Welding Code - Aluminum.

3. AWS D1.6 - Structural Welding Code - Stainless Steel

E. Federal Specifications:

1. FS-FF-B-575C - Bolts, Hexagonal and Square.

F. Occupational Safety and Health Administration (OSHA).

G. International Code Council (ICC):

1. The International Building Code (IBC).

H. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. The work of this Section shall be completely coordinated with the work of other Sections. Verify, at the site, both the dimensions and work of other trades adjoining items of work in this Section before fabrication and installation of items herein specified.

B. Furnish to the pertinent trades all items included under this Section that are to be built into the work of other Sections.

C. All welding shall be performed by qualified welders and shall conform to the applicable AWS welding code. Welding of steel shall conform to AWS D1.1 and welding of

aluminum shall conform to AWS D1.2 and welding of stainless steel shall conform to AWS D1.6.

1.06 DELIVERY, STORAGE AND HANDLING

A. Deliver items to be incorporated into the work of other trades in sufficient time to be checked prior to installation.

B. Store materials on skids and not on the ground and block up so that they will not become bent or otherwise damaged. Handle materials with cranes or derricks. Do not dump material off cars or trucks nor handle in any other way that will cause damage.

C. Repair items that have become damage or corroded to the satisfaction of the Engineer prior to incorporating them into the work.

1.07 PROJECT/SITE REQUIREMENTS

A. Field measurements shall be taken at the site, prior to fabrication of items, to verify or supplement indicated dimensions and to ensure proper fitting of all items.

PART 2 PRODUCTS

2.01 GENERAL

A. The use of manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired.

B. Like items of materials shall be the end products of one manufacturer in order to provide standardization for appearance, maintenance and manufacturer's service.

2.02 MATERIALS

A. Unless otherwise noted, materials for miscellaneous metals shall conform to the following standards:

1.	Structural Steel:	Wide flange shapes: ASTM A992.
2.	Other shapes; plates; rods and bars:	ASTM A36.
3.	Structural Steel Tubing:	ASTM A500, Grade B.
4.	Welded and Seamless Steel Pipe:	ASTM A501 or ASTM A53, Type E or S, Grade B Schedule 40. Use standard malleable iron fittings, galvanized for exterior work.
5.	Steel Sheets:	ASTM A1008.
6.	Gray Iron Castings:	ASTM A48, Class 35.

7. Ductile Iron Castings: ASTM A536, Grade 65-45-12.

8. Aluminum Extruded Pipe: ASTM B429, Alloy 6063 T6 and Alloy 6061 T6 as indicated.

9. Aluminum Extruded Shapes: ASTM B221, Alloy 6061 T6.

10. Aluminum Sheet and Plate: ASTM B209, Alloy 6061 T6.

11. Stainless Steel Plates, Sheets, and Washers:
    a. Exterior, Submerged or Industrial Use: ASTM A240, Type 316 (Type 316L for welded components).
    b. Interior and Architectural Use: ASTM A240, Type 304.

12. Stainless Steel Shapes and Bars:
    a. Exterior, Submerged or Industrial Use: ASTM A276, Type 316 (Type 316L for welded components).
    b. Interior and Architectural Use: ASTM A276, Type 304.

13. Stainless Steel Bolts ASTM F593, Type 316.

14. Stainless Steel Nuts: ASTM F594, Type 316.

15. Carbon Steel Bolts and Studs: ASTM A307, Grade A (hot dip galvanized nuts and washers where noted).

16. High Strength Steel Bolts, Nuts and washers: ASTM A325 (mechanically galvanized per ASTM B695, Class 50, where noted)
    a. Elevated Temperature Exposure: Type I.
    b. General Application: Type I or Type II.

17. Galvanizing: ASTM A123, Zn w/0.05 percent minimum Ni.

18. Galvanizing, hardware: ASTM A153, Zn w/0.05 percent minimum Ni.

19. Galvanizing, anchor bolts: ASTM F2329, Zn w/0.05 percent minimum Ni.

20. Welding electrodes, steel: AWS A5.1 E70xx.

2.03 ANCHORS, BOLTS AND FASTENING DEVICES

A. Unless otherwise noted, anchor bolts shall be ASTM F1554, Grade 36. Provide standard headed bolts with heavy hex nuts and Grade A washers.

B. Unless otherwise noted, bolts for the connection of carbon steel or iron shall be steel machine bolts; bolts for the connection of galvanized steel or iron shall be galvanized

steel or stainless steel machine bolts; and bolts for the connection of aluminum or stainless steel shall be stainless steel machine bolts.

C. Unless otherwise noted, expansion anchors shall be zinc plated carbon steel wedge type anchors complete with nuts and washers. Type 316 stainless steel wedge type anchors shall be used where they will be submerged or exposed to the weather or where stainless steel wedge type anchors are shown or specified. When the length or embedment of the bolt is not noted on the Drawings, provide length sufficient to place the wedge and expansion cone portion of the bolt at least 1-in behind the concrete reinforcing steel. Expansion anchors shall be Hilti, Kwik-Bolt TZ; Simpson Strong-Tie Wedge-All; Powers Power-Stud or approved equal.

D. Adhesive anchor system, for fastening to solid concrete substrate, shall be a system manufactured for the installation of post installed studs including anchoring hardware and chemical dispenser. Injection adhesive shall be a two-component epoxy system including a hardener and a resin, furnished in pre-measured side-by-side cartridges which keep the two components separate. Side-by-side cartridges shall be designed to accept a static mixing nozzle which thoroughly blends the two components and allows injection directly into the drilled hole. Provide Type 316 stainless steel stud assemblies as indicated on the Drawings consisting of an all-thread anchor rod with nut and washer. Adhesive anchor system shall be Hilti HIT-HY 200; Simpson Strong Tie SET-XP; ITW Ramset Red Head Epcon G5; or approved equal. Unless otherwise noted, anchorage designs shown on the Drawings are based on Hilti HIT-HY 200.

E. Adhesive anchor system, for fastening to hollow concrete block or brick, or hollow-core precast concrete planks shall be a three-part stud, screen tube and chemical dispenser anchoring system. Adhesive cartridges shall contain pre-measured amounts of resin and hardener which are mixed and deposited in a screen tube by a dispenser. Provide zinc plated carbon steel or Type 316 stainless steel stud assemblies as indicated on the Drawings consisting of an all-thread anchor rod with nut and washer. Adhesive anchor system shall meet ICC ES AC58. Anchors shall be Hilti HIT HY-270 System, or approved equal.

F. Automatic end welded headed anchor studs shall be flux ended studs made from cold drawn steel, ASTM A108 Grades C-1010 through C-1020. Headed anchor studs shall be Nelson, H4L Headed Concrete Anchors or Nelson, S3L Shear Connectors or approved equal.

G. Machine bolts and nuts shall conform to Federal Specification FF-B-575C. Bolts and nuts shall be hexagon type. Bolts, nuts, screws, washers and related appurtenances shall be Type 316 stainless steel.

H. Toggle bolts shall be Hilti, Toggler Bolt or approved equal.

2.04 ACCESS HATCHES

A. Access hatches shall have single or double leaf doors as indicated by the Drawings. The doors shall be 1/4-in aluminum diamond pattern plate with welded stiffeners, as necessary, to withstand a live load of 300 lbs/sq ft with a maximum deflection of 1/150th of the span. Hatches shall have a 1/4-in aluminum channel frame with a perimeter

anchor flange or strap anchors for concrete embedment around the perimeter. Unless otherwise noted on the Drawings, use pivot torsion bars for counterbalance or spring operators for easy operation along with automatic door hold open. Hardware shall be durable and corrosion resistant with Type 316 stainless steel hardware used throughout. Provide removable lock handle. Finish shall be the factory mill finish for aluminum doors and frames with bituminous coating on the exterior of the frames in contact with concrete. Hatches shall be watertight and have a 1-1/2-in drainage coupling to the channel frame. Access hatches shall be Type J aluminum or as otherwise indicated on the Drawings by Bilco Company, New Haven, CT or approved equal.

B. Hatches shall be furnished with a fall protection grating system. Grating panels shall be constructed of fiberglass, molded in one piece and have load bearing bars in both directions to allow for use without continuous side support. Panel shall be designed to support a 300 PSF live load. The fall protection grating shall be high visibility safety yellow in color. Torsion rod lift assistance shall be provided for ease of operation and a hold open arm shall be included to automatically lock the panel in the fully open 90-degree position. A release handle shall be provided to close the grating panel and there shall be a provision to lock the panel to prevent unauthorized access.

2.05 MISCELLANEOUS ALUMINUM

A. All miscellaneous metal work shall be formed true to detail, with clean, straight, sharply defined profiles and smooth surfaces of uniform color and texture and free from defects impairing strength or durability. Holes shall be drilled or punched. Edges shall be smooth and without burrs. Fabricate supplementary pieces necessary to complete each item though such pieces are not definitely shown or specified.

B. Connections and accessories shall be of sufficient strength to safely withstand the stresses and strains to which they will be subjected. Exposed joints shall be close fitting and jointed where least conspicuous. Threaded connections shall have the threads concealed where practical. Welded connections shall have continuous welds or intermittent welds as specified or shown. The face of welds shall be dressed flush and smooth. Welding shall be on the unexposed side as much as possible in order to prevent pitting or discoloration of the aluminum exposed surface. Grind smooth continuous welds that will be exposed. Provide holes for temporary field connections and for attachment of the work of other trades.

C. Miscellaneous aluminum items shall include: beams, angles, columns and any other miscellaneous aluminum called for on the Drawings and not otherwise specified.

D. Stair treads for aluminum stairs shall have abrasive non-slip nosing as approved.

E. Aluminum items shall have a cleaned and degreased mill finish.

2.06 MISCELLANEOUS STEEL

A. All miscellaneous metal work shall be formed true to detail, with clean, straight, sharply defined profiles and smooth surfaces of uniform color and texture and free from defects impairing strength or durability. Holes shall be drilled or punched. Edges shall be

smooth and without burrs. Fabricate supplementary pieces necessary to complete each item though such pieces are not definitely shown or specified.

B. Connections and accessories shall be of sufficient strength to safely withstand the stresses and strains to which they will be subjected. Exposed joints shall be close fitting and jointed where least conspicuous. Threaded connections shall have the threads concealed where practical. Welded connections shall have continuous welds or intermittent welds as specified or shown. The face of welds shall be dressed flush and smooth. Provide holes for temporary field connections and for attachment of the work of other trades.

C. Miscellaneous steel items shall include: any miscellaneous steel called for on the Drawings and not otherwise specified.

D. Steel pipe pieces for sleeves, lifting attachments and other functions shall be Schedule 40 pipe unless otherwise shown on the Drawings. Wall and floor sleeves, of steel pipe, shall have welded circumferential steel waterstops at mid-length.

E. All steel finish work shall be thoroughly cleaned, by effective means, of all loose mill scale, rust and foreign matter and shall be given one shop coat of primer compatible with the finish coat after fabrication but before shipment. Paint shall be omitted within 3-in of proposed field welds. Paint shall be applied to dry surfaces and shall be thoroughly and evenly spread and well worked into joints and other open spaces.

F. Galvanizing, where required, shall be the hot-dip zinc process after fabrication. Coating shall be not less than 2 oz/sq ft of surface.

2.07 MISCELLANEOUS STAINLESS STEEL

A. All miscellaneous metal work shall be formed true to detail, with clean, straight, sharply defined profiles and smooth surfaces of uniform color and texture and free from defects impairing strength or durability. Holes shall be drilled or punched. Edges shall be smooth and without burrs. Fabricate supplementary pieces necessary to complete each item though such pieces are not definitely shown or specified.

B. Connections and accessories shall be of sufficient strength to safely withstand the stresses and strains to which they will be subjected. Exposed joints shall be close fitting and jointed where least conspicuous. Threaded connections shall have the threads concealed where practical. Welded connections shall have continuous welds or intermittent welds as specified or shown. The face of welds shall be dressed flush and smooth. Grind smooth continuous welds that will be exposed. Provide holes for temporary field connections and for attachment of the work of other trades.

C. Miscellaneous stainless steel items shall include: any miscellaneous stainless steel called for on the Drawings and not otherwise specified.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install all items except those to be embedded in concrete which shall be installed under Division 03. Items to be attached to concrete or masonry after such work is completed shall be installed in accordance with the details shown. Fastening to wood plugs in masonry will not be permitted.

B. Abrasions in the shop primer shall be touched up immediately after erection. Areas left unprimed for welding shall be painted with primer after welding.

C. Zinc coating which has been burned by welding, abraded, or otherwise damaged shall be cleaned and repaired after installation. The damage area shall be thoroughly cleaned by wire brushing and all traces of welding flux and loose or cracked zinc coating removed prior to painting. The cleaned area shall be painted with two coats of zinc oxide-zinc dust paint conforming to the requirements of Military Specifications MIL-P-15145. The paint shall be properly compounded with a suitable vehicle in the ratio of one part zinc oxide to four parts zinc dust by weight.

D. Specialty products shall be installed in accordance with the manufacturer's recommendations.

E. Expansion bolts shall be checked for tightness a minimum of 24 hours after initial installation.

F. Install adhesive anchor system in strict compliance with the manufacturer's recommendations, including drill bit diameter, surface preparation, temperature, moisture conditions, injection and installation of bolts. Use oil free compressed air to blast out loose particles and dust from the drilled holes. Bolts must be clean and free of dirt, oil, grease, ice or other material which would reduce bond.

G. All steel surfaces that come into contact with exposed concrete or masonry shall receive a protective coating of an approved heavy bitumastic troweling mastic applied in accordance with the manufacturer's instructions prior to installation.

H. Where aluminum contacts a dissimilar metal, apply a heavy brush coat of zinc-chromate primer followed by two coats of aluminum metal and masonry paint to the dissimilar metal.

I. Where aluminum contacts masonry or concrete, apply a heavy coat of approved alkali resistant paint to the masonry or concrete.

J. Where aluminum contacts wood, apply two coats of aluminum metal and masonry paint to the wood.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install rough carpentry complete as shown on the drawings and as specified herein.

B. This Section includes the following:

1. Wood blocking and nailers.

1.02 RELATED WORK

A. Roofing is included in Section 07 41 20.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, detailed information on materials proposed and installation methods.

B. Product Data: For each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details.

1. Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Indicate type of preservative used and net amount of preservative retained.

2. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.

3. Include copies of warranties from chemical treatment manufacturers for each type of treatment.

1.04 REFERENCES

A. American Forest & Paper Association

1. Details for Conventional Wood Frame Construction.

B. American Wood Protection Association (AWPA)

1. AWPA C2 - Lumber, Timber, Bridge Ties and Mine Ties - Preservative Treatment by Pressure Processes

2. AWPA C20 - Structural Lumber - Fire-Retardant Treatment by Pressure Process

3. AWPA C27 - Plywood - Fire-Retardant Treatment by Pressure Process

4. AWPA C31 - Lumber Used out of Contact with the Ground and Continuously Protected from Liquid Water - Treatment by Pressure Processes

5. AWPA M4 - Care of Preservative-Treated Wood Products

C. ASME International

1. ASME B18.2.1 - Square and Hex Bolts and Screws (Inch Series)

2. ASME B18.6.1 - Wood Screws (Inch Series)

D. ASTM International

1. ASTM A 153/A 153M - Specification for Zinc-Coating (Hot-Dip) of Iron and Steel Hardware

2. ASTM A 307 - Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength

3. ASTM A 563 - Specification for Carbon and Alloy Steel Nuts

4. ASTM A 653/A 653M - Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

5. ASTM A 666 - Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar

6. ASTM B 633 - Specification for Electrodeposited Coatings of Zinc on Iron and Steel

7. ASTM C 954 - Specification for Steel Drill Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Steel Studs from 0.033 in. (0.84 mm) to 0.112 in. (2.84 mm) in Thickness

8. ASTM D 3498 - Specification for Adhesives for Field-Gluing Plywood to Lumber Framing for Floor Systems

9. ASTM D 5664 - Test Method for Evaluating the Effects of Fire-Retardant Treatments and Elevated Temperatures on Strength Properties of Fire-Retardant Treated Lumber

10. ASTM E 488 - Test Methods for Strength of Anchors in Concrete and Masonry Elements

11. ASTM F 593 - Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs

12. STM F 594 - Specification for Stainless Steel Nuts

13. ASTM F 1667 - Specification for Driven Fasteners: Nails, Spikes, and Staples

E. Code of Federal Regulations

1. 40 CFR, Part 59, Subpart D - National Volatile Organic Compound Emission Standards for Architectural Coatings

F. Forest Stewardship Council

1. FSC STD-01-001 - FSC Principles and Criteria for Forest Stewardship

G. ICC Evaluation Service, Inc.

1. NES NER-272 - Pneumatic or Mechanically Driven Staples, Nails, P-Nails and Allied Fasteners for Use in All Types of Building Construction

H. International Code Council, Inc.

1. International Building Code.

I. National Lumber Grades Authority

1. Standard Grading Rules for Canadian Lumber.

J. Northeastern Lumber Manufacturers' Association

1. Standard Grading Rules for Northeastern Lumber.

K. The Southern Pine Inspection Bureau

1. Standard Grading Rules for Southern Pine Lumber.

L. U.S. Department of Commerce, National Institute of Standards and Technology

1. DOC PS 1 - U.S. Product Standard for Construction and Industrial Plywood

2. DOC PS 20 - American Softwood Lumber Standard

M. West Coast Lumber Inspection Bureau

1. Standard No. 17 - Grading Rules for West Coast Lumber

N. Western Wood Products Association

1. Western Lumber Grading Rules.

O. Moulding & Millwork Producers Association

1. WMMPA WM 4 - General Requirements for Wood Moulding

2. WMMPA WM 7 - WM/Series Wood Moulding Patterns

P. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 DEFINITIONS

A. Dimension Lumber: Lumber of 2 inches nominal or greater but less than 5 inches nominal in least dimension.

B. Lumber grading agencies, and the abbreviations used to reference them, include the following:

1. NeLMA: Northeastern Lumber Manufacturers' Association.

2. NHLA: National Hardwood Lumber Association.

3. NLGA: National Lumber Grades Authority.

4. SPIB: The Southern Pine Inspection Bureau.

5. WCLIB: West Coast Lumber Inspection Bureau.

6. WWPA: Western Wood Products Association.

1.06 DELIVERY, STORAGE AND HANDLING

A. Stack lumber flat with spacers between each bundle to provide air circulation. Provide for air circulation around stacks and under coverings.

B. Deliver interior wood materials that are to be exposed to view only after building is enclosed and weatherproof, wet work other than painting is dry, and HVAC system is operating and maintaining temperature and humidity at occupancy levels.

PART 2 PRODUCTS

2.01 WOOD PRODUCTS, GENERAL

A. Lumber: DOC PS 20 and applicable rules of grading agencies indicated. If no grading agency is indicated, provide lumber that complies with the applicable rules of any rules-writing agency certified by the ALSC Board of Review. Provide lumber graded by an agency certified by the ALSC Board of Review to inspect and grade lumber under the rules indicated.

1. Factory mark each piece of lumber with grade stamp of grading agency.

2. Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry lumber.

3. Provide dressed lumber, S4S, unless otherwise indicated.

2.02 WOOD-PRESERVATIVE-TREATED MATERIALS

A. Preservative Treatment by Pressure Process: AWPA C2.

1. Preservative Chemicals: Acceptable to authorities having jurisdiction and containing no arsenic or chromium.

B. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent. Do not use material that is warped or does not comply with requirements for untreated material.

C. Mark lumber with treatment quality mark of an inspection agency approved by the ALSC Board of Review.

D. Application: Treat all miscellaneous carpentry, unless otherwise indicated.

2.03 MISCELLANEOUS LUMBER

A. General: Provide miscellaneous lumber indicated and lumber for support or attachment of other construction, including the following:

1. Blocking.

2. Nailers.

B. For items of dimension lumber size, provide Construction or No. 2 grade lumber with 19 percent maximum moisture content of any species.

C. For blocking not used for attachment of other construction Utility, Stud, or No. 3 grade lumber of any species may be used provided that it is cut and selected to eliminate defects that will interfere with its attachment and purpose.

D. For blocking and nailers used for attachment of other construction, select and cut lumber to eliminate knots and other defects that will interfere with attachment of other work.

2.04 FASTENERS

A. General: Provide fasteners of size and type indicated that comply with requirements specified in this Article for material and manufacture.

1. Where carpentry is exposed to weather, in ground contact, pressure-preservative treated, or in area of high relative humidity, provide fasteners with hot-dip zinc coating complying with ASTM A 153/A 153M, Grade D.

B. Nails, Brads, and Staples: ASTM F 1667.

C. Power-Driven Fasteners: NES NER-272.

D. Wood Screws: ASME B18.6.1.

E. Lag Bolts: ASME B18.2.1.

F. Bolts: Steel bolts complying with ASTM A 307, Grade A; with ASTM A 563 hex nuts and, where indicated, flat washers.

G. Expansion Anchors: Anchor bolt and sleeve assembly of material indicated below with capability to sustain, without failure, a load equal to 6 times the load imposed when installed in unit masonry assemblies and equal to 4 times the load imposed when installed in concrete as determined by testing per ASTM E 488 conducted by a qualified independent testing and inspecting agency.

1. Material: Carbon-steel components, zinc plated to comply with ASTM B 633, Class Fe/Zn 5.

2.05 MISCELLANEOUS MATERIALS

A. Adhesives for Gluing to Concrete or Masonry: Formulation complying with ASTM D 3498 that is approved for use indicated by adhesive manufacturer.

1. Use adhesives that have a VOC content of 70 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Flexible Flashing: Self-adhesive, rubberized-asphalt compound, bonded to a high-density, polyethylene film to produce an overall thickness of not less than 0.025 inch.

PART 3 EXECUTION

3.01 INSTALLATION, GENERAL

A. Set carpentry to required levels and lines, with members plumb, true to line, cut, and fitted. Fit carpentry to other construction; scribe and cope as needed for accurate fit. Locate nailers, blocking, and similar supports to comply with requirements for attaching other construction.

B. Where wood-preservative-treated lumber is installed adjacent to metal decking, install continuous flexible flashing separator between wood and metal decking.

C. Provide blocking as indicated and as required to support facing materials, fixtures, specialty items, and trim.

D. Provide fire blocking in furred spaces, stud spaces, and other concealed cavities as indicated and as follows:

1. Fire block furred spaces of walls, at each floor level, at ceiling, and at not more than 96 inches o.c. with solid wood blocking or noncombustible materials accurately fitted to close furred spaces.

E. Sort and select lumber so that natural characteristics will not interfere with installation or with fastening other materials to lumber. Do not use materials with defects that

interfere with function of member or pieces that are too small to use with minimum number of joints or optimum joint arrangement.

F. Comply with AWPA M4 for applying field treatment to cut surfaces of preservative-treated lumber.

1. Use inorganic boron for items that are continuously protected from liquid water.

2. Use copper naphthenate for items not continuously protected from liquid water.

G. Securely attach carpentry work to substrate by anchoring and fastening as indicated, complying with the following:

1. NES NER-272 for power-driven fasteners.

2. Table 2304.9.1, "Fastening Schedule," in ICC's International Building Code.

3. Table 23-II-B-1, "Nailing Schedule," and Table 23-II-B-2, "Wood Structural Panel Roof Sheathing Nailing Schedule," in ICBO's Uniform Building Code.

4. Table 2305.2, "Fastening Schedule," in BOCA's BOCA National Building Code.

5. Table 2306.1, "Fastening Schedule," in SBCCI's Standard Building Code.

6. Table R602.3(1), "Fastener Schedule for Structural Members," and Table R602.3(2), "Alternate Attachments," in ICC's International Residential Code for One- and Two-Family Dwellings.

7. Table 602.3(1), "Fastener Schedule for Structural Members," and Table 602.3(2), "Alternate Attachments," in ICC's International One- and Two-Family Dwelling Code.

H. Use common wire nails, unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood; do not countersink nail heads, unless otherwise indicated.

3.02 WOOD BLOCKING, AND NAILER INSTALLATION

A. Install where indicated and where required for screeding or attaching other work. Form to shapes indicated and cut as required for true line and level of attached work. Coordinate locations with other work involved.

B. Attach items to substrates to support applied loading. Recess bolts and nuts flush with surfaces, unless otherwise indicated.

C. Provide permanent grounds of dressed, pressure-preservative-treated, key-beveled lumber not less than 1-1/2 inches wide and of thickness required to bring face of ground to exact thickness of finish material. Remove temporary grounds when no longer required.

3.03 PROTECTION

A. Protect wood that has been treated with inorganic boron (SBX) from weather. If, despite protection, inorganic boron-treated wood becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

B. Protect rough carpentry from weather. If, despite protection, rough carpentry becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required to complete bituminous dampproofing as shown on the Drawings and as specified herein.

B. Section Includes:

1. Cold-applied, emulsified-asphalt dampproofing.

1.02 RELATED WORK

A. Waterproofing Repellents on masonry veneer surfaces included in Section 04 20 00.

1.03 REFERENCES

A. ASTM International

1. ASTM C 272 - Test Method for Water Absorption of Core Materials for Structural Sandwich Constructions

2. ASTM D 41 - Specification for Asphalt Primer Used in Roofing, Dampproofing, and Waterproofing

3. ASTM D 449 - Specification for Asphalt Used in Dampproofing and Waterproofing

4. ASTM D 6506 - Specification for Asphalt Based Protection for Below-Grade Waterproofing

B. Code of Federal Regulations

1. 40 CFR 59, Subpart D - National Volatile Organic Compound Emission Standards for Architectural Coatings.

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.04 SUBMITTALS

A. Provide in accordance with Section 01 33 23.

B. Product Data: For each type of product.

1.05 FIELD CONDITIONS

A. Weather Limitations: Proceed with application only when existing and forecasted weather conditions permit dampproofing to be performed according to manufacturers' written instructions.

B. Ventilation: Provide adequate ventilation during application of dampproofing in enclosed spaces. Maintain ventilation until dampproofing has cured.

PART 2 PRODUCTS

2.01 MATERIALS, GENERAL

A. Source Limitations: Obtain primary dampproofing materials and primers from single source from single manufacturer. Provide protection course and auxiliary materials recommended in writing by manufacturer of primary materials.

B. VOC Content: Products shall comply with VOC content limits of authorities having jurisdiction unless otherwise required.

2.02 COLD-APPLIED, EMULSIFIED-ASPHALT DAMPPROOFING

A. Manufacturers: Provide products by the following

1. BASF Construction Chemicals - Building Systems; Sonneborn Brand Products.

2. Euclid Chemical Company (The); an RPM company.

3. Karnak Corporation.

4. Meadows, W. R., Inc.

5. Or equal.

B. Brush and Spray Coats: ASTM D 1227, Type III, Class 1.

C. VOC Content: 30 g/L or less.

2.03 AUXILIARY MATERIALS

A. General: Furnish auxiliary materials recommended in writing by dampproofing manufacturer for intended use and compatible with bituminous dampproofing.

B. Emulsified-Asphalt Primer: ASTM D 1227, Type III, Class 1, except diluted with water as recommended in writing by manufacturer.

1. Primer shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

C. Asphalt-Coated Glass Fabric: ASTM D 1668, Type I.

D. Patching Compound: Asbestos-free fibered mastic of type recommended in writing by dampproofing manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions with Applicator present, for compliance with requirements for surface smoothness, surface moisture, and other conditions affecting performance of bituminous dampproofing work.

1. Test for surface moisture according to ASTM D 4263.

B. Proceed with application only after substrate construction and penetrating work have been completed and unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Mask or otherwise protect adjoining exposed surfaces from being stained, spotted, or coated with dampproofing. Prevent dampproofing materials from entering and clogging weep holes and drains.

B. Clean substrates of projections and substances detrimental to the dampproofing work; fill voids, seal joints, and remove bond breakers if any, as recommended in writing by prime material manufacturer.

C. Apply patching compound to patch and fill tie holes, honeycombs, reveals, and other imperfections; cover with asphalt-coated glass fabric.

3.03 APPLICATION, GENERAL

A. Comply with manufacturer's written instructions for dampproofing application, cure time between coats, and drying time before backfilling unless more stringent requirements are indicated.

1. Apply dampproofing to provide continuous plane of protection.

2. Apply additional coats if recommended in writing by manufacturer or to achieve a smooth surface and uninterrupted coverage.

B. Where dampproofing exterior face of inner wythe of exterior masonry cavity walls, lap dampproofing at least 1/4 inch onto flashing, masonry reinforcement, veneer ties, and other items that penetrate inner wythe.

1. Extend dampproofing over outer face of structural members and concrete slabs that interrupt inner wythe.

2. Lap dampproofing at least 1/4 inch onto shelf angles supporting veneer.

3.04 COLD-APPLIED, EMULSIFIED-ASPHALT DAMPPROOFING

A. Exterior Face of Inner Wythe of Cavity Walls: Apply primer and one brush or spray coat at not less than 1 gal./100 sq. ft.

3.05 CLEANING

A. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended in writing by manufacturer of affected construction.

END OF SECTION

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:

1. Extruded polystyrene foam-plastic board.

B. Related Sections:

1. Section 042000 "Unit Masonry" for insulation installed in masonry cells.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.04 INFORMATIONAL SUBMITTALS

A. Product Test Reports: For each product, for tests performed by a qualified testing agency.

B. Evaluation Reports: For foam-plastic insulation, from ICC-ES.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect insulation materials from physical damage and from deterioration due to moisture, soiling, and other sources. Store inside and in a dry location. Comply with manufacturer's written instructions for handling, storing, and protecting during installation.

B. Protect foam-plastic board insulation as follows:

1. Do not expose to sunlight except to necessary extent for period of installation and concealment.

2. Protect against ignition at all times. Do not deliver foam-plastic board materials to Project site until just before installation time.

3. Quickly complete installation and concealment of foam-plastic board insulation in each area of construction.

PART 2 PRODUCTS

2.01 EXTRUDED POLYSTYRENE FOAM-PLASTIC BOARD

A. Extruded polystyrene boards in this article are also called "XPS boards." Roman numeral designators in ASTM C578 are assigned in a fixed random sequence, and their numeric order does not reflect increasing strength or other characteristics.

B. Extruded Polystyrene Board, Type IV: ASTM C578C578, Type IV, 25-psi minimum compressive strength; unfaced; maximum flame-spread and smoke-developed indexes of 25 and 450, respectively, per ASTM E84.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Dow Chemical Company (The).
   b. Owens Corning.

2. Fire Propagation Characteristics: Passes NFPA 285 testing as part of an approved assembly.

PART 3 EXECUTION

3.01 PREPARATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, metal panel supports, and other conditions affecting performance of the Work.

3.02 INSTALLATION, GENERAL

A. Comply with insulation manufacturer's written instructions applicable to products and applications.

B. Install insulation that is undamaged, dry, and unsoiled and that has not been left exposed to ice, rain, or snow at any time.

C. Extend insulation to envelop entire area to be insulated. Fit tightly around obstructions and fill voids with insulation. Remove projections that interfere with placement.

D. Provide sizes to fit applications and selected from manufacturer's standard thicknesses, widths, and lengths. Apply single layer of insulation units unless multiple layers are otherwise shown or required to make up total thickness or to achieve R-value.

3.03 INSTALLATION OF SLAB INSULATION

A. On vertical slab edge and foundation surfaces, set insulation units using manufacturer's recommended adhesive according to manufacturer's written instructions.

1. If not otherwise indicated, extend insulation a minimum of 24 inches below exterior grade line.

B. On horizontal surfaces, loosely lay insulation units according to manufacturer's written instructions. Stagger end joints and tightly abut insulation units.

1. If not otherwise indicated, extend insulation a minimum of 24 inches in from exterior walls.

3.04 PROTECTION

A. Protect installed insulation from damage due to harmful weather exposures, physical abuse, and other causes. Provide temporary coverings or enclosures where insulation is subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install intumescent paints complete as shown on the drawings and as specified herein.

B. Section includes standing-seam metal roof panels.

1.02 RELATED WORK

A. Metal panels used in horizontal soffit applications are included in Section 07 42 93.

1.03 SUBMITTALS

A. Submit in accordance with Section 01 33 23.

B. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type of panel and accessory.

C. Shop Drawings:

1. Include fabrication and installation layouts of metal panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details.

2. Accessories: Include details of the flashing, trim, and anchorage systems, at a scale of not less than 1-1/2 inches per 12 inches.

D. Samples for Verification: For each type of exposed finish required, prepared on Samples of size indicated below.

1. Metal Panels: 12 inches long by actual panel width. Include clips, fasteners, closures, and other metal panel accessories.

E. Qualification Data: For Installer.

F. Product Test Reports: For each product, for tests performed by a qualified testing agency.

G. Field quality-control reports.

H. Sample Warranties: For special warranties.

I. Maintenance Data: For metal panels to include in maintenance manuals.

1.04 REFERENCED STANDARDS

A. American Architectural Manufacturers Association

1. AAMA 611 - Voluntary Specification for Anodized Architectural Aluminum

2. AAMA 620 - Voluntary Specification for High Performance Organic Coatings on Coil Coated Architectural Aluminum Substrates

3. AAMA 621 - Voluntary Specification for High Performance Organic Coatings on Coil Coated Architectural Hot Dipped Galvanized (HDG) and Zinc-Aluminum Coated Steel Substrates

B. ASTM International

1. ASTM A 240/A 240M - Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

2. ASTM A 653/A 653M - Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

3. ASTM A 755/A 755M - Specification for Steel Sheet, Metallic Coated by the Hot-Dip Process and Prepainted by the Coil-Coating Process for Exterior Exposed Building Products

4. ASTM A 792/A 792M - Specification for Steel Sheet, 55 Percent Aluminum-Zinc Alloy-Coated by the Hot-Dip Process

5. ASTM B 209 - Specification for Aluminum and Aluminum-Alloy Sheet and Plate

6. ASTM B 209M - Specification for Aluminum and Aluminum-Alloy Sheet and Plate

7. ASTM B 370 - Specification for Copper Sheet and Strip for Building Construction

8. ASTM B 882 - Specification for Pre-Patinated Copper for Architectural Applications

9. ASTM C 645 - Specification for Nonstructural Steel Framing Members

10. ASTM C 754 - Specification for Installation of Steel Framing Members to Receive Screw-Attached Gypsum Panel Products

11. ASTM C 920 - Specification for Elastomeric Joint Sealants

12. ASTM C 1311 - Specification for Solvent Release Sealants

13. ASTM D 226/D 226M - Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing

14. ASTM D 1970 - Specification for Self-Adhering Polymer Modified Bituminous Sheet Materials Used as Steep Roofing Underlayment for Ice Dam Protection

15. ASTM D 2244 - Practice for Calculation of Color Differences from Instrumentally Measured Color Coordinates

16. ASTM D 4214 - Test Methods for Evaluating the Degree of Chalking of Exterior Paint Films

17. ASTM E 283 - Test Method for Determining Rate of Air Leakage through Exterior Windows, Curtain Walls, and Doors under Specified Pressure Differences across the Specimen

18. ASTM E 331 - Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference

19. ASTM E 1514 - Specification for Structural Standing Seam Steel Roof Panel Systems

20. ASTM E 1592 - Test Method for Structural Performance of Sheet Metal Roof and Siding Systems by Uniform Static Air Pressure Difference

21. ASTM E 1637 - Specification for Structural Standing Seam Aluminum Roof Panel Systems

22. ASTM E 1646 - Test Method for Water Penetration of Exterior Metal Roof Panel Systems by Uniform Static Air Pressure Difference

23. ASTM E 1680 - Test Method for Rate of Air Leakage through Exterior Metal Roof Panel Systems

24. ASTM E 1980 - Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces

25. ASTM E 2140 - Test Method for Weather Penetration of Metal Roof Panel Systems by Static Water Pressure Head

C. Cool Roof Rating Council

1. CRRC-1 - CRRC Product Rating Program

D. FM Global

1. FMG 4471 - Approval Standard, Class I Panel Roofs

2. Approval Guide.

E. Sheet Metal and Air Conditioning Contractors' National Association

1. Architectural Sheet Metal Manual.

F. Underwriters Laboratories Inc.

1. UL 580 - Tests for Uplift Resistance of Roof Assemblies

G. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 PRE-INSTALLATION MEETINGS

A. Pre-installation Conference: Conduct conference at Project site .

1. Meet with Owner, Engineer, Owner's insurer if applicable, metal panel Installer, metal panel manufacturer's representative, structural-support Installer, and installers whose work interfaces with or affects metal panels, including installers of roof accessories and roof-mounted equipment.

2. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.

3. Review methods and procedures related to metal panel installation, including manufacturer's written instructions.

4. Examine support conditions for compliance with requirements, including alignment between and attachment to structural members.

5. Review structural loading limitations of deck during and after roofing.

6. Review flashings, special details, drainage, penetrations, equipment curbs, and condition of other construction that affect metal panels.

7. Review governing regulations and requirements for insurance, certificates, and tests and inspections if applicable.

8. Review temporary protection requirements for metal panel systems during and after installation.

9. Review procedures for repair of metal panels damaged after installation.

10. Document proceedings, including corrective measures and actions required, and furnish copy of record to each participant.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

B. UL-Certified, Portable Roll-Forming Equipment: UL-certified, portable roll-forming equipment capable of producing metal panels warranted by manufacturer to be the same as factory-formed products. Maintain UL certification of portable roll-forming equipment for duration of work.

1.07 DELIVERY, STORAGE AND HANDLING

A. Deliver components, metal panels, and other manufactured items so as not to be damaged or deformed. Package metal panels for protection during transportation and handling.

B. Unload, store, and erect metal panels in a manner to prevent bending, warping, twisting, and surface damage.

C. Stack metal panels horizontally on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal panels to ensure dryness, with positive slope for drainage of water. Do not store metal panels in contact with other materials that might cause staining, denting, or other surface damage.

D. Retain strippable protective covering on metal panels during installation.

1.08 FIELD CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit assembly of metal panels to be performed according to manufacturers' written instructions and warranty requirements.

1.09 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

B. Coordinate metal panel installation with rain drainage work, flashing, trim, construction of soffits, and other adjoining work to provide a leakproof, secure, and noncorrosive installation.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal panel systems that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Structural failures including rupturing, cracking, or puncturing.
   b. Deterioration of metals and other materials beyond normal weathering.

2. Warranty Period: Two years from date of Substantial Completion.

B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.

1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:
   a. Color fading more than 5 Hunter units when tested according to ASTM D 2244.

b. Chalking in excess of a No. 8 rating when tested according to ASTM D 4214.
c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Finish Warranty Period: 20 years from date of Substantial Completion.

C. Special Weathertightness Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace standing-seam metal roof panel assemblies that fail to remain weathertight, including leaks, within specified warranty period.

1. Warranty Period: 20 years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E 1592:

1. Wind Loads: As indicated on Drawings.

2. Other Design Loads: As indicated on Drawings.

3. Deflection Limits: For wind loads, no greater than 1/180 of the span.

B. Air Infiltration: Air leakage of not more than 0.06 cfm/sq. ft.when tested according to ASTM E 1680 at the following test-pressure difference:

1. Test-Pressure Difference: 6.24 lbf/sq. ft..

C. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E 1646 at the following test-pressure difference:

1. Test-Pressure Difference: 6.24 lbf/sq. ft.

D. Hydrostatic-Head Resistance: No water penetration when tested according to ASTM E 2140.

E. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

2.02 STANDING-SEAM METAL ROOF PANELS

A. General: Provide factory-formed metal roof panels designed to be installed by lapping and interconnecting raised side edges of adjacent panels with joint type indicated and mechanically attaching panels to supports using concealed clips in side laps. Include clips, cleats, pressure plates, and accessories required for weathertight installation.

1. Aluminum Panel Systems: Unless more stringent requirements are indicated, comply with ASTM E 1637.

B. Vertical-Rib, Seamed-Joint, Standing-Seam Metal Roof Panels: Formed with vertical ribs at panel edges and intermediate stiffening ribs symmetrically spaced between ribs; designed for sequential installation by mechanically attaching panels to supports using concealed clips located under one side of panels, engaging opposite edge of adjacent panels, and mechanically seaming panels together.

1. Basis-of-Design Product: Subject to compliance with requirements, provide comparable product by one of the following:
   a. Architectural Metal Systems; a Nucor company.
   b. Berridge Manufacturing Company.
   c. Englert, Inc.
   d. Fabral.
   e. Firestone Metal Products, LLC.
   f. Merchant & Evans.
   g. Metal-Fab Manufacturing, LLC.
   h. Petersen Aluminum Corporation.
   i. Or equal.

2. Aluminum Sheet: Coil-coated sheet, ASTM B 209, alloy as standard with manufacturer, with temper as required to suit forming operations and structural performance required.
   a. Thickness: 0.040 inch.
   b. Surface: Smooth, flat finish.
   c. Exterior Finish: Two-coat fluoropolymer.
   d. Color: Custom color to match existing roof panels at tennis center.

3. Clips: Two-piece floating]to accommodate thermal movement.
   a. Material: 0.062-inch-thick, stainless-steel sheet.

4. Joint Type: As standard with manufacturer.

5. Panel Coverage: 16 inches.

6. Panel Height: 2.0 inches.

2.03 UNDERLAYMENT MATERIALS

A. Self-Adhering, High-Temperature Underlayment: Provide self-adhering, cold-applied, sheet underlayment, a minimum of 30 mils thick, consisting of slip-resistant, polyethylene-film top surface laminated to a layer of butyl or SBS-modified asphalt adhesive,

with release-paper backing. Provide primer when recommended by underlayment manufacturer.

1. Thermal Stability: Stable after testing at 240 deg F; ASTM D 1970.

2. Low-Temperature Flexibility: Passes after testing at minus 20 deg F; ASTM D 1970.

3. Products: Provide one of the following:
   a. Carlisle Residential, a division of Carlisle Construction Materials; WIP 300HT.
   b. Grace Construction Products, a unit of W. R. Grace & Co.; Grace Ice and Water Shield HT.
   c. Henry Company; Blueskin PE200 HT.
   d. Kirsch Building Products, LLC; Sharkskin Ultra SA.
   e. Metal-Fab Manufacturing, LLC; MetShield.
   f. Owens Corning; WeatherLock Metal High Temperature Underlayment.
   g. Or equal.

B. Slip Sheet: Manufacturer's recommended slip sheet, of type required for application.

2.04 MISCELLANEOUS MATERIALS

A. Panel Accessories: Provide components required for a complete, weathertight panel system including trim, copings, fasciae, mullions, sills, corner units, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal panels unless otherwise indicated.

1. Closures: Provide closures at eaves and ridges, fabricated of same metal as metal panels.

2. Backing Plates: Provide metal backing plates at panel end splices, fabricated from material recommended by manufacturer.

3. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch- thick, flexible closure strips; cut or premolded to match metal panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.

B. Flashing and Trim: Provide flashing and trim formed from same material as metal panels as required to seal against weather and to provide finished appearance. Locations include, but are not limited to, eaves, rakes, corners, bases, framed openings, ridges, fasciae, and fillers. Finish flashing and trim with same finish system as adjacent metal panels.

C. Panel Fasteners: Self-tapping screws designed to withstand design loads.

D. Panel Sealants: Provide sealant type recommended by manufacturer that are compatible with panel materials, are non-staining, and do not damage panel finish.

1. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch wide and 1/8 inch thick.

2. Joint Sealant: ASTM C 920; elastomeric polyurethane or silicone sealant; of type, grade, class, and use classifications required to seal joints in metal panels and remain weathertight; and as recommended in writing by metal panel manufacturer.

3. Butyl-Rubber-Based, Solvent-Release Sealant: ASTM C 1311.

2.05 FABRICATION

A. General: Fabricate and finish metal panels and accessories at the factory, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.

B. On-Site Fabrication: Subject to compliance with requirements of this Section, metal panels may be fabricated on-site using UL-certified, portable roll-forming equipment if panels are of same profile and warranted by manufacturer to be equal to factory-formed panels. Fabricate according to equipment manufacturer's written instructions and to comply with details shown.

C. Provide panel profile, including major ribs and intermediate stiffening ribs, if any, for full length of panel.

D. Fabricate metal panel joints with factory-installed captive gaskets or separator strips that provide a weathertight seal and prevent metal-to-metal contact, and that minimize noise from movements.

E. Sheet Metal Flashing and Trim: Fabricate flashing and trim to comply with manufacturer's recommendations and recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of item indicated.

1. Form exposed sheet metal accessories that are without excessive oil canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.

2. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.

3. Sealed Joints: Form non-expansion, but movable, joints in metal to accommodate sealant and to comply with SMACNA standards.

4. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.

5. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal recommended in writing by metal panel manufacturer.

a. Size: As recommended by SMACNA's "Architectural Sheet Metal Manual" or metal panel manufacturer for application, but not less than thickness of metal being secured.

2.06 FINISHES

A. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in same piece are unacceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

C. Aluminum Panels and Accessories:

1. Two-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, metal panel supports, and other conditions affecting performance of the Work.

1. Examine primary and secondary roof framing to verify that rafters, purlins, angles, channels, and other structural panel support members and anchorages have been installed within alignment tolerances required by metal roof panel manufacturer.

2. Examine solid roof sheathing to verify that sheathing joints are supported by framing or blocking, and that installation is within flatness tolerances required by metal roof panel manufacturer.
   a. Verify that air- or water-resistive barriers have been installed over sheathing or backing substrate to prevent air infiltration or water penetration.

B. Examine roughing-in for components and systems penetrating metal panels to verify actual locations of penetrations relative to seam locations of metal panels before installation.

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

3.02 PREPARATION

A. Miscellaneous Supports: Install subframing, furring, and other miscellaneous panel support members and anchorages according to ASTM C 754 and metal panel manufacturer's written recommendations.

3.03 UNDERLAYMENT INSTALLATION

A. Self-Adhering Sheet Underlayment: Apply primer if required by manufacturer. Comply with temperature restrictions of underlayment manufacturer for installation. Apply at locations indicated below, wrinkle free, in shingle fashion to shed water, and with end laps of not less than 6 inches staggered 24 inches between courses. Overlap side edges not less than 3-1/2 inches. Roll laps with roller. Cover underlayment within 14 days.

1. Apply over the entire roof surface.

B. Slip Sheet: Apply slip sheet over underlayment before installing metal roof panels.

C. Flashings: Install flashings to cover underlayment to comply with requirements specified in Section 07 62 00.

3.04 METAL PANEL INSTALLATION

A. General: Install metal panels according to manufacturer's written instructions in orientation, sizes, and locations indicated. Install panels perpendicular to supports unless otherwise indicated. Anchor metal panels and other components of the Work securely in place, with provisions for thermal and structural movement.

1. Shim or otherwise plumb substrates receiving metal panels.

2. Flash and seal metal panels at perimeter of all openings. Fasten with self-tapping screws. Do not begin installation until air- or water-resistive barriers and flashings that will be concealed by metal panels are installed.

3. Install screw fasteners in predrilled holes.

4. Locate and space fastenings in uniform vertical and horizontal alignment.

5. Install flashing and trim as metal panel work proceeds.

6. Locate panel splices over, but not attached to, structural supports. Stagger panel splices and end laps to avoid a four-panel lap splice condition.

7. Align bottoms of metal panels and fasten with blind rivets, bolts, or self-tapping screws. Fasten flashings and trim around openings and similar elements with self-tapping screws.

8. Provide weathertight escutcheons for pipe- and conduit-penetrating panels.

B. Fasteners:

1. Aluminum Panels: Use aluminum or stainless-steel fasteners for surfaces exposed to the exterior; use aluminum or galvanized-steel fasteners for surfaces exposed to the interior.

C. Anchor Clips: Anchor metal roof panels and other components of the Work securely in place, using manufacturer's approved fasteners according to manufacturers' written instructions.

D. Metal Protection: Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action as recommended in writing by metal panel manufacturer.

E. Standing-Seam Metal Roof Panel Installation: Fasten metal roof panels to supports with concealed clips at each standing-seam joint at location, spacing, and with fasteners recommended in writing by manufacturer.

1. Install clips to supports with self-tapping fasteners.

2. Install pressure plates at locations indicated in manufacturer's written installation instructions.

3. Snap Joint: Nest standing seams and fasten together by interlocking and completely engaging factory-applied sealant.

4. Seamed Joint: Crimp standing seams with manufacturer-approved, motorized seamer tool so clip, metal roof panel, and factory-applied sealant are completely engaged.

5. Watertight Installation:
   a. Apply a continuous ribbon of sealant or tape to seal joints of metal panels, using sealant or tape as recommend in writing by manufacturer as needed to make panels watertight.
   b. Provide sealant or tape between panels and protruding equipment, vents, and accessories.
   c. At panel splices, nest panels with minimum 6-inch end lap, sealed with sealant and fastened together by interlocking clamping plates.

F. Accessory Installation: Install accessories with positive anchorage to building and weathertight mounting and provide for thermal expansion. Coordinate installation with flashings and other components.

1. Install components required for a complete metal panel system including trim, copings, corners, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items. Provide types indicated by metal roof panel manufacturers; or, if not indicated, types recommended by metal roof panel manufacturer.

G. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible and set units true to line and level as indicated. Install work with laps, joints, and seams that will be permanently watertight and weather resistant.

1. Install exposed flashing and trim that is without buckling and tool marks, and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and achieve waterproof and weather-resistant performance.

2. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet with no joints allowed within 24 inches of corner or intersection. Where lapped expansion provisions cannot be used or would not be sufficiently weather resistant and waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with mastic sealant (concealed within joints).

H. Pipe Flashing: Form flashing around pipe penetration and metal roof panels. Fasten and seal to metal roof panels as recommended by manufacturer.

3.05 ERECTION TOLERANCES

A. Installation Tolerances: Shim and align metal panel units within installed tolerance of 1/4 inch in 20 feet on slope and location lines as indicated and within 1/8-inch offset of adjoining faces and of alignment of matching profiles.

3.06 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect metal roof panel installation, including accessories. Report results in writing.

B. Remove and replace applications of metal roof panels where tests and inspections indicate that they do not comply with specified requirements.

C. Additional tests and inspections, at Contractor's expense, are performed to determine compliance of replaced or additional work with specified requirements.

D. Prepare test and inspection reports.

3.07 CLEANING AND PROTECTION

A. Remove temporary protective coverings and strippable films, if any, as metal panels are installed, unless otherwise indicated in manufacturer's written installation instructions. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.

B. Replace metal panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION

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PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Section Includes:

1. Metal soffit panels.

B. Related Sections:

1. Section 07 41 20 Standing Seam Metal Roof Panels for lap-seam metal roof panels.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each type of panel and accessory.

B. Shop Drawings:

1. Include fabrication and installation layouts of metal panels; details of edge conditions, joints, panel profiles, corners, anchorages, attachment system, trim, flashings, closures, and accessories; and special details.

2. Accessories: Include details of flashing, trim, and anchorage systems, at a scale of not less than 1-1/2 inches per 12 inches.

C. Samples for Verification: For each type of exposed finish required, prepared on Samples of size indicated below:

1. Metal Panels: 12 inches long by actual panel width. Include fasteners, closures, and other metal panel accessories.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Product Test Reports: For each product, tests performed by a qualified testing agency.

C. Sample Warranties: For special warranties.

1.05 CLOSEOUT SUBMITTAL

A. Maintenance Data: For metal panels to include in maintenance manuals.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver components, metal panels, and other manufactured items so as not to be damaged or deformed. Package metal panels for protection during transportation and handling.

B. Unload, store, and erect metal panels in a manner to prevent bending, warping, twisting, and surface damage.

C. Stack metal panels horizontally on platforms or pallets, covered with suitable weathertight and ventilated covering. Store metal panels to ensure dryness, with positive slope for drainage of water. Do not store metal panels in contact with other materials that might cause staining, denting, or other surface damage.

D. Retain strippable protective covering on metal panels during installation.

1.08 FIELD CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit assembly of metal panels to be performed according to manufacturers' written instructions and warranty requirements.

1.09 COORDINATION

A. Coordinate metal panel installation with rain drainage work, flashing, trim, construction of walls, and other adjoining work to provide a leakproof, secure, and noncorrosive installation.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of metal panel systems that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Structural failures including rupturing, cracking, or puncturing.
   b. Deterioration of metals and other materials beyond normal weathering.

2. Warranty Period: Two years from date of Substantial Completion.

B. Special Warranty on Panel Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace metal panels that show evidence of deterioration of factory-applied finishes within specified warranty period.

1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:
   a. Color fading more than 5 Delta E units when tested according to ASTM D2244.
   b. Chalking in excess of a No. 8 rating when tested according to ASTM D4214.
   c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Finish Warranty Period: 20 years from date of Substantial Completion

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Structural Performance: Provide metal panel systems capable of withstanding the effects of the following loads, based on testing according to ASTM E1592:

1. Wind Loads: As indicated on Structural Drawings.

2. Other Design Loads: As indicated on Structural Drawings.

3. Deflection Limits: For wind loads, no greater than 1/240 of the span.

B. Air Infiltration: Air leakage of not more than 0.06 cfm/sq. ft. when tested according to ASTM E283 at the following test-pressure difference:

1. Test-Pressure Difference: 1.57 lbf/sq. ft..

C. Water Penetration under Static Pressure: No water penetration when tested according to ASTM E331 at the following test-pressure difference:

1. Test-Pressure Difference: 2.86 lbf/sq. ft..

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes by preventing buckling, opening of joints, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects. Base calculations on surface temperatures of materials due to both solar heat gain and nighttime-sky heat loss.

1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

2.02 METAL SOFFIT PANELS

A. Provide metal soffit panels designed to be installed by lapping and interconnecting side edges of adjacent panels and mechanically attaching through panel to supports using concealed fasteners in side laps. Include accessories required for weathertight installation.

B. Flush-Profile Metal Soffit Panels: Solid panels formed with vertical panel edges and intermediate stiffening ribs symmetrically spaced between panel edges; with flush joint between panels.

1. Manufacturers:: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
   a. Berridge Manufacturing Company.
   b. CENTRIA Architectural Systems.
   c. Englert, Inc.
   d. Fabral.
   e. Firestone Building Products.
   f. McElroy Metal, Inc.
   g. Metal Sales Manufacturing Corporation.
   h. PAC-CLAD; Petersen Aluminum Corporation; a Carlisle company.

2. Aluminum Sheet: Coil-coated sheet, ASTM B209, alloy as standard with manufacturer, with temper as required to suit forming operations and structural performance required.
   a. Thickness: 0.040 inch.
   b. Surface: Smooth, flat finish.
   c. Exterior Finish: Two-coat fluoropolymer.
   d. Color: Custom color to match soffit panels at tennis center.

3. Panel Coverage: 16 inches.

4. Panel Height: 0.875 inch

2.03 MISCELLANEOUS MATERIALS

A. Miscellaneous Metal Subframing and Furring: ASTM C645, cold-formed, metallic-coated steel sheet, ASTM A653/A653M, G90 coating designation or ASTM A792/A792M, Class AZ50 aluminum-zinc-alloy coating designation unless otherwise indicated. Provide manufacturer's standard sections as required for support and alignment of metal panel system.

B. Panel Accessories: Provide components required for a complete, weathertight panel system including trim, clips, flashings, sealants, gaskets, fillers, closure strips, and similar items. Match material and finish of metal panels unless otherwise indicated.

1. Closure Strips: Closed-cell, expanded, cellular, rubber or crosslinked, polyolefin-foam or closed-cell laminated polyethylene; minimum 1-inch- thick, flexible closure strips; cut or premolded to match metal panel profile. Provide closure strips where indicated or necessary to ensure weathertight construction.

C. Flashing and Trim: Provide flashing and trim formed from same material as metal panels as required to seal against weather and to provide finished appearance. Finish flashing and trim with same finish system as adjacent metal panels.

D. Panel Fasteners: Self-tapping screws designed to withstand design loads. Provide exposed fasteners with heads matching color of metal panels by means of plastic caps

or factory-applied coating. Provide EPDM or PVC sealing washers for exposed fasteners.

E. Panel Sealants: Provide sealant types recommended by manufacturer that are compatible with panel materials, are nonstaining, and do not damage panel finish.

1. Sealant Tape: Pressure-sensitive, 100 percent solids, gray polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch wide and 1/8 inch thick.

2. Joint Sealant: ASTM C920; elastomeric polyurethane or silicone sealant; of type, grade, class, and use classifications required to seal joints in metal panels and remain weathertight; and as recommended in writing by metal panel manufacturer.

3. Butyl-Rubber-Based, Solvent-Release Sealant: ASTM C1311.

2.04 FABRICATION

A. Fabricate and finish metal panels and accessories at the factory, by manufacturer's standard procedures and processes, as necessary to fulfill indicated performance requirements demonstrated by laboratory testing. Comply with indicated profiles and with dimensional and structural requirements.

B. Provide panel profile for full length of panel.

C. Fabricate metal panel joints with factory-installed captive gaskets or separator strips that provide a weathertight seal and prevent metal-to-metal contact, and that minimize noise from movements.

D. Sheet Metal Flashing and Trim: Fabricate flashing and trim to comply with manufacturer's recommendations and recommendations in SMACNA's "Architectural Sheet Metal Manual" that apply to design, dimensions, metal, and other characteristics of item indicated.

1. Form exposed sheet metal accessories that are without excessive oil canning, buckling, and tool marks and that are true to line and levels indicated, with exposed edges folded back to form hems.

2. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.

3. Seams for Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.

4. Sealed Joints: Form nonexpansion, but movable, joints in metal to accommodate sealant and to comply with SMACNA standards.

5. Conceal fasteners and expansion provisions where possible. Exposed fasteners are not allowed on faces of accessories exposed to view.

6. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal recommended in writing by metal panel manufacturer.
    a. Size: As recommended by SMACNA's "Architectural Sheet Metal Manual" or metal soffit panel manufacturer for application but not less than thickness of metal being secured.

2.05 FINISHES

A. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

C. Aluminum Panels and Accessories:

1. Two-Coat Fluoropolymer: AAMA 620. Fluoropolymer finish containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, metal panel supports, and other conditions affecting performance of the Work.

1. Examine framing to verify that girts, angles, channels, studs, and other structural panel support members and anchorage have been installed within alignment tolerances required by metal panel manufacturer.

2. Examine sheathing to verify that sheathing joints are supported by framing or blocking and that installation is within flatness tolerances required by metal panel manufacturer.
    a. Verify that air- or water-resistive barriers been installed over sheathing or backing substrate to prevent air infiltration or water penetration.

B. Examine roughing-in for components and systems penetrating metal panels to verify actual locations of penetrations relative to seam locations of metal panels before installation.

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

3.02 PREPARATION

A. Miscellaneous Supports: Install subframing, furring, and other miscellaneous panel support members and anchorages according to ASTM C754 and metal panel manufacturer's written recommendations.

1. Soffit Framing: Wire tie or clip furring channels to supports.

3.03 INSTALLATION

A. Install metal panels according to manufacturer's written instructions in orientation, sizes, and locations indicated. Install panels perpendicular to supports unless otherwise indicated. Anchor metal panels and other components of the Work securely in place, with provisions for thermal and structural movement.

1. Shim or otherwise plumb substrates receiving metal panels.

2. Flash and seal metal panels at perimeter of all openings. Fasten with self-tapping screws. Do not begin installation until air- or water-resistive barriers and flashings that will be concealed by metal panels are installed.

3. Install screw fasteners in predrilled holes.

4. Locate and space fastenings in uniform vertical and horizontal alignment.

5. Install flashing and trim as metal panel work proceeds.

6. Locate panel splices over, but not attached to, structural supports. Stagger panel splices and end laps to avoid a four-panel lap splice condition.

7. Provide weathertight escutcheons for pipe- and conduit-penetrating panels.

B. Fasteners:

1. Aluminum Panels: Use aluminum or stainless steel fasteners for surfaces exposed to the exterior; use aluminum or galvanized-steel fasteners for surfaces exposed to the interior.

C. Metal Protection: Where dissimilar metals contact each other or corrosive substrates, protect against galvanic action as recommended in writing by metal panel manufacturer.

D. Lap-Seam Metal Panels: Fasten metal panels to supports with fasteners at each lapped joint at location and spacing recommended by manufacturer.

1. Apply panels and associated items true to line for neat and weathertight enclosure.

2. Provide metal-backed washers under heads of exposed fasteners bearing on weather side of metal panels.

3. Locate and space exposed fasteners in uniform vertical and horizontal alignment. Use proper tools to obtain controlled uniform compression for positive seal without rupture of washer.

4. Install screw fasteners with power tools having controlled torque adjusted to compress washer tightly without damage to washer, screw threads, or panels. Install screws in predrilled holes.

E. Watertight Installation:

1. Apply a continuous ribbon of sealant or tape to seal lapped joints of metal panels, using sealant or tape as recommend by manufacturer on side laps of nesting-type panels and elsewhere as needed to make panels watertight.

2. Provide sealant or tape between panels and protruding equipment, vents, and accessories.

3. At panel splices, nest panels with minimum 6-inch end lap, sealed with sealant and fastened together by interlocking clamping plates.

F. Accessory Installation: Install accessories with positive anchorage to building and weathertight mounting, and provide for thermal expansion. Coordinate installation with flashings and other components.

1. Install components required for a complete metal panel system including trim, corners, seam covers, flashings, sealants, gaskets, fillers, closure strips, and similar items. Provide types indicated by metal panel manufacturer; or, if not indicated, provide types recommended by metal panel manufacturer.

G. Flashing and Trim: Comply with performance requirements, manufacturer's written installation instructions, and SMACNA's "Architectural Sheet Metal Manual." Provide concealed fasteners where possible, and set units true to line and level as indicated. Install work with laps, joints, and seams that are permanently watertight.

1. Install exposed flashing and trim that is without buckling, and tool marks, and that is true to line and levels indicated, with exposed edges folded back to form hems. Install sheet metal flashing and trim to fit substrates and to achieve waterproof performance.

2. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at a maximum of 10 feet with no joints allowed within 24 inches of corner or intersection. Where lapped expansion provisions cannot be used or would not be waterproof, form expansion joints of intermeshing hooked flanges, not less than 1 inch deep, filled with mastic sealant (concealed within joints).

3.04 CLEANING AND PROTECTION

A. Remove temporary protective coverings and strippable films, if any, as metal panels are installed unless otherwise indicated in manufacturer's written installation instructions. On completion of metal panel installation, clean finished surfaces as recommended by metal panel manufacturer. Maintain in a clean condition during construction.

B. After metal panel installation, clear weep holes and drainage channels of obstructions, dirt, and sealant.

C. Replace metal panels that have been damaged or have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required to complete joint sealants as shown on the Drawings and as specified herein.

B. Section Includes:

1. Silicone joint sealants.

2. Urethane joint sealants.

3. Butyl joint sealants.

1.02 RELATED WORK

A. Sealing joints in paved roads, parking lots, walkways, and curbing are included in Section 32 13 73.

1.03 REFERENCES

A. ASTM International

1. ASTM C 834 - Specification for Latex Sealants

2. ASTM C 1021 - Practice for Laboratories Engaged in Testing of Building Sealants

3. ASTM C 1193 - Guide for Use of Joint Sealants

4. ASTM C 1247 - Test Method for Durability of Sealants Exposed to Continuous Immersion in Liquids

5. ASTM C 1248 - Test Method for Staining of Porous Substrate by Joint Sealants

6. ASTM C 1311 - Specification for Solvent Release Sealants

7. ASTM C 1330 - Specification for Cylindrical Sealant Backing for Use with Cold Liquid Applied Sealants

8. ASTM C 1521 - for Evaluating Adhesion of Installed Weatherproofing Sealant Joints

B. California Department of Public Health (formerly, the California Department of Health Services)

1. Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers.

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.04 SUBMITTALS

A. Provide in accordance with Section 01 33 23.

B. Product Data: For each joint-sealant product.

C. Samples: Manufacturer's color charts consisting of strips of cured sealants showing the full range of colors available for each product exposed to view.

D. Joint-Sealant Schedule: Include the following information:

1. Joint-sealant application, joint location, and designation.

2. Joint-sealant manufacturer and product name.

3. Joint-sealant formulation.

4. Joint-sealant color.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Product Test Reports: For each kind of joint sealant, for tests performed by manufacturer and witnessed by a qualified testing agency.

C. Sample Warranties: For special warranties.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

B. Product Testing: Test joint sealants using a qualified testing agency.

1. Testing Agency Qualifications: Qualified according to ASTM C 1021 to conduct the testing indicated.

1.07 FIELD CONDITIONS

A. Do not proceed with installation of joint sealants under the following conditions:

1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer or are below 40 deg F.

2. When joint substrates are wet.

3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.

4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

1.08 WARRANTY

A. Special Installer's Warranty: Installer agrees to repair or replace joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

B. Special Manufacturer's Warranty: Manufacturer agrees to furnish joint sealants to repair or replace those joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

C. Special warranties specified in this article exclude deterioration or failure of joint sealants from the following:

1. Movement of the structure caused by stresses on the sealant exceeding sealant manufacturer's written specifications for sealant elongation and compression.

2. Disintegration of joint substrates from causes exceeding design specifications.

3. Mechanical damage caused by individuals, tools, or other outside agents.

4. Changes in sealant appearance caused by accumulation of dirt or other atmospheric contaminants.

PART 2 PRODUCTS

2.01 JOINT SEALANTS, GENERAL

A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

B. VOC Content of Interior Sealants: Sealants and sealant primers used inside the weatherproofing system shall comply with the following:

1. Sealants and sealant primers for nonporous substrates shall have a VOC content of 250 g/L or less.

C. Colors of Exposed Joint Sealants: As selected by Engineer from manufacturer's full range.

2.02 SILICONE JOINT SEALANTS

A. Silicone, S, NS, 50, NT: Single-component, nonsag, plus 50 percent and minus 50 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant; ASTM C 920, Type S, Grade NS, Class 50, Use NT.

1. Products: Provide one of the following:
   a. Dow Corning Corporation; 791.
   b. GE Construction Sealants; SCS2000 SilPruf.
   c. May National Associates, Inc., a subsidiary of Sika Corporation U.S.; Bondaflex Sil 265 LTS.
   d. Pecora Corporation; PCS.
   e. Sika Corporation U.S.; [Sikasil WS-295] [Sikasil WS-295 FPS].
   f. Or equal.

2.03 URETHANE JOINT SEALANTS

A. Urethane, S, NS, 25, NT: Single-component, non-sag, non-traffic-use, plus 25 percent and minus 25 percent movement capability, urethane joint sealant; ASTM C 920, Type S, Grade NS, Class 25, Use NT.

1. Products: Provide one of the following:
   a. BASF Construction Chemicals, LLC, Building Systems; Sonalastic TX1.
   b. Pecora Corporation; Dynatrol I-XL.
   c. Sika Corporation U.S.; Sikaflex Textured Sealant.
   d. Tremco Incorporated; Dymonic.
   e. Or equal.

B. Urethane, M, P, 25, T, NT: Multi-component, pourable, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, urethane joint sealant; ASTM C 920, Type M, Grade P, Class 25, Uses T and NT.

1. Products: Provide one of the following:
   a. Bostik, Inc.; Chem-Calk 555-SL.
   b. Pecora Corporation; Dynatrol II SG
   c. Tremco Incorporated; THC 900/901.
   d. Or equal.

2.04 BUTYL JOINT SEALANTS

A. Butyl-Rubber-Based Joint Sealants: ASTM C 1311.

1. Products: Provide one of the following:
   a. Bostik, Inc.; Chem-Calk 300.
   b. Pecora Corporation; BC-158.
   c. Or equal.

2.05 JOINT-SEALANT BACKING

A. Sealant Backing Material, General: Non-staining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.

1. Manufacturers: Provide products by the following:
   a. BASF Construction Chemicals, LLC, Building Systems.
   b. Construction Foam Products, a division of Nomaco, Inc.
   c. Or equal.

B. Cylindrical Sealant Backings: ASTM C 1330, Type C (closed-cell material with a surface skin) and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance.

C. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint. Provide self-adhesive tape where applicable.

2.06 MISCELLANEOUS MATERIALS

A. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from pre-construction joint-sealant-substrate tests and field tests.

B. Cleaners for Non-porous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent non-porous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.

C. Masking Tape: Nonstaining, non-absorbent material compatible with joint sealants and surfaces adjacent to joints.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine joints indicated to receive joint sealants, with installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting performance of the Work.

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

3.02 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions and the following requirements:

1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.

2. Clean porous joint substrate surfaces by brushing, grinding, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air. Porous joint substrates include the following:
   a. Concrete.
   b. Masonry.
   c. Unglazed surfaces of ceramic tile.

3. Remove laitance and form-release agents from concrete.

4. Clean non-porous joint substrate surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants. Non-porous joint substrates include the following:
   a. Metal.
   b. Glass.
   c. Glazed surfaces of ceramic tile.

B. Joint Priming: Prime joint substrates where recommended by joint-sealant manufacturer or as indicated by pre-construction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

C. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

3.03 INSTALLATION OF JOINT SEALANTS

A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.

B. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

C. Install sealant backings of kind indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.

1. Do not leave gaps between ends of sealant backings.

2. Do not stretch, twist, puncture, or tear sealant backings.

3. Remove absorbent sealant backings that have become wet before sealant application, and replace them with dry materials.

D. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.

E. Install sealants using proven techniques that comply with the following and at the same time backings are installed:

1. Place sealants so they directly contact and fully wet joint substrates.

2. Completely fill recesses in each joint configuration.

3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

F. Tooling of Non-sag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified in subparagraphs below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.

1. Remove excess sealant from surfaces adjacent to joints.

2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.

3. Provide concave joint profile per Figure 8A in ASTM C 1193 unless otherwise indicated.

3.04 FIELD QUALITY CONTROL

A. Field-Adhesion Testing: Field test joint-sealant adhesion to joint substrates as follows:

1. Extent of Testing: Test completed and cured sealant joints as follows:
   a. Perform 10 tests for the first 1000 feet of joint length for each kind of sealant and joint substrate.

2. Test Method: Test joint sealants according to Method A, Field-Applied Sealant Joint Hand Pull Tab, in Appendix X1 in ASTM C 1193 or Method A, Tail Procedure, in ASTM C 1521.
   a. For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.

3. Inspect tested joints and report on the following:
   a. Whether sealants filled joint cavities and are free of voids.
   b. Whether sealant dimensions and configurations comply with specified requirements.
   c. Whether sealants in joints connected to pulled-out portion failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each kind of product and joint substrate. Compare these results to determine if

adhesion complies with sealant manufacturer's field-adhesion hand-pull test criteria.

4. Record test results in a field-adhesion-test log. Include dates when sealants were installed, names of persons who installed sealants, test dates, test locations, whether joints were primed, adhesion results and percent elongations, sealant material, sealant configuration, and sealant dimensions.

5. Repair sealants pulled from test area by applying new sealants following same procedures used originally to seal joints. Ensure that original sealant surfaces are clean and that new sealant contacts original sealant.

B. Evaluation of Field-Adhesion-Test Results: Sealants not evidencing adhesive failure from testing or non-compliance with other indicated requirements will be considered satisfactory. Remove sealants that fail to adhere to joint substrates during testing or to comply with other requirements. Retest failed applications until test results prove sealants comply with indicated requirements.

3.05 CLEANING

A. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.06 PROTECTION

A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out, remove, and repair damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from original work.

3.07 JOINT-SEALANT SCHEDULE

A. Joint-Sealant Application: Exterior joints in vertical surfaces and horizontal non-traffic surfaces.

1. Joint Locations:
   a. Construction joints in cast-in-place concrete.
   b. Joints between plant-precast architectural concrete units.
   c. Control and expansion joints in unit masonry.
   d. Joints in dimension stone cladding.
   e. Joints in glass unit masonry assemblies.
   f. Joints in exterior insulation and finish systems.
   g. Joints between metal panels.
   h. Joints between different materials listed above.
   i. Perimeter joints between materials listed above and frames of doors and louvers.
   j. Control and expansion joints in overhead surfaces.

k. Other joints as indicated on Drawings.

2. Joint Sealant: Silicone, nonstaining, S, NS, 50, NT.

3. Joint-Sealant Color: As selected by Engineer from manufacturer's full range of colors.

B. Joint-Sealant Application: Interior joints in vertical surfaces and horizontal non-traffic surfaces.

1. Joint Locations:
   a. Control and expansion joints on exposed interior surfaces of exterior walls.
   b. Tile control and expansion joints.
   c. Vertical joints on exposed surfaces of unit masonry.
   d. Other joints as indicated on Drawings.

2. Joint Sealant: Urethane, S, NS, 25, NT.

3. Joint-Sealant Color: As selected by Engineer from manufacturer's full range of colors.

C. Joint-Sealant Application: Concealed mastics.

1. Joint Locations:
   a. Aluminum thresholds.
   b. Sill plates.
   c. Other joints as indicated on Drawings.

2. Joint Sealant: Butyl-rubber based.

3. Joint-Sealant Color: As selected by Engineer from manufacturer's full range of colors.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and design and deliver aluminum doors and frames for the Project as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A. Masonry is included in Section 04 20 00.

B. Door Hardware is included in Section 08 71 00.

C. Glazing is included in Section 08 80 00.

1.03 SUBMITTALS

A. Submit the following, in accordance with Section 01 33 23:

1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for aluminum-framed systems.

2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

3. Samples: For each type of exposed finish required, in manufacturer's standard sizes.

4. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for aluminum-framed systems, indicating compliance with performance requirements.

1.04 REFERENCE STANDARDS

A. Aluminum Association (AA)

1. AA DAF-45 - Designation System for Aluminum Finishes

B. American Architectural Manufacturers Association (AAMA)

1. AAMA 2604 - High Performance Organic Coatings on Architectural Extrusions and Panels

C. ASTM International (ASTM)

1. ASTM B 209 - Aluminum and Aluminum-Alloy Sheet and Plate

2. ASTM B 221 - Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

3. ASTM E 283 - Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen

D. National Association of Architectural Metal Manufacturers

1. Metal Finishes Manual for Architectural and Metal Products.

E. Where reference is made to one of the above or other referenced standards, the revisions in effect at the time of bid opening shall apply.

1.05 PERFORMANCE REQUIREMENTS

A. General: Aluminum doors and frames shall withstand structural loads, air infiltration, water infiltration and thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction.

B. Structural: Shapes and thicknesses of framing members shall be sufficient to withstand the design wind load indicated with a deflection of not more than 1/175 times the length of the member and a safety factor of not less than 1.65. Provide glazing beads, moldings, and trim of not less than 0.050 inch nominal thickness.

C. Air Infiltration: Provide aluminum-framed systems with maximum air leakage through fixed glazing and framing areas of 0.06 cfm/sq. ft. of fixed wall area when tested according to ASTM E 283 at a minimum static-air-pressure difference of 6.24 lbf/sq. ft.

D. Water Penetration under Static Pressure: Provide aluminum-framed systems that do not evidence water penetration through fixed glazing and framing areas when tested according to ASTM E 331 at a minimum static-air-pressure difference of 20 percent of positive wind-load design pressure, but not less than 8.00 lbf/sq. ft.

E. Thermal Movements: Provide sheet metal flashing and trim that allows for thermal movements from ambient and surface temperature changes.

1. Temperature Change (Range): 120 deg F, ambient; 180 deg F, material surfaces.

1.06 QUALITY ASSURANCE

A. Fabricator Qualifications: Shop that employs skilled workers who fabricate aluminum doors and frames similar to that required for this Project and whose products have a record of successful in-service performance.

B. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

C. Source Limitations for Aluminum-Framed Systems: Obtain from single source from single manufacturer.

D. Welding Qualifications: Qualify procedures and personnel according to AWS D1.2, "Structural Welding Code - Aluminum."

1.07 DELIVERY, STORAGE, AND HANDLING

A. Do not store aluminum doors and frames in contact with other materials that might cause staining, denting, or other surface damage. Store aluminum doors and frames away from uncured concrete and masonry.

B. Protect strippable protective covering on aluminum doors and frames from exposure to sunlight and high humidity, except to the extent necessary for the period of aluminum doors and frames installation.

1.08 PROJECT CONDITIONS

A. Field Measurements: Verify actual locations of structural supports for aluminum-framed systems by field measurements before fabrication and indicate measurements on Shop Drawings.

1.09 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of aluminum-framed systems that do not comply with requirements or that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Structural failures including, but not limited to, excessive deflection.
   b. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
   c. Water leakage through fixed glazing and framing areas.

2. Warranty Period: 10 years from date of Substantial Completion.

B. Special Finish Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components on which finishes do not comply with requirements or that fail in materials or workmanship within specified warranty period. Warranty does not include normal weathering.

1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 MATERIALS

A. Anchors: Stainless steel or steel with hot-dipped galvanized finish.

B. Weatherstripping: Continuous wool pile, silicone treated, or type recommended by door manufacturer

C. Aluminum Alloy for Doors and Frames: ASTM B 221 / ASTM B 221M, alloy 6063-T5 for extrusions; ASTM B 209 / B 209M, alloy and temper best suited for aluminum sheets and strips.

D. Fasteners: Hard aluminum or stainless steel.

E. Structural Steel: ASTM A 36/A 36M.

F. Aluminum Paint: Aluminum door manufacturer's standard aluminum paint.

2.02 FABRICATION

A. Aluminum Frames: Extruded aluminum shapes with contours approximately as indicated. Provide removable glass stops and glazing beads for frames accommodating fixed glass. Use countersunk stainless steel Phillips screws for exposed fastenings, and space not more than 12 inches on center. Mill joints in frame members to a hairline fit, reinforce, and secure mechanically.

1. Construction: Non-thermal at interior locations; thermally broken at exterior locations.

B. Aluminum Doors: Of type, size, and design indicated and not less than 1-3/4 inch thick. Minimum wall thickness, 0.125 inch, except beads and trim, 0.050 inch. Door sizes shown are nominal and shall include standard clearances as follows: 0.093 inch at hinge and lock stiles, 0.125 inch between meeting stiles, 0.125 inch at top rails, 0.187 inch between bottom and threshold, and 0.687 inch between bottom and floor.

C. Flush Doors: Use facing sheets with an embossed or a plain smooth surface. Use one of the following constructions:

1. A phenolic resin-impregnated kraft paper honeycomb core, surrounded at edges and around glass and louvered areas with extruded aluminum shapes. The impregnation of core shall have a minimum of 18 percent resin content. Provide sheet aluminum door facings, not less than 0.032 inch thick laminated to a 0.10 inch thick tempered hardboard backing, and bond the backing to the honeycomb core. Bond facing sheets to core under heat and pressure with a thermosetting adhesive, and mechanically lock to the extruded edge members.

2. A phenolic resin-impregnated kraft paper honeycomb core. Use aluminum facing sheets not less than 0.050 inch thick and form into two pans which will eliminate seams on the faces. Bond honeycomb core to the face sheets using an epoxy resin or contact cement-type adhesive.

3. A solid fibrous core, surrounded at edges and around glass and louvered areas and cross-braced at intermediate points with extruded aluminum shapes. Use aluminum facing sheets of not less than 0.050 inch thickness. Bond facing sheets to core under heat and pressure with a thermosetting adhesive, and mechanically lock to the extruded edge members.

4. Form from extruded tubular stiles and rails mitered at corners, reinforce, and continuously weld at miters. Facing sheets shall consist of 0.032 inch thick sheet

aluminum internally reinforced with aluminum channels or Z-bars placed horizontally not more than 16 inch apart and extending full width of panel. Fit spaces between reinforcing with sound-deadening insulation. Facing sheets shall finish flush with faces of stiles and rails and be welded to reinforcing bars or channels and to stiles and rails.

5. Form from an internal grid system composed of extruded aluminum tubular sections. Provide extruded aluminum tubular sections at both sides, and at perimeters of louver and glass cutouts. Provide three extruded aluminum tubular sections at top and bottom of door. Wall thickness of tubular sections shall be not less than 0.09 inch except that lock rail shall be not less than 0.125 inch thick, hinge lock rail shall be not less than 0.125 inch thick, and hinge rail edge shall be not less than 0.19 inch thick. Fill spaces in door with mineral insulation. Facing sheets shall be of aluminum not less than 0.09 inch thick.

6. Form from extruded aluminum members at top and bottom, both sides, and at perimeters of louver and glass cutouts. Wall sections of extruded aluminum members shall be not less than 0.09 inch thick and be properly reinforced for application of hardware. Framing members shall be covered on both sides with aluminum facing sheets not less than 0.064 inch thick. Fill door with foamed-in urethane with a 3 pound density.

D. Welding and Fastening: Where possible, locate welds on unexposed surfaces. Dress welds on exposed surfaces smoothly. Select welding rods, filler wire, and flux to produce a uniform texture and color in finished work. Remove flux and spatter from surfaces immediately after welding. Exposed screws or bolts will be permitted only in inconspicuous locations and shall have countersunk heads. Weld concealed reinforcements for hardware in place.

2.03 ACCESSORIES

A. Weatherstripping: Provide on stiles and rails of exterior doors. Fit into slots which are integral with doors or frames. Weatherstripping shall be replaceable without special tools, and adjustable at meeting rails of pairs of doors. Installation shall allow doors to swing freely and close positively. Air leakage of a single leaf weatherstripped door shall not exceed 0.5 cubic feet per minute of air per square foot of door area when tested in accordance with ASTM E 283.

B. Anchors: On the backs of subframes, provide anchors of the sizes and shapes indicated for securing subframes to adjacent construction. Anchor transom bars at ends and mullions at head and sill. Reinforce and anchor freestanding door frames to floor construction as indicated on approved shop drawings and in accordance with manufacturer's recommendation. Place anchors near top and bottom of each jamb and at intermediate points not more than 25 inches apart.

C. Hardware: Coordinate with Section 08 71 00. Deliver hardware templates and hardware (except field-applied hardware) to the door manufacturer for use in fabrication of aluminum doors and frames. Cut, reinforce, drill, and tap doors and frames at the factory to receive template hardware. Provide doors to receive surface-applied hardware, except push plates, kick plates, and mop plates, with reinforcing only; drill and tap in the field. Provide hardware reinforcements of stainless steel or

steel with hot-dipped galvanized finish, and secure with stainless steel screws. Provide reinforcement in core of flush doors as required to receive locks, door closers, and other hardware.

D. Glazing: Provide extruded aluminum snap-in glazing beads on interior side of doors. Provide extruded aluminum, theft-proof, snap-in glazing beads or fixed glazing beads on exterior or security side of doors. Glazing beads shall have vinyl insert glazing gaskets. Design glazing beads to receive glass of thickness indicated or specified.

2.04 GENERAL FINISH REQUIREMENTS

A. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Finish aluminum doors and frames after assembly.

2.05 ALUMINUM FINISHES

A. High-Performance Organic Finish: 2-coat fluoropolymer finish complying AAMA 2604 and containing not less than 70 percent PVDF resin by weight in color coat. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.

1. Color and Gloss: Custom color to match doors and frames at the tennis center.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

3.02 INSTALLATION

A. General:

1. Comply with manufacturer's written instructions.

2. Do not install damaged components.

3. Fit joints to produce hairline joints free of burrs and distortion.

4. Rigidly secure non-movement joints.

5. Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration.

6. Seal joints watertight unless otherwise indicated.

B. Metal Protection:

1. Where aluminum will contact dissimilar metals, protect against galvanic action by painting contact surfaces with primer or applying sealant or tape, or by installing nonconductive spacers as recommended by manufacturer for this purpose.

2. Where aluminum will contact concrete or masonry, protect against corrosion by painting contact surfaces with bituminous paint.

C. Install components to drain water passing joints, condensation occurring within framing members, and moisture migrating within the system to exterior.

D. Set continuous sill members and flashing in full sealant bed to produce weathertight installation.

E. Install components plumb and true in alignment with established lines and grades, and without warp or rack.

F. Doors: Install doors to produce smooth operation and tight fit at contact points.

1. Exterior Doors: Install to produce weathertight enclosure and tight fit at weather stripping.

2. Field-Installed Entrance Door Hardware: Install surface-mounted entrance door hardware according to entrance door hardware manufacturers' written instructions using concealed fasteners to greatest extent possible.

G. Perimeter joint sealants are installed under Section 07 10 00.

3.03 ERECTION TOLERANCES

A. Install aluminum-framed systems to comply with the following maximum erection tolerances:

1. Location and Plane: Limit variation from true location and plane to 1/8 inch in 12 feet; 1/4 inch over total length.

2. Alignment:

3.04 CLEANING

A. Upon completion of installation, clean door and frame surfaces in accordance with door manufacturer's written recommended procedure. Do not use abrasive, caustic, or acid cleaning agents.

3.05 PROTECTION

A. Protect doors and frames from damage and from contamination by other materials such as cement mortar. Prior to completion and acceptance of the work, restore damaged doors and frames to original condition, or replace with new ones.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and design and deliver door hardware for the Project as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A. Aluminum doors and frames are included in Section 08 11 16.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23.

B. Product Data: Include construction and installation details, material descriptions, dimensions of individual components and profiles, and finishes.

C. Qualification Data: For Architectural Hardware Consultant.

D. Maintenance Data: For each type of door hardware to include in maintenance manuals. Include final hardware and keying schedule.

E. Warranty: Special warranty specified in this Section.

F. Other Action Submittals:

1. Door Hardware Sets: Prepared by or under the supervision of an Architectural Hardware Consultant, detailing fabrication and assembly of door hardware, as well as procedures and diagrams. Coordinate the final door hardware sets with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of door hardware.
   a. Format: Comply with scheduling sequence and vertical format in DHI's "Sequence and Format for the Hardware Schedule." Double space entries, and number and date each page and use same door numbers as indicated.
   b. Content: Include the following information:
      1) Identification number, location, hand, fire rating, and material of each door and frame.
      2) Type, style, function, size, quantity, and finish of each door hardware item. Include description and function of each lockset and exit device.
      3) Complete designations of every item required for each door or opening including name and manufacturer.
      4) Fastenings and other pertinent information.
      5) Location of each door hardware set, cross-referenced to Drawings, both on floor plans and in door and frame schedule.
      6) Explanation of abbreviations, symbols, and codes contained in schedule.
      7) Mounting locations for door hardware.
      8) Door and frame sizes and materials.

9) List of related door devices specified in other Sections for each door and frame.

c. Submittal Sequence: Submit the final door hardware sets at earliest possible date, particularly where approval of the door hardware sets must precede fabrication of other work that is critical in Project construction schedule. Include Product Data, Samples, Shop Drawings of other work affected by door hardware, and other information essential to the coordinated review of the door hardware sets.

2. Keying Schedule: Prepared by or under the supervision of Architectural Hardware Consultant, detailing Owner's final keying instructions for locks. Include schematic keying diagram and index each key set to unique door designations.

1.04 REFERENCE STANDARDS

A. American Architectural Manufacturers Association

1. AAMA 701/702 - Voluntary Specifications for Pile Weatherstripping and Replaceable Fenestration Weatherseals

B. ASTM International

1. ASTM D 2000 - Classification System for Rubber Products in Automotive Applications

2. ASTM E 283 - Test Method for Determining the Rate of Air Leakage through Exterior Windows, Curtain Walls, and Doors under Specified Pressure Differences across the Specimen

C. Builders Hardware Manufacturers Association

1. BHMA A156.1 - Butts and Hinges (ANSI)

2. BHMA A156.4 - Door Controls - Closers (ANSI)

3. BHMA A156.5 - Auxiliary Locks and Associated Products (ANSI)

4. BHMA A156.6 - Architectural Door Trim (ANSI)

5. BHMA A156.7 - Template Hinge Dimensions (ANSI)

6. BHMA A156.13 - Mortise Locks & Latches Series 1000 (ANSI)

7. BHMA A156.16 - Auxiliary Hardware (ANSI)

8. BHMA A156.18 - Materials and Finishes (ANSI)

9. BHMA A156.21 - Thresholds (ANSI)

10. BHMA A156.22 - Door Gasketing and Edge Seal Systems (ANSI)

11. BHMA A156.30 - High Security Cylinders (ANSI)

12. Certified Product Directory.

D. Door and Hardware Institute

1. Sequence and Format for the Hardware Schedule.

E. NFPA

1. NFPA 101 - Life Safety Code

F. Where reference is made to one of the above or other referenced standards, the revisions in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by lock manufacturer.

1. Installer's responsibilities include supplying and installing door hardware and providing a qualified Architectural Hardware Consultant available during the course of the Work to consult with Contractor, Engineer, and Owner about door hardware and keying.

2. Installer shall have warehousing facilities in Project's vicinity.

3. Scheduling Responsibility: Preparation of door hardware and keying schedules.

B. Architectural Hardware Consultant Qualifications: A person who is currently certified by DHI as an Architectural Hardware Consultant and who is experienced in providing consulting services for door hardware installations that are comparable in material, design, and extent to that indicated for this Project.

C. Source Limitations: Obtain each type and variety of door hardware from a single manufacturer, unless otherwise indicated.

D. Keying Conference: Conduct conference at Project site. In addition to Owner, Contractor, and Engineer, conference participants shall also include Installer's Architectural Hardware Consultant. Incorporate keying conference decisions into final keying schedule after reviewing door hardware keying system including, but not limited to, the following:

1. Function of building, flow of traffic, purpose of each area, degree of security required, and plans for future expansion.

2. Preliminary key system schematic diagram.

3. Requirements for key control system.

4. Address for delivery of keys.

1.06 DELIVERY, STORAGE AND HANDLING

A. Inventory door hardware on receipt and provide secure lock-up for door hardware delivered to Project site.

B. Tag each item or package separately with identification related to the final door hardware sets, and include basic installation instructions, templates, and necessary fasteners with each item or package.

C. Deliver keys to manufacturer of key control system for subsequent delivery to Owner.

D. Deliver keys and permanent cores to Owner by registered mail or overnight package service.

1.07 COORDINATION

A. Templates: Distribute door hardware templates for doors, frames, and other work specified to be factory prepared for installing door hardware. Check Shop Drawings of other work to confirm that adequate provisions are made for locating and installing door hardware to comply with indicated requirements.

1.08 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of door hardware that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Structural failures including excessive deflection, cracking, or breakage.
   b. Faulty operation of operators and door hardware.
   c. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.

2. Warranty Period: Three years, except 10 years for manual closers.

1.09 MAINTENANCE SERVICE

A. Maintenance Tools and Instructions: Furnish a complete set of specialized tools and maintenance instructions as needed for Owner's continued adjustment, maintenance, and removal and replacement of door hardware.

B. Maintenance Service: Provide six months' full maintenance by skilled employees of door hardware Installer. Include quarterly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper door hardware operation. Provide parts and supplies same as those used in the manufacture and installation of original products.

PART 2 PRODUCTS

2.01 SCHEDULED DOOR HARDWARE

A. General: Provide door hardware for each door to comply with requirements in this Section.

1. Door Hardware Sets: Provide quantity, item, size, finish or color indicated, and products equivalent in function and comparable in quality to named products and the BHMA standard referenced.

B. Designations: Requirements for design, grade, function, finish, size, and other distinctive qualities of each type of door hardware are indicated in Part 3 "Door Hardware Sets" Article. Products are identified by using door hardware designations, as follows:

1. Named Manufacturers' Products: Manufacturer and product designation are listed for each door hardware type required for the purpose of establishing minimum requirements. Manufacturers' names are abbreviated in Part 3 "Door Hardware Sets" Article.

2. References to BHMA Standards: Provide products complying with these standards and requirements for description, quality, and function.

2.02 HINGES, GENERAL

A. Quantity: Provide the following, unless otherwise indicated:

1. Two Hinges: For doors with heights up to 60 inches.

2. Three Hinges: For doors with heights 61 to 90 inches.

3. Four Hinges: For doors with heights 91 to 120 inches.

4. For doors with heights more than 120 inches, provide 4 hinges, plus 1 hinge for every 30 inches of door height greater than 120 inches.

B. Template Requirements: Except for hinges and pivots to be installed entirely (both leaves) into wood doors and frames, provide only template-produced units.

C. Hinge Weight: Provide Heavy-weight hinges.

D. Hinge Base Metal: Stainless steel, with stainless-steel pin.

E. Hinge Corners: Square.

F. Fasteners: Comply with the following:

1. Machine Screws: For metal doors and frames. Install into drilled and tapped holes.

2. Screws: Phillips flat-head; machine screws (drilled and tapped holes) for metal doors. Finish screw heads to match surface of hinges.

2.03 HINGES

A. Butts and Hinges: BHMA A156.1. Listed under Category A in BHMA's "Certified Product Directory."

B. Template Hinge Dimensions: BHMA A156.7.

C. Manufacturers: Provide products by one of the following:

1. Hager Companies (HAG).

2. IVES Hardware; Allegion, plc (IVS).

3. Stanley Commercial Hardware; Div. of The Stanley Works (STH).

4. Or equal.

2.04 LOCKS AND LATCHES, GENERAL

A. Latches and Locks for Means of Egress Doors: Comply with NFPA 101. Latches shall not require more than 15 lbf to release the latch. Locks shall not require use of a key, tool, or special knowledge for operation.

B. Lock Trim:

1. Levers: Match to the following:
   a. "P Lever Design," by SARGENT Manufacturing Company; an ASSA ABLOY Group company (SGT).
   b. "17 (D Sparta)," by Schlage Commercial Lock Division; Allegion, plc (SCH).
   c. "JEFFERSON - JNE," by Yale Commercial Locks and Hardware; an ASSA ABLOY Group company (YAL).

2. Lockset Designs: Provide designs that match those scheduled.

C. Lock Throw: Comply with testing requirements for length of bolts required for labeled fire doors, and as follows:

1. Mortise Locks: Minimum 3/4-inch latchbolt throw.

2. Deadbolts: Minimum 1-inch bolt throw.

D. Backset: 2-3/4 inches, unless otherwise indicated.

E. Strikes: Manufacturer's standard strike with strike box for each latchbolt or lock bolt, with curved lip extended to protect frame, finished to match door hardware set, and as follows:

1. Strikes for Mortise Locks and Latches: BHMA A156.13.

2.05 MECHANICAL LOCKS AND LATCHES

A. Lock Functions: Function numbers and descriptions indicated in door hardware sets comply with the following:

1. Mortise Locks: BHMA A156.13.

B. Mortise Locks: Stamped steel case with steel or brass parts; BHMA A156.13, Grade 1; Series 1000. Listed under Category F in BHMA's "Certified Product Directory."

1. Manufacturers: Provide products by one of the following:
   a. SARGENT Manufacturing Company; an ASSA ABLOY Group company (SGT).
   b. Schlage Commercial Lock Division; allegion, plc (SCH).
   c. Yale Commercial Locks and Hardware; an ASSA ABLOY Group company (YAL).
   d. Or equal.

2.06 DOOR BOLTS

A. Bolt Throw: Comply with testing requirements for length of bolts required for labeled fire doors, and as follows:

1. Fire-Rated Surface Bolts: Minimum 1-inch throw; listed and labeled for fire-rated doors.

2. Mortise Flush Bolts: Minimum 3/4-inch throw.

B. Dustproof Strikes: BHMA A156.16, Grade 1.

C. Manual Flush Bolts: BHMA A156.16, Grade 1; designed for mortising into door edge.

1. Manufacturers: Provide products by one of the following:
   a. Hager Companies (HAG).
   b. IVES Hardware; Allegion, plc (IVS).
   c. Rockwood Manufacturing Company (RM).
   d. Or equal.

2.07 LOCK CYLINDERS

A. Standard Lock Cylinders: BHMA A156.5, Grade 1.

B. Cylinders: Manufacturer's standard tumbler type, constructed from brass or bronze, stainless steel, or nickel silver, and complying with the following:

1. Number of Pins: Seven.

2. Mortise Type: Threaded cylinders with rings and straight- or clover-type cam.

C. Permanent Cores: Manufacturer's standard; finish face to match lockset; complying with the following:

1. Interchangeable Cores: Core insert, removable by use of a special key; usable with other manufacturers' cylinders.

D. Construction Keying: Do not provide construction keying. Contractor shall provide access to all areas during construction, so not to interrupt the Owners unhindered use of all areas.

E. Manufacturer: Same manufacturer as for locks and latches.

2.08 EXIT DEVICES AND AUXILARY ITEMS

A. Exit Devices and Auxiliary Items: BHMA A156.3.

1. Manufacturers: Provide products by one of the following:
   a. SARGENT Manufacturing Company; an ASSA ABLOY Group company (SGT).
   b. Hager Companies (HAG
   c. Yale Commercial Locks and Hardware; an ASSA ABLOY Group company (YAL).
   d. Or equal.

2.09 KEYING

A. Keys: Nickel silver.

1. Stamping: Permanently inscribe each key with a visual key control number and include the notation "DO NOT DUPLICATE."

2. Quantity: In association with Owner requirements, determined at keying conference, provide up to the following maximum number of keys.
   a. Cylinder Change Keys: Three.
   b. Master Keys: Five.
   c. Grand Master Keys: Five.
   d. Great-Grand Master Keys: Five.

2.10 CLOSERS

A. Door Closers for Means of Egress Doors: Comply with NFPA 101. Door closers shall not require more than 30 lbf to set door in motion and not more than 15 lbf to open door to minimum required width.

B. Size of Units: Unless otherwise indicated, comply with manufacturer's written recommendations for size of door closers depending on size of door, exposure to weather, and anticipated frequency of use. Provide factory-sized closers, adjustable to meet field conditions and requirements for opening force.

C. Surface Closers: BHMA A156.4, Grade 1. Listed under Category C in BHMA's "Certified Product Directory." Provide type of arm required for closer to be located on non-public side of door, unless otherwise indicated.

1. Manufacturers: Provide products by one of the following:
   a. LCN Closers; Allegion, plc (LCN).
   b. Norton Door Controls; an ASSA ABLOY Group company (NDC).
   c. SARGENT Manufacturing Company; an ASSA ABLOY Group company (SGT).
   d. Yale Commercial Locks and Hardware; an ASSA ABLOY Group company (YAL).
   e. Or equal.

2.11 PROTECTIVE TRIM UNITS

A. Size: 1-1/2 inches less than door width on push side and 1/2 inch less than door width on pull side, by height specified in door hardware sets.

B. Fasteners: Manufacturer's standard machine or self-tapping screws.

C. Metal Protective Trim Units: BHMA A156.6; beveled top and 2 sides; fabricated from the following material:

1. Material: 0.050-inch-thick stainless steel.

2. Manufacturers: Provide products by one of the following:
   a. Hager Companies (HAG).
   b. IVES Hardware; Allegion, plc (IVS).
   c. Rockwood Manufacturing Company (RM).
   d. Or equal.

2.12 STOPS AND HOLDERS

A. Stops and Bumpers: BHMA A156.16, Grade 1.

1. Provide floor stops for doors. Do not mount floor stops where they will impede traffic. Where floor or wall stops are not appropriate, provide overhead holders.

B. Manufacturers: Provide products by one of the following:

1. Hager Companies (HAG).

2. IVES Hardware; Allegion, plc (IVS).

3. Rockwood Manufacturing Company (RM).

4. Or equal.

2.13 DOOR GASKETING

A. Standard: BHMA A156.22. Listed under Category J in BHMA's "Certified Product Directory."

B. General: Provide continuous weather-strip gasketing on exterior doors. Provide noncorrosive fasteners for exterior applications and elsewhere as indicated.

1. Perimeter Gasketing: Apply to head and jamb, forming seal between door and frame.

C. Air Leakage: Not to exceed 0.50 cfm per foot of crack length for gasketing other than for smoke control, as tested according to ASTM E 283.

D. Replaceable Seal Strips: Provide only those units where resilient or flexible seal strips are easily replaceable and readily available from stocks maintained by manufacturer.

E. Gasketing Materials: ASTM D 2000 and AAMA 701/702.

F. Manufacturers: Provide products by one of the following:

1. Hager Companies (HAG).

2. National Guard Products (NGP).

3. Pemko Manufacturing Co. (PEM).

4. Zero International (ZRO).

5. Or equal.

2.14 THRESHOLDS

A. Standard: BHMA A156.21. Listed under Category J in BHMA's "Certified Product Directory."

B. Thresholds for Means of Egress Doors: Comply with NFPA 101. Maximum 1/2 inch high.

C. Manufacturers: Provide products by one of the following:

1. Hager Companies (HAG).

2. National Guard Products (NGP).

3. Pemko Manufacturing Co. (PEM).

4. Or equal.

2.15 MISCELLANEOUS DOOR HARDWARE

A. Auxiliary Hardware: BHMA A156.16, Grade 1.

1. Manufacturers: Provide products by one of the following:
   a. Hager Companies (HAG).
   b. Rockwood Manufacturing Company (RM).
   c. Stanley Commercial Hardware; Div. of The Stanley Works (STH).
   d. Or equal.

2.16 FABRICATION

A. Manufacturer's Nameplate: Do not provide products that have manufacturer's name or trade name displayed in a visible location except in conjunction with required fire-rated labels and as otherwise approved by Engineer.

1. Manufacturer's identification is permitted on rim of lock cylinders only.

B. Base Metals: Produce door hardware units of base metal, fabricated by forming method indicated, using manufacturer's standard metal alloy, composition, temper, and hardness. Furnish metals of a quality equal to or greater than that of specified door hardware units and BHMA A156.18. Do not furnish manufacturer's standard materials or forming methods if different from specified standard.

C. Fasteners: Provide door hardware manufactured to comply with published templates generally prepared for machine, wood, and sheet metal screws. Provide screws according to commercially recognized industry standards for application intended, except aluminum fasteners are not permitted. Provide Phillips flat-head screws with finished heads to match surface of door hardware, unless otherwise indicated.

1. Concealed Fasteners: For door hardware units that are exposed when door is closed, except for units already specified with concealed fasteners. Do not use through bolts for installation where bolt head or nut on opposite face is exposed unless it is the only means of securely attaching the door hardware. Where through bolts are used on hollow door and frame construction, provide sleeves for each through bolt.

2. Steel Machine: For the following fire-rated applications:
   a. Mortise hinges to doors.
   b. Strike plates to frames.
   c. Closers to doors and frames.

3. Spacers or Sex Bolts: For through bolting of hollow-metal doors.

2.17 FINISHES

A. Standard: BHMA A156.18, as indicated in door hardware sets.

B. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine doors and frames, with Installer present, for compliance with requirements for installation tolerances, labeled fire door assembly construction, wall and floor construction, and other conditions affecting performance.

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

3.02 INSTALLATION

A. Mounting Heights: Mount door hardware units at heights indicated as follows unless otherwise indicated or required to comply with governing regulations.

B. Install each door hardware item to comply with manufacturer's written instructions. Where cutting and fitting are required to install door hardware onto or into surfaces that are later to be painted or finished in another way, coordinate removal, storage, and reinstallation of surface protective trim units with finishing work specified in Division 09 Sections. Do not install surface-mounted items until finishes have been completed on substrates involved.

1. Set units level, plumb, and true to line and location. Adjust and reinforce attachment substrates as necessary for proper installation and operation.

2. Drill and countersink units that are not factory prepared for anchorage fasteners. Space fasteners and anchors according to industry standards.

C. Thresholds: Set thresholds for exterior and acoustical doors in full bed of sealant.

3.03 FIELD QUALITY CONTROL

A. Independent Architectural Hardware Consultant: Owner will engage a qualified independent Architectural Hardware Consultant to perform inspections and to prepare inspection reports.

1. Independent Architectural Hardware Consultant will inspect door hardware and state in each report whether installed work complies with or deviates from requirements, including whether door hardware is properly installed and adjusted.

3.04 ADJUSTING

A. Initial Adjustment: Adjust and check each operating item of door hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate as intended. Adjust door control devices to compensate for final operation of heating and ventilating equipment and to comply with referenced accessibility requirements.

1. Door Closers: Unless otherwise required by authorities having jurisdiction, adjust sweep period so that, from an open position of 70 degrees, the door will take at

least 3 seconds to move to a point 3 inches from the latch, measured to the leading edge of the door.

B. Occupancy Adjustment: Approximately six months after date of Substantial Completion, Installer's Architectural Hardware Consultant shall examine and readjust, including adjusting operating forces, each item of door hardware as necessary to ensure function of doors, door hardware, and electrified door hardware.

3.05 CLEANING AND PROTECTION

A. Clean adjacent surfaces soiled by door hardware installation.

B. Clean operating items as necessary to restore proper function and finish.

C. Provide final protection and maintain conditions that ensure that door hardware is without damage or deterioration at time of Substantial Completion.

3.06 DEMONSTRATION

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

3.07 DOOR HARDWARE SETS

Door Hardware Set No. 1 (Exterior Locked – Single with Exit Device)

No.	Item	Description	Manufacturer	Finish
*	Hinges	A5111 x NRP	ANSI	630
		BB1199	HAG	
		5BB1HW	IVS	
		FBB199	STH	
1	Exit Device	8813	SGT	630
		4500	HAG	
		6000	YAL	
1	Closing Device	C02021	ANSI	689
		4110 x parallel x metal cover	LCN	
			NDC	
		P8501MA	SGT	
		P1431-P9	YAL	
		(PA)4400M		
1	Kick Plate	J102 x B3E x 12"	ANSI	630
		193S	HAG	
		8400	IVS	
		K1050	RM	
1	Door Shoe	R5B435	ANSI	
		751S	HAG	
		113NA	NGP	
		211PK	PEM	
1	Weather Stripping	R5B435	ANSI	628

set		875S	HAG	
		130NA	NGP	
		297PK-PG	PEM	
1	Threshold	J32139	ANSI	628
		421S	HAG	
		8425	NGP	
		252X3FG	PEM	
1	Stop	L02251	ANSI	630
		236W	HAG	
		409 1/2	IVS	
	Where wall stop	405	RM	
	cannot be installed	L12141	ANSI	
		243F	HAG	
		FS13	IVS	
		441CU	RM	
*	Number of hinges, as specified.			

Door Hardware Set No. 2 (Exterior Locked – Double with Exit Device on Active Leaf)

No.	Item	Description	Manufacturer	Finish
*	Hinges	A5111 x NRP	ANSI	630
		BB1199	HAG	
		5BB1HW	IVS	
		FBB199	STH	
1	Exit Device	8813	SGT	630
		4500	HAG	
		6000	YAL	
1	Closing Devices	C02021	ANSI	689
	active leaf	4110 x parallel x metal	LCN	
		cover	NDC	
		P8501MA	SGT	
		P1431-P9	YAL	
		(PA)4400M		
1	Lever Extension	L04251	ANSI	630
	Flush Bolt	282D	HAG	
	Top & Bottom	FB258N	IVS	
	Inactive leaf	550	RM	
1	Astragal	835S	HAG	630
		109NSS	NGP	
		44STST	ZRO	
2	Kick Plate	J102 x B3E x 12"	ANSI	630
		193S	HAG	
		8400	IVS	
		K1050	RM	
2	Door Shoe	R5B435	ANSI	
		751S	HAG	
		113NA	NGP	
		211PK	PEM	

1 set	Weather Stripping	R5B435 875S 130NA 297PK-PG	ANSI HAG NGP PEM	628
1	Threshold	J32139 421S 8425 252X3FG	ANSI HAG NGP PEM	628
2	Stop	L02251 236W 409 1/2	ANSI HAG IVS	630
	Where wall stop cannot be installed	405 L12141 243F FS13 441CU	RM ANSI HAG IVS RM	
*	Number of hinges, as specified.			

Door Hardware Set No. 3 (Toilet Room - Locked - Single)

No.	Item	Description	Manufacturer	Finish
*	Hinges	A5111 x NRP BB1199 5BB1HW FBB199	ANSI HAG IVS STH	630
1	Lockset	1000 Series, Grade 1 x F22 8265 L9010 SL8862FL	ANSI SGT SCH YAL	630
1	Kick Plate	J102 x B3E x 12" 193S 8400 K1050	ANSI HAG IVS RM	630
1	Stop	L02251 236W 409 1/2	ANSI HAG IVS	630
	Where wall stop cannot be installed	405 L12141 243F FS13 441CU	RM ANSI HAG IVS RM	
*	Number of hinges, as specified.			

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and design and deliver glazing for the Project as shown on the Drawings and as specified herein.

B. Section includes glazing for the following products and applications, including those specified in other Sections where glazing requirements are specified by reference to this Section:

1. Doors.

1.02 RELATED WORK

A. Doors are included in Section 08 11 16.

B. Mirrors are included in Section 10 28 00.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23.

B. Product Data: For each glass product and glazing material indicated.

C. Glass Samples: For each type of glass product other than clear monolithic vision glass; 12 inches square.

D. Product Certificates: For glass and glazing products, from manufacturer.

E. Preconstruction adhesion and compatibility test report.

F. Warranties: Sample of special warranties.

1.04 REFERENCE STANDARDS

A. American Architectural Manufacturers Association

1. AAMA 800 - Voluntary Specifications and Test Methods for Sealants

2. AAMA GDSG-1 - Glass Design for Sloped Glazing

3. AAMA TIR-A7 - Sloped Glazing Guidelines

B. American National Standards Institute

1. ANSI Z97.1 - Safety Glazing Materials Used in Buildings - Safety Performance Specifications and Methods of Test

C. American Society of Civil Engineers/Structural Engineering Institute

1. ASCE/SEI 7 - Minimum Design Loads for Buildings and Other Structures

D. ASTM International

1. ASTM C 509 - Specification for Elastomeric Cellular Preformed Gasket and Sealing Material

2. ASTM C 542 - Specification for Lock-Strip Gaskets

3. ASTM C 716 - Specification for Installing Lock-Strip Gaskets and Infill Glazing Materials

4. ASTM C 864 - Specification for Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers

5. ASTM C 920 - Specification for Elastomeric Joint Sealants

6. ASTM C 1021 - Practice for Laboratories Engaged in the Testing of Building Sealants

7. ASTM C 1036 - Specification for Flat Glass

8. ASTM C 1048 - Specification for Heat-Treated Flat Glass - Kind HS, Kind FT Coated and Uncoated Glass

9. ASTM C 1087 - Test Method for Determining Compatibility of Liquid-Applied Sealants with Accessories Used in Structural Glazing Systems

10. ASTM C 1115 - Specification for Dense Elastomeric Silicone Rubber Gaskets and Accessories

11. ASTM C 1172 - Specification for Laminated Architectural Flat Glass

12. ASTM C 1281 - Specification for Preformed Tape Sealants for Glazing Applications

13. ASTM C 1330 - Specification for Cylindrical Sealant Backing for Use with Cold Liquid Applied Sealants

14. ASTM C 1376 - Specification for Pyrolytic and Vacuum Deposition Coatings on Flat Glass

15. ASTM E 1300 - Practice for Determining Load Resistance of Glass in Buildings

16. ASTM E 2190 - Specification for Insulating Glass Unit Performance and Evaluation

E. Code of Federal Regulations

1. 16 CFR 1201 - Safety Standard for Architectural Glazing Materials

2. 40 CFR 59, Subpart D - National Volatile Organic Compound Emission Standards for Architectural Coatings

F. Glass Association of North America

1. Engineering Standards Manual.

2. Glazing Manual.

3. Laminated Glazing Reference Manual

G. International Code Council

1. International Building Code.

H. National Fenestration Rating Council

1. NFRC 100 - Procedure for Determining Fenestration Product Thermal Properties (Currently Limited to U-Factors)

2. NFRC 200 - Procedure for Determining Fenestration Product Solar Heat Gain Coefficients at Normal Incidence

3. NFRC 300 - Procedures for Determining Solar Optical Properties of Simple Fenestration Products

I. Where reference is made to one of the above or other referenced standards, the revisions in effect at the time of bid opening shall apply.

1.05 DEFINITIONS

A. Glass Manufacturers: Firms that produce primary glass, fabricated glass, or both, as defined in referenced glazing publications.

B. Glass Thicknesses: Indicated by thickness designations in millimeters according to ASTM C 1036.

1.06 PERFORMANCE REQUIREMENTS

A. General: Installed glazing systems shall withstand normal thermal movement and wind and impact loads (where applicable) without failure, including loss or glass breakage attributable to the following: defective manufacture, fabrication, or installation; failure of sealants or gaskets to remain watertight and airtight; deterioration of glazing materials; or other defects in construction.

B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes acting on glass framing members and glazing components.

1. Temperature Change: 120 deg F, ambient; 180 deg F, material surfaces.

1.07 QUALITY ASSURANCE

A. Manufacturer Qualifications for Insulating-Glass Units with Sputter-Coated, Low-E Coatings: A qualified insulating-glass manufacturer who is approved and certified by coated-glass manufacturer.

B. Installer Qualifications: A qualified installer who employs glass installers for this Project who are certified under the National Glass Association's Certified Glass Installer Program.

C. Glass Testing Agency Qualifications: A qualified independent testing agency accredited according to the NFRC CAP 1 Certification Agency Program.

D. Sealant Testing Agency Qualifications: An independent testing agency qualified according to ASTM C 1021 to conduct the testing indicated.

E. Source Limitations for Glass: Obtain laminated glass from single source from single manufacturer for each glass type.

F. Source Limitations for Glazing Accessories: Obtain from single source from single manufacturer for each product and installation method.

G. Glazing Publications: Comply with published recommendations of glass product manufacturers and organizations below, unless more stringent requirements are indicated. Refer to these publications for glazing terms not otherwise defined in this Section or in referenced standards.

1. GANA Publications: GANA's "Laminated Glazing Reference Manual" and GANA's "Glazing Manual."

2. AAMA Publications: AAMA GDSG-1, "Glass Design for Sloped Glazing," and AAMA TIR-A7, "Sloped Glazing Guidelines."

3. IGMA Publication for Sloped Glazing: IGMA TB-3001, "Guidelines for Sloped Glazing."

4. IGMA Publication for Insulating Glass: SIGMA TM-3000, "North American Glazing Guidelines for Sealed Insulating Glass Units for Commercial and Residential Use."

1.08 DELIVERY, STORAGE AND HANDLING

A. Protect glazing materials according to manufacturer's written instructions. Prevent damage to glass and glazing materials from condensation, temperature changes, direct exposure to sun, or other causes.

B. Comply with insulating-glass manufacturer's written recommendations for venting and sealing units to avoid hermetic seal ruptures due to altitude change.

1.09 PROJECT CONDITIONS

A. Environmental Limitations: Do not proceed with glazing when ambient and substrate temperature conditions are outside limits permitted by glazing material manufacturers and when glazing channel substrates are wet from rain, frost, condensation, or other causes.

1. Do not install glazing sealants when ambient and substrate temperature conditions are outside limits permitted by sealant manufacturer or below 40 deg F.

1.10 WARRANTY

A. Manufacturer's Special Warranty on Laminated Glass: Manufacturer's standard form in which laminated-glass manufacturer agrees to replace laminated-glass units that deteriorate within specified warranty period. Deterioration of laminated glass is defined as defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning laminated glass contrary to manufacturer's written instructions. Defects include edge separation, delamination materially obstructing vision through glass, and blemishes exceeding those allowed by referenced laminated-glass standard.

1.11 GLASS PRODUCTS, GENERAL

A. Thickness: Where glass thickness is indicated, it is a minimum. Provide glass lites in thicknesses as needed to comply with requirements indicated.

1. Minimum Glass Thickness for Exterior Lites: Not less than 6.0 mm.

B. Strength: Where float glass is indicated, provide annealed float glass, Kind HS heat-treated float glass, or Kind FT heat-treated float glass as needed to comply with "Performance Requirements" Article. Where heat-strengthened glass is indicated, provide Kind HS heat-treated float glass or Kind FT heat-treated float glass as needed to comply with "Performance Requirements" Article. Where fully tempered glass is indicated, provide Kind FT heat-treated float glass.

C. Thermal and Optical Performance Properties: Provide glass with performance properties specified, as indicated in manufacturer's published test data, based on procedures indicated below:

1. For laminated-glass lites, properties are based on products of construction indicated.

1.12 GLASS PRODUCTS

A. Float Glass: ASTM C 1036, Type I, Quality-Q3, Class I (clear) unless otherwise indicated.

B. Heat-Treated Float Glass: ASTM C 1048; Type I; Quality-Q3; Class I (clear) unless otherwise indicated; of kind and condition indicated.

1. Fabrication Process: By horizontal (roller-hearth) process with roll-wave distortion parallel to bottom edge of glass as installed unless otherwise indicated.

2. For uncoated glass, comply with requirements for Condition A.

1.13 LAMINATED GLASS

A. Laminated Glass: ASTM C 1172, and complying with testing requirements in 16 CFR 1201 for Category II materials, and with other requirements specified. Use materials that have a proven record of no tendency to bubble, discolor, or lose physical and mechanical properties after fabrication and installation.

1. Construction: Laminate glass with polyvinyl butyral interlayer to comply with interlayer manufacturer's written recommendations.

2. Interlayer Thickness: Provide thickness not less than that indicated and as needed to comply with requirements.

3. Interlayer Color: Clear unless otherwise indicated.

B. Glass: Comply with applicable requirements in "Glass Products" Article as indicated by designations in "Laminated-Glass Types" Article.

1.14 GLAZING GASKETS

A. Dense Compression Gaskets: Molded or extruded gaskets of profile and hardness required to maintain watertight seal, made from one of the following:

1. Neoprene complying with ASTM C 864.

2. EPDM complying with ASTM C 864.

3. Silicone complying with ASTM C 1115.

4. Thermoplastic polyolefin rubber complying with ASTM C 1115.

B. Soft Compression Gaskets: Extruded or molded, closed-cell, integral-skinned neoprene, silicone or thermoplastic polyolefin rubber gaskets complying with ASTM C 509, Type II, black; of profile and hardness required to maintain watertight seal.

1. Application: Use where soft compression gaskets will be compressed by inserting dense compression gaskets on opposite side of glazing or pressure applied by means of pressure-glazing stops on opposite side of glazing.

C. Lock-Strip Gaskets: Neoprene extrusions in size and shape indicated, fabricated into frames with molded corner units and zipper lock-strips, complying with ASTM C 542, black.

1.15 GLAZING SEALANTS

A. General:

1. Compatibility: Provide glazing sealants that are compatible with one another and with other materials they will contact, including glass products, seals of insulating-glass units, and glazing channel substrates, under conditions of service and application, as demonstrated by sealant manufacturer based on testing and field experience.

2. Suitability: Comply with sealant and glass manufacturers' written instructions for selecting glazing sealants suitable for applications indicated and for conditions existing at time of installation.

3. VOC Content: For sealants used inside of the weatherproofing system, not more than 250 g/L when calculated according to 40 CFR 59, Subpart D.

4. Colors of Exposed Glazing Sealants: As selected by Engineer from manufacturer's full range.

B. Glazing Sealant: Neutral-curing silicone glazing sealant complying with ASTM C 920, Type S, Grade NS, Class 100/50, Use NT.

1. Products: Provide one of the following:
   a. Dow Corning Corporation; 790.
   b. GE Advanced Materials - Silicones; SilPruf LM SCS2700.
   c. May National Associates, Inc.; Bondaflex Sil 290.
   d. Pecora Corporation; 890.
   e. Sika Corporation, Construction Products Division; SikaSil-C990.
   f. Tremco Incorporated; Spectrem 1.
   g. Or equal.

1.16 GLAZING TAPES

A. Back-Bedding Mastic Glazing Tapes: Preformed, butyl-based, 100 percent solids elastomeric tape; non-staining and non-migrating in contact with non-porous surfaces; with or without spacer rod as recommended in writing by tape and glass manufacturers for application indicated; and complying with ASTM C 1281 and AAMA 800 for products indicated below:

1. AAMA 804.3 tape, where indicated.

2. AAMA 806.3 tape, for glazing applications in which tape is subject to continuous pressure.

3. AAMA 807.3 tape, for glazing applications in which tape is not subject to continuous pressure.

B. Expanded Cellular Glazing Tapes: Closed-cell, PVC foam tapes; factory coated with adhesive on both surfaces; and complying with AAMA 800 for the following types:

1. AAMA 810.1, Type 1, for glazing applications in which tape acts as the primary sealant.

2. AAMA 810.1, Type 2, for glazing applications in which tape is used in combination with a full bead of liquid sealant.

1.17 MISCELLANEOUS GLAZING MATERIALS

A. General: Provide products of material, size, and shape complying with referenced glazing standard, requirements of manufacturers of glass and other glazing materials for application indicated, and with a proven record of compatibility with surfaces contacted in installation.

B. Cleaners, Primers, and Sealers: Types recommended by sealant or gasket manufacturer.

C. Setting Blocks: Elastomeric material with a Shore, Type A durometer hardness of 85, plus or minus 5.

D. Spacers: Elastomeric blocks or continuous extrusions of hardness required by glass manufacturer to maintain glass lites in place for installation indicated.

E. Edge Blocks: Elastomeric material of hardness needed to limit glass lateral movement (side walking).

F. Cylindrical Glazing Sealant Backing: ASTM C 1330, Type O (open-cell material), of size and density to control glazing sealant depth and otherwise produce optimum glazing sealant performance.

1.18 FABRICATION OF GLAZING UNITS

A. Fabricate glazing units in sizes required to fit openings indicated for Project, with edge and face clearances, edge and surface conditions, and bite complying with written instructions of product manufacturer and referenced glazing publications, to comply with system performance requirements.

B. Clean-cut or flat-grind vertical edges of butt-glazed monolithic lites to produce square edges with slight chamfers at junctions of edges and faces.

C. Grind smooth and polish exposed glass edges and corners.

1.19 LAMINATED-GLASS TYPES

A. Glass Type: Clear laminated glass with two plies of heat-strengthened float glass.

1. Thickness of Each Glass Ply: 6.0 mm.

2. Interlayer Thickness: 0.090 inch.

3. Provide safety glazing labeling.

PART 2 EXECUTION

2.01 EXAMINATION

A. Examine framing, glazing channels, and stops, with Installer present, for compliance with the following:

1. Manufacturing and installation tolerances, including those for size, squareness, and offsets at corners.

2. Presence and functioning of weep systems.

3. Minimum required face and edge clearances.

4. Effective sealing between joints of glass-framing members.

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

2.02 PREPARATION

A. Clean glazing channels and other framing members receiving glass immediately before glazing. Remove coatings not firmly bonded to substrates.

B. Examine glazing units to locate exterior and interior surfaces. Label or mark units as needed so that exterior and interior surfaces are readily identifiable. Do not use materials that will leave visible marks in the completed work.

2.03 GLAZING, GENERAL

A. Comply with combined written instructions of manufacturers of glass, sealants, gaskets, and other glazing materials, unless more stringent requirements are indicated, including those in referenced glazing publications.

B. Adjust glazing channel dimensions as required by Project conditions during installation to provide necessary bite on glass, minimum edge and face clearances, and adequate sealant thicknesses, with reasonable tolerances.

C. Protect glass edges from damage during handling and installation. Remove damaged glass from Project site and legally dispose of off Project site. Damaged glass is glass with edge damage or other imperfections that, when installed, could weaken glass and impair performance and appearance.

D. Apply primers to joint surfaces where required for adhesion of sealants, as determined by preconstruction testing.

E. Install setting blocks in sill rabbets, sized and located to comply with referenced glazing publications, unless otherwise required by glass manufacturer. Set blocks in thin course of compatible sealant suitable for heel bead.

F. Do not exceed edge pressures stipulated by glass manufacturers for installing glass lites.

G. Provide spacers for glass lites where length plus width is larger than 50 inches.

1. Locate spacers directly opposite each other on both inside and outside faces of glass. Install correct size and spacing to preserve required face clearances, unless gaskets and glazing tapes are used that have demonstrated ability to maintain required face clearances and to comply with system performance requirements.

2. Provide 1/8-inch minimum bite of spacers on glass and use thickness equal to sealant width. With glazing tape, use thickness slightly less than final compressed thickness of tape.

H. Provide edge blocking where indicated or needed to prevent glass lites from moving sideways in glazing channel, as recommended in writing by glass manufacturer and according to requirements in referenced glazing publications.

I. Set glass lites in each series with uniform pattern, draw, bow, and similar characteristics.

J. Set glass lites with proper orientation so that coatings face exterior or interior as specified.

K. Where wedge-shaped gaskets are driven into one side of channel to pressurize sealant or gasket on opposite side, provide adequate anchorage so gasket cannot walk out when installation is subjected to movement.

L. Square cut wedge-shaped gaskets at corners and install gaskets in a manner recommended by gasket manufacturer to prevent corners from pulling away; seal corner joints and butt joints with sealant recommended by gasket manufacturer.

2.04 TAPE GLAZING

A. Position tapes on fixed stops so that, when compressed by glass, their exposed edges are flush with or protrude slightly above sightline of stops.

B. Install tapes continuously, but not necessarily in one continuous length. Do not stretch tapes to make them fit opening.

C. Cover vertical framing joints by applying tapes to heads and sills first and then to jambs. Cover horizontal framing joints by applying tapes to jambs and then to heads and sills.

D. Place joints in tapes at corners of opening with adjoining lengths butted together, not lapped. Seal joints in tapes with compatible sealant approved by tape manufacturer.

E. Do not remove release paper from tape until right before each glazing unit is installed.

F. Apply heel bead of elastomeric sealant.

G. Center glass lites in openings on setting blocks and press firmly against tape by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings.

H. Apply cap bead of elastomeric sealant over exposed edge of tape.

2.05 GASKET GLAZING (DRY)

A. Cut compression gaskets to lengths recommended by gasket manufacturer to fit openings exactly, with allowance for stretch during installation.

B. Insert soft compression gasket between glass and frame or fixed stop so it is securely in place with joints miter cut and bonded together at corners.

C. Installation with Drive-in Wedge Gaskets: Center glass lites in openings on setting blocks and press firmly against soft compression gasket by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended by gasket manufacturer.

D. Installation with Pressure-Glazing Stops: Center glass lites in openings on setting blocks and press firmly against soft compression gasket. Install dense compression gaskets and pressure-glazing stops, applying pressure uniformly to compression gaskets. Compress gaskets to produce a weathertight seal without developing bending stresses in glass. Seal gasket joints with sealant recommended by gasket manufacturer.

E. Install gaskets so they protrude past face of glazing stops.

2.06 SEALANT GLAZING (WET)

A. Install continuous spacers, or spacers combined with cylindrical sealant backing, between glass lites and glazing stops to maintain glass face clearances and to prevent sealant from extruding into glass channel and blocking weep systems until sealants cure. Secure spacers or spacers and backings in place and in position to control depth of installed sealant relative to edge clearance for optimum sealant performance.

B. Force sealants into glazing channels to eliminate voids and to ensure complete wetting or bond of sealant to glass and channel surfaces.

C. Tool exposed surfaces of sealants to provide a substantial wash away from glass.

2.07 LOCK-STRIP GASKET GLAZING

A. Comply with ASTM C 716 and gasket manufacturer's written instructions. Provide supplementary wet seal and weep system unless otherwise indicated.

2.08 CLEANING AND PROTECTION

A. Protect exterior glass from damage immediately after installation by attaching crossed streamers to framing held away from glass. Do not apply markers to glass surface. Remove nonpermanent labels and clean surfaces.

B. Protect glass from contact with contaminating substances resulting from construction operations. If, despite such protection, contaminating substances do come into contact with glass, remove substances immediately as recommended in writing by glass manufacturer.

C. Examine glass surfaces adjacent to or below exterior concrete and other masonry surfaces at frequent intervals during construction, but not less than once a month, for buildup of dirt, scum, alkaline deposits, or stains; remove as recommended in writing by glass manufacturer.

D. Remove and replace glass that is broken, chipped, cracked, or abraded or that is damaged from natural causes, accidents, and vandalism, during construction period.

E. Wash glass on both exposed surfaces in each area of Project not more than four days before date scheduled for inspections that establish date of Substantial Completion. Wash glass as recommended in writing by glass manufacturer.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and design and deliver non-structural metal framing for the Project as shown on the Drawings and as specified herein.

B. Section Includes:

1. Grid suspension systems for gypsum board ceilings.

1.02 RELATED WORK

A. Concrete floor slabs are included in Section 03 30 00.

B. Blocking related rough carpentry work is included in Section 06 10 00.

C. Joint sealants are included in Section 07 92 00.

D. Door frames are included in Section 08 11 16.

E. Plumbing work is included in various Division 22.

F. HVAC work is included in various Division 23.

G. Electrical, communication, and security work is included in various Division 26 - 28 Sections.

1.03 REFERENCED STANDARDS

A. ASTM International (ASTM):

1. ASTM A 641/A 641M - Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire.

2. ASTM C 645 - Standard Specification for Pressure Vessel Plates, 5 % And 5-1/2 % Nickel Alloy Steels, Specially Heat Treated.

3. ASTM A 653/A 653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) Or Zinc-Iron Alloy-Coated (Galvannealed) By The Hot-Dip Process.

4. ASTM C 754 - Standard Specification for Installation of Steel Framing Members to Receive Screw-Attached Gypsum Panel Products.

5. ASTM C 841 - Standard Specification for Installation of Interior Lathing and Furring.

6. ASTM C 844 - Standard Specification for Application of Gypsum Base to Receive Gypsum Veneer Plaster.

7. ASTM C 1063 - Standard Specification for Installation of Lathing and Furring to Receive Interior and Exterior Portland Cement-Based Plaster.

8. ASTM D 226/D 226M - Standard Specification for Asphalt-Saturated Organic Felt Used In Roofing and Waterproofing.

9. ASTM E 90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.

10. ASTM E 119 - Standard Test Methods for Fire Tests of Building Construction and Materials.

11. ASTM E 413 - Classification for Rating Sound Insulation.

12. ASTM E 1190 - Standard Test Methods for Strength of Power-Actuated Fasteners Installed In Structural Members.

B. ICC Evaluation Service (ICC-ES):

1. ICC-ES AC70.

C. Steel Framing Industry Association (SFIA):

1. "Code Compliance Certification Program for Cold-Formed Steel Structural and Non-Structural Framing Members."

D. Where reference is made to one of the above or other referenced standards, the revisions in effect at the time of bid opening shall apply.

1.04 SUBMITTALS

A. Submit in accordance with Section 01 33 23.

B. Product Data: For each type of product.

1. Studs and Runners: Provide documentation that framing members' certification is according to SFIA's "Code Compliance Certification Program for Cold-Formed Steel Structural and Non-Structural Framing Members."

C. Evaluation Reports: For embossed steel studs and runners, from ICC-ES or other qualified testing agency acceptable to authorities having jurisdiction.

PART 2 PRODUCTS

2.01 FRAMING SYSTEMS

A. Framing Members, General: Comply with ASTM C 754 for conditions indicated.

1. Steel Sheet Components: Comply with ASTM C 645 requirements for metal unless otherwise indicated.

2. Protective Coating: ASTM A 653/A 653M, G40, hot-dip galvanized unless otherwise indicated.

2.02 SUSPENSION SYSTEMS

A. Carrying Channels: Cold-rolled, commercial-steel sheet with a base-metal thickness of 0.0538 inch and minimum 1/2-inch- wide flanges.

1. Depth: 2-1/2 inches.

B. Furring Channels (Furring Members):

1. Hat-Shaped, Rigid Furring Channels: ASTM C 645, 7/8 inch deep.
   a. Minimum Base-Metal Thickness: 0.0329 inch.

C. Grid Suspension System for Gypsum Board Ceilings: ASTM C 645, direct-hung system composed of main beams and cross-furring members that interlock.

1. Manufacturers: Provide products by one of the following:
   a. Armstrong World Industries, Inc.
   b. Chicago Metallic Corporation.
   c. United States Gypsum Company.
   d. Or equal.

2.03 AUXILIARY MATERIALS

A. General: Provide auxiliary materials that comply with referenced installation standards.

1. Fasteners for Metal Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.

B. Isolation Strip at Exterior Walls: Provide the following:

1. Foam Gasket: Adhesive-backed, closed-cell vinyl foam strips that allow fastener penetration without foam displacement, 1/8 inch thick, in width to suit steel stud size.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and substrates, with Installer present, and including welded hollow-metal frames, cast-in anchors, and structural framing, for compliance with requirements and other conditions affecting performance of the Work.

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

3.02 PREPARATION

A. Suspended Assemblies: Coordinate installation of suspension systems with installation of overhead structure to ensure that inserts and other provisions for anchorages to building structure have been installed to receive hangers at spacing required to support the Work and that hangers will develop their full strength.

1. Furnish concrete inserts and other devices indicated to other trades for installation in advance of time needed for coordination and construction.

3.03 INSTALLATION, GENERAL

A. Installation Standard: ASTM C 754.

1. Gypsum Board Assemblies: Also comply with requirements in ASTM C 840 that apply to framing installation.

B. Install framing and accessories plumb, square, and true to line, with connections securely fastened.

C. Install bracing at terminations in assemblies.

D. Do not bridge building control and expansion joints with non-load-bearing steel framing members. Frame both sides of joints independently.

3.04 INSTALLING SUSPENSION SYSTEMS

A. Install suspension system components according to spacings indicated, but not greater than spacings required by referenced installation standards for assembly types.

1. Carrying Channels (Main Runners): 48 inches o.c.

2. Furring Channels (Furring Members): 16 inches o.c.

B. Isolate suspension systems from building structure where they abut or are penetrated by building structure to prevent transfer of loading imposed by structural movement.

C. Seismic Bracing: Sway-brace suspension systems with hangers used for support.

D. Grid Suspension Systems: Attach perimeter wall track or angle where grid suspension systems meet vertical surfaces. Mechanically join main beam and cross-furring members to each other and butt-cut to fit into wall track.

E. Installation Tolerances: Install suspension systems that are level to within 1/8 inch in 12 feet measured lengthwise on each member that will receive finishes and transversely between parallel members that will receive finishes.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and design and deliver gypsum board for the Project as shown on the Drawings and as specified herein.

B. Section Includes:

1. Interior gypsum board.

1.02 RELATED WORK

A. Non-Structural Metal Framing for non-structural steel framing systems that support gypsum board panels is included in Section 09 22 16.

1.03 REFERENCED STANDARDS

A. American National Standards Institute (ANSI)

1. ANSI A118.9 - Standard Specifications for Test Methods and Specifications for Cementitious Backer Units.

2. ANSI A108.11 - Interior Installation of Cementitious Backer Units.

B. ASTM International

1. ASTM B 221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes

2. ASTM B 221M - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes (Metric)

3. ASTM C 423 - Standard Specification for Nickel-Iron-Chromium-Molybdenum-Copper Alloy (UNS N08825, N08221, and N06845) Seamless Pipe and Tube

4. ASTM C 475/C 475M - Standard Specification for Joint Compound and Joint Tape for Finishing Gypsum Board

5. ASTM C 665 - Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing

6. ASTM C 834 - Standard Specification for Latex Sealants

7. ASTM C 840 - Standard Specification for Application and Finishing of Gypsum Board

8. ASTM C 954 - Standard Specification for Steel Drill Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Steel Studs from 0.033 in. (0.84 mm) to 0.112 in. (2.84 mm) in Thickness

9. ASTM C 1002 - Standard Specification for Steel Self-Piercing Tapping Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs

10. ASTM C 1047 - Standard Specification for Steel Self-Piercing Tapping Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs

11. ASTM C 1177/C 1177M - Standard Specification for Glass Mat Gypsum Substrate for Use as Sheathing

12. ASTM C 1178/C 1178M - Standard Specification for Coated Glass Mat Water-Resistant Gypsum Backing Panel

13. ASTM C 1288 - Standard Specification for Discrete Non-Asbestos Fiber-Cement Interior Substrate Sheets

14. ASTM C 1325 - Standard Specification for Non-Asbestos Fiber-Mat Reinforced Cementitious Backer Units

15. ASTM C 1396/C 1396M - Standard Specification for Gypsum Board

16. ASTM C 1658/C 1658M - Standard Specification for Glass Mat Gypsum Panels

17. ASTM D 3273 - Standard Test Method for Resistance to Growth of Mold on the Surface of Interior Coatings in an Environmental Chamber

18. ASTM D 3274 - Standard Test Method for Evaluating Degree of Surface Disfigurement of Paint Films by Fungal or Algal Growth, or Soil and Dirt Accumulation

19. ASTM E 84 - Standard Test Method for Surface Burning Characteristics of Building Materials

20. ASTM E 90 - Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements

21. ASTM E 119 - Standard Test Methods for Fire Tests of Building Construction and Materials

C. California Department of Public Health

1. Standard Method for the Testing and Evaluation of Volatile Organic Chemical Emissions from Indoor Sources Using Environmental Chambers.

D. Where reference is made to one of the above or other referenced standards, the revisions in effect at the time of bid opening shall apply.

1.04 SUBMITTALS

A. Submit in accordance with Section 01 33 23.

B. Product Data: For each type of product.

1.05 DELIVERY, STORAGE AND HANDLING

A. Store materials inside under cover and keep them dry and protected against weather, condensation, direct sunlight, construction traffic, and other potential causes of damage. Stack panels flat and supported on risers on a flat platform to prevent sagging.

1.06 FIELD CONDITIONS

A. Environmental Limitations: Comply with ASTM C 840 requirements or gypsum board manufacturer's written instructions, whichever are more stringent.

B. Do not install paper-faced gypsum panels until installation areas are enclosed and conditioned.

C. Do not install panels that are wet, moisture damaged, and mold damaged.

1. Indications that panels are wet or moisture damaged include, but are not limited to, discoloration, sagging, or irregular shape.

2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

PART 2 PRODUCTS

2.01 GYPSUM BOARD, GENERAL

A. Size: Provide maximum lengths and widths available that will minimize joints in each area and that correspond with support system indicated.

2.02 INTERIOR GYPSUM BOARD

A. Mold-Resistant Gypsum Board: ASTM C 1396/C 1396M. With moisture- and mold-resistant core and paper surfaces.

1. Manufacturers: Provide products by one of the following:
   a. American Gypsum.
   b. CertainTeed Corporation.
   c. Continental Building Products, LLC.
   d. Georgia-Pacific Building Products.
   e. National Gypsum Company.
   f. PABCO Gypsum.
   g. Temple-Inland Building Products by Georgia-Pacific.
   h. USG.

i. Or equal.

2. Core: 5/8 inch (15.9 mm), Type X.

3. Long Edges: Tapered.

4. Mold Resistance: ASTM D 3273, score of 10 as rated according to ASTM D 3274.

2.03 JOINT TREATMENT MATERIALS

A. General: Comply with ASTM C 475/C 475M.

B. Joint Tape:

1. Interior Gypsum Board: Paper.

C. Joint Compound for Interior Gypsum Board: For each coat, use formulation that is compatible with other compounds applied on previous or for successive coats.

1. Prefilling: At open joints, rounded or beveled panel edges, and damaged surface areas, use setting-type taping compound.

2. Embedding and First Coat: For embedding tape and first coat on joints, fasteners, and trim flanges, use drying-type, all-purpose compound.
   a. Use setting-type compound for installing paper-faced metal trim accessories.

3. Fill Coat: For second coat, use drying-type, all-purpose compound.

4. Finish Coat: For third coat, use drying-type, all-purpose compound.

2.04 AUXILIARY MATERIALS

A. General: Provide auxiliary materials that comply with referenced installation standards and manufacturer's written instructions.

B. Steel Drill Screws: ASTM C 1002 unless otherwise indicated.

1. Use screws complying with ASTM C 954 for fastening panels to steel members from 0.033 to 0.112 inch (0.84 to 2.84 mm) thick.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and substrates including welded hollow-metal frames and support framing, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

B. Examine panels before installation. Reject panels that are wet, moisture damaged, and mold damaged.

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

3.02 APPLYING AND FINISHING PANELS, GENERAL

A. Comply with ASTM C 840.

B. Install ceiling panels across framing to minimize the number of abutting end joints and to avoid abutting end joints in central area of each ceiling. Stagger abutting end joints of adjacent panels not less than one framing member.

C. Install panels with face side out. Butt panels together for a light contact at edges and ends with not more than 1/16 inch (1.5 mm) of open space between panels. Do not force into place.

D. Locate edge and end joints over supports, except in ceiling applications where intermediate supports or gypsum board back-blocking is provided behind end joints. Do not place tapered edges against cut edges or ends. Stagger vertical joints on opposite sides of partitions. Do not make joints other than control joints at corners of framed openings.

E. Cover both faces of support framing with gypsum panels in concealed spaces (above ceilings, etc.), except in chases braced internally.

1. Unless concealed application is indicated or required for sound, fire, air, or smoke ratings, coverage may be accomplished with scraps of not less than 8 sq. ft. (0.7 sq. m) in area.

2. Fit gypsum panels around ducts, pipes, and conduits.

3. Where partitions intersect structural members projecting below underside of floor/roof slabs and decks, cut gypsum panels to fit profile formed by structural members; allow 1/4- to 3/8-inch (6.4- to 9.5-mm-) wide joints to install sealant.

F. Isolate perimeter of gypsum board applied to non-load-bearing partitions at structural abutments. Provide 1/4- to 1/2-inch (6.4- to 12.7-mm-) wide spaces at these locations and trim edges with edge trim where edges of panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.

G. Attachment to Steel Framing: Attach panels so leading edge or end of each panel is attached to open (unsupported) edges of stud flanges first.

3.03 APPLYING INTERIOR GYPSUM BOARD

A. Install interior gypsum board in the following locations:

1. Mold-Resistant Type: As indicated on Drawings.

B. Single-Layer Application:

1. On ceilings, apply gypsum panels before wall/partition board application to greatest extent possible and at right angles to framing unless otherwise indicated.

2. Fastening Methods: Apply gypsum panels to supports with steel drill screws.

3.04 FINISHING GYPSUM BOARD

A. General: Treat gypsum board joints, interior angles, edge trim, control joints, penetrations, fastener heads, surface defects, and elsewhere as required to prepare gypsum board surfaces for decoration. Promptly remove residual joint compound from adjacent surfaces.

B. Prefill open joints and damaged surface areas.

C. Apply joint tape over gypsum board joints, except for trim products specifically indicated as not intended to receive tape.

D. Gypsum Board Finish Levels: Finish panels to levels indicated below and according to ASTM C 840:

1. Level 4: At panel surfaces that will be exposed to view unless otherwise indicated.
   a. Primer and its application to surfaces are specified in Section 09 91 23.

3.05 PROTECTION

A. Protect adjacent surfaces from drywall compound and promptly remove from floors and other non-drywall surfaces. Repair surfaces stained, marred, or otherwise damaged during drywall application.

B. Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.

C. Remove and replace panels that are wet, moisture damaged, and mold damaged.

1. Indications that panels are wet or moisture-damaged include, but are not limited to, discoloration, sagging, or irregular shape.

2. Indications that panels are mold damaged include, but are not limited to, fuzzy or splotchy surface contamination and discoloration.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and design and deliver ceramic tiling for the Project as shown on the Drawings and as specified herein.

B. The work includes:

1. Ceramic tile.

2. Crack isolation membrane.

1.02 RELATED WORK

A. Joint Sealants for sealing of expansion, contraction, control, and isolation joints in tile surfaces are included in Section 09 72 00.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23.

B. Product Data: For each type of product indicated.

C. Shop Drawings: Show locations of each type of tile and tile pattern. Show widths, details, and locations of expansion, contraction, control, and isolation joints in tile substrates and finished tile surfaces.

D. Samples:

1. Full-size units of each type and composition of tile and for each color and finish required.

2. Assembled samples mounted on a rigid panel, with grouted joints, for each type and composition of tile and for each color and finish required. Make samples at least 12 inches square, but not fewer than 4 tiles. Use grout of type and in color or colors approved for completed Work.

3. Full-size units of each type of trim and accessory.

E. Qualification Data: For qualified Installer.

F. Master Grade Certificates: For each shipment, type, and composition of tile, signed by tile manufacturer and Installer.

G. Product Certificates: For each type of product, signed by product manufacturer.

H. Material Test Reports: For each tile-setting and -grouting product and special purpose tile.

1.04 REFERENCE STANDARDS

A. American National Standards Institute

1. ANSI A108 Series (A108.01, .02, .1A, .1B, .1C, .4, .5, .6, .8, .9, .10, .11, .12, .13, .14, .15, .16, and .17): Specifications for Installation of Ceramic Tile

2. ANSI A118.1 - Specifications for Dry-Set Portland Cement Mortar

3. ANSI A118.4 - Specifications for Latex-Portland Cement Mortar

4. ANSI A118.6 - Specifications for Standard Cement Grouts for Tile Installation

5. ANSI A118.7 - Specifications for Polymer Modified Cement Grouts for Tile Installation

6. ANSI A118.9 - Test Methods and Specifications for Cementitious Backer Units

7. ANSI A118.10 - Specifications for Load Bearing, Bonded, Waterproof Membranes for Thin-Set Ceramic Tile and Dimension Stone Installations

8. ANSI A118.12 - Specifications for Crack Isolation Membranes for Thin-Set Ceramic Tile and Dimension Stone Installations

9. ANSI A137.1 - Specifications for Ceramic Tile

B. ASTM International

1. ASTM A 666 - Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar

2. ASTM C 241 - Test Method for Abrasion Resistance of Stone Subjected to Foot Traffic

3. ASTM C 503 - Specification for Marble Dimension Stone

4. ASTM C 615 - Specification for Granite Dimension Stone

5. ASTM C 629 - Specification for Slate Dimension Stone

6. ASTM C 1028 - Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method

7. ASTM C 1288 - Specification for Discrete Non-Asbestos Fiber-Cement Interior Substrate Sheets

8. ASTM C 1325 -Specification for Non-Asbestos Fiber-Mat Reinforced Cement Substrate Sheets

9. ASTM C 1353 - Test Method Using the Taber Abraser for Abrasion Resistance of Dimension Stone Subjected to Foot Traffic

10. ASTM D 87 - Test Method for Melting Point of Petroleum Wax (Cooling Curve)

C. Code of Federal Regulations

1. 40 CFR, Part 59, Subpart D - National Volatile Organic Compound Emission Standards for Architectural Coatings

D. Tile Council of North America, Inc. (TCA)

1. Handbook for Ceramic Tile Installation.

E. Where reference is made to one of the above or other referenced standards, the revisions in effect at the time of bid opening shall apply.

1.05 DEFINITIONS

A. General: Definitions in the ANSI A108 series of tile installation standards and in ANSI A137.1 apply to Work of this Section unless otherwise specified.

B. ANSI A108 Series: ANSI A108.01, ANSI A108.02, ANSI A108.1A, ANSI A108.1B, ANSI A108.1C, ANSI A108.4, ANSI A108.5, ANSI A108.6, ANSI A108.8, ANSI A108.9, ANSI A108.10, ANSI A108.11, ANSI A108.12, ANSI A108.13, ANSI A108.14, ANSI A108.15, ANSI A108.16, and ANSI A108.17, which are contained in "American National Standard Specifications for Installation of Ceramic Tile."

C. Module Size: Actual tile size plus joint width indicated.

D. Face Size: Actual tile size, excluding spacer lugs.

1.06 PERFORMANCE REQUIREMENTS

A. Static Coefficient of Friction: For tile installed on walkway surfaces, provide products with the following values as determined by testing identical products per ASTM C 1028:

1. Level Surfaces: Minimum <Insert required static coefficient of friction>.

2. Step Treads: Minimum <Insert required static coefficient of friction>.

3. Ramp Surfaces: Minimum <Insert required static coefficient of friction>.

1.07 QUALITY ASSURANCE

A. Source Limitations for Tile: Obtain tile of each type and color or finishfrom one source or producer.

1. Obtain tile of each type and color or finish from same production run and of consistent quality in appearance and physical properties for each contiguous area.

B. Source Limitations for Setting and Grouting Materials: Obtain ingredients of a uniform quality for each mortar, adhesive, and grout component from one manufacturer and each aggregate from one source or producer.

C. Source Limitations for Other Products: Obtain each of the following products specified in this Section from a single manufacturer for each product:

1. Crack isolation membrane.

2. Joint sealants.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store packaged materials in original containers with seals unbroken and labels intact until time of use. Comply with requirements in ANSI A137.1 for labeling tile packages.

B. Store tile and cementitious materials on elevated platforms, under cover, and in a dry location.

C. Store aggregates where grading and other required characteristics can be maintained, and contamination can be avoided.

D. Store liquid materials in unopened containers and protected from freezing.

E. Handle tile that has temporary protective coating on exposed surfaces to prevent coated surfaces from contacting backs or edges of other units. If coating does contact bonding surfaces of tile, remove coating from bonding surfaces before setting tile.

1.09 PROJECT CONDITIONS

A. Environmental Limitations: Do not install tile until construction in spaces is complete and ambient temperature and humidity conditions are maintained at the levels indicated in referenced standards and manufacturer's written instructions.

1.10 EXTRA MATERIALS

A. Furnish extra materials that match and are from same production runs as products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Tile and Trim Units: Furnish quantity of full-size units equal to 3 percent of amount installed for each type, composition, color, pattern, and size indicated.

2. Grout: Furnish quantity of grout equal to 3 percent of amount installed for each type, composition, and color indicated.

PART 2 PRODUCTS

2.01 PRODUCTS, GENERAL

A. ANSI Ceramic Tile Standard: Provide tile that complies with ANSI A137.1 for types, compositions, and other characteristics indicated.

1. Provide tile complying with Standard grade requirements unless otherwise indicated.

B. ANSI Standards for Tile Installation Materials: Provide materials complying with ANSI A108.02, ANSI standards referenced in other Part 2 articles, ANSI standards referenced by TCA installation methods specified in tile installation schedules, and other requirements specified.

C. Factory Blending: For tile exhibiting color variations within ranges, blend tile in factory and package so tile units taken from one package show same range in colors as those taken from other packages and match approved Samples.

D. Mounting: For factory-mounted tile, provide back- or edge-mounted tile assemblies as standard with manufacturer unless otherwise indicated.

1. Where tile is indicated for installation in wet areas, do not use back- or edge-mounted tile assemblies unless tile manufacturer specifies in writing that this type of mounting is suitable for installation indicated and has a record of successful in-service performance.

E. Factory-Applied Temporary Protective Coating: Where indicated under tile type, protect exposed surfaces of tile against adherence of mortar and grout by pre-coating with continuous film of petroleum paraffin wax, applied hot. Do not coat unexposed tile surfaces.

2.02 TILE PRODUCTS

A. Factory-mounted unglazed ceramic mosaic tile.

1. Manufacturers: Provide products by one of the following:
   a. American Olean; Division of Dal-Tile International Inc.
   b. Daltile; Division of Dal-Tile International Inc.
   c. Or equal.

2. Composition: Porcelain.

3. Module Size: 2 by 2 inches.

4. Thickness: 1/4 inch.

5. Face: Plain with cushion edges.

6. Surface: Slip-resistant, with abrasive admixture.

7. Finish: Mat, clear glaze.

8. Tile Color and Pattern: As selected by Engineer from manufacturer's full range.

9. Grout Color: As selected by Engineer from manufacturer's full range.

10. Trim Units: Coordinated with sizes and coursing of adjoining flat tile where applicable and matching characteristics of adjoining flat tile. Provide shapes as follows, selected from manufacturer's standard shapes:
    a. Built Up Base: Cove, module size 2 by 2 inch
    b. External Corners for Thin-Set Mortar Installations: Surface bullnose, module size 2 by 2 inches.
    c. Internal Corners: Field-butted square corners. For coved base and cap, use angle pieces designed to fit with stretcher shapes.

B. Glazed wall tile.

1. Manufacturers: Provide products by one of the following:
    a. American Olean; Division of Dal-Tile International Inc.
    b. Daltile; Division of Dal-Tile International Inc.
    c. Or equal.

2. Module Size: 6 by 6 inches.

3. Thickness: 5/16 inch.

4. Face: Plain with modified square edges or cushion edges.

5. Finish: Bright, clear glaze.

6. Tile Color and Pattern: As selected by Engineer from manufacturer's full range.

7. Grout Color: As selected by Engineer from manufacturer's full range.

8. Mounting: Factory, back mounted.

9. Trim Units: Coordinated with sizes and coursing of adjoining flat tile where applicable and matching characteristics of adjoining flat tile. Provide shapes as follows, selected from manufacturer's standard shapes:
    a. External Corners for Thin-Set Mortar Installations: Surface bullnose, same size as adjoining flat tile.
    b. Internal Corners: Field-butted square corners. For coved base and cap use angle pieces designed to fit with stretcher shapes.

2.03 CRACK ISOLATION MEMBRANE

A. General: Manufacturer's standard product, selected from the following, that complies with ANSI A118.12 for high performance and is recommended by the manufacturer for the application indicated. Include reinforcement and accessories recommended by manufacturer.

B. Provide one of the following:

1. Polyethylene Sheet: Polyethylene faced on both sides with fleece webbing; 0.008-inch nominal thickness.
   a. Products: Provide Schluter Systems L.P.; KERDI.

2. Corrugated Polyethylene: Corrugated polyethylene with dovetail-shaped corrugations and with anchoring webbing on the underside; 3/16-inch nominal thickness.
   a. Products: Provide Schluter Systems L.P.; DITRA.

3. Fabric-Reinforced, Modified-Bituminous Sheet: Self-adhering, modified-bituminous sheet with fabric reinforcement facing; 0.040-inch nominal thickness.
   a. Products: Provide one of the following:
      1) MAPEI Corporation; Mapelastic SM.
      2) National Applied Construction Products, Inc.; Strataflex.
      3) Or equal.

2.04 SETTING MATERIALS

A. Dry-Set Portland Cement Mortar (Thin Set): ANSI A118.1.

1. Manufacturers: Provide products by one of the following:
   a. Boiardi Products; a QEP company.
   b. Bonsal American; an Oldcastle company.
   c. Bostik, Inc.
   d. C-Cure.
   e. Custom Building Products.
   f. Jamo Inc.
   g. Laticrete International, Inc.
   h. MAPEI Corporation.
   i. Southern Grouts & Mortars, Inc.
   j. Summitville Tiles, Inc.
   k. TEC; a subsidiary of H. B. Fuller Company.
   l. Or equal.

2. For wall applications, provide mortar that complies with requirements for non-sagging mortar in addition to the other requirements in ANSI A118.1.

B. Latex-Portland Cement Mortar (Thin Set): ANSI A118.4.

1. Manufacturers: Provide products by one of the following:
   a. Boiardi Products; a QEP company.
   b. Bonsal American; an Oldcastle company.

c. Bostik, Inc.
d. C-Cure.
e. Custom Building Products.
f. Jamo Inc.
g. Laticrete International, Inc.
h. MAPEI Corporation.
i. Mer-Kote Products, Inc.
j. Southern Grouts & Mortars, Inc.
k. Summitville Tiles, Inc.
l. TEC; a subsidiary of H. B. Fuller Company.
m. Or equal.

2. Provide prepackaged, dry-mortar mix containing dry, redispersible, vinyl acetate or acrylic additive to which only water must be added at Project site.

3. Provide prepackaged, dry-mortar mix combined with liquid-latex additive at Project site.

4. For wall applications, provide mortar that complies with requirements for non-sagging mortar in addition to the other requirements in ANSI A118.4.

2.05 GROUT MATERIALS

A. Sand-Portland Cement Grout: ANSI A108.10, composed of white or gray cement and white or colored aggregate as required to produce color indicated.

B. Standard Cement Grout: ANSI A118.6.

1. Manufacturers: Provide products by one of the following:
a. Boiardi Products; a QEP company.
b. Bonsal American; an Oldcastle company.
c. Bostik, Inc.
d. C-Cure.
e. Custom Building Products.
f. Jamo Inc.
g. Laticrete International, Inc.
h. MAPEI Corporation.
i. Southern Grouts & Mortars, Inc.
j. Summitville Tiles, Inc.
k. TEC; a subsidiary of H. B. Fuller Company.
l. Or equal.

C. Polymer-Modified Tile Grout: ANSI A118.7.

1. Manufacturers: Provide products by one of the following:
a. Boiardi Products; a QEP company.
b. Bonsal American; an Oldcastle company.
c. Bostik, Inc.
d. C-Cure.
e. Custom Building Products.
f. Jamo Inc.

g. Laticrete International, Inc.
h. MAPEI Corporation.
i. Southern Grouts & Mortars, Inc.
j. Summitville Tiles, Inc.
k. TEC; a subsidiary of H. B. Fuller Company.
l. Or equal.

2. Polymer Type: Ethylene vinyl acetate or acrylic additive, in dry, redispersible form, prepackaged with other dry ingredients.

3. Polymer Type: Acrylic resin in liquid-latex form for addition to prepackaged dry-grout mix.

D. Grout for Pre-Grouted Tile Sheets: Same product used in factory to pre-grout tile sheets.

2.06 MISCELLANEOUS MATERIALS

A. Tile Cleaner: A neutral cleaner capable of removing soil and residue without harming tile and grout surfaces, specifically approved for materials and installations indicated by tile and grout manufacturers.

B. Grout Sealer: Manufacturer's standard silicone product for sealing grout joints and that does not change color or appearance of grout.

1. Products: Provide one of the following:
a. Bonsal American; an Oldcastle company; Grout Sealer.
b. Bostik, Inc.; CeramaSeal Siloxane 220.
c. C-Cure; Penetrating Sealer 978.
d. Custom Building Products; Surfaceguard Sealer.
e. MAPEI Corporation; KER 004, Keraseal Penetrating Sealer for Unglazed Grout and Tile.
f. Or equal.

2.07 MIXING MORTARS AND GROUT

A. Mix mortars and grouts to comply with referenced standards and mortar and grout manufacturers' written instructions.

B. Add materials, water, and additives in accurate proportions.

C. Obtain and use type of mixing equipment, mixer speeds, mixing containers, mixing time, and other procedures to produce mortars and grouts of uniform quality with optimum performance characteristics for installations indicated.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions where tile will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of installed tile.

1. Verify that substrates for setting tile are firm, dry, clean, free of coatings that are incompatible with tile-setting materials including curing compounds and other substances that contain soap, wax, oil, or silicone; and comply with flatness tolerances required by ANSI A108.01 for installations indicated.

2. Verify that concrete substrates for tile floors installed with thin-set mortar comply with surface finish requirements in ANSI A108.01 for installations indicated.
   a. Verify that surfaces that received a steel trowel finish have been mechanically scarified.
   b. Verify that protrusions, bumps, and ridges have been removed by sanding or grinding.

3. Verify that installation of grounds, anchors, recessed frames, electrical and mechanical units of work, and similar items located in or behind tile has been completed.

4. Verify that joints and cracks in tile substrates are coordinated with tile joint locations; if not coordinated, adjust joint locations in consultation with Engineer.

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

3.02 PREPARATION

A. Fill cracks, holes, and depressions in concrete substrates for tile floors installed with thin-set mortar with trowelable leveling and patching compound specifically recommended by tile-setting material manufacturer.

B. Where indicated, prepare substrates to receive waterproofing by applying a reinforced mortar bed that complies with ANSI A108.1A and is sloped 1/4 inch per foot toward drains.

C. Blending: For tile exhibiting color variations, verify that tile has been factory blended and packaged so tile units taken from one package show same range of colors as those taken from other packages and match approved Samples. If not factory blended, either return to manufacturer or blend tiles at Project site before installing.

D. Field-Applied Temporary Protective Coating: If indicated under tile type or needed to prevent grout from staining or adhering to exposed tile surfaces, pre-coat them with continuous film of temporary protective coating, taking care not to coat unexposed tile surfaces.

3.03 TILE INSTALLATION

A. Comply with TCA's "Handbook for Ceramic Tile Installation" for TCA installation methods specified in tile installation schedules. Comply with parts of the ANSI A108 Series "Specifications for Installation of Ceramic Tile" that are referenced in TCA installation methods, specified in tile installation schedules, and apply to types of setting and grouting materials used.

1. For the following installations, follow procedures in the ANSI A108 Series of tile installation standards for providing 95 percent mortar coverage:
   a. Tile floors in wet areas.
   b. Tile floors composed of rib-backed tiles.

B. Extend tile work into recesses and under or behind equipment and fixtures to form complete covering without interruptions unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.

C. Accurately form intersections and returns. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.

D. Jointing Pattern: Lay tile in grid pattern unless otherwise indicated. Lay out tile work and center tile fields in both directions in each space or on each wall area. Lay out tile work to minimize the use of pieces that are less than half of a tile. Provide uniform joint widths unless otherwise indicated.

1. For tile mounted in sheets, make joints between tile sheets same width as joints within tile sheets so joints between sheets are not apparent in finished work.

2. Where adjoining tiles on floor, base, walls, or trim are specified or indicated to be same size, align joints.

3. Where tiles are specified or indicated to be whole integer multiples of adjoining tiles on floor, base, walls, or trim, align joints unless otherwise indicated.

E. Joint Widths: Install tile with 1/16 inch joint widths.

F. Lay out tile wainscots to dimensions indicated or to next full tile beyond dimensions indicated.

G. Expansion Joints: Provide expansion joints and other sealant-filled joints, including control, contraction, and isolation joints, where indicated. Form joints during installation of setting materials, mortar beds, and tile. Do not saw-cut joints after installing tiles.

1. Where joints occur in concrete substrates, locate joints in tile surfaces directly above them.

2. Prepare joints and apply sealants to comply with requirements in Section 07 92 00.

H. Grout Sealer: Apply grout sealer to grout joints in tile floors according to grout-sealer manufacturer's written instructions. As soon as grout sealer has penetrated grout joints, remove excess sealer and sealer from tile faces by wiping with soft cloth.

3.04 CRACK ISOLATION MEMBRANE INSTALLATION

A. Install crack isolation membrane to comply with ANSI A108.17 and manufacturer's written instructions to produce membrane of uniform thickness and bonded securely to substrate.

B. Do not install tile or setting materials over crack isolation membrane until membrane has cured.

3.05 CLEANING AND PROTECTING

A. Cleaning: On completion of placement and grouting, clean all ceramic tile surfaces so they are free of foreign matter.

1. Remove latex-portland cement grout residue from tile as soon as possible.

2. Clean grout smears and haze from tile according to tile and grout manufacturer's written instructions but no sooner than 10 days after installation. Use only cleaners recommended by tile and grout manufacturers and only after determining that cleaners are safe to use by testing on samples of tile and other surfaces to be cleaned. Protect metal surfaces and plumbing fixtures from effects of cleaning. Flush surfaces with clean water before and after cleaning.

3. Remove temporary protective coating by method recommended by coating manufacturer and that is acceptable to tile and grout manufacturer. Trap and remove coating to prevent drain clogging.

B. Protect installed tile work with kraft paper or other heavy covering during construction period to prevent staining, damage, and wear. If recommended by tile manufacturer, apply coat of neutral protective cleaner to completed tile walls and floors.

C. Prohibit foot and wheel traffic from tiled floors for at least seven days after grouting is completed.

D. Before final inspection, remove protective coverings and rinse neutral protective cleaner from tile surfaces.

3.06 INTERIOR TILE INSTALLATION SCHEDULE

A. Interior Floor Installations, Concrete Subfloor:

1. Tile Installation F125A: Thin-set mortar on crack isolation membrane; TCA F125A.
   a. Tile Type: Unglazed mosaic ceramic tile.
   b. Thin-Set Mortar: Latex-portland cement mortar.
   c. Grout: Standard unsanded cement grout.

B. Interior Wall Installations, Masonry or Concrete:

1. Tile Installation W202: Thin-set mortar; TCA W202.
   a. Tile Type: Glazed wall tile.
   b. Thin-Set Mortar: Dry-set portland cement mortar.
   c. Grout: Standard unsanded cement grout.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install all painting complete as shown on the Drawings and as specified herein.

B. It is the intent of this Section to paint all exposed structural and miscellaneous steel; mechanical and electrical equipment; pipe, fittings and valves; electrical conduit and appurtenances; new CMU walls; all as specified in the attached painting schedules and all other work obviously required to be painted unless otherwise specified. Minor items not mentioned in the schedule of work shall be included in the work of this Section where they come within the general intent of this Section as stated herein.

C. The following items will not be painted:

1. Concrete except where specified above and scheduled to be painted and seamless flooring.

2. Finish hardware.

3. Non-ferrous metals and stainless steel, unless specifically noted otherwise.

4. Factory pre-finished architectural components.

5. Packing glands and other adjustable parts and name plates of mechanical equipment.

6. Parts of buildings not exposed to sight, unless specifically noted otherwise.

7. Maintenance equipment

8. Plumbing fixtures.

9. Mechanical, HVAC, Plumbing and Electrical equipment which has been finished painted in the factory as specified in Divisions 11, 13, 14, 22, 23, 26, 41, 42, 43, 44, 46 and 48.

1.02 RELATED WORK

A. Valve identification is included in Divisions 11, 22, 23, 41, 42, 43, 44, 46 and 48.

B. Shop priming and surface preparation of equipment and piping (except copper piping) are specified in Section 09 91 10 and included in the respective Section with the item to be primed.

C. Shop priming of metal substrates with primers is included in Division 05.

1.03 SUBMITTALS

A. Submit the following in accordance with Section 01 33 23.

B. Product Data: For each type of product indicated.

C. Samples: Submit the following for each type of coating system and in each color and gloss of finish coat indicated.

1. Color cards for initial color selections.

2. Three sets of 8-in by 8-in samples, on 1/4-in hardboard, of all colors required for all types of paint. Resubmit until approved.

D. Product List: For each product indicated. Cross-reference products to coating system and locations of application areas. Use same designations indicated on Drawings and in schedules.

1.04 REFERENCE STANDARDS

A. Steel Structures Painting Council (SSPC)

1. SSPC SP-1 - Surface Preparation Specification No. 1 Solvent Cleaning.

2. SSPC SP-2 - Surface Preparation Specification No. 2 Hand Tool Cleaning.

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 DELIVERY, STORAGE AND HANDLING

A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F.

1. Maintain containers in clean condition, free of foreign materials and residue.

2. Remove rags and waste from storage areas daily.

1.06 PROJECT CONDITIONS

A. Apply coatings only when temperature of surfaces to be coated and surrounding air temperatures are between 50 and 95 deg F.

B. Do not apply coatings in snow, rain, fog, or mist; when relative humidity exceeds 85 percent; at temperatures less than 5 deg F above the dew point; or to damp or wet surfaces.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers: Provide products by one of the following:

1. Tnemec, Inc.(TN);

2. The Sherwin Williams Company (SW)

3. PPG Architectural Finishes, Inc. (PPG)

4. PPG Architectural Finishes, Inc. Ameron (AME)

5. Or equal.

2.02 MATERIALS

A. Material Compatibility:

1. Provide materials for use within each coating system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.

2. Provide products of same manufacturer for each coat in a coating system.

B. All painting materials shall be delivered to the work site in unbroken packages, bearing the manufacturer's brand and name. They shall be used without adulteration and mixed, thinned and applied in strict accordance with manufacturer's directions for the applicable materials and surface and with the Engineer's approval before using.

C. Shop priming shall be done with primers that are guaranteed by the manufacturer to be compatible with the finish paints to be used. Refer to Section 09 91 10 for special primers.

D. Work areas will be designated by the Engineer for storage and mixing of all painting materials. Materials shall be in full compliance with the requirements of pertinent codes and fire regulations. Proper containers outside of the buildings shall be provided and used for painting wastes and no plumbing fixture shall be used for this purpose.

E. Colors: As selected by Engineer from manufacturer's full range.

2.03 COLOR CODING FOR PIPES AND EQUIPMENT

A. The color code establishes, defines and assigns a definite color for each process system. All elements which are an integral part of the system, that is originating from the equipment and/or supplying the equipment, shall be painted between and up to but not including the fixed flanges nor the flexible conduit connections on the

equipment. Valves and fittings shall be painted in the color of the main body of the pipe.

B. All pipes and equipment shall be painted with final coat color selected by the Engineer and shall be treated as an integral part of the Contract.

C. All hanger saddles and pipe support floor stands shall be painted the same color and with the same paint as the pipe it supports. Hanger rods and hanger rod connections to building structure shall be painted to match the color of the wall or ceiling to which it is attached.

2.04 LETTERING OF TITLES

A. The name of the materials in each pipeline and alongside this an arrow indicating the direction of flow of fluids, shall be indicated on each pipe system. Titles shall not be located more than 26 linear feet apart and shall also appear directly adjacent to each side of any wall the pipeline breaches, adjacent to each side of the valve regulator, flowcheck, strainer cleanout and all pieces of equipment.

B. Titles shall identify the contents by complete name at least once in each space through which it passes and thereafter by generally recognized abbreviations, letters or numerals as approved. Identification title locations shall be determined by the Engineer but in general they shall be placed where the view is unobstructed and on the two lower quarters of pipe or covering where they are overhead. Title should be clearly visible from operating positions especially those adjacent to control valves.

C. Numbers and letters shall be die-cut from 3.5 mil vinyl film and pre-spaced on carrier tape. Adhesive and finish surface shall be protected with one piece removable liners. Color shall be white or black as approved depending on substrate color.

D. Letter size shall be as indicated in the following table:

OUTSIDE DIAMETER OF PIPE OR COVERING	SIZE OF LEGEND LETTERS
3/4-in to 1-1/4-in	1/2-in
1-1/2-in to 2-in	3/4-in
2-1/2-in to 6-in	1-1/2-in
8-in to 10-in	2-1/2-in
Over 10-in	3-in

E. The system for preparation and application of letters shall be Type B a.s.i/2 by ASI Sign Systems; Architectural Graphics Inc. or equal. Letter type shall be Optima Bold, upper case. Grid 2 spacing shall be employed. Arrow shall match as approved, letter type and size. The instructions of the manufacturer shall be followed in respect to storage, surface preparation and applications of letters.

2.05 TITLES FOR EQUIPMENT

A. Titles shall be provided in vinyl film as specified above on all equipment using 1-in high Optima Bold upper case, Grid 2 spacing, white or black in color as approved depending on substrate. Use titles shown on mechanical drawings for bidding purposes. Titles shall be mounted at eye level on machines where possible or at the upper most broad vertical surface of low equipment. Where more than one piece of the equipment item to be titled exists, the items shall be numbered consecutively as indicated on the mechanical drawings or as directed by the Engineer; for example, Pump No. 1, Pump No. 2, etc. Titles shall be composed in more than one line if required and justified on the left-hand side as approved.

2.06 TESTING EQUIPMENT

A. Furnish to the Engineer for use on the Project for paint inspection, wet and dry film thickness gauges and all other equipment required by the Engineer for inspection.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of work.

1. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:
   a. Concrete: 12 percent.
   b. Masonry (CMU): 12 percent.
   c. Gypsum Board: 12 percent.

2. Verify compatibility with and suitability of substrates, including compatibility with existing finishes or primers.

3. Begin coating application only after unsatisfactory conditions have been corrected and surfaces are dry.

4. Coating application indicates acceptance of surfaces and conditions.

3.02 PREPARATION

A. All surfaces to be painted shall be prepared as specified herein and shall be dry and clean before painting. Special care shall be given to thoroughly clean interior concrete and CMU surfaces to receive polyamide cured epoxy paint of all marks before application of finish.

B. All metal welds, blisters, etc., shall be ground and sanded smooth. All pits and dents shall be filled, and all imperfections shall be corrected so as to provide a smooth surface for painting. All rust, loose scale, oil, tar and asphalt bearing coatings, grease

and dirt shall be removed by use of approved solvents, wire brushing, grinding or sanding.

C. Concrete surfaces shall have been finished as specified in Section 03 35 00. Report unsatisfactory surfaces to the Engineer. Concrete shall be left for one month minimum before painting and shall be free of dust, oil, curing compounds and other foreign matter.

D. All PVC pipe and other plastic matrix surfaces to be painted shall be sanded to an approved profile and cleaned of residue before painting.

E. All PVC pipe and other plastic matrix surfaces to be painted shall be lightly sanded and cleaned of residue before painting.

F. Galvanized, aluminum, and copper surfaces shall have all oxidation and foreign material removed before painting by SSPC SP-1, using an approved V.O.C. compliant method. Galvanized and, when ordered, the other metal surfaces specified above shall be hand tool cleaned to SSPC SP-2 standards to provide a uniform 1 mil surface profile.

3.03 WORKMANSHIP

A. General

1. At the request of the Engineer, sample areas of the finished work prepared in strict accordance with this Section shall be furnished and all painting shall be equal in quality to the approved sample areas. Finished areas shall be adequate for the purpose of determining the quality of workmanship. Experimentation with factory or paint manufacturer's warehouse mixed colors shall be furnished to the satisfaction of the Engineer where standard chart colors are not satisfactory.

2. Protection of furniture and other movable objects, equipment, fittings and accessories shall be provided throughout the painting operation. Canopies of lighting fixtures shall be loosened and removed from contact with surface, covered and protected and reset upon completion. Remove all electric plates, surface hardware, etc., before painting, protect and replace when completed. Mask all machinery name plates and all machined parts not receiving a paint finish. Dripped or spattered paint shall be promptly removed. Lay drop cloths in all areas where painting is being done to adequately protect flooring and other work from all damage during the operation and until the finished job is accepted.

3. On metal surfaces apply each coat of paint at the rate specified by the manufacturer to achieve the minimum dry mil thickness required. If material has thickened or must be diluted for application by spray gun, the coating shall be built up to the same film thickness achieved with undiluted material. One gallon of paint as originally furnished by the manufacturer shall not cover a greater area when applied by spray gun than when applied unthinned by brush. Deficiencies in film thickness shall be corrected by the application of an additional coat(s). On masonry, application rates will vary according to surface

texture; however, in no case shall the manufacturer's stated coverage rate be exceeded. On porous surfaces, it shall be the painter's responsibility to achieve a protective and decorative finish either by decreasing the coverage rate or by applying additional coats of paint.

B. Field Priming

1. Steel members, metal castings, mechanical and electrical equipment and other metals which are shop primed before delivery at the site will not require a prime coat on the job. All piping and other bare metals to be painted shall receive one coat of primer before exposure to the weather, and this prime coat shall be the first coat as specified in the painting schedule. Surface preparation of bare metal shall be the responsibility of the Contractor.

2. Equipment which is specified to receive a baked-on enamel finish or other factory finish shall not be field painted unless the finish has been damaged in transit or during installation. Surfaces that have been shop painted and have been damaged, or where the shop coat or coats of paint have deteriorated, shall be properly cleaned and retouched before any successive painting is done on them in the field. All such field painting shall match as nearly as possible the original finish. Preparation and painting shall be provided by the Contractor.

3. Equipment shipped with a protective shop painting coat or coats shall be touched up to the satisfaction of the Engineer with primers as recommended by the manufacturer of the finish paint. Preparation and painting shall be provided by the Contractor.

C. Field Painting

1. All painting at the site shall be under the strict inspection of the Engineer. Only skilled painters and, where dictated by special conditions or systems and so ordered, specialist painters shall be used on the work.

2. All paint shall be at room temperature before applying, and no painting shall be done when the temperature is below 60 degrees F, in dust-laden air, when rain or snow is falling, or until all traces of moisture have completely disappeared from the surface to be painted.

3. Successive coats of paint shall be different shades (from paint manufacturer's stock or shop mixed paint) of the required colors so as to make each coat easily distinguishable from each other with the final undercoat the approximate shade of the finished coat to ensure no show-through as approved.

4. Finish surfaces shall not show brush marks or other irregularities. Undercoats shall be thoroughly and uniformly sanded with the type paper appropriate for the undercoats to remove defects and provide a smooth even surface. Top and bottom edges of doors shall be painted.

5. Painting shall be continuous and shall be accomplished in an orderly manner so as to facilitate inspection. Materials subject to weather shall be primed coated

as quickly as possible. Surfaces of exposed members that will be inaccessible after erection shall be cleaned and painted before erection.

6. All painting shall be performed by approved methods with number of coats modified as required to obtain the total dry film thickness specified. Spray painting shall be performed specifically by methods submitted and as approved by the Engineer.

7. All surfaces to be painted as well as the atmosphere in which painting is to be done shall be kept warm and dry by heating and ventilation, if necessary, until each coat of paint has hardened. Any defective paint shall be scraped off and repainted in accordance with the Engineer's directions.

8. Before final acceptance of the work, all damaged surfaces of paint shall be cleaned and repainted as directed by the Engineer.

9. Only the aluminum work noted on the Drawings or in the Painting Schedule shall be field painted.

3.04 FIELD QUALITY CONTROL

A. Owner reserves the right to invoke the following procedure at any time and as often as Owner deems necessary during the period when coatings are being applied:

1. Owner will engage the services of a qualified testing agency to sample coating material being used. Samples of material delivered to Project site will be taken, identified, sealed, and certified in presence of Contractor.

2. Testing agency will perform tests for compliance with specified requirements.

3. Owner may direct Contractor to stop applying coatings if test results show materials being used do not comply with specified requirements. Contractor shall remove noncomplying coating materials from Project site, pay for testing, and recoat surfaces coated with rejected materials. Contractor will be required to remove rejected materials from previously coated surfaces if, on recoating with complying materials, the two coatings are incompatible.

3.05 CLEANING AND PROTECTION

A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

B. After completing coating application, clean spattered surfaces. Remove spattered coatings by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

C. Protect work of other trades against damage from coating operation. Correct damage by cleaning, repairing, replacing, and recoating, as approved by Engineer, and leave in an undamaged condition.

D. At completion of construction activities of other trades, touch up and restore damaged or defaced coated surfaces.

3.06 PAINTING SCHEDULE

A. All colors will be selected by the Engineer.

B. DFT for each paint product is not part of paint schedule. Submit both WFT and DFT for each product as part of submittal process. Apply paint and coating products to comply with manufacturer's DFT thickness and application recommendations in the approved submittal.

C. The following types of paints by Tnemec Co. (TN), The Sherwin Williams Company (SW), PPG Protective & Marine Coatings, (PPG), and Ameron International (AME) have been used as a basis for the paint schedule; use one of these paints or equal:

1. Epoxy:
   a. TN: Hi-build Epoxoline II, Series N69.
   b. SW: Macropoxy 646, B58 Series.
   c. PPG: Pitt-Guard 97-145 Series Epoxy Mastic.
   d. AME: Amerlock 2/400 Series Epoxy.

2. Waterborne Cementitious Acrylic: Result in pinhole free surface.
   a. TN: Envirofil, Series 130-6602.
   b. SW: Cement-Plex 875, B42 Series.
   c. PPG: Cementitious Waterproofing Block Filler 95-217 Series.
   d. AME: Amerlock 400 BF Epoxy Block Filler.

3. High-Build Acrylic Polyurethane Enamel:
   a. TN: Endura-Shield - semi-gloss, Series V73.
   b. SW: Acrolon 218 HS, B65 Series.
   c. PPG: Pitthane HB Semigloss Urethane 95-8800 Series.
   d. AME: Amercoat 450HSG Polyurethane.

4. High Heat Silicone Aluminum (to 600 degrees F):
   a. TN: No product.
   b. SW: Heat-Flex Hi-Temp 1000 Aluminum, B59-820 Series.
   c. PPG: Speedhide 6-220 Series Silicone Aluminum Coating.
   d. AME: Amercoat 878 Silicone Aluminum Coating.

5. Tie Coat, Low VOC, Epoxy:
   a. TN: FC Typoxy, Series V27.
   b. SW: Macropoxy 646, B58 Series.
   c. PPG: Pitt-Guard Epoxy Mastic 95-245 Series.
   d. AME: Amercoat 385 Multi-Purpose Epoxy.

6. Acrylic Latex Emulsion, Eggshell Finish:
   a. TN: Tneme-Cryl, Series 6.
   b. SW: DTM Primer/Finish, B66 Series.
   c. PPG: Pitt-Tech Plus 90-1110 Series Satin DTM Acrylic.
   d. AME: Amercoat 220 Waterborne Acrylic.

7. Vinyl Acrylic Surface Sealer:
   a. TN: PVA Sealer, Series 51.
   b. SW: Prep-Rite 200 Primer, B28 Series.
   c. PPG: Speedhide 6-2 Vinyl Acrylic Drywall Primer.
   d. AME: Amercoat 148 Acrylic Primer.

D. The following surfaces shall have the types of paint scheduled below applied at the dry film thickness (DFT) in mils per coat as recommended by manufacturer:

1. Exterior non-submerged ferrous metals (except first coat-hollow metal-pressed metal work):
   a. First Coat: On properly prepared unprimed metal or for touch-up:
      1) TN: Hi-build Epoxoline II, Series N69.
      2) SW: Macropoxy 646, B58 Series.
      3) PPG: Pitt-Guard 97-145 Series Epoxy Mastic.
      4) AME: Amerlock 2/400 Series Epoxy.
   b. Second Coat:
      1) TN: Hi-build Epoxoline II, Series N69.
      2) SW: Macropoxy 646, B58 Series.
      3) PPG: Pitt-Guard 97-145 Series Epoxy Mastic.
      4) AME: Amerlock 2/400 Series Epoxy.
   c. Third Coat:
      1) TN: Endura-Shield - semi-gloss, Series V73.
      2) SW: Acrolon 218 HS, B65 Series.
      3) PPG: Pitthane HB Semigloss Urethane 95-8800 Series.
      4) AME: Amercoat 450HSG Polyurethane.

2. Submerged ferrous metals and ferrous metals subject to submersion or splashing. Surface shall be lightly sanded or abraded before application of first field coat.
   a. First and Second Coats:
      1) TN: Hi-build Epoxoline II, Series N69.
      2) SW: Macropoxy 646, B58 Series.
      3) PPG: Pitt-Guard 97-145 Series Epoxy Mastic.
      4) PPG: Amerlock 2/400 Series Epoxy.

3. Interior concrete masonry units:
   a. First Coat: Result in pinhole free surface.
      1) TN: No. 130-6602.
      2) SW: Cement-Plex 875, B42 Series.
      3) PPG: Cementitious Waterproofing Block Filler 95-217 Series.
      4) AME: Amerlock 400 BF Epoxy Block Filler.
   b. Second and Third Coats:
      1) TN: Hi-build Epoxoline II, Series N69.
      2) SW: Macropoxy 646, B58 Series.
      3) PPG: Pitt-Guard 97-145 Series Epoxy Mastic.
      4) AME: Amerlock 2/400 Series Epoxy.

4. Plastic piping and, where scheduled to be painted, plastic components:
   a. First and Second Coats:
      1) TN: Hi-build Epoxoline II, Series N69.

2) SW: Macropoxy 646, B58 Series.
3) PPG: Pitt-Guard 97-145 Series Epoxy Mastic.
4) AME: Amerlock 2/400 Series Epoxy.

5. Pipe insulation: (Plastic or metal sheathed insulation-paint as scheduled for appropriate substrate):
   a. First Coat:
      1) TN: Vinyl-Acrylic Sealer, No. 51-792.
      2) SW: Prep-Rite 200, B28 Series.
      3) PPG: Speedhide 6-2 Vinyl Acrylic Drywall Primer.
      4) AME: Amercoat 148 Acrylic Primer.
   b. Second and Third Coats:
      1) TN: Hi-build Epoxoline II, Series N69.
      2) SW: Macropoxy 646, B58 Series.
      3) PPG: Pitt-Guard 97-145 Series Epoxy Mastic.
      4) AME: Amerlock 2/400 Series Epoxy.

6. Hot Ferrous Metal Surfaces:
   a. First and Second Coats:
      1) TN: No product.
      2) SW: Heat-Flex Hi-Temp 1000 Aluminum, B59-820 Series, Aluminum.
      3) PPG: Speedhide 6-220 Series Silicone Aluminum Coating.
      4) AME: Amercoat 878 Silicone Aluminum Coating.

7. Exterior galvanized steel surfaces:
   a. Mechanically abrade surfaces to comply with SSPC SP 16 "Brush-off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-ferrous Metals."
   b. First Coat:
      1) TN: FC Typoxy, Series V27.
      2) SW: Macropoxy 646, B58 Series.
      3) PPG: Pitt-Guard Epoxy Mastic 95-245 Series.
      4) AME: Amercoat 385 Multi-Purpose Epoxy.
   c. Second Coat:
      1) TN: Endura-Shield - semi-gloss, Series V73.
      2) SW: Acrolon 218 HS.
      3) PPG: Pitthane HB Semigloss Urethane 95-8800 Series.
      4) AME: Amercoat 450HSG Polyurethane.

8. Gypsum Work:
   a. First Coat:
      1) TN: PVA Sealer No. 51-792.
      2) SW: PrepRite 200 Primer, B28 Series.
      3) PPG: Speedhide 6-2 Vinyl Acrylic Drywall Primer.
      4) AME: Amercoat 148 Acrylic Primer.
   b. Second and Third Coats:
      1) TN: Tneme-Cryl Series 6.
      2) SW: DTM Primer/Finish, B66 Series.
      3) PPG: Pitt-tech Plus 90-1110 Series Satin DTM Acrylic.
      4) AME: Amercoat 220 Waterborne Acrylic.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required for the surface preparation and application of shop primers on ferrous metals, excluding stainless steels, as specified herein.

1.02 RELATED WORK

A. Finish painting is included in Section 09 91 00.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, shop drawings, manufacturer's specifications and data on the proposed primers and detailed surface preparation, application procedures and dry mil thicknesses.

B. Submit representative physical samples of the proposed primers, if required by the Engineer.

1.04 REFERENCE STANDARDS

A. The Society for Protective Coatings (SSPC)

1. SSPC-SP 6/NACE No. 3 - Joint Surface Preparation Standard SSPC-SP 6/NACE No. 3: Commercial Blast Cleaning

2. SSPC-SP 10/NACE No. 2 - Joint Surface Preparation Standard SSPC-SP 10/NACE No. 2: Near-White Blast Cleaning.

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

PART 2 PRODUCTS

2.01 MATERIALS

A. Submerged Surfaces - Shop primer for ferrous metals which will be in contact with water being treated, either submerged or which are subject to splash action or which are specified to be considered submerged service shall be shop primed with the following:

1. Shop Prime Coat: (Zinc Micaceous Iron Oxide Polyurethane Aromatic Shop Primer)
   a. TNEMEC: Series 1 Omnithane
   b. Carboline: Carboguard 561

c. Sherwin-Williams Company (The): Corothane I Zinc Primer 1K Mio-Zinc.
d. PPG PMC Durathane MCZ 97-679 Series or PPG PMC Amerlock 400.
e. Or equal.

B. Non-Submerged Surfaces: Shop primer for ferrous metals which will not be in contact with water being treated, not submerged and not subject to splash action shall be shop primed with the following:

1. Shop Prime Coat: (Zinc Micaceous Iron Oxide Polyurethane Aromatic Shop Primer)
   a. TNEMEC: Series 1 Omnithane
   b. Carboline: Carboguard 561
   c. Sherwin-Williams Company (The): Corothane I Zinc Primer 1K Mio-Zinc.
   d. PPG PMC Durathane MCZ 97-679 Series or PPG PMC Amercoat 68HS.
   e. Or equal.

C. Submerged Surfaces:

1. Shop Prime Coat for Ductile Iron Pipe: (Epoxy, Polyamidoamine Shop Primer)
   a. TNEMEC: Series N140 Pota-Pox-Plus
   b. Carboline: Carboguard 561
   c. Sherwin-Williams Company (The): Macropoxy 846 NSF Winter Grade Epoxy Mill White
   d. PPG PMC Aquapon HB Potable Water Epoxy Coating 95-132 Series or PPG PMC Amerlock 2 Epoxy.
   e. Or equal.

2. Shop Prime Coat for Ferrous Metal Surfaces: (Zinc Micaceous Iron Oxide Polyurethane Aromatic Shop Primer)
   a. TNEMEC: Series 1 Omnithane
   b. Carboline: Carboguard 561
   c. Sherwin-Williams Company (The): Corothane I Zinc Primer 1K Mio-Zinc.
   d. PPG PMC Durathane MCZ 97-679 Series
   e. Or equal.

D. Non-Primed Surfaces - Gears, bearings surfaces and other similar surfaces obviously not to be painted shall be given a heavy shop coat of grease or other suitable rust-resistant coating. This coating shall be maintained as necessary to prevent corrosion during all periods of storage and erection and shall be satisfactory to the Engineer up to the time of the final acceptance test.

E. Compatibility of Coating Systems - Shop priming shall be done with primers that are guaranteed by the manufacturer to be compatible with their corresponding primers and finish coats specified in Section 09 91 00 for use in the field and which are recommended for use together.

PART 3 EXECUTION

3.01 APPLICATION

A. Surface Preparation and Priming

1. Non-submerged components scheduled for priming, as defined above, shall be blast cleaned in accordance with SSPC-SP 6/NACE No. 3, immediately prior to priming. Submerged components scheduled for priming, as defined above, shall be blast cleaned in accordance with SSPC-SP 10/NACE No. 2, immediately prior to priming. Consult manufacturer regarding required surface profiles.

2. Surfaces shall be dry and free of dust, oil, grease and other foreign material before priming.

3. Shop prime in accordance with approved manufacturer's recommendations.

B. Non-Primed Surfaces

1. Apply approved coating per manufacturer's recommendations.

3.02 FABRICATED ITEMS

A. All items to be shop primed shall be blast cleaned as specified for applicable service prior to priming. If, in the opinion of the Engineer, any prime coating that has been improperly applied or if material contrary to this Section has been used, that coating shall be removed by abrasive blasting to white metal and reprimed in accordance with this Section.

B. All shop prime coats shall be of the correct materials and applied in accordance with this Section. Remove prime coats not in accordance with this Section by blast cleaning and apply the specified prime coat at no additional cost to the Owner.

C. Shop primed surfaces shall be cleaned thoroughly and damaged or bare spots prepared as approved and retouched with the specified primer before the application of successive paint coats in the field.

D. Shop finish coats, if proposed and allowed, shall be equal in appearance and protection quality to a field applied finish coat. If, in the opinion of the Engineer, a shop finish coat system does not give the appearance and protection quality of other work of similar nature, prepare the surfaces and apply the coat or coats of paint as directed by the Engineer to accomplish the desired appearance and protection quality. Submit to the Engineer substantial evidence that the standard finish is compatible with the specified finish coat.

E. Properly protect the shop prime and finish coats against damage from weather or any other cause.

F. Wherever fabricated equipment is required to be blast cleaned, protect all motors, drives, bearings, gears, etc., from the entry of grit. Equipment found to contain grit shall be promptly and thoroughly cleaned.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The Contractor shall furnish and install all labor, materials, equipment, and incidentals required to supply and install concrete coating on interior wall surfaces, and overhead slabs exposed to wastewater and as indicated on the drawings and specified herein.

B. Concrete coating shall be designed and installed to protect concrete surfaces from corrosion.

C. It is the intent of these Specifications to coat the interior surfaces of the Diversion Structure exposed to wastewater, including the walls and underside of slabs above the waterline. These surfaces are exposed to H2S, humidity, water, other components of raw wastewater, and the corrosive by-products formed above the water level.

1.02 SUBMITTALS

A. The Contractor shall submit for review, in accordance with Section 01 33 23, complete detailed shop drawings and a coating schedule for all materials furnished under this section.

B. The Manufacturer of the coating shall furnish an affidavit attesting to the successful use of its material as a lining for concrete structures for a minimum period of 10 years in conditions recognized as corrosive or otherwise detrimental to concrete.

C. Product Data: Submit manufacturer's product data for each coating, including generic description, complete technical data, safety data sheets (SDS), surface preparation, and application instructions.

D. Applicator’s Quality Assurance: Submit list of a minimum of 5 completed projects in Tennessee of similar size and complexity to this Work. Include for each project:

1. Project name and location.

2. Name of owner.

3. Name of contractor.

4. Name of engineer.

5. Name of coating manufacturer.

6. Approximate area of coatings applied.

7. Date of completion.

E. Submit certification that the applicator has been trained in the handling, mixing and application of the products to be used.

F. Submit certification that the equipment to be used for applying the products has been approved by the protective coating manufacturer and applicator personnel have been trained and certified for proper use of the equipment.

G. Submit certification that the manufacturer's representative is a NACE Level 3 Certified Coating Inspector.

H. Warranty: Submit manufacturer's standard warranty or a 1-year warranty (whichever is greater).

1.03 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. ASTM D16 - Terminology Relating to Paint, Varnish, Lacquer, and Related Products

2. ASTM D3359 - Standard Test Methods for Measuring Adhesion by Tape Test

3. ASTM D4258 - Standard Practice for Surface Cleaning Concrete for Coating

4. ASTM D4259 - Standard Practice for Abrading Concrete.

5. ASTM D4260 - Standard Practice for Etching Concrete.

6. ASTM D4263 - Indicating Moisture in Concrete by the Plastic Sheet Method

7. ASTM F1869 - Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete.

B. International Concrete Repair Institute (ICRI)

1. ICRI No. 310.2 - Concrete Surface Preparation

2. ICRI Guideline No. 310.2R - Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays.

C. The Society for Protective Coatings (SSPC)

1. SSPC-SP 13/NACE No. 6 - Surface Preparation of Concrete

2. SSPC-Guide No. 11 – Guide for Coating Concrete

3. SSPC-PA 2 - Measurement of Dry Paint Thickness with Magnetic Gages

4. SSPC VIS-1-89T - Pictorial Surface Preparation Standard

D. National Association of Corrosion Engineers (NACE)

1. RP0188-88 - Standard Recommended Practice for Discontinuing (Holiday) Testing of Protective Coatings

E. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.04 DEFINITIONS

A. Definitions of Painting Terms: ASTM D 16, unless otherwise specified.

B. Dry Film Thickness (DFT): Thickness of a coat of paint in fully cured state measured in mils (1/1000 inch).

1.05 QUALITY ASSURANCE

A. Manufacturer’s Qualifications:

1. Specialize in manufacture of coatings with a minimum of 10 years successful experience.

2. Able to demonstrate successful performance on comparable projects.

3. Single Source Responsibility: Coatings and coating application accessories shall be products of a single manufacturer.

B. Manufacturer Representative

1. The Contractor shall require the coating manufacturer to furnish a manufacturer’s qualified technical representative to visit the project site for technical support as required and ordered and as may be necessary to resolve field questions or problems attributable to or associated with the manufacturer's products furnished under this Contract or the application thereof.

2. The manufacturer’s representative shall be a NACE Level 3 Certified Coating Inspector.

C. Applicator’s Qualifications:

1. Experienced in application of specified coatings for a minimum of 5 years on projects of similar size and complexity to this Work.

2. Applicator's Personnel: Employ persons trained for application of specified coatings.

D. Pre-application Meeting: Convene a pre-application meeting one-week before start of application of coating systems. Require attendance of parties directly affecting work of this section, including Contractor, Engineer, applicator, and manufacturer’s representative. Review the following:

1. Environmental requirements.

2. Protection of surfaces not scheduled to be coated.

3. Surface preparation.

4. Application.

5. Inspection.

6. Repair.

7. Field quality control.

8. Cleaning.

9. Protection of coating systems.

10. One-year inspection.

11. Coordination with other work.

E. Inspection and Testing

1. All materials and work shall be accessible and subject to inspection by the Engineer and the manufacturer's representative.

2. The completed surface preparation and completed coating work shall be inspected visually by the manufacturer's representative for skips, holidays, hiding, uniform color and appearance, and other imperfections. All defective work shall be corrected by the Contractor.

3. Coating integrity for coatings in immersion areas or subjected to splash and spillage shall be determined in accordance with NACE RP0188-88 using the low voltage wet sponge test method. All holidays will be clearly marked for repair.

4. The Contractor shall furnish to the job site and use for coating inspection and make available to the Engineer, the following test equipment:
   a. Wet film thickness gauge.
   b. Dry film thickness gauge (with certified thickness calibrator) equal to Mikrotest III; Elcometer Inspector III; or Positest.
   c. Surface Temperature Gauge.
   d. Holiday Detector, low voltage type such as Tinker & Rasor Model M-1, Series 9533.
   e. SSPC VIS-1-89T "Pictorial Surface Preparation Standard."
   f. Keane-Tator Surface Comparator Number 372, or equal.
   g. NBS Certified Coating Thickness Standards.
   h. Sling Psychrometer.
   i. Surface moisture metering device equal to Delmhors Model DB.

F. Warranty Inspection

1. A warranty inspection shall be conducted during the 11th month following completion of all coating work. The Contractor, coating subcontractor, and a representative of the coating material manufacturer shall attend this inspection with the Engineer and representative of the Owner.

2. All defective work shall be repaired in accordance with these specifications and to the satisfaction of the Engineer. The Owner may, by written notice to the Contractor, reschedule the warranty inspection to another date within the 1-year correction period or may cancel the warranty inspection altogether. If a warranty inspection is not held, the Contractor is not relieved of his responsibilities under the Contract Documents.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly identifying:

1. Coating or material name.

2. Manufacturer.

3. Color name and number.

4. Batch or lot number.

5. Date of manufacture

6. Mixing and thinning instructions.

B. Storage:

1. Store materials in a clean dry area and within temperature range in accordance with manufacturer's instructions.

2. Keep containers sealed until ready for use.

3. Do not use materials beyond manufacturer’s shelf life limits.

C. Handling: Protect materials during handling and application to prevent damage or contamination.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Weather:

1. Air and Surface Temperatures: Prepare surfaces and apply and cure coatings within air and surface temperature range in accordance with manufacturer’s instructions.

2. Surface Temperature: Minimum of 5 degrees F (3 degrees C) above dew point.

3. Relative Humidity: Prepare surfaces and apply and cure coatings within relative humidity range in accordance with manufacturer's instructions.

4. Precipitation: Do not prepare surfaces or apply coatings in rain, snow, fog, or mist.

5. Wind: Do not spray coatings if wind velocity is above manufacturer's limit.

B. Ventilation: Provide ventilation during coating evaporation stage in confined or enclosed areas.

C. Dust and Contaminants:

1. Schedule coating work to avoid excessive dust and airborne contaminants.

2. Protect work areas from excessive dust and airborne contaminants during coating application and curing.

D. Cold Weather Construction

1. All coatings shall be at room temperature before applying, and no painting shall be done when the temperature is below 40 degrees F, in dust-laden air, when rain or snow is falling, or until all traces of moisture have completely disappeared from the surface to be painted. Lower temperatures will only be allowed with written instructions from the coating manufacturer.

PART 2 PRODUCTS

2.01 MATERIALS

A. Coating system shall be a trowel applied, 100% solids epoxy, including primer as required by the manufacturer, for a complete system. The coating shall be Raven 405 as manufactured by Raven Lining Systems, Kansas City, KS, Sewerguard Glaze No. 210GL as manufactured by Sauereisen, Pittsburgh, PA, Plasite 5371 as manufactured by Carboline Inc., St. Louis, MO, Perma-Shield H2S Series 434 as manufactured by Tnemec Inc., Kansas City, MO, or approved equal.

B. Total dry film thickness (DFT) shall be 125 mils minimum.

2.02 ACCESSORIES

A. Coating Application Accessories:

1. Accessories required for application of specified coatings in accordance with manufacturer's instructions, including thinners.

2. Products of coating manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions under which coating systems are to be applied. Notify Engineer of areas or conditions not acceptable. Do not begin surface preparation or application until unacceptable areas or conditions have been corrected.

3.02 SURFACE PREPARATION OF CONCRETE

A. All Concrete surfaces:

1. Prepare concrete surfaces in accordance with manufacturer's instructions, SSPC-SP 13/NACE No. 6, and ICRI 310.2R.

2. New Concrete - The compressive strength of the concrete must be at least 4000 psi and have a minimum 28-day cure.

3. Test concrete for moisture in accordance with ASTM D 4263. One test shall be completed for every 500 square feet or part thereof. Application of coating must begin within 12 hours after the test is completed; otherwise, a new test must be done.

4. All surfaces of the concrete must be either abrasive-blasted using 16-30 mesh sand, or hydro-blasted. All surfaces must be dry prior to application. Coating MANUFACTURER shall provide standard testing procedures, such as ASTM-D4263-63, to determine if excess moisture is present in the concrete.

5. Concrete surfaces that have been cured with conventional curing compounds or are contaminated with form oils or grease must be chemically cleaned or scarified to remove these contaminants before abrasive blasting or hydroblasting is started.

6. Suitably finished concrete must have a uniform surface texture exposing fine aggregate, and resembling coarse sandpaper. If surface texture is not uniform in appearance, repeat surface preparation procedure until the desired surface is obtained.

7. Fill holes, pits, voids, and cracks with approved Filler and Surfacer. Approved products include Sauereisen Underlayment No F-120 or approved equal.

8. If sandblasting is used as the method of surface preparation, remove all sand and debris by thoroughly vacuuming the area. If hydroblasting is used, all surfaces must be surface dry without any standing water prior to application of coating.

3.03 APPLICATION

A. Do NOT apply coatings until surface preparation of concrete has been Approved by the manufacturer's representative in accordance with Paragraph 1.05 E.1.

B. Apply coatings in accordance with manufacturer's instructions.

C. Mix and thin coatings, including multi-component materials, in accordance with manufacturer's instructions.

D. Keep containers closed when not in use to avoid contamination.

E. Do not use mixed coatings beyond pot life limits.

F. Once the compound has begun to set, it cannot be recovered by adding more liquid; such material must be discarded.

G. Never add water, Portland cement, or any other additive or adulterant to any component or the mixed compound.

H. Use application equipment, tools, pressure settings, and techniques in accordance with manufacturer's instructions.

I. Uniformly apply coatings at spreading rate required to achieve a minimum thickness of 125 mils.

J. Apply coatings to be free of film characteristics or defects that would adversely affect performance or appearance of coating systems.

K. Stripe paint with brush critical locations on aluminum such as welds, corners, and edges using specified primer.

L. Curing - CONTRACTOR shall not allow water or chemicals on the coating for a minimum of 24 hours at 70°F. For temperatures below 70°F, cure a minimum of 48 hours prior to water or chemical exposure.

3.04 REPAIR

A. Materials and Surfaces Not Scheduled to Be Coated: Repair or replace damaged materials and surfaces not scheduled to be coated.

B. Damaged Coatings: Touch-up or repair damaged coatings. Touch-up of minor damage shall be acceptable where result is not visibly different from adjacent surfaces. Recoat entire surface where touch-up result is visibly different, either in sheen, texture, or color.

C. Coating Defects: Repair in accordance with manufacturer's instructions coatings that exhibit film characteristics or defects that would adversely affect performance or appearance of coating systems.

3.05 FIELD QUALITY CONTROL

A. Manufacturer's Field Services: Manufacturer's representative shall provide technical assistance and guidance for surface preparation and application of coating systems. Manufacturer's representative shall hold point inspections to review surface preparation prior to application of coatings.

B. Quality Control Testing After Coating Application

C. Contractor shall perform High Voltage Holiday Test using 100 volts per DFT mil. Owner Representative and Manufacturer's Representative shall be present. All pinholes, holidays, or other defects shall be repaired in accordance with the manufacturer's recommendations and Engineer's approval. All repairs and costs associated are the responsibility of the Contractor.

D. Adhesion of the coating to the substrate shall be measured in accordance with ASTM D3359, method A. Adhesion tests must meet a minimum scale rating of 4A. One adhesion test shall be completed for every 500 square feet of surface area or part thereof. All costs shall be the responsibility of the Contractor.

3.06 CLEANING

A. Remove temporary coverings and protection of surrounding areas and surfaces.

3.07 PROTECTION OF COATING SYSTEMS

A. Protect surfaces of coating systems from damage during construction.

3.08 ONE-YEAR INSPECTION

A. Owner will set date for one-year inspection of coating systems.

B. Inspection shall be attended by Owner, Contractor, Engineer, and manufacturer's representative.

C. Repair deficiencies in coating systems as determined by Engineer in accordance with manufacturer's instructions.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and design and deliver toilet accessories for the Project as shown on the Drawings and as specified herein.

B. The work includes:

1. Public-use washroom accessories.

2. Under-lavatory guards.

1.02 RELATED WORK

A. Gypsum board is included in Section 09 29 00.

B. Tiling is included in Section 09 30 13.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23.

B. Product Data: For each type of product indicated. Include the following:

1. Construction details and dimensions.

2. Anchoring and mounting requirements, including requirements for cutouts in other work and substrate preparation.

3. Material and finish descriptions.

4. Features that will be included for Project.

5. Manufacturer's warranty.

C. Product Schedule: Indicating types, quantities, sizes, and installation locations by room of each accessory required.

1. Identify locations using room designations indicated.

2. Identify products using designations indicated.

D. Maintenance Data: For toilet accessories to include in maintenance manuals.

E. Warranty: Sample of special warranty.

1.04 REFERENCE STANDARDS

A. ASTM International

1. ASTM A 153/A 153M - Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

2. ASTM A 653/A 653M - Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

3. ASTM A 666 - Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar

4. ASTM A 1008/A 1008M - Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable

5. ASTM C 1503 - Specification for Silvered Flat Glass Mirror

6. ASTM F 446 - Consumer Safety Specification for Grab Bars and Accessories Installed in the Bathing Area

B. Where reference is made to one of the above or other referenced standards, the revisions in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Source Limitations: For products listed together in the same Part 2 articles, obtain products from single source from single manufacturer.

1.06 COORDINATION

A. Coordinate accessory locations with other work to prevent interference with clearances required for access by people with disabilities, and for proper installation, adjustment, operation, cleaning, and servicing of accessories.

B. Deliver inserts and anchoring devices set into concrete or masonry as required to prevent delaying the Work.

1.07 WARRANTY

A. Special Mirror Warranty: Manufacturer's standard form in which manufacturer agrees to replace mirrors that develop visible silver spoilage defects and that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 15 years from date of Substantial Completion.

PART 2 PRODUCTS

2.01 MATERIALS

A. Stainless Steel: ASTM A 666, Type 304, 0.031-inch minimum nominal thickness unless otherwise indicated.

B. Steel Sheet: ASTM A 1008/A 1008M, Designation CS (cold rolled, commercial steel), 0.036-inch minimum nominal thickness.

C. Galvanized-Steel Sheet: ASTM A 653/A 653M, with G60 hot-dip zinc coating.

D. Galvanized-Steel Mounting Devices: ASTM A 153/A 153M, hot-dip galvanized after fabrication.

E. Fasteners: Screws, bolts, and other devices of same material as accessory unit and tamper-and-theft resistant where exposed, and of galvanized steel where concealed.

F. Chrome Plating: ASTM B 456, Service Condition Number SC 2 (moderate service).

G. Mirrors: ASTM C 1503, Mirror Glazing Quality, clear-glass mirrors, nominal 6.0 mm thick.

H. ABS Plastic: Acrylonitrile-butadiene-styrene resin formulation.

2.02 PUBLIC-USE WASHROOM ACCESSORIES

A. Manufacturers: Provide products by one of the following:

1. Bobrick Washroom Equipment, Inc.
2. A & J Washroom Accessories, Inc.
3. American Specialties, Inc.
4. Bradley Corporation.
5. GAMCO Specialty Accessories; a division of Bobrick Washroom Equipment, Inc.
6. Tubular Specialties Manufacturing, Inc.
7. Or equal.

B. Toilet Tissue (Roll) Dispenser:

1. Basis-of-Design Product: Bobrick.
2. Description: Double-roll dispenser.
3. Mounting: Surface mounted.

4. Operation: Non-control delivery with theft-resistant spindle .

5. Capacity: Designed for 4-1/2- or 5-inch- diameter tissue rolls.

6. Material and Finish: Stainless steel, No. 4 finish (satin).

C. Combination Towel (Folded) Dispenser/Waste Receptacle:

1. Basis-of-Design Product: Bobrick.

2. Description: Combination unit for dispensing C-fold or multifold towels, with removable waste receptacle.

3. Mounting: Surface mounted.

4. Minimum Towel-Dispenser Capacity: 800 multifold paper towels.

5. Minimum Waste-Receptacle Capacity: 12 gal.

6. Material and Finish: Stainless steel, No. 4 finish (satin).

7. Liner: Reusable, vinyl waste-receptacle liner.

8. Lockset: Tumbler type for towel-dispenser compartment and waste receptacle.

D. Liquid-Soap Dispenser:

1. Basis-of-Design Product: Bobrick.

2. Description: Designed for dispensing soap in liquid or lotion form.

3. Mounting: Horizontally oriented, surface mounted.

4. Capacity: 40 fl. oz.

5. Materials: Black molded plastic push button and spout, anti-bacterial soap resistant plastic cylinder.

6. Lockset: Tumbler type.

7. Refill Indicator: Window type.

E. Grab Bar:

1. Basis-of-Design Product: Bobrick.

2. Mounting: Flanges with concealed fasteners.

3. Material: Stainless steel, 0.05 inch thick.
   a. Finish: Smooth, No. 4 finish (satin) on ends and slip-resistant texture in grip area.

4. Outside Diameter: 1-1/4 inches.

5. Configuration and Length: As indicated on Drawings.

F. Seat-Cover Dispenser:

1. Basis-of-Design Product: Bobrick.

2. Mounting: Surface mounted.

3. Minimum Capacity: 500 seat covers.

4. Exposed Material and Finish: Stainless steel, No. 4 finish (satin).

5. Lockset: Tumbler type.

G. Mirror Unit:

1. Basis-of-Design Product: Bobrick.

2. Frame: Stainless steel, fixed tilt.
   a. Corners: Manufacturer's standard.

3. Integral Shelf: 5 inches deep.

4. Hangers: Produce rigid, tamper- and theft-resistant installation, using method indicated below.
   a. One-piece, galvanized-steel, wall-hanger device with spring-action locking mechanism to hold mirror unit in position with no exposed screws or bolts.

5. Size: As indicated on Drawings.

2.03 UNDERLAVATORY GUARDS

A. Manufacturers: Provide products by one of the following:

1. Plumberex Specialty Products, Inc.

2. Truebro by IPS Corporation.

3. Or equal.

B. Description: Insulating pipe covering for supply and drain piping assemblies that prevent direct contact with and burns from piping; allow service access without removing coverings.

C. Material and Finish: Antimicrobial, molded plastic, white.

2.04 FABRICATION

A. General: Fabricate units with tight seams and joints, and exposed edges rolled. Hang doors and access panels with full-length, continuous hinges. Equip units for concealed anchorage and with corrosion-resistant backing plates.

B. Keys: Provide universal keys for internal access to accessories for servicing and resupplying. Provide minimum of six keys to Owner's representative.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install accessories according to manufacturers' written instructions, using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated.

B. Grab Bars: Install to withstand a downward load of at least 250 lbf, when tested according to ASTM F 446.

3.02 ADJUSTING AND CLEANING

A. Adjust accessories for unencumbered, smooth operation. Replace damaged or defective items.

B. Remove temporary labels and protective coatings.

C. Clean and polish exposed surfaces according to manufacturer's written recommendations.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install signage as specified and scheduled herein.

B. The types to be furnished are as follows:

1. Room identification signs.

2. Restrictive signs.

3. Process identification signs.

1.02 RELATED WORK

A. Piping and equipment identification is specified in Section 09 91 00.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, shop drawings showing details of construction and erection. Submittals shall include the following:

1. Manufacturer's complete color range and type styles.

2. Sign layout with shop drawings as follows:
   a. Full size layout of typical Room Identification, Restrictive and Process Identification signs.

3. Submit two each of the following samples. Samples shall be resubmitted as required until approved.
   a. A 12-in minimum square sample of each proposed plastic restrictive sign and proposed framing and mounting device.
   b. A 6-in minimum square sample of proposed pressure sensitive vinyl for Room Identification cut into letters in the colors proposed for the required color scheme.

4. Cleaning and maintenance instructions for all signage components.

PART 2 PRODUCTS

2.01 MATERIALS

A. Signs shall be manufactured by Architectural Signing Inc., Marina del Ray, CA; Architectural Graphics Inc., Norfolk, VA; Metal Art, Boston, MA or equal. Catalog numbers indicated are those of Architectural Signing Inc., (ASI) unless otherwise indicated. All lettering shall be Optima Bold, upper and lower case and sized as

specified or as shown on scale sign drawings. All exposed surfaces shall be matte finish as approved.

B. Room Identification signs, pressure sensitive letter type, shall be ASI, LTV Series, applied directly to doors. All letters shall be 1-in high as scheduled and located as directed. Letters shall be die-cut from 3.5 mil thick, pressure sensitive vinyl film and prespaced on carrier tape. The adhesive and finish surface shall be protected with one piece removable liners. Color shall be white or black as selected depending on substrate color and in upper case letters.

C. Restrictive Signs

1. Signs shall be 20 gauge galvanized steel backed butyrate by Seton Name Plate Corp. or equal. Signs shall be mounted with two strips 1/32-in two-sided vinyl tape on doors and smooth surfaces and with two strips approved liquid adhesive with temporary hold by two strips vinyl tape on rough surfaces, each continuous across back.

2. Restrictive signs shall conform with OSHA regulations for accident prevention and shall have square corners. Size of sign 10-in high by 14-in. Provide signs with the following text, located as directed by the Engineer:
   a. DANGER High Voltage Electric
   b. DANGER Authorized Personnel Only
   c. No Trespassing
   d. DANGER Diesel Fuel – No Smoking

D. Unframed exterior plaque type process identification sign shall be ASI Sintra Signs, semi-matte finish, 3/8-in laminated acrylic with four reinforced plastic studs drilled into and cemented on back and 1/2-in radius corners. Graphics shall be subsurface applied vinyl die cut letters in Optima Bold font.

PART 3 EXECUTION

3.01 INSTALLATION

A. Signage shall be installed at the locations detailed or as directed, in accordance with the manufacturer's recommendations and approved shop drawings.

B. Damaged units or components shall be removed and replaced at no additional cost to the Owner.

C. Signage shall be cleaned to the satisfaction of the Engineer using the approved methods, upon completion of the installation and again, just prior to acceptance of the project.

Room Identification	
Signage Schedule	
Door Number	Signage
101	Toilet Room

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install fire protection specialties complete as shown on the Drawings and as specified herein.

B. This Section includes portable, hand-carried fire extinguishers and mounting brackets for fire extinguishers.

1.02 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, detailed information on materials proposed and installation methods.

B. Product Data: For each type of product indicated. Include rating and classification, material descriptions, dimensions of individual components and profiles, and finishes for fire extinguisher and mounting brackets.

C. Operation and Maintenance Data: For fire extinguishers to include in maintenance manuals.

D. Warranty: Sample of special warranty.

1.03 REFERENCES

A. ASTM International (ASTM)

1. ASTM A 1008/A 1008M - Specification for Steel Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability

B. National Association of Architectural Metal Manufacturers

1. Metal Finishes Manual for Architectural and Metal Products.

C. NFPA (NFPA)

1. NFPA 10 - Portable Fire Extinguishers

D. SSPC: The Society for Protective Coatings (SSPC)

1. SSPC-SP 8 - Surface Preparation Specification No. 8: Pickling

2. SSPC-SP 5/NACE No. 1 - Joint Surface Preparation Standard SSPC-SP 5/NACE No. 1: White Metal Blast Cleaning

E. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.04 QUALITY ASSURANCE

A. NFPA Compliance: Fabricate and label fire extinguishers to comply with NFPA 10, "Portable Fire Extinguishers."

B. Fire Extinguishers: Listed and labeled for type, rating, and classification by an independent testing agency acceptable to authorities having jurisdiction.

1. Provide fire extinguishers approved, listed, and labeled by FMG.

1.05 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace fire extinguishers that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Failure of hydrostatic test according to NFPA 10.
   b. Faulty operation of valves or release levers.

2. Warranty Period: Six years from date of Completion.

PART 2 PRODUCTS

2.01 PORTABLE, HAND-CARRIED FIRE EXTINGUISHERS

A. Fire Extinguishers: Type, size, and capacity for each mounting bracket indicated.

1. Manufacturers: Provide products by one of the following:
   a. Amerex Corporation.
   b. J. L. Industries, Inc.; a division of Activar Construction Products Group.
   c. Larsen's Manufacturing Company.
   d. Potter Roemer LLC.
   e. Or equal.

2. Valves: Manufacturer's standard.

3. Handles and Levers: Manufacturer's standard.

4. Instruction Labels: Include pictorial marking system complying with NFPA 10, Appendix B.

B. Multipurpose Dry-Chemical Type in Steel Container: UL-rated 4-A:80-B:C, 10-lb nominal capacity, with mono-ammonium phosphate-based dry chemical in enameled-steel container.

2.02 MOUNTING BRACKETS

A. Mounting Brackets: Manufacturer's standard steel, designed to secure fire extinguisher to wall or structure, of sizes required for types and capacities of fire extinguishers indicated, with plated or black baked-enamel finish.

1. Manufacturers: Provide products by one of the following:
   a. Amerex Corporation.
   b. J. L. Industries, Inc.; a division of Activar Construction Products Group.
   c. Potter Roemer LLC.
   d. Or equal.

B. Identification: Lettering complying with authorities having jurisdiction for letter style, size, spacing, and location. Locate as indicated by Engineer.

1. Identify bracket-mounted fire extinguishers with the words "FIRE EXTINGUISHER" in red letter decals applied to mounting surface.
   a. Orientation: Vertical.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine fire extinguishers for proper charging and tagging.

1. Remove and replace damaged, defective, or undercharged fire extinguishers.

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

3.02 INSTALLATION

A. General: Install fire extinguishers and mounting brackets in locations indicated and in compliance with requirements of authorities having jurisdiction.

1. Mounting Brackets: 54 inches above finished floor to top of fire extinguisher.

B. Mounting Brackets: Fasten mounting brackets to surfaces, square and plumb, at locations indicated.

C. Identification: Apply decals at locations indicated.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install floor mats as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A. Concrete work is included in Division 03.

B. Flooring is included in Division 09.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, shop drawings showing materials and construction with substrate surface preparation installation procedures. Submittals shall include the following:

1. Two samples of each type of mat proposed and proposed adhesive. Sample size shall be approximately 6-in by 6-in.

1.04 REFERENCE STANDARDS

A. ASTM International

1. ASTM D178 - Standard Specification for Rubber Insulating Matting

B. Green Seal (GS)

1. GS 36 - Commercial Adhesives

C. South Coast Air Quality Management District (SCAQMD)

1. SCAQMD Rule 1168 - Adhesive and Sealant Applications

D. Where reference is made to the above standard, the revision in effect at the time of bid opening shall apply.

PART 2 PRODUCTS

2.01 FLOOR MATS

A. Electrically Energized Equipment Mats: Rubber or vinyl electric insulating type mats conforming to ASTM D178, Type I, Class 2; branded continuously on back. Bevel edges of mats or attach electric insulating rubber reducing strips as approved to provide a non-trip perimeter.

1. Locations: Provide as indicated.

2. Size: 1/4-in thick, 3-ft wide, in lengths equal to bench length or equipment piece length.

3. Materials and Construction: Construct electrically energized equipment mats of prime quality rubber compound, free of calendaring and curing defects, with narrow continuous longitudinal corrugations.

4. Color: Black.

5. Product: Provide one of the following:
   a. "ASTM Switchboard" by American Floor Products Company, Inc.
   b. "Switchboard Runner Matting," by Musson, R. C. Rubber Co.
   c. "Corrugated Switchboard," by Tennessee Mat Co.
   d. Or equal.

2.02 ACCESSORIES

A. Provide waterproof adhesive, approved by the manufacturer, for securing floor mat to substrate.

1. Toxicity/IEQ: Comply with applicable regulations regarding toxic and hazardous materials, GS-36 for Commercial Adhesive, and as specified

2.03 FABRICATION

A. Floor Mats: Shop fabricate units to greatest extent possible in sizes indicated. Unless otherwise indicated, provide single unit for each mat installation; do not exceed manufacturer's recommended maximum sizes for units that are removed for maintenance and cleaning. Where joints in mats are necessary, space symmetrically and away from normal traffic lanes. Miter corner joints in framing elements with hairline joints or provide prefabricated corner units without joints.

PART 3 EXECUTION

3.01 INSTALLATION

A. Lay floor mats in place when and where directed.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment, services and incidentals required and install and test a complete plumbing system as specified and shown on the following:

1. 22 00 00 – Plumbing - General Provisions

2. 22 10 00 – Plumbing - Piping Systems

3. 22 30 00 – Plumbing Equipment

4. 22 40 00 – Plumbing Fixtures

5. Drawings

   P-1 – Plumbing Symbols and Abbreviations
   P-2 – Electrical Building Plumbing Plan
   PD-1 – Plumbing Details

B. More specifically the work shall include, but shall not be limited to the following:

1. All items included under the Scope of Work of other Plumbing Sections.

2. Cutting, coring and rough patching in accordance with Section 01 73 29.

3. All parts necessary to make a complete Plumbing System ready for continuous operation.

4. The absence of pipe supports and details on the Drawings shall not relieve the Contractor of the responsibility for providing them.

1.02 RELATED WORK

A. The following work related to, but not covered under the plumbing work will be done under other related Sections.

1. All piping systems in the building other than the plumbing work specified in the Plumbing Sections.

2. Yard piping for sanitary drains beyond 5-ft-0-in outside the building unless otherwise indicated.

3. Source for potable and protected water and gas services shall terminate as hereinafter specified.

4. Valve tags are furnished under Section 01 13 10, but installed on Plumbing items under this Section.

5. Excavating and backfilling is included under Division 31.

6. Sump pit frames and covers not specified under the plumbing work will be included under Division 05.

7. Manholes, catch basins, gasoline trap and buried pipe encasement are included under Division 33.

8. Concrete is included under Division 03.

9. Painting is included under Division 09.

10. Portable fire extinguishers are included under Division 10.

11. Ductwork is included elsewhere in Division 23.

12. Electrical work is included under Division 26.

1.03 SUBMITTALS

A. Inspection by the Engineer's representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.

B. Submit, in accordance with Section 01 33 23, shop drawings and product data to establish compliance with this Section. Submittals shall include the following:

1. Shop drawings and technical literature covering details of all equipment, fixtures and accessories being furnished under this Section prior to fabrication, assembly or shipment.

2. Provide a recommended list of spare parts to be provided.

3. Furnish no less than 60 days before start-up, a schedule of all exposed valves installed under this Section. The schedule shall include for each valve the location, type, a number, words to identify the valve function, and the normal operating position.

4. Detailed layout drawings of all piping and equipment shall be provided. Drawings shall show the locations of piping appurtenances, specialties, and all valve banks.

5. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.

6. Provide manufacturers catalogs, literature, and engineering data on all hangers and supports. Load ratings, materials, and installation shall be in accordance with the recommendations of MSS SP-58 and MSS SP-69.

7. All submittals shall contain a statement that Sections 22 00 00, 22 10 00, 22 40 00, 22 30 00 and all other referenced Sections have been read and complied with. The certification statement shall be made by all of the following that are applicable; the

Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.

C. Operation and Maintenance Data

1. Operating and maintenance manuals shall be furnished to the Engineer as provided in 01 78 23. The manuals shall be prepared specifically for this installation and shall include all required cuts, drawings, equipment lists, descriptions, etc., that are required to assist operation and maintenance personnel unfamiliar with such equipment. The following information shall be considered a minimum. Where applicable, provide information required for specific pieces of equipment.
   a. Personnel familiar with the operation and maintenance of the specific information shall prepare manuals.
   b. Equipment shall be identified with the Engineers Equipment Numbers and Identification as shown in the Schedules and on the Drawings.

2. Contents - Each volume shall contain the following minimum contents:
   a. Installation including instructions for unpacking, installing, aligning, checking and testing. Foundation data, allowable piping loads, and electrical design shall be included.
   b. Operating Instructions to provide pre-operational checks, start up and shut down, and description of all control modes. Include emergency procedures for all fault conditions and actions to be taken for all alarms. Procedures for long term storage shall be included.
   c. Maintenance shall include preventive, and corrective. Schedules for test of other functions are to be included. Provide a list of tools required to service the equipment. Trouble shooting instructions to include a trouble-shooting guide shall be included.

3. Recommended spare parts list.

4. Shop drawing data to include performance curves, data sheets, flow diagrams, wiring diagrams, and descriptive drawings.

D. In general, corrections or comments or lack thereof, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.04 MANUFACTURERS SERVICES

A. A representative of the manufacturer who has complete knowledge of proper operation and maintenance shall be provided for the number of 8-hour days as listed below to instruct representatives of the Owner and the Engineer on proper operation and maintenance. With the Owner's permission, this work may be conducted in conjunction with the inspection and the installation and test run as provided under Part 3. If there are

difficulties in operation of the equipment due to the manufacturer's design or fabrication, additional service shall be provided at no additional cost to the Owner.

B. Provide manufacturer's services for testing and start-up of the following equipment:

1. Water Heaters (1-Day).

2. Reduced Pressure Backflow Preventers (1-Day).

1.05 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM)

B. American National Standards Institute (ANSI)

C. American Water Works Association (AWWA)

D. National Fire Protection Association (NFPA)

E. National Electrical Manufacturers Association (NEMA)

F. Plumbing and Drainage Institute (PDI)

G. Cast Iron Soil Pipe Institute (CISP)

H. Underwriters Laboratories (UL)

I. Factory Mutual (FM)

J. American Society of Plumbing Engineers Data Book (May be used as a design guide.)

K. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.06 QUALITY ASSURANCE

A. The Contractor shall be fully responsible for the proper execution and performance of the work described herein. It shall be their responsibility to inspect all installation conditions and bring to the attention of the Engineer any conditions which may affect their work adversely. They shall report to the Engineer, prior to commencing any portion of this work, any conditions unsuitable for the installation of their portion of the work.

B. All products and materials provided for potable water service application under the plumbing sections shall be certified “lead-free”, by an ANSI certified, third party independent organization. The term “lead-free” shall refer to the wetted surface of pipe, fittings, and fixtures in potable water systems that have a weighted average lead content less than or equal to 0.25 percent per the Safe Drinking Water Act (Sec. 1417) amended 1-4-2011 and other equivalent state regulations. Non-lead-free materials can be purchased and installed in non-potable water systems.

C. Mention herein or indication on the Drawings of equipment, materials, operation or methods shall require that each item mentioned or indicated be provided to make a complete system of plumbing ready for continuous operation.

D. The location of all equipment, fixtures and piping shall be considered as approximate only and the right is reserved by the Engineer to change at any time, before the work is installed, the position of such equipment and piping to meet structural conditions and to provide proper headroom clearance or for other sufficient causes and such changes shall be made without additional expense to the Owner.

E. Attention is called to the necessity for elimination of transmission of vibration from mechanical equipment to building structures. All equipment, therefore, shall be carefully selected and installed to meet this condition and isolators and water hammer arrestors shall be provided where required.

F. Instruct such persons as designated by the Owner in the care and use of all plumbing equipment and piping systems installed.

G. Comply with all the laws, ordinances, codes, rules and regulations of the State, local or other authorities having jurisdiction over any of the work specified herein.

H. Obtain all required permits and pay all legal fees for the same and in general take complete charge and responsibility for all legal requirements pertaining to this Section of the work.

I. Requirements set forth in this Section and indicated on the Drawings shall be followed when in excess of the required or minimum regulations.

J. If any work is performed and subsequent changes are necessary to conform to the regulations, such change shall be made as part of this work at no additional cost to the Owner.

K. All work shown on the Drawings is intended to be approximately correct to scale, but figured dimensions and detailed drawings shall be followed in every case. The Drawings shall be taken in a sense as diagrammatic. Size of pipes and general method of running them are shown, but it is not intended to show every offset and fitting nor every structural difficulty that may be encountered. To carry out the true intent and purpose of the Drawings all necessary parts to make complete working systems ready for use shall be furnished without extra charge.

L. Refer to the Structural and Architectural Drawings which indicate the type of construction in which the work shall be installed. Locations shown on the Plumbing Drawings shall be checked against the general and detailed drawings of the construction proper. All measurements must be taken at the building.

M. All equipment of a given type included in this Section shall be furnished by or through a single manufacturer or as specified on the schedules

N. Inspection by the Engineer’s representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.

O. The piping manufacturer shall furnish an affidavit of compliance certifying that all materials used and work performed complies with the specified requirements. The Contractor shall provide copies of mill test confirming the type of material used in the various components.

P. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

Q. An authorized representative of the manufacturer shall perform the initial startup of the equipment. The Owner and Engineer shall witness startup. The use of local sales representatives to perform this work is not acceptable, unless the manufacturer provides documented evidence that the sales representative has been specifically trained for this work.

R. All rotating parts of equipment shall be statically and dynamically balanced at the factory.

1.07 ENGINEERING SERVICES

A. When engineering services are specified to be provided by the Contractor, the Contractor shall retain a licensed professional engineer to perform the work. The engineer shall be licensed at the time the work is done and in the state in which the project is located. If the state issues discipline specific licenses, the engineer shall be licensed in the applicable discipline. In addition, the engineer shall be experienced in the type of work being provided.

B. All work is to be done according to the applicable regulations for professional engineers, to include signing, sealing and dating documents. When submittals are required by a professional engineer, in addition to state required signing and sealing, a copy of the current wallet card or wall certificate indicating the date of expiration shall be included with the submittal.

1.08 SERVICE AND UTILITY CONNECTIONS

A. Sanitary

1. The sanitary waste and drainage systems shall terminate at the sump pits or at points 5-ft-0-in outside the building or as otherwise shown on the Drawings.

B. Water Service

1. The source of water for potable and protected use in the building will be brought to the building under another Division of the work and left as a flanged connection 8-in to 12-in inside the foundation wall or above the finish floor, except where noted otherwise.

2. The backflow preventer units shall be furnished and installed complete with all components as shown on Water Piping Diagrams. The water connections shall be made to these units as shown and from these points furnish and install all water to the building, equipment, fixtures and apparatus, as shown on the Drawings.

1.09 DELIVERY, STORAGE AND HANDLING

A. All materials shall be inspected for size, quality and quantity against approved shop drawings upon delivery.

B. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed-on shipping date shall be stored without cost to the Owner by the manufacturer.

C. All materials shall be suitably packed for shipment and long-term storage. Each package shall be labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.

D. All equipment shipped that is exposed such as on a flatbed truck shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.

E. Instructions for the servicing and startup of equipment in long term or prolonged storage shall accompany each item.

F. All materials shall be stored in a covered dry location off of the ground. When required to protect the materials they shall be stored in a temperature-controlled location.

1.10 COORDINATION

A. The Drawings indicate the extent and general arrangement of the systems. If any departures from the drawings or specifications are deemed necessary, details of such departures and the reasons therefore shall be submitted as soon as practical for review. No such departures shall be made without the prior written concurrence of the Engineer.

B. The Contractor shall coordinate the location and placement of all concrete inserts and welding attachments with the structural engineer.

C. The Contractor shall assume full responsibility for coordination of the Plumbing systems, including; scheduling, and verification that all structures, piping and the mounting of equipment are compatible.

D. The Contractor shall start up each piece of equipment and system and shall make all adjustments so that the system is placed in proper operating condition.

1.11 ELECTRICAL EQUIPMENT

A. Electric motors in NEMA frame sizes shall conform to the requirements in Section 26 05 40, unless otherwise specified herein.

B. Electrical equipment which is furnished under this Section shall meet the requirements specified in Division 26:

1. Disconnect switches, motor starters and combination motor starters (starters with disconnecting means and short circuit protection) shall be as specified in Section 26 19 00.

2. Cord-connected controls for hazardous areas shall be provided with intrinsically safe relays, which shall be as specified in Section 26 19 00.

3. Raceways, boxes, fittings and supports shall be as specified in Section 26 05 33.

4. Wires and cables shall be as specified in Section 26 05 10.

C. Electrical enclosures, panels and components shall be suitable for the environment and electrical classification for the space they are located in. The type of enclosure for the various spaces shall be as specified in Division 26. Refer to the electrical drawings for the space classifications.

1.12 SUPPORTS

A. All components shall be provided with lugs, brackets or field supplied devices to allow the components to be firmly attached to the structure. The lugs, brackets or field supplied devices shall be sized to withstand the seismic and wind loads for the area and type of application.

1.13 SEISMIC RESTRAINTS

A. Seismic restraints shall be provided for all plumbing piping, and equipment as required by applicable codes. All seismic criteria and design shall comply with the International Building Code with Amendments.

B. Materials of construction for seismic supports shall be the same as those specified for equipment supports and hangers, and pipe hangers. All bolts shall be stainless steel regardless of the specified support material.

C. Restraints shall be selected from Tables for Seismic Design Category C, Occupancy Category/ Use Group III, with an importance factor of 1.25 for all components.

D. The contractor shall retain a professional engineer to provide seismic loadings and designs of seismic restraints. This will include but not be limited to the following:

1. Provide seismic loadings to the vibration isolation supplier based on actual equipment being used to allow the proper selection of vibration isolators.

2. Provide sizing of bolts for attachment of non-vibrating equipment to the structure based on the actual equipment being used.

3. Provide design of required additional bracing for equipment when vibration isolators or bolts are not adequate to withstand seismic forces.

4. Provide design of bracing for all suspending equipment.

5. Provide design of bracing for all piping.

6. Where piping is subject to thermal expansion, the loads caused by the thermal expansion and contraction shall be included in the design of the restraint bracing.

E. Signed and sealed calculations and details shall be submitted for record purposes.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 INSTALLATION

A. All the items specified in Sections 22 10 00, 22 40 00, and 22 30 00 under PART 2 shall be installed according to the applicable manufacturer's recommendations, the details shown on the Drawings and as specified herein and in other related Sections.

B. The Contractor shall start up each piece of equipment and system and shall make all adjustments so that the system is placed in proper operating condition.

C. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

D. All work shall be installed in accordance with the manufacturer's printed instructions and shall be rigid, plumb and true to line, with all parts in perfect working order. Maintain protective covers on all units until final cleanup time and at that time remove covers and clean and polish all surfaces.

3.02 VALVE TAGS

A. The work of this Section shall also include the installation of valve tags furnished by the Contractor. All valves provided under this Section shall be tagged.

3.03 PROTECTION

A. Materials, fixtures and equipment shall be properly protected at all times and all pipe openings shall be temporarily closed so as to prevent obstruction and damage.

3.04 COORDINATION SKETCHES

A. It shall be the responsibility of the subcontractor to have employed a competent coordinator of mechanical systems and as such to provide all coordination of drawings or sketches as may be required or deemed necessary by the Engineer to obtain the required ceiling heights and eliminate conflicts with all piping, ducts and electrical installation.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Refer to Section 22 00 00 for the areas where work is to be accomplished.

B. This Section specifies the basic Plumbing Systems of Piping and the materials of each system, including valves. Specific uses and applications are specified in other related Sections.

C. Furnish all labor, materials, equipment, services and incidentals required and install complete interior Plumbing Piping Systems as shown on the Drawings and as specified herein.

1. Sanitary - Waste and Vent Systems

2. Potable Hot and Cold Water Systems

3. Furnishing and installing all pipe, fittings, valves, floor drains, cleanouts, sleeves, hangers and insulation in conjunction with the above listed piping systems.

4. All piping, and equipment shown on the Drawings is intended to be approximately correct to scale, but figured dimensions and detailed drawings of the actual equipment furnished shall be followed in every case. The Drawings shall be taken in a sense as diagrammatic. Size of piping is shown, but it is not the intent to show every offset or fitting, nor every hanger or support, or structural difficulty that may be encountered. To carry out the intent and purpose of the Drawings all necessary parts to make a complete working system ready for use shall be furnished without extra charge. The Contractor shall be responsible to coordinate the system installation and routing with the work of all trades.

D. Refer to Section 22 00 00 for additional requirements.

1.02 RELATED WORK

A. Refer to Section 22 00 00.

1.03 SUBMITTALS

A. Refer to Section 22 00 00.

1.04 REFERENCE STANDARDS

A. Refer to Section 22 00 00.

1.05 SERVICE AND UTILITY CONNECTIONS

A. Refer to Section 22 00 00.

1.06 QUALITY ASSURANCE

A. Refer to Section 22 00 00.

1.07 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 22 00 00.

1.08 COORDINATION

A. Refer to Section 22 00 00.

1.09 SEISMIC RESTRAINTS

A. Refer to Section 22 00 00.

PART 2 PRODUCTS

2.01 PIPING SYSTEM MATERIALS

A. Sanitary

1. The pipe and fittings shall be SV (Service) hub and spigot cast iron soil pipe and fittings conforming to ASTM A74 and ANSI A112.5.1 tarred inside and out at the foundry.

2. Joints shall be resilient gasketed compression joints conforming to ASTM C564. Provide additional supports and hangers as required to provide piping system rigidity equal to that of leaded joints.

3. Piping above grade shall be of the above mentioned hub and spigot type or of the No-Hub type conforming to the Cast Iron Soil Pipe Institute Standards 301. Pipe shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute.

4. The No-Hub coupling shall be Anaheim Foundry Co. Husky SD4000, Clamp-All 125 or by MG Coupling Co.

5. Copper piping may be used for sanitary waste and vent in sizes 2-in and smaller. Pipe shall be Type "K" used with either cast or wrought DWV fittings. Solder Alloy 95TA (95 percent Tin, 5 percent Antimony), ASTM B32. No solder containing lead shall be utilized on the project.

B. Water Systems (Potable)

1. Piping shall be schedule 80, Chlorinated Polyvinylchloride (CPVC) conforming to ASTM standards D 1784, D 2846, F442/F442M, and F 493.

2. Fittings shall be pressure type CPVC, conforming to ASTM standards F 437 and F 439.

3. All pipe and fittings shall confirm to National Sanitary Foundation (NSF) Standards 14 and 61.

4. Joints shall be primed and solvent welded.

C. Dielectric Fittings

1. On all water piping systems, provide dielectric fittings at all locations between piping and components of dissimilar metals.

D. Insulating Fittings

1. Provide on all connections between cast or ductile iron and copper water service lines.

2. Fittings shall be of type to provide control of electrolysis.

2.02 VALVES

A. General

1. It is the intention of the Plumbing Drawings and this Section to require control valves at the bottom of all potable and protected hot and cold water service risers and as shown on the Drawings.

2. Install draw-off valves on the house side of main control valves, at the bottom of all risers, at all low points and where shown on the Drawings. Draw-offs shall consist of a hose end valve as hereinafter described.

3. Group and locate control valves in all locations so they may be easily operated, through access panels, doors, or adjacent to equipment.

4. Valves, in general, shall be of the same manufacture throughout unless noted otherwise. All valves, except as noted otherwise, shall be made for 125 lb steam working pressure and shall have round iron wheel handles.

5. All valves shall be Lead Free.

B. Water Valves

1. All water valves 2-in and smaller shall be full port ball type similar to Apollo 77CLF Series or equal.

2. All water valves 2-1/2-in and 3-in unless otherwise noted, shall be brass body gates and shall be Nibco Inc. S-113-LF or equal.

3. All water valves, 4-in and larger, shall be iron body gates, bronze trim, flanged ends, OS&Y pattern, solid wedge, rising spindle and shall be Hammond IR1140-HI or equal.

4. All check valves 3-in and smaller shall be Hammond UP912 or equal.

5. Check valves 4-in and larger shall be flanged and equal to Hammond IR1124-HI or equal.

C. Plastic Water Valves

1. Water valves in PVC piping shall be PVC body, double union type ends for solvent weld socket connections, EPDM O-rings and stem seals, PTFE seat with O-ring backup, rated for 250 psi non shock service at 73 degrees F, full port ball, and PVC lever handle. The basis of design is Chemtrol Model D, Figure U45TB-E or similar by Asahi/America, Plast-O-Matic, Georg Fischer, or IPEX.

2. Water valves in CPVC piping shall be CPVC body, double union type ends for solvent weld socket connections, EPDM O-rings and stem seals, PTFE seat with O-ring backup, rated for 130 psi at 180 degrees F, full port ball, and PVC lever handle. The basis of design is Chemtrol Model D, Figure U51TB-E or similar by Asahi/America, Plast-O-Matic, Georg Fischer, or IPEX.

D. Pressure Reducing Valves

1. Shall be Watts Regulator Co. Series LFN45-BL for 1-1/4-in and larger and Series LFN45B-EZ for units smaller than 1-1/4-in or equal with strainer and of size shown on the Drawings. Shall be diaphragm type, pressure reducing globe valves.

2. Provide and install a valve full size bypass around each PRV.

3. Provide and install an all brass strainer ahead of each PRV with pressure gauges on high and low side.

4. Smaller PRV shall have pressure setting 10 psi higher than main valve.

2.03 DRAINS

A. For the purpose of explanation and description only, the following drain catalog numbers are taken from the catalogs of Zurn Industries, Inc. unless otherwise noted. Those drains as manufactured by J.R. Smith Mfg. Co. or Josam Mfg. Co. and determined by the Engineer to be equal in every respect to those specified will be acceptable for installation. All drains shall be of sizes, shown on the Drawings.

B. Floor Drains (FD)

1. All floor drains and open-ended drains shall be fitted with a deep seal cast iron "P" type or "running" type trap to suit drain outlet. Traps shall be acid resisting material where noted.

2. Floor drains shown on the Drawings as (AW) and installed in corrosive resistant piping systems shall be of same material as the acid resisting pipe and fittings described above.

3. All floor drains shall have cast iron or acid resisting drainage flange, seepage control, clamping collar and inside caulk outlet unless noted otherwise to be IPS outlet.

4. Schedule of Floor Drains

Type	Cat. No.	Remarks
"FD"	ZN-415	Type B strainer with nickel bronze 6-inch diameter top, acid resisting coating, deep seal P-trap, and trap guard fitting.

2.04 CLEANOUTS

A. For the purpose of explanation and description only, the following cleanout catalog numbers are taken from the catalogs of Zurn Industries, Inc. unless otherwise noted. Those drains manufactured by J.R. Smith Mfg. Co. or Josam Mfg. Co. as and determined by the Engineer to be equal in every respect to those specified will be acceptable for installation. All cleanouts shall be of size shown on the Drawings.

B. In cast iron bell and spigot pipe, cleanouts shall consist of a cast iron ferrule and extra heavy brass tapered screw cleanout plug with square or hexagonal nuts.

C. In threaded pipe, (galvanized steel with recessed drainage pattern fittings) cleanouts shall consist of standard iron pipe size (IPS) brass plugs screwed into drainage fittings.

D. In copper tubing they shall consist of copper to IPS adapters with IPS brass plugs screwed into female threaded portion of the adapter.

E. Acid resisting pipe terminal cleanouts shall be of acid resisting material and of the type recommended by the manufacturer of the pipe and fittings.

F. Wall Cleanouts

1. Wall cleanouts (WCO) shall be equal to Zurn Z-1440 with stainless steel shallow cover and screw.

2. Cleanout tees shall be equal to Zurn Z-1446 or Z-1445, as suitable to the specific application.

G. Exterior Cleanouts

1. Exterior cleanouts shown as Exterior FCO shall consist of cast iron floor cleanout with serrated cutoff sections and brass screwed raised head plug, Zurn Z-1449, with heavy cast iron access box and gasketed cover, Zurn Z-1474, or equal. Set flush with concrete slab or collar.

2.05 SLEEVES AND CASTINGS

A. Sleeves

1. Sleeve all piping through walls, beams and partitions. All wall sleeves shall finish flush with the finish line.

2. Sleeve all piping passing through floor slabs. All sleeves shall extend 2-in above the finish floor slab.

3. All sleeves for exterior emergency shower eye wash units shall be packed with insulation.

4. Materials and installation conforming to the requirements of Section 01 60 09 shall be furnished under this Section.

5. Refer to "Typical Detail Sheets" for additional information.

B. Castings

1. Provide waterproof castings on each plumbing pipe penetrating walls of wet wells, tanks or pits. Castings shall be of size and length to suit pipe and wall thickness.

2. Materials and installation conforming to the requirements of Section 01 60 09 shall be furnished under this Section.

2.06 HANGERS, SUPPORTS AND ANCHORS

A. Piping support systems shall include restraints as required by the applicable building codes to withstand seismic and wind loadings. Design shall be provided by a professional engineer hired by the Contractor as specified in other Sections.

B. The absence of pipe supports and details on the drawings shall not relieve the contractor of the responsibility for providing them.

C. In certain locations, pipe supports, anchors, guides, and expansion joints may be indicated on the drawings. The contractor shall be responsible to provide a complete system of supports, expansion joints, and anchors. Additional supports may be required adjacent to expansion joints, couplings, and valves.

D. Hangers supporting the vertical stacks of soil, waste, drain, vent and rainwater leaders shall be heavy friction clamps at each floor and at 10-ft intervals. Supply and service vertical risers shall be supported by friction clamps on the riser which shall rest on the sleeve at each floor level and at 10-ft intervals.

E. Hangers supporting horizontal piping at ceilings shall be of the clevis type and spaced 5-ft apart for soil, waste, drain, rainwater leaders and vent pipes; 8-ft apart for supply and service pipe 1-1/2-in diameter and larger; and 6-ft apart for pipe smaller than 1-1/2-in diameter.

F. Horizontal piping buried in earth under lowest floor slabs or buried within the slab shall be supported with the hanger types shown on the Drawings.

G. All hangers shall be of a type to permit vertical adjustment after installation.

H. Supports and hangers for cast iron soil piping shall be installed in accordance with the latest addition of the cast iron soil pipe handbook unless noted otherwise.

I. Materials and installation shall be furnished under this Section. All hangers and supports for copper piping shall be PVC coated where in contact with copper.

J. All piping hangers, supports, and anchors shall be Type 316 stainless steel.

2.07 INSULATION

A. All water piping of every description specified herein including potable, protected, DI, emergency, and drinking fountain waste shall be completely insulated throughout with 1-in thick Heavy Density Pipe Insulation. Provide ½-inc thick insulation for piping drops located inside walls.

B. All fittings, flanges, roof drain bodies and valves shall be covered with permanently non-combustible, one-piece, factory premolded, PVC insulated fitting covers.

C. Provide at each hanger location a rigid insulation insert with a galvanized metal covering protector shield, equal to items as manufactured by Pipe Shields Inc. or equal. Protector shields shall be of length as recommended by the manufacturer and shall be the same thickness and jacket material as the adjoining insulation.

D. Insulation material shall be of molded rigid fiberglass sectional pipe insulation rated to 500 degrees F. The insulation shall have a minimum density of 3.5 lbs/cu ft and a maximum "K" factor of 0.24 at 75 degrees F mean temperature. Jacket shall be kraft paper bonded to aluminum foil reinforced with fiberglass yarn and self-sealing lap with maximum permeability of 0.02 perms.

E. All exposed piping within 10-feet of finished floor, and all exterior piping, shall have a field applied 0.016-inch thick aluminum insulation protective jacket and preformed aluminum fitting covers.

F. Supplies, drain and trap on handicapped lavatories shall be insulated with fully molded, white, closed cell vinyl insulation kit, Truebro, Model 120W-105 or equal.

2.08 PIPE MARKING AND COLOR CODING

A. Pipe marking is included in Division 09, but it shall be part of the work of this Section to assist as required by the Engineer to identify the pipe contents, direction of flow and all pertinent data required for proper marking of pipe.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install all piping, valves, hangers and appurtenances as specified herein and in the referenced Sections above.

B. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

C. In general, corrections or comments or lack thereof, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

D. Valves

1. Install control valves to all locations grouped and located to be easily operated, through access panels, doors, or adjacent to equipment.

2. Install all final Protected Water connections to Process and HVAC equipment. Each connection shall be preceded by a ball valve directly adjacent to the unit.

3. Install all valves in a horizontal to upright position. Valves shall not be installed in down position from the horizontal.

4. Securely anchor pressure reducing valves and components to wall or floor at a height as directed by the Engineer.

E. Welding

1. Welding of joints shall be by metal-arc welding process. Welding shall be by qualified welders meeting the requirements outlined in Section IX of the ASME Boiler and Pressure Vessel Code and certified by the Hartford Steam Boiler Inspection Company.

2. Welding shall not be done when the atmospheric temperature is less than 32 degrees F or when surfaces to be welded are wet.

3. Surface to be welded shall be free from loose scale, slag, rust, paint, oil and other foreign material. Joint surfaces shall be smooth, uniform and free from fins, tears and other defects which might affect proper welding.

4. Bevels shall be accurately cut by machining or by a mechanically guided cutting torch.

5. Piping shall be carefully aligned before welding and maintained in alignment during welding. Tack welds may be used to maintain alignment. They shall be the same quality as the final welds and shall be fused thoroughly therein. Defective tack welds shall be removed before the final weld is made.

6. The surface of the finished welds shall have a bright metallic luster after cleaning, a fairly smooth and uniform contour with regular ripples and be free from overlaps, undercuts and excessive convexity.

7. Welds shall be sound throughout, fused thoroughly and free from gas pockets, oxide, slag inclusions and surface porosity. The inside of the pipe shall be free from

globules of weld metal, spacers or other material which would restrict the pipe area or become loose to enter the fluid stream.

8. Defective or unsound welds shall be corrected by removing and replacing the welds. Pipe or fittings which cannot be re-welded satisfactorily shall be replaced with new pipe or fittings at the Contractor's expense.

9. All welded joints will be visually inspected by the Engineer or Owner's Representative for defects beyond those acceptable in ANSI B31.1. Method of repair shall be in accordance with instructions as received from the Engineer or Owner's Representative.

F. Flanged Connections

1. All flange faces shall be in perfect alignment with the holes straddling the vertical center line of the piping.

2. All bolts shall be well lubricated over the entire thread length with a heavy graphite and oil mixture prior to the tightening operation. Bolts shall be tightened with proper wrenches, care being taken to secure uniform pressure on the bolts and gasket and to avoid overstressing of the bolts, dishing of the flanges and compression of the gasket beyond its proper limits.
   a. Commercial grade carbon steel bolts, ASTM A307, Grade B shall be tightened to obtain approximately 15,000 psi stress based on the root area of the thread. Alloy steel bolts, ASTM A193, Grade B7 shall be tightened to obtain a stress of 45,000 psi.

3. All bolts shall be of sufficient length so that when fully tightened, a minimum of two full threads shall extend beyond the nut.

G. Screwed Connections

1. All screwed connections shall have full thread of true taper, accurate to gauge and conform to ANSI.

2. Reduction in size shall be made using reducing fittings.

3. The use of bushings or close nipples is prohibited. Nipples shorter than 4-in in length shall be Schedule 80.

4. Plugs shall be steel or brass with square head.

5. Screwed joints shall be made with an approved joint compound applied to the male thread only. Caulking of screwed joints will not be allowed.

H. Soldering (Copper Tubing)

1. Tubing shall be cut with square ends and reamed to prevent burrs, out-of-round or improperly sized ends.

2. After cutting, all surfaces to be soldered shall be thoroughly cleaned to a metal-bright finish, free from dirt, grease or other material before fluxing and soldering. This cleaning shall be performed by using emery cloth, sandpaper or steel wool. Clean the outside end of the tubing for a length of 1/2-in greater than the depth of the fitting. The inside of the fittings shall be cleaned in a similar manner. Apply non-corrosive flux and assemble the joint. Acid solder or acid flux will not be allowed.

3. The surfaces to be joined shall be heated up slowly and uniformly to the melting point of the solder. The surface being soldered shall be maintained above the melting point of the solder for sufficient time to draw the solder completely into the joint. When the solder congeals to a plastic state the excess metal shall be removed with a cloth brush, leaving a fillet around the end of the fitting. Full penetration of the solder uniformly throughout the entire socket is required. The soldered joints shall be allowed to cool in still air until only warm to the hand after which the work may be quenched.

4. Any type of crack, pinhole, area of incomplete penetration, or similar defect will not be accepted. Peening for closing up defects shall not be permitted.

5. Heating torches of sufficient size shall be used for heating of large fittings prior to soldering. Multiple tips or ring burners for use on combination torches may be used.

6. Remove all external and internal loose solder and flux after joint cools.

I. Grooved Joints

1. Grooved piping joints are to be made in strict accordance with the joint manufacturer’s recommendations. The depth, width and distance from the end of the pipe are to all be within the joint manufacturers tolerances.

2. Grooves are to be cut in steel piping systems. Piping shall be cut to length and squared before grooving.

3. Lubricant for the gaskets shall be supplied by the joint manufacturer. Gaskets are to be checked to be sure that they are the proper gasket for the piping system. Lubricant shall be applied to the gasket prior to installing the gasket on the pipe.

4. The gaping between the ends of the pipe being joined is to be set based on the piping systems needs to expand and contract. In general pipe expansion and contraction in grooved piping systems is to be taken up by the proper gaping of the individual joints.

5. The housing is to be assembled around the piping being sure that the housing does not pinch the gasket and that it also drops into the grooves on the two sections of piping. Bolts are to be tightened by hand uniformly. Only metal to metal contact is required between the segments of the housing. Do not over tighten the bolts.

J. Brazing

1. Cutting and cleaning of tubing shall be as specified for soldering operations.

2. Apply flux in accordance with recommendations of manufacturer of brazing filler material being used. Apply to outside of fitting and heat affected area of tubing. Avoid getting flux inside tube. Flux may be omitted when joining copper tubes to wrought copper fittings but is required for joining to cast (bronze) fittings.

3. Assemble joint by inserting tube into socket hard against stop and turning.

4. Heat parts to be joined beginning 1-in from edge of fitting, continuously moving the flame. When flux has become transparent, begin to heat the fitting at the base of the cup, still continuously moving the flame. When flux at fitting is quiet and transparent, maintain heat along joint by moving flame along axis between fitting and tubing.

5. Apply brazing material at point were tubing enters socket of fitting. Avoid putting flame on brazing material. Heated joint should melt brazing material and capillary action will draw material into the joint. When joint is properly made, a fillet of filler metal will be visible completely around the joint. Stop adding filler metal when fillet is formed.

6. After brazing material has solidified, clean off flux residue. Fittings must cool naturally. Quenching will not be allowed.

7. Any type of crack, pinhole, area of incomplete penetration, or similar defect will not be accepted. Penning for closing up defects will not be permitted.

K. Joints for Plastic Pipe

1. Joints for PVC and CPVC pipe shall be solvent cemented unless flanged or threaded are otherwise shown on the Drawings or are specified as other types herein. In making solvent cemented connections, clean dirt and moisture from pipe and fittings, bevel pipe ends slightly with emery cloth to remove any shoulder or burrs created by cutting of the pipe. Solvent cement joints shall be made in accordance with ASTM D2855 except that solvent cement formulated especially for and as specified above shall be used for joining CPVC pipe and fittings. Primer shall be used whenever recommended by the pipe, fitting, or cement manufacturer and in all cases for joints on pipe systems 4-in in diameter or larger. Making solvent cement joints shall not be performed when the temperature, measured in the shade, is 40 degrees F and falling.

2. Joints between PVC drain, waste and vent pipe and cast-iron soil pipe shall be made with approved mechanical compression joints designed for such use.

L. Insulation

1. Do not apply insulation until pipes and tanks have been tested and accepted by all parties making inspection. All insulated covering shall be guaranteed for a period of one year.
   a. Insulate hot and cold water runouts to fixtures in partitioned pipe spaces.
   b. Insulate drops to wash hose stations and hose outlets to a point six feet above the floor.

c. Short exposed supply pipe at or immediately near regular plumbing fixtures shall not be covered but shall be finished as trim for regular plumbing fixtures specified in PART 2 of Section 22 40 00.

M. Cleanouts

1. Install cleanouts as directed by applicable code, at end of each branch soil, waste and rainwater line where rainwater, waste and soil lines change direction, at the bottom of every riser either as a cleanout tee above floor or end cleanout in the horizontal below the floor.

3.02 FIELD TESTING

A. Provide all air and water necessary for testing the piping systems as specified under this Section of the work. Provide all connections for testing under this Section. Remove all debris resulting from testing. Use the water in an efficient and economical manner.

B. Provide all apparatus and all other supplies or materials which may be necessary for testing the systems and operating the apparatus during the period while tests of any kind are being made, or for carrying out the work of the Contract.

C. The various piping systems shall be subjected to water, smoke, or air tests as noted and shall hold tight at pressures stated without extra pumping or water addition for the time intervals stated.

D. All additional tests, methods or materials that may be required by the local ordinances and not specifically specified herein, shall be made as directed by the Engineer or the local inspection authority.

E. Provide for all repeated tests as necessary to make systems tight as required.

F. Test soil, waste, drain, and vent piping as follows:

1. Test rough drainage of soil, waste, drain, and vent piping by plugging piping where it terminates in the building or where it leaves the building by filling each system completely with water to the outlets on the roof after all outlets in section have been plugged or capped, for at least 1-hour duration.

2. If it becomes necessary during the construction of the building to test a part of a section for any reason or to cover permanently any pipe before piping above the part or section has been completed, apply a water test to such part or section of the piping by maintaining a 10-ft head of water on the highest section of the piping and the test shall hold tight for 1 hour.

G. Test water piping as follows:

1. Test all interior potable hot, cold and protected water piping to a water pressure of 150 psi to the lowest level and maintain this pressure without additional pumping for 2 hours.

3.03 CLEANING

A. At the completion of the work, clean all piping, fixtures, equipment, apparatus and exposed trim for same included in this Section and, where required, polish ready for use.

B. Thoroughly disinfect the entire potable water distribution systems with a solution of not less than 50 ppm of available chlorine. Allow the disinfecting solution to remain in the system for a period of 3 hours after which time, open all valves and faucets and flush the system with clean water until the residual chlorine content is not greater than 0.2 ppm, unless otherwise directed.

3.04 PAINTING

A. CPVC and PVC pipe and fittings exposed to the direct sunlight shall be field painted to provide additional UV protection. This painting shall be required whether or not marking is required.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Refer to Section 22 00 00 for the areas where work is to be accomplished.

B. Furnish all labor and materials required and install the following Plumbing Equipment:

1. Caution Sign
2. Water Hammer Arresters
3. Thermometers
4. Pressure Gauges
5. Water Heaters (Electric)
6. Reduced Pressure Zone Backflow Preventer
7. Thermostatic Water Controller Assembly (Mixing Valve)
8. Hose Bibb (HB)

C. Refer to Section 22 00 00 for additional requirements.

1.02 RELATED WORK

A. Refer to Section 22 00 00

1.03 SUBMITTALS

A. Refer to Section 22 00 00.

1.04 REFERENCE STANDARDS

A. Refer to Section 22 00 00.

1.05 QUALITY ASSURANCE

A. Refer to Section 22 00 00.

1.06 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 22 00 00.

1.07 SEISMIC RESTRAINTS

A. Refer to Section 22 00 00.

PART 2 PRODUCTS

2.01 GENERAL

A. The use of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired.

B. Similar items of materials/equipment shall be the end products of one manufacturer in order to provide standardization for, appearance, operation, maintenance, spare parts and manufacturer's service.

C. Attention is particularly called to the fact that written approval of all specified equipment proposed for purchase shall be received from the Engineer before purchase of any equipment or components of the equipment.

2.02 ELECTRICAL EQUIPMENT

A. Refer to Section 22 00 00.

2.03 ATTACHMENTS

A. All equipment shall be provided with lugs, brackets, or field supplied devices to allow all equipment to be firmly attached to the structure. The lugs, brackets or field supplied devices shall be sized to withstand the seismic and wind loads for the area and type of application.

2.04 WATER HAMMER ARRESTERS (WHA)

A. Water hammer arresters shall be sized in accordance with manufacturer's recommendations.

B. Arresters shall be stainless steel bellows type as manufactured by J.R. Smith Co.; Zurn Industries Inc. or equal.

2.05 THERMOMETERS (T)

A. Thermometers shall be red reading mercury, adjustable angle, stem type, with 9-in long scale. Range shall be 30 to 240 degrees F with 2-degree scale divisions.

B. Thermometers for installation in piping shall have separable sockets. Sockets for installation in insulated piping shall be of the extended neck type to extend beyond the pipe insulation.

C. Units shall be manufactured by H.O. Trerice Co.; Weiss Instruments; Taylor or equal.

2.06 PRESSURE GAUGES (PG)

A. Shall be 4-1/2-in dial, phenolic turret case, micro-adjustable pointer and Type 316 stainless steel movement, solid front gauge.

B. Bourdon tube and connection shall be Type 316 stainless steel.

C. Accuracy shall be 1/2 percent of span.

D. Range shall be selected so that the expected normal pressure will be read at or slightly above the midpoint of the range.

E. All pressure gauges shall be fitted with a stop cock or ball valve.

F. Gauges shall be Ametek/U.S. Gauge Series 1900, similar unit by Ashcroft/Dresser or equal.

2.07 WATER HEATERS

A. Water heaters and storage tanks shall conform to the most current applicable energy conservation regulation and codes. All heaters shall be provided with lugs, brackets or field supplied devices to allow the equipment to be firmly fastened to the structure. The lugs, brackets or field supplied devices shall be sized to withstand the expected seismic loads for the area and type of application. Location of the attachments shall be based on the equipment being hung or base mounted as shown on the Drawings and the schedules.

B. Electric Water Heater (EWH-1)

1. Shall be point of use electric water heater.

2. Heating element shall be 3000 Watt, 208 VAC, single phase, removable immersion type.

3. Shall be equipped with immersion thermostat with adjustable range, integral Hi-Limit with manual reset for over temperature protection, pressure and temperature relief valve, vacuum valve, NEMA 4X stainless steel water proof corrosion resistant cabinet, and wall brackets provided by the heater manufacturer.

4. Unit shall be a Model EX3208T-N4X as manufactured by EEMAX or equal.

2.08 THERMOSTATIC MIXING VALVE (MXV)

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Leonard Valve Company.
   b. WATTS.
   c. Zurn Industries, LLC.

2. Standard: ASSE 1017.

3. Pressure Rating: 125 psig.
4. Type: Thermostatically controlled, water mixing valve.
5. Material: Bronze body with corrosion-resistant interior components.
6. Connections: Threadedor union inlets and outlet.
7. Accessories: Check stops on hot- and cold-water supplies, and adjustable, temperature-control handle.
8. Tempered-Water Setting: 104 deg F.
9. Tempered-Water Design Flow Rate: 0.5 gpm.
10. Valve Finish: Rough bronze.

2.09 REDUCED PRESSURE ZONE BACKFLOW PREVENTER (BFP)

A. Shall be of the size shown on the Drawings and body shall be constructed of bronze for sizes less than 2-1/2-in and epoxy coated cast iron for sizes 2-1/2-in and larger.

B. Each unit shall be complete with two companion OS&Y gate (full bore ball) valves equipped with test connections. Valves shall be of similar material as that of the backflow device body, including epoxy coating. Unit shall have replaceable bronze seats and captured springs.

C. Each unit shall be provided with a complete set of spare parts, which shall be stored adjacent to the unit in a wood crate labeled with list of contents.

D. Unit shall be supported on galvanized steel floor stanchions with floor flange secured to floor.

E. Unit shall be of the manufacture that meets the approval of the authority having jurisdiction. Submittal for approval shall be accompanied by the authority's "acceptable device list" or alternately by their written approval.

F. Acceptable manufacturers shall include Watts Regulator; Hersey; Cla-Val Co. or equal.

2.10 HOSE BIBB (HB)

A. Hose bibbs shall be a Chicago Faucet Co., No. 952-CP or equal, chrome plated, inside sill faucet with vacuum breaker, 3/4-in hose thread outlet and loose key handle. (For use in Toilet Rooms.)

PART 3 EXECUTION

3.01 INSTALLATION

A. Install all the items specified under PART 2 according to the applicable manufacturer's instructions and the details shown on the Drawings.

B. Install protected water wash hose stations and hose outlets approximately 4-ft-0-in above the finished floor.

C. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

D. Install water hammer arresters on all potable and protected water lines, at top of all risers and immediately adjacent to all quick closing mechanical and electrical operating valves and on all flush valve headers.

E. Install vacuum valves, pressure relief and temperature relief valves on the potable and protected hot water tanks and heaters. Pipe relief valves to drain over floor drains.

F. Install flow switch as described above for emergency shower and eye wash units in the horizontal pipeline; it shall be on top of the pipe with the vane vertical. It shall be located at a specified distance from any fitting that changes the direction of flow, as recommended by the manufacturer.

3.02 CLEANING

A. Properly protect all materials and equipment at all times to prevent obstruction and damage. Maintain protective covers on all units until final clean-up time.

B. At the completion of the work, all equipment and exposed trim for the same included in this Section shall be thoroughly cleaned and, where required, polished ready for use.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Refer to Section 22 00 00 for the areas where work is to be accomplished.

B. Furnish all labor and materials required and install the following Plumbing Fixtures and companion Fixture Trim.

1. Water closets

2. Lavatories

C. Refer to Section 22 00 00 for additional requirements.

1.02 RELATED WORK

A. Refer to Section 22 00 00.

1.03 SUBMITTALS

A. Refer to Section 22 00 00.

1.04 REFERENCE STANDARDS

A. Refer to Section 22 00 00.

1.05 QUALITY ASSURANCE

A. Refer to Section 22 00 00.

1.06 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 22 00 00.

1.07 SEISMIC RESTRAINTS

A. Refer to Section 22 00 00.

PART 2 PRODUCTS

2.01 GENERAL

A. The use of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired.

B. Similar items of materials/equipment shall be the end products of one manufacturer in order to provide standardization for appearance, operation, maintenance, spare parts and manufacturer's service.

2.02 MATERIALS

A. Exposed fixture trim shall be brass chrome plated unless otherwise noted.

B. Water Closet and Urinal supplies from wall shall be chrome plated at all locations.

C. All fixture traps shall be brass chrome plated except for Water Closets, Urinals, Mop Sinks and as otherwise noted.

D. All supply and waste nipples shall be fitted with one-piece set screw cast brass escutcheons finished in the same manner as pipes they serve.

2.03 PLUMBING FIXTURES AND TRIM

A. For the purpose of explanation and description only, plumbing fixtures and trim plate numbers are from the catalogs of Kohler Co. and Elkay Manufacturing Co. unless otherwise noted.

B. Fixtures shall be as manufactured by the Kohler Co.; American Standard Inc.; Eljer Plumbingware; Elkay Manufacturing Co.; Just Manufacturing Co. or equal.

C. Obtain written approval from the Engineer before purchasing all equipment and fixtures.

D. Refer to Architectural and Structural details of partitions and floor finish before placing order for brackets and supports for fixtures.

E. Height of rim of all fixtures from finish floor shall be as shown on the Architectural details. Chair carrier standards shall be of sufficient length to meet these requirements and handicapped fixture requirements.

2.04 WATER CLOSET (WC-HP) (HANDICAPPED)

A. Water closet shall be vitreous china wall hung elongated bowl, 1.5-gallon siphon jet flushing with 1-1/2-in top spud, Kohler K-4330 Kingston Lite or equal. Top of seat shall be between 17-in and 19-in above finish floor for handicapped use.

B. Flush valve shall be Sloan-Royal 111 or equal, 1.5-gallon flush valve with vacuum breaker, 1-in screwdriver angle stop and chrome plated flush connection.

C. Seat shall be white solid plastic, extended back, open front and less cover with check hinge as manufactured by Church; Bemis or equal.

D. Combined carrier and drainage fitting shall be suitable to provide 18-in height of rim above finish floor required for handicapped closet and shall be as manufactured by J.R. Smith Co.; Zurn Industries, Inc.; Josam Manufacturing Co. or equal.

2.05 LAVATORY (LAV-HP) (HANDICAPPED)

A. 20-in by 18-in vitreous china lavatory with 5-in back, rectangular basin, anti-splash rim, front overflow, two soap depressions and punched for concealed arm brackets, Kohler K-2032 Greenwich or equal.

B. Metering 0.5 gpm lavatory faucet with Maxline thermostatic mixing valve, Symmons-Scot SLC-6000-ML or equal.

C. Lavatory drain with perforated strainer, Kohler K-7717 or equal.

D. Kohler K-7601, or equal, 3/8-in angle supply with loose key stops and annealed vertical tube, chrome plated with cast brass escutcheons.

E. Kohler K-9010 or equal, 1-1/2-in chrome plated cast brass P trap with cleanout plug. K-9015 chrome plated brass waste nipple and cast brass chrome plated escutcheons.

F. Concealed arm chair carrier with foot support of type suitable to meet building conditions as manufactured by J.R. Smith Co.; Zurn Industries, Inc.; Josam Manufacturing Co. or equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install all the items specified under PART 2 according to the applicable manufacturer's instructions and the details as shown on the Drawings.

B. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

C. Install all fixtures and trim in accordance with the manufacturer's printed instructions and install rigid, plumb and true to line, with all parts in perfect working order.

D. Installation of the plumbing fixtures and accessories shall meet the applicable requirements of the Physically Handicapped Code and shall be located as shown and detailed on the architectural drawings.

3.02 CLEANING

A. Properly protect all plumbing fixtures and trim at all times and temporarily close all openings to prevent obstruction and damage.

B. Maintain protective covers on all units until final clean-up time and, at that time, remove covers, clean and polish all fixtures and trim surfaces.

C. At the completion of the work, clean, polish and make ready for use, all fixtures, equipment, apparatus and exposed trim included in this Section.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. These Sections and Drawings cover(s) the requirements of the HVAC Work to be performed and shall not void any of the requirements specified under the General Conditions or General Requirements.

B. The areas where work is to be accomplished are specified and shown in the following:

1. Specification Sections
   23 00 00 HVAC
   23 05 93 Testing, Adjusting, and Balancing

2. Drawings
   H-1 HVAC Symbols and Abbreviations
   H-2 Electrical Building HVAC Plan
   HD-1 HVAC Schedules and Details

C. The requirements specified herein shall be modified only if specified otherwise for particular application in other Divisions.

D. This HVAC specification is incomplete without the information contained on the Drawings and in the Schedules on the drawings.

E. Work included under the "Scope of Work" of this HVAC Section includes all labor, material, equipment, tools and services necessary to furnish, deliver, unload, install, test and place in satisfactory operation, the equipment, services and systems as called for under the HVAC Section(s) including any incidental work not shown, or not specified but which can reasonably be inferred as belonging to the various systems and necessary in good practice to provide complete and fully operational systems. Cutting and patching is included in this Section and shall be done as described in Section 01 73 29 unless otherwise indicated.

F. Equipment shall consist of the following:

1. Fans

2. Split system units, condensing units, air handling units, and filters

3. Electric Unit Heaters

G. The following work descriptions are not intended to in any way limit the above broad statement but are intended as a more specific mention of the most important items included therein.

1. For all Areas:
   a. Contractor shall provide temporary air conditioning, heating, and/or ventilation systems for all new construction as required for start-up/testing/operation of process equipment and/or electrical systems when the new HVAC systems are not operational. Refer to the drawings for new air conditioning system, heating system, and ventilation system capacities.
   b. All work done regarding refrigerant removal and replacement shall be in accordance with all Federal, State and Local laws and regulations. This includes, but is not limited to, evacuation, purging, and testing. All refrigerant shall be captured, and no refrigerant shall be released to the atmosphere. Contractor shall provide all necessary refrigerant as required to recharge the systems at the completion of the relocation, and after the equipment is returned to its original location.
   c. Coordinate salvage/disposal with the requirements of Section 02 41 00 and the Owner.

2. Electrical Room: Provide split system electrical room air conditioning systems, including all associated equipment, controls, ductwork, air distribution devices, and piping.

H. Design Conditions

1. Outdoor Design Conditions

Summer:	93ºF Dry-bulb,77ºF Wet-bulb
Winter	18ºF Dry-bulb
Approximate Heating Degree Days	3254
Approximate Cooling Degree Days	1544
Site Elevation (Approximate)	676.0 ft. Above Sea Level

2. Indoor Design Conditions

Space designation	Summer Space Temp. ºF	Winter Outdoor Air Vent.	Space Temp. ºF	Outdoor Air Vent.
Electrical Room	80ºF±5ºF	N/A	50ºF±5ºF	N/A

I. This Section is incomplete without the information contained in the HVAC equipment schedules on the Drawings. Provide equipment of the type, size, capacity and arrangement as shown on the Drawings and as scheduled. Equipment shall consist of the particular components listed in the schedules in addition to those components normally required for the type of unit. The order of component assembly will be as stated in the schedule. Particular attention must be paid to the remarks and notes in the schedules and on the Drawings.

J. All ductwork, piping, and equipment shown on the Drawings is intended to be approximately correct to scale, but figured dimensions and detailed drawings of the actual equipment furnished shall be followed in every case. The Drawings shall be taken in a sense as diagrammatic. Size of ductwork and piping are shown, but it is not the intent to show every offset or fitting, nor every hanger or support, or structural difficulty

that may be encountered. To carry out the intent and purpose of the drawings all necessary parts to make a complete working system ready for use shall be furnished without extra charge. The Contractor shall be responsible to coordinate the system installation and routing with the work of all trades.

K. Furnish and install all HVAC Systems in accordance with all requirements of the International Mechanical Code with Amendments, International Building Code with Amendments, NFPA 820, all other applicable codes and standards and the requirements of this specification.

1.02 RELATED WORK

A. Cutting and patching is included in Division 01, except for items specified herein.

B. Temporary, cooling, heating, electric power and lighting is included in Division 01.

C. Trenching, excavation and backfill is included in Division 31, except for items specified herein.

D. Concrete work is included in Division 03, except for required HVAC anchor bolts, sleeves and templates which shall be furnished under this Section.

E. Structural steel and miscellaneous metal is included in Division 05, except for supplementary steel required for HVAC hangers, equipment supports, anchors and guides, which shall be furnished under this Section.

F. Painting is included in Division 09, except for factory finished HVAC equipment, HVAC shop painting and HVAC identification labeling.

G. Heat tracing for hot water piping is included in Section 40 41 13.

H. Electrical field wiring is included in Division 26, except for field wiring for automatic temperature controls as specified herein or as shown on the HVAC Drawings.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, shop drawings and product data for the following:

1. Catalog cuts and data sheets for all equipment.

2. Design calculations for record purposes, signed and sealed by a professional engineer hired by the Contractor as specified in 1.08, Engineering Services. Engineering services shall be provided as required in Part 2.

3. Automatic control drawings with composite wiring diagrams, including bills of material and descriptions of operation for all systems. Panel layouts and name plate lists for all local and central panels. Data sheets for all control system components.

4. Software licensing and user agreements will be submitted for approval with the shop drawings for the equipment using the software. The submittal shall be a copy of the final agreement document that is to be signed.

5. Complete damper schedules for damper submittals including the following for each type or model of damper to be furnished for the project: materials of construction for blades, frames, bearings, linkages and seals; flow and leakage characteristics; typical operating torque requirements or characteristics; options to be furnished; general installation and maintenance instructions. Damper schedules shall include damper type; unit served; damper service; damper size; duct size; drive linkage location; installation arrangement (flanged or in duct) and damper operator type.

6. All fans, submit in accordance with sections 01 33 23 and 23 00 00, all data on the fan schedules. In addition, the submittal shall include catalog data, fan data sheets with a description of the proposed fan, fan size, type, arrangement, materials of construction, weight, motor horsepower, motor type, power supply, and frame size. Provide catalog data and selections for vibration isolators, include materials of construction. For belt drive equipment; provide drive data indicating the sheave sizes, belts size, number and length. Each submittal shall include pertinent equipment dimensional data, fan performance (operating data) information, and a performance curve showing the fan operating point and range. Minimum curve size shall be 8-in by 6-in. Faxed copies of curves are not acceptable. A list of accessories to be furnished shall be included on each submittal. Copies of operating and maintenance manuals shall be submitted. Significant dimensional differences between the specified equipment and the proposed equipment shall be noted on the equipment submittal. The contractor shall provide data to show the dimensionally different equipment will fit within the space and still provide suitable clearance. Where corrosion resistance is required, provide conformation of material suitability for the specified service. Where called for on the schedules, provide certified test data for the fans.

7. For all air handling units, submit, in accordance with Section 01 33 23 and 23 00 00, the following:
   a. Unit data sheets; to include catalog data, a description of the proposed unit, size, type, arrangement, and materials of construction.
   b. For belt drive equipment, provide drive data indicating sheave sizes, belt size, number and length.
   c. Each submittal shall include pertinent equipment dimensional data, heating and cooling coil operating data. Submit, in accordance with Sections 01 33 23 and 23 00 00, all data and the unit schedules. The submittal shall include fan data sheets with a description of the proposed fan, fan size, type, arrangement, materials of construction, weight, motor horsepower, motor type, power supply, and frame size. Provide catalog data and selections for vibration isolators, include materials of construction. For belt drive equipment; provide drive data indicating the sheave sizes, belts size, number and length. Each submittal shall include pertinent equipment dimensional data, fan performance (operating data) information, and a performance curve showing the fan operating point and range. Minimum curve size shall be 8-in by 6-in. Faxed copies of curves are not acceptable. A list of accessories to be furnished shall be included on each submittal. Copies of operating and maintenance manuals shall be submitted. Significant dimensional differences between the specified equipment and the

proposed equipment shall be noted on the equipment submittal. The Contractor shall provide data to show the dimensionally different equipment will fit within the space and still provide suitable clearance. Where corrosion resistance is required, provide conformation of material suitability for the specified service.

d. For heating sections, provide information on type of heating, air entering and leaving conditions, air pressure drop, heating media entering and leaving conditions and flow or consumption, and pressure drop. Provide size, type, arrangement, materials of construction, and operating weight.
e. For cooling sections, provide information on type of cooling, air entering and leaving conditions, air pressure drop, cooling media entering and leaving conditions, flow, and pressure drop. Provide size, type, arrangement, materials of construction, and operating weight.
f. For condensing sections provide information on number and type of compressors, type of refrigerant and refrigerant charge, and controls provided and operating weight. Provide electrical data for power and controls. For condensing coils, provide air entering and leaving conditions, air pressure drop, size, type, arrangement, and materials of construction.
g. Pertinent data on standard filters: types and sizes, quantity of modules required for each filter type, efficiency ratings performance data and manufacturer catalog cutsheets.
h. Pertinent data on chemical filters: type and description of media, sizes of modules, quantity of modules required per module, performance data based on contaminant concentrations indicated on the schedules, estimated life of chemical filters based on expected contaminant concentrations at site and manufacturer catalog cutsheets.
i. Include chemical media sampling services. Indicate contact name, company address and phone number of designated factory representative who will conduct sampling services for Owner.
j. Include cost of replacement chemical filter media.
k. List of accessories to be furnished shall be included on each submittal.
l. Provide a recommended list of spare parts to be provided.

8. Detailed equipment, ductwork and piping layout drawings; minimum scale 1/4-in = 1-ft-0-in for interior systems and equipment, dimension clear service spaces for motors and drives, filter, coils and spacer section access doors, and ductwork access panels and doors. (Site layout drawings and roof plans showing HVAC equipment and systems may be prepared and submitted at scales smaller than 1/4-in = 1-ft-0-in, subject to Engineer's prior approval.)

9. Standard shop and field installation details for transitions, elbows, takeoffs, discharge nozzles, turning vanes, access panels and doors, volume control and splitter dampers and extractors.

10. Piping and appurtenances, materials and joining methods. Pipe hanger materials and methods.

11. Ductwork materials, joining methods, reinforcing and material gauges. Where options are allowed by SMACNA, the proposed option shall be clearly defined. Indicate proposed materials and methods for ductwork and equipment hangers.

12. Prepare dimensional comparisons between proposed equipment and scheduled equipment when the proposed equipment is dimensionally larger than that scheduled. Do not propose dimensionally larger equipment from an alternate manufacturer for installation in confined areas, or when the installation of alternate equipment will result in reduction of service access below that recommended by the manufacturer.

13. Prepare layouts showing size, arrangement, and routing of field fabricated refrigerant piping for split-systems and air handling units with remote condensers. Include a letter from the AC system manufacturer indicating their approval of the proposed sizing and routing.

14. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.

15. When special hangers, supports, anchors, or hold downs are required that are not covered by standards provide signed and sealed calculations and details for record purposes.

16. All submittals shall contain a statement that Section 23 00 00, 23 34 00, 23 05 93, and all other referenced Sections have been read and complied with. The certification statement shall be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved and shall be included with every submittal and resubmittal.

17. Submit air system testing, adjusting and balancing reports for review and approval.

18. Operation and Maintenance Data
    a. Submit to the Engineer as provided in Section 01 78 23, Operating and Maintenance Manuals. The following information shall be considered a minimum. Where applicable, provide information required for specific pieces of equipment.
        1) Personnel familiar with the operation and maintenance of the specific information shall prepare manuals.
        2) Equipment shall be identified with the Engineers Equipment Numbers and Identification as shown in the Schedules and on the Drawings.
    b. Contents - Each volume shall contain the following minimum contents:
        1) Installation including instructions for unpacking, installing, aligning, checking and testing. Foundation data, allowable piping loads, and electrical design shall be included.
        2) Operating Instructions to provide pre-operational checks, start up and shut down, and description of all control modes. Include emergency procedures for all fault conditions and actions to be taken for all alarms. Procedures for long term storage shall be included.
        3) Maintenance shall include preventive, and corrective. Schedules for test of other functions are to be included. Provide a list of tools required to service the equipment. Trouble shooting instructions to include a trouble-shooting guide shall be included.
    c. Spare Parts List

d. Shop Drawing Data to include performance curves, data sheets, flow diagrams, wiring diagrams, and descriptive drawings.

19. Submit the following for each insulation by System: manufacturer's product data showing conformance with this Section for all required insulation, jackets, covers, coatings, adhesives, fasteners, supports and appurtenances; complete manufacturer's instructions for installation of all required items.

20. All materials deliveries must have accompanying manufacturer's certifications attesting to satisfactory results of product testing showing conformance with this Section.

21. Provide a recommended list of spare parts to be provided.

22. In general, corrections or comments or lack thereof, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.04 REFERENCE STANDARDS

A. These standards shall be considered as minimum requirements. This is a general list and not all standards listed are necessarily referenced elsewhere in this Section. Specific requirements of this Section and/or Drawings shall have precedence. In case of conflict between published requirements, the Engineer shall determine which is to be followed.

B. Abbreviation and the title of Federal, State and industry standards, technical societies, associations and institutes and other organizations which may be used are as follows:

1. Associated Air Balance Council (AABC)

2. American Conference of Governmental Industrial Hygienists (ACGIH)

3. Air Diffusion Council (ADC)

4. American Bearing Manufacturers Association (ABMA)

5. Air Movement and Control Association (AMCA)

6. American National Standards Institute (ANSI)

7. Air Conditioning and Refrigeration Institute (ARI)

8. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)

9. American Society of Mechanical Engineers (ASME)

10. American Society for Testing and Materials (ASTM)
11. Factory Mutual (FM)
12. Institute of Electrical and Electronic Engineers (IEEE)
13. National Institute of Standards and Technology (NIST)
14. National Environmental Balancing Bureau (NEBB)
15. National Electrical Code (NEC)
16. National Electrical Manufacturers Association (NEMA)
17. National Fire Protection Association (NFPA)
18. Occupational Safety and Health Administration (OSHA)
19. Sheet Metal and Air Conditioning Contractors National Association (SMACNA)
20. Underwriters Laboratories (UL)

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Contractor shall comply with the following criteria:

1. Has been regularly engaged in the installation of Mechanical (HVAC) systems.
2. Has performed work of similar or greater complexity on at least three (3) projects within the last five (5) years. Submit documentation demonstrating required experience.
3. Submit a minimum of two references for projects of similar or greater complexity.
4. Submit resumes of key personnel to be utilized on this project.

B. Provide single source supplier/installer responsibility for the following systems or services:

1. ATC Equipment
2. Thermal Insulation
3. Testing and Balancing
4. Air Conditioning Systems
5. Fans

C. Provide single source supplier/installer responsibility for systems where specified in other related Sections.

D. Services of Manufacturer's Representative

1. Provide services of a manufacturer's service engineer or test engineer, as required in Section 01 13 10, specifically trained on type of equipment supplied or service provided. Submit qualifications of service engineer for approval. Man-day requirements listed below are exclusive of travel time and do not relieve Contractor of obligation to provide sufficient service to place equipment in satisfactory operation.
   a. Equipment (Air Conditioning Systems, Fans, Make-up Air Units, Electric Unit Heaters) - Start-up and Operation and Maintenance Instructions. 2 Man-days.
   b. Automatic Temperature Controls - Operation and maintenance instructions. 2 Man-days.
   c. Testing and Balancing - Spot check HVAC system flows and system inspection during the first year of operation at Owner's request exclusive of repair, malfunction, or other trouble-shooting service calls. 2 Man-days.

E. The insulation materials to be furnished under this section shall be essentially the standard products of manufactures regularly engaged in the manufacture of insulation systems.

F. Several manufacturers are indicated as acceptable for each type of insulation in these specifications. The insulation sub-contractor shall be responsible for determining that all insulation supplied for the project is suitable for installation in the spaces indicated. The insulation sub-contractor shall also insure that all materials used are compatible and in compliance with applicable codes and standards.

G. All equipment of a given type included in this section shall be furnished by or through a single manufacturer or as specified on the schedules.

H. Inspection by the Engineer’s representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.

I. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

J. An authorized representative of the manufacturer shall perform the initial startup of the equipment. The Owner and Engineer shall witness startup. The use of local sales representatives to perform this work is not acceptable, unless the manufacturer provides documented evidence that the sales representative has been specifically trained for this work.

K. All rotating parts of equipment shall be statically and dynamically balanced at the factory.

1.06 DELIVERY, STORAGE AND HANDLING

A. All materials shall be inspected for size, quality and quantity against approved shop drawings upon delivery.

B. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed-on shipping date shall be stored without cost to the Owner by the manufacturer.

C. All materials shall be suitably packed for shipment and long-term storage. Each package shall be labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.

D. All equipment shipped that is exposed such as on a flatbed truck shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.

E. Instruction for the servicing and startup of equipment in long term or prolonged storage shall accompany each item.

F. All materials shall be stored in a covered dry location off of the ground. When required to protect the materials they shall be stored in a temperature-controlled location.

1.07 COORDINATION

A. The Drawings indicate the extent and general arrangement of the systems. If any departures from the drawings or specifications are deemed necessary, details of such departures and the reasons therefore shall be submitted as soon as practical for review. No such departures shall be made without the prior written concurrence of the Engineer.

B. The Contractor shall coordinate the location and placement of all concrete inserts and welding attachments with the structural engineer.

C. The Contractor shall assume full responsibility for coordination of the HVAC systems, including; scheduling, and verification that all structures, ducts, piping and the mounting of equipment are compatible.

D. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

1.08 ENGINEERING SERVICES

A. When engineering services are specified to be provided by the Contractor, the Contractor shall retain a licensed professional engineer to perform the services. The engineer shall be licensed at the time the work is done and in the State in which the project is located. If the State issues discipline specific licenses, the engineer shall be

licensed in the applicable discipline. In addition, the engineer shall be experienced in the type of work being provided.

B. All work is to be done according to the applicable regulations for professional engineers, to include signing, sealing and dating documents. When submittals are required by a professional engineer, in addition to state required signing and sealing, a copy of the current wallet card or wall certificate indicating the date of expiration shall be included with the submittal.

1.09 UL LISTING

A. All materials, equipment and system components of the HVAC system must be UL Listed. If factory UL listing of all system components is not available, the manufacturer must include in their scope of supply, ALL expenses associated with getting the complete installation UL field labeled, by a UL representative. This includes all hourly or per diem costs and expenses of the UL representative, all costs to bring the system or specific components, within UL field labeling compliance, and all costs of the manufacturer's representative.

1.10 SPARE PARTS

A. Spare parts shall include all special items on the manufacturer's standard list of spare parts

B. In addition to special items, the following spare parts shall be provided:

1. Furnish all special tools required for normal operation and proper servicing of the equipment.

2. Spare parts shall include all items on the manufacturer's standard list of spare parts and the following for each unit:
   a. One complete set of drive belts for each piece of belt driven equipment
   b. One complete seal for each pump using a seal.
   c. One complete set of gaskets for each unit.

3. Provide a minimum of 1 or 5 percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.
   a. Thermostats
   b. Control relays
   c. Damper operators
   d. Control transmitters
   e. Control transformers

4. Provide a minimum of 4 or 10 percent of the total units rounded to the next full unit whichever is greater for each size and rating of the following components.
   a. Panel light bulbs
   b. Fuses

C. Pack spare parts in containers suitable for extended storage without deterioration of the parts. Containers shall be clearly labeled designating contents, pieces of equipment for which intended and equipment identification numbers.

1.11 MAINTENANCE

A. Maintain and service all equipment and systems until the particular equipment or the system has been accepted by the Owner.

B. Maintenance shall include compliance with the manufacturers operating and maintenance instructions as well as periodic cleaning or replacement of air handling system filters.

C. Compile records of all maintenance and lubrication work performed on Owner or Contractor furnished equipment. Maintain records at the construction or installation site and make available at all times for review by the Owner or Engineer. At the request of the Owner or Engineer submit copies of these records to the Owner for information and/or review.

D. Provide all special tools required for normal maintenance. Tools shall be packaged in a steel case, clearly and indelibly marked on the exterior to indicate equipment for which tools are intended.

E. Provide to the Owner a list of all spare and replacement parts with individual prices and location where they are available. Prices shall remain in effect for a period of not less than 1 year after start-up and final acceptance.

1.12 DEFINITIONS

A. Particular terminology used under this Section is defined as follows:

1. Traffic Level and Personnel Level - Areas, including process areas, equipment rooms, boiler rooms and other areas where insulation may be damaged by normal activity and local personnel traffic. Area extends to 8-ft above floor, walkways, platforms and stairs, and horizontally 3-ft beyond the edge of walkways, platforms, and stairs.

2. Exposed Piping and Ductwork - Piping and ductwork visible from the floor level and includes all piping and ductwork in equipment rooms, boiler rooms, etc.

3. Concealed Piping and Ductwork - Piping and ductwork not visible from the floor level and includes piping and ductwork above hung ceilings and in shaftways.

4. Supply Air Ductwork - Ductwork carrying air from a fan or air handling unit to the space or spaces to which it will be introduced. This air may have been heated or cooled or in the case of ventilation system the air would be neither heated nor cooled. Supply air ductwork extends from the fan or air handling unit to the registers, grills or diffusers at the end of the ductwork.

5. Return Air Ductwork - Ductwork carrying air from the space it was supplied to back to a fan or air handling unit. Return air ductwork extends from the registers or grills at the end of the ductwork to the air handling unit or connection with an outdoor air intake duct.

6. Exhaust Air Ductwork - Ductwork carrying air from a space to a fan and then to be discharged to the outdoors. Exhaust air ductwork extends from the registers of grills at the end of the ductwork to the fan. From the fan exhaust ductwork extends to the discharge point, exhaust air damper, or exhaust air plenum, whichever comes first.

7. Relief Air Ductwork - Ductwork carrying air from a space without a fan to be discharged to the outdoors. Relief air ductwork extends from the registers or grills at the end of the ductwork, to the discharge point, relief air damper, or relief air plenum, whichever comes first.

8. Outdoor Air Ductwork - Ductwork carrying untreated air from the outside to a fan or air handling unit. Outdoor air ductwork starts at the intake point, outdoor air damper, or outdoor air plenum, whichever comes last. The outdoor air ductwork extends to the fan, air handling unit, or connection with a return air duct, whichever comes first.

9. Mixed Air Ductwork - Ductwork that can carry either return air or outdoor air or a combination of both. Mixed air ductwork starts at the connection of the return air and outdoor air ducts and extends to the fan or air handling unit.

10. Outdoor Air Plenum - A plenum that extends from the opening in the skin of the structure to the outdoor air duct. If the outdoor air damper is directly at the intake or there is no outdoor air damper, the plenum will extend to the first size reduction. If the outdoor air damper is not at the intake, the plenum will extend to the outdoor air damper.

11. Exhaust Air Plenum - A plenum that extends from the opening in the skin of the structure to the exhaust air duct. If the exhaust air damper is directly at the discharge or there is no exhaust air damper, the plenum will extend from the last size reduction. If the exhaust air damper is not at the discharge, the plenum will extend to the exhaust air damper.

12. Relief Air Plenum - A plenum that extends from the opening in the skin of the structure to the relief air duct. If the relief air damper is directly at the discharge or there is no relief air damper, the plenum will extend from the last size reduction. If the relief air damper is not at the discharge, the plenum will extend to the relief air damper.

13. Ventilated Spaces - Areas supplied with outdoor air on a continuous or intermittent basis. The outdoor air may be heated and/or cooled or untreated.

14. Heated Spaces - Areas where heat is supplied to maintain a minimum temperature during the heating season.

15. Unheated Spaces - Areas where heat is not applied and there is no minimum temperature during the heating season.

16. Conditioned Spaces - Areas that are provided with heating and mechanical cooling.

17. Non-Conditioned Spaces - Areas that are not provided with mechanical cooling.

18. Indoor Piping - Piping within a building that is not exposed to the weather.

19. Outdoor Piping - Piping that is not within a building and which is exposed to the weather.

20. Indoor Ductwork - Ductwork within a building that is not exposed to the weather.

21. Outdoor Ductwork - Ductwork that is not within a building and is exposed to the weather.

22. Hot Ductwork - Ductwork carrying air with a temperature above the surrounding space temperature.

23. Cold Ductwork - Ductwork carrying air with a temperature below the surrounding space temperature.

24. Hot/Cold Ductwork - Ductwork carrying air with a temperature that can be either above or below the surrounding space temperature.

25. Thermal Conductivity - The rate of heat flow through unit area of a homogeneous substance under the influence of unit temperature gradient in the direction perpendicular to the area. Units-BTU per (hour)(sq ft)(degrees F temp. difference)(per inch thickness).

26. Flues/Stacks/Breeching - Ductwork carrying products of combustion to atmosphere.

PART 2 PRODUCTS

2.01 ELECTRICAL EQUIPMENT

A. Electric Motors

1. Electric motors in NEMA frame sizes shall conform to the requirements in Section 26 05 40, unless otherwise specified herein.

2. The motor manufacturer shall confirm that motors used to power equipment are provided with bearings that will provide a bearing life equal to the driven equipment or better. Confirmation shall be included with shop drawing submittal.

3. Motors will be selected to be non-overloading over the entire operating range of the equipment. A safety factor of 25 percent will be added to all motors up to and including 50 horsepower. A safety factor of 15 percent will be added to all motors over 50 horsepower. Motors indicated on the schedules are to be considered a minimum. This sizing is not to limit compliance with the above requirements

B. Electrical Equipment

1. Electrical equipment which is furnished under this Section shall meet the requirements specified in Division 26:
   a. Disconnect switches, motor starters and combination motor starters (starters with disconnecting means and short circuit protection) shall be as specified in Section 26 19 00.

b. Cord-connected controls for hazardous areas shall be provided with intrinsically safe relays, which shall be as specified in Section 26 19 00.
c. Raceways, boxes, fittings and supports shall be as specified in Section 26 05 33.
d. Wires and cables shall be as specified in Section 26 05 10.

C. Electrical enclosures and panels to include automatic temperature control panels and components shall be suitable for the environment and electrical classification for the space they are located in. The type of enclosure for the various spaces shall be as specified in Division 26. Refer to the electrical drawings for the space classifications.

D. Where noted in the HVAC equipment schedules, or when shown on the Drawings, provide fan speed control switches and integral unit thermostats.

2.02 SEISMIC RESTRAINTS

A. Seismic restraints shall be provided for all ductwork, piping, and equipment as required by applicable codes. All seismic criteria and design shall comply with the International Building Code with Amendments and ASCE-7.

B. Materials of construction for seismic supports shall be the same as those specified for equipment supports and hangers, and duct and pipe hangers. All bolts shall be stainless steel regardless of the specified support material.

C. Restraints shall be selected from Tables for Seismic Design Category D, Occupancy Category/Use Group III, with an importance factor of 1.5 for all components.

D. The contractor shall retain a professional engineer to provide seismic loadings and designs of seismic restraints. This will include but not be limited to the following:

1. Provide seismic loadings to the vibration isolation supplier based on actual equipment being used to allow the proper selection of vibration isolators.

2. Provide sizing of bolts for attachment of non-vibrating equipment to the structure based on the actual equipment being used.

3. Provide design of required additional bracing for equipment when vibration isolators or bolts are not adequate to withstand seismic forces.

4. Provide design of bracing for all suspending equipment.

5. Provide design of bracing for all piping and ductwork.

6. Where piping or ductwork is subject to thermal expansion, the loads caused by the thermal expansion and contraction shall be included in the design of the restraint bracing.

E. Signed and sealed calculations and details shall be submitted for record purposes.

2.03 EQUIPMENT VIBRATION ISOLATOR AND MOUNTINGS

A. General

1. Unless otherwise specified in this Division all machinery or vibrating mechanical equipment shall be isolated from the building structure by vibration isolators with a minimum deflection as specified. Operating equipment that can transmit objectionable vibration and noise must be installed with special types of vibration isolators such as flexible connectors to ductwork, piping and wiring. In more critical areas and under particular conditions, additional vibration isolators shall be installed as specified in other related Sections in this Division, or in specific equipment schedules.

2. All equipment shall be provided with attachment points for floor or suspended mounting that will safety transmit all loads including seismic to the supports.

3. The vibration isolator manufacturer shall be responsible for the proper selection of vibration isolators suitable for the particular application. Selection of the vibration isolator shall include the following factors.
   a. Equipment weight
   b. Equipment operating frequencies
   c. Type of building support structure
   d. Seismic forces as required by the applicable building codes to include shear, tension and compression due to the code specified loads.

4. All floor mounted vibration isolators shall be bolted to the floor or framing on which they rest. Bolts shall be arranged to prevent transmission of vibration through the bolts.

5. All isolation devices for a single piece of equipment shall be selected for a uniform static deflection according to distribution of weight in the equipment.

6. All pieces of equipment that have a variation in weight during operation or maintenance such as, but not limited to, cooling towers and hoppers, shall have built-in vertical limit restraints to limit motion to a maximum of 1/4-in.

7. Isolators exposed to the weather, in rooms classified on electrical drawings as damp, wet, or corrosive or where called for on the Drawings shall be provided with corrosion protection. Steel parts other than springs shall be galvanized. Parts subject to wear, rubbing, shall be non-corrosive material such as rubber or stainless steel. Springs and hardware shall be cadmium plated or otherwise provided with an approved coating.

8. After installation of equipment, isolators shall be adjusted for proper loading and distribution of weight.

B. Types - The following types of vibration isolators may be used.

1. Isolation Types for Floor Mounting
   a. Single elastomer-in-shear isolators, molded mound shaped element designed for 1/4-in deflection under the imposed static load. Double elastomer-in-shear

isolators shall be two such elements assembled in series or a molded element designed to provide 1/2-in deflection under the imposed static load. Elastomer-in-shear isolators shall be properly housed to prevent bulging and shall be provided with adequate facilities for bolting to equipment and floor slab.

b. Spring isolators shall be free standing and laterally stable and shall be equipped with acoustical-friction pads, leveling bolts and bolt holes for anchoring to floor slab. Springs shall have a minimum ratio of outside diameter to operating spring height of 0.8 and an additional travel to solid equal to 50 percent of the specified deflection. Where housed springs are specified or required, provide units with telescoping cast iron or steel housing, containing one or more springs, complete with resilient alignment insert and a minimum of 1/4-in thick rubber or neoprene sound deadening pad bonded to the base of housing.
c. Heavy load pads shall be 1-1/4-in thick and shall consist of a high load capacity elastomer pad and sandwiched between two 1/8-in thick steel load distribution plates capable of supporting loads up to 250 psi. For large pad area, steel plates of suitable thickness shall be provided to distribute the load.
d. Light load pads shall be neoprene corrugated single, laminated double or laminated with 1/2-in thick fine granular composition cork sandwiched between two 1/4-in layers of corrugated, oil resistant neoprene. Pads shall be capable of loading to 50 psi.

2. Isolation for Suspension
   a. Isolation hangers for suspension of equipment and piping shall have a single element of elastomer for 1/4-in deflection, a double or a single molded element of 1/2-in deflection, a single spring element with an elastomer grommet for up to 3/4-in deflection and a combination of an elastomer and spring elements in series for 1-in deflection and up contained within a structural rigid one piece steel hanger box. Springs shall have a minimum ratio of outside diameter to operating spring height of 0.8 and an additional travel to solid equal to 50 percent of the specified deflection.
   b. The neoprene element shall have a bushing to prevent hanger rod contact with the housing box. The lower rod shall be free to swing in a 30 degree arc without touching the spring or the housing.

3. Rails and Bases - Rails and bases shall be of the following types based on the equipment and deflection required.
   a. Rubber in shear type shall be steel rails running the full length of the supported equipment and extending under any overhang to counteract cantilever effects. The rails shall incorporate single or double deflection elastomer-in-shear fastened in place and a continuous steel floor bearing plate running the full length of each rail. The rails shall be drilled and tapped to accept the supported equipment and shall serve as a template.
   b. Steel spring type shall be steel rails running the full length of the supported equipment and extending under any overhang to counteract cantilever effects. The rails shall consist of structural members supported by individual free standing springs. The rails shall be drilled to accept the supported equipment and shall serve as a template.
   c. Fans and their driving motors shall be mounted on structural steel channel members forming a rigid base. A common member parallel to the V-belt drive shall run the full length of the fan and motor and shall be of sufficient rigidity to resist the bending stress of belt pull. The structural steel base shall incorporate

single or double deflection elastomer-in-shear elements or free standing springs located for proper weight distribution. The base shall be drilled and tapped to accept the fan and motor and shall serve as a template. Integral motor slide rails shall be provided and welded in place.

d. Unless specifically noted in other sections of the specification or on specific equipment schedules, all equipment will be provided with vibration isolation as defined by the following table:

Type of Equipment	Vibration Isolation Type	Minimum Deflection for Slab on Grade Inches	Minimum Deflection for up to 20-ft floor span inches	Minimum Deflection for 20-ft to 30-ft Floor Span Inches	Minimum Deflection for 30-ft to 40-ft Floor Span Inches
Condensing Units	Rubber	0.25	--	--	--
Air Handling Units	Rubber	0.25	--	--	--

C. Rigidly Mounted Equipment

1. When equipment does not require vibration isolation, it shall be firmly attached to the building structure. Bolts and support structure shall include allowances for seismic loads as required by the applicable building codes to include shear and moment loads.

2.04 FLAME AND SMOKE RATINGS

A. All materials, including adhesives, surface coatings, sealers, assemblies of several materials, insulation, jacketing, finish, etc., shall have flame spread ratings not over 25 (fire resistive), and smoke development ratings not over 50, as established by tests conducted in accordance with ASTM E84, NFPA 255, and UL 723.

B. These requirements apply to all circumstances whether the materials are field applied or applied by a manufacturer in his/her shop, or elsewhere, prior to delivery to the project.

2.05 NOISE CRITERIA

A. The selection of pumps, fans, air handling equipment, air conditioners, heating ventilating and air conditioning machinery and mechanical equipment and the installation of the system components such as duct work and piping shall be such as not to exceed to maximum permissible noise for non-equipment spaces as defined in Table 2, Design Guidelines for HVAC System Noise in Unoccupied Spaces contained in the 1995 edition of the ASHRAE Application Handbook. Under no conditions shall the noise created by equipment exceed the levels of permissible noise exposures of occupational areas as established by the OSHA and other Federal, State and local safety and health standards, codes and ordinances.

B. The equipment supplier shall provide actual data for the equipment submitted. If the space does not meet the required criteria, and the noise level of the equipment is found to be the cause, the equipment supplier shall be responsible for the modifications required to correct the condition.

2.06 BEARINGS

A. General - Furnish equipment bearings suitable for the intended equipment service. Furnish bearings designed to carry both thrust and radial loads for equipment designed for all angle operation.

B. Provide extended lube lines with pressure relief equipped grease fittings for all bearings which are not readily accessible from outside the equipment.

C. Bearings for all equipment in the schedule below shall have heavy-duty grease lubricated self-aligning ball or roller bearings. Bearings shall have ample thrust provision to prevent end play during the normal life of the bearing. Unless specifically noted otherwise, all fans shall have bearings for both the equipment and motors with the following ABMA L-50 life.

1. Fans over 3000 cfm - 100,000 hours.

2. Fan impellers greater than 10-in diameter

3. Continuous duty fans with motors over 25 horse power 200,000 hours.

4. All fans with motors over 50 horse power 200,000 hours.

D. Belt driven fans, including air handling unit fans shall be equipped with self-aligning single row ball bearings, double row tapered or spherical roller bearings.

E. For systems with bearings requiring L-50 lives of 200,000 hours or greater, the equipment supplier shall provide calculations for both the equipment bearings and the motor bearings to confirm the bearing selections. For belt drives, the calculations shall include the effect of the sheave size, number of belts, the sheave location on the shaft, and the location of the motor to the driven sheave.

F. Provide seals for bearings installed in airstreams, exposed outdoors, and for applications in corrosive or dusty atmosphere.

G. Provide bearings suitable for high temperature service where heat fan construction is required.

2.07 HANGERS, SUPPORTS AND ANCHORS

A. General

1. Furnish supports, hangers and other devices necessary to support and anchor firmly and substantially the piping, equipment and ductwork described in this Section. Piping and duct support systems shall include restraints as required by the applicable building codes to withstand seismic and wind loading. Design shall be provided by a licensed professional engineer hired by the Contractor as specified in Part 1. Signed and sealed calculations shall be submitted for record purposes.

2. All equipment, ductwork, piping, and supports that are installed outdoors shall be designed and installed to meet wind loadings as required by the International

Mechanical Code, the International Building Code, all other applicable codes, and the requirements of this specification. Design services shall be provided by a licensed professional engineer as specified in Part 1. All equipment shall be furnished with factory supports and/or tie downs to properly secure the equipment to applicable structure, equipment pad, etc.

3. For all outdoor equipment, each equipment manufacturer shall provide a signed and sealed letter certifying that their equipment's unit integrity and anchoring system meet the requirements of the International Mechanical Code and the International Building Code.

4. All equipment shall be provided with lugs or brackets to allow the equipment to be firmly fastened to the structure. The lugs and brackets shall be sized to withstand the expected seismic and wind loads for the area and type of application. Location of the attachments shall be based on the equipment being hung or base mounted as shown on the Drawings and the schedules.

5. Design of hangers, supports, anchors and hold downs shall include the effect of all loads applied to the equipment, pipe or duct as well as the load of the component. These loads include, but are not limited to wind, seismic and internal dirt or liquid buildup.

B. Hangers and Suspension

1. Furnish and install all miscellaneous metalwork in accordance with Division 05 requirements.

2. Where C-clamp type hangers are used, furnish with a retainer strap.

3. Hangers shall not be supported from roof decking or bulb tees. Where required, provide supplemental steel to span between the building structures.

4. All piping supported at a maximum of 10-ft-0-in intervals. Hangers or rings, sized to fit outside the insulation.

5. All piping 2-in diameter and smaller supported by pipe rings or bands with one 3/8-in adjustable steel rod hanger and one concrete insert.

6. Anchor piping mains where indicated or wherever necessary to limit pipe expansion and to prevent vibration. Furnish anchors constructed of steel securely bolted to masonry and welded to pipes.

7. Rectangular, Round and Flat-Oval Ductwork - Spacing and size of hangers shall be as called for in the SMACNA standards, except as detailed below:
   a. Rectangular ductwork 48-in wide and larger shall be supported by two adjustable threaded rods.
   b. Round ductwork 37-in and larger shall be supported by two adjustable threaded rods.
   c. The following methods of hanger attachment to the building structure are NOT allowed. The numbers and letters refer to hanger methods shown in Figure 4-

1, 4-2 and 4-3 of the 1985 edition of the HVAC Duct Construction Standards Metal and Flexible as published by SMACNA.

1) "T" wrap around straps of open web joist.
2) "W" bent over band on open web joist.
3) "14" Friction clamps
4) "17" Bent wire in metal deck.

8. All hanger and fastener material shall be of same finish as ductwork which they serve, e.g., galvanized, aluminum, black steel, etc., except for PVC ductwork which shall be Type 316 stainless steel. When a material other than the duct construction material must be used, the material used must be as corrosion resistant or greater than the duct material.

9. Perforated band iron or wire for supporting ducts shall not be permitted.

10. Support flexible duct by band hangers, 1-in wide minimum, attached so as not to crush the ductwork. The use of wire to hang flexible ductwork shall not be permitted.

11. Duct supports at flexible connections shall be adjustable.

2.08 PAINTING AND COATINGS

A. Unless otherwise specified, all machinery and factory finished equipment such as pumps, fans, air handling units, air conditioning units, and other items of manufacture shall be hot dipped galvanized or will have a factory applied finish, color as standard with the manufacturer. Components fabricated from stainless steel do not require a coating finish unless otherwise specified. All tanks, supporting steel, hangers, rods and all other uncoated or non-galvanized steel other than standard piping and fittings shall have a shop coat consisting of a suitable primer and finish coat. If not factory-applied, the prime coat shall be as specified in Division 09. All items not factory or shop primed prior to installation shall be suitably cleaned of rust and mill scale by wire brushing, sanding, or other means and prime painted, immediately after installation.

B. The Contractor shall be responsible for the repair of all defects, blemishes, holidays and the like apparent in manufactures coatings and shall ensure that the materials used for such repair shall match and be compatible with the manufacturer’s standard color, coatings and practices. Surfaces to be repaired or recoated are to be prepared as recommended by the paint or coating supplier. Care shall be taken not to paint over nameplates.

C. Furnish touch up paint for the various types of equipment furnished and deliver unopened paint to the Owner at completion of the project. The amount of touch-up paint supplied shall be sufficient to cover 15 percent of the applicable painted surfaces or one pint, whichever is greater.

D. Where specified, or called for on the following schedule, special corrosion resistant/protective coatings shall be provided. Whenever a protective coating is specified, the equipment shall be coated both inside and out. Whenever necessary to provide full coverage of the equipment, the equipment shall be completely disassembled to allow proper preparation and coating application. Any component that would block the coating process shall be removed. Equipment provided with gaskets or liners shall be

coated before the application of the gasketing or liner. The equipment Vendor shall test rotating equipment after coating to confirm dynamic balance. If work needs to be done to correct the equipment balance, the integrity of the coating must be corrected after such work.

E. Ductwork connections to units that require corrosion resistant coatings shall be made with flanges. Flanges shall be factory drilled before coating. Resilient washers suitable for the environment shall be used to protect the coating from the bolts in the flange. The use of self-tapping screws or other fastening methods that will damage the coating are not acceptable.

F. All items to be provided with a protective coating shall have the following data on the coating included with the unit submittal. Submittal shall include vendor data sheets on the specific coating being used, corrosion resistance data sheets, detailed application data sheets to include surface preparation procedures. For baked coatings submit a letter from the coating manufacturer, that the company doing the actual coating operation is an approved coating company. When an equipment supplier provides the coating, the information shall be supplied by the coating manufacturers.

G. Inspection and Preparation of Coil prior to Cleaning and Coating

1. Coil shall be inspected for fin damage. Bent fins shall be straightened using the proper fitting fin comb. Tubes and tube “U” bends shall be inspected for dents, punctures or pinched areas. Where possible, and with equipment manufacturer’s approval bent, punctured, pinched tube or “U” bend areas shall be repaired and leak tested by coating vendor’s A/C technician prior to coating. Vendor shall securely seal all open tubes to prevent the infiltration of dirt, water, cleaning and coating solutions into the tube. The header tube shall be fitted with a Schrader valve and the coil placed under no less than 5 and no greater than 50 psi nitrogen blanket throughout the cleaning and coating process. The charge shall be recorded and verified following coating to ensure the coil was not damaged allowing cleaning or coating solutions to infiltrate the tube side.

H. Cleaning and Conditioning of the Coil Fin and Tube Surfaces Prior to Coating

1. Following initial preparation of the coil, the coil shall be thoroughly cleaned using a non-etching and non-oxidizing detergent solution having less than 10- ppm chlorides, and formulated for use on ferrous and non-ferrous metals to remove shop soils, dirt, grease and oils from the surface of the coil fins, tubes and casings. Following the detergent cleaning the coil shall be thoroughly rinsed using clean filtered water to flush off soils removed by the detergent. The surface to be water break free when rinsed ensuring a clean surface. A non-oxidizing chemical solution sealer shall then be applied to enhance adhesion and provide secondary corrosion protection. The coil shall then be dried at temperatures up to 220 degrees F until thoroughly dry prior to applying the coating.

I. Coatings shall be of the following types:

1. MANUFACTURER STANDARD COATINGS
   a. Coating material shall be manufacturer’s standard as specified in the schedule below. Surfaces shall be prepared, primed and coated as required be the

coating supplier. Heat curing shall be provided where required by the coating supplier.

2. BAKED PHENOLIC (for heat transfer coils, dipped) TYPE 1A and TYPE 1B
   a. Type 1A- Coating Material Heresite P-413C baking phenolic with a plastizer or approved equal. The surface shall be degreased and etched or phosphatizing by immersion. The coating shall be applied in multiple coats by immersion, with a baking (partial cure) in an oven following each immersion. After the final immersion and the application of one (1) spray coat, the coating shall be completely cured with a baking at 400 degrees F. The coating shall provide a final dry film thickness of approximately 2 mils.
   b. Type 1B – Coating material Husky Coil Coat and Husky E-Vap Coat from Bronz-Glow. Coil shall receive corrosion protection treatment from a qualified coating vendor through application of vendor's in-house dip coating process. The coating material applied by this process shall have passed a minimum 3,500 hours salt spray test in accordance with ASTM B-117.85. Coating solution shall provide effective corrosion protection throughout the entire pH range of 1.0 to 14.0. Coating material shall consist of a synthetic polyelastomer material having properties of a minimum 5,000 psi tensile strength, 400% or greater flexibility, 250% or greater elasticity to prevent chipping, cracking or flaking, have negligible (less than ½ of 1%) effect on heat transfer coefficients, coating shall contain a UV inhibitor rating at 10 year Florida sun protection and coating shall be of a type that can be repaired in the field in the event of damage to the coating. The protective coating shall be applied by dip application (complete immersion) of the coil into the coating solution. Following curing of the coating the dry mill thickness of the coating shall be not less than 1 or greater than 1½ dry mills. Following dip coating the coil fin edges shall be sprayed to enhance fin edge coverage then the coating shall be cured at temperature of not greater than 200°F until fully cured.
   c. Equivalent complete immersion coating products by ElectoFin or equal will be considered upon Engineer's review and approval of product data, application data, and corrosion resistance data.

3. BAKED PHENOLIC (equipment) TYPE 2A and TYPE 2B
   a. Coating Material Heresite baked phenolic coating. The surface shall be prepared by degreasing with an appropriate solvent. Steel surfaces for immersion shall be sand blasted in accordance with NACE No.1 or SSPC-SP5. Steel surfaces for non-emersion shall be sand blasted in accordance with NACE No. 3 or SSPC-SP6. Surface profile shall be 20 to 25 percent of dry film thickness in accordance with the supplier's recommendations. Thinner where required shall be of the same manufacturer as the coating. Coating shall be applied by spraying in multiple passes. The piece shall be baked in accordance to the manufacture's time and temperature schedules with the final baking at 400 degrees F.
   b. Type 2A - Heresite P-403 baked phenolic coatings. Dry film thickness shall be 5 to 7 mils applied in 3 to 4 coats.
   c. Type 2B - Heresite P-413 baked pheniloc coating. If surface cannot be adequately cleaned use Heresite P-700A primer in accordance with the manufacturer's recommendations. Dry film thickness shall be 4 to 6 mils applied in 4 to 5 coats.

d. Equivalent complete immersion coating products will be considered upon Engineer's review and approval of product data, application data, and corrosion resistance data.

4. AIR DRIED PHENOLIC (equipment) TYPE 3A and TYPE 3B
   a. Type 3A - Coating Material Heresite VR-507 air dried phenolic coating. The surface shall be prepared by degreasing with an appropriate solvent. Steel surfaces for non-immersion shall be sand blasted in accordance with NACE No. 3 or SSPC-SP6. Surface profile shall be 20 to 25 percent of dry film thickness. If blasting is not possible, the surface shall be primed with Heresite P-750 in accordance with the supplier's recommendations. Dry film thickness shall be 0.5 to 0.75 mills. Thinner where required shall be of the same manufacturer as the coating. Coating shall be applied by spraying in multiple passes. The piece shall be dried in accordance to the manufactures time schedule. The equipment shall be given a minimum of three coats resulting in a dry film thickness of 4 to 6mils. All equipment coated with VR-500 shall be given a topcoat of Heresite UC-5500. The UC-5500 series shall be applied by spraying and shall have a dry film thickness of 4 to 5 mils.
   b. Type 3B - Coating material Husky SPC or Husky Pat Coat and Lin Coat from Bronz-Glow. When spray coating interior or exterior metal surfaces for corrosion protection vendor shall prepare the coated or uncoated metal surface in accordance with coating manufacture's specification. Coating shall have passed 3,000 hours salt spray test in accordance with ASTM B-117.85 Coating shall be a synthetic resin elastomer having a minimum 300% flexibility, 200% elongation, and effectively provide protection throughout the entire a pH range of 1.0-14.0. The coating shall be applied to a dry thickness of 4-6 mils. Coating to be field repairable in the event of damage to the coating. Following coating application coating shall be fully cured in accordance with manufacture's specifications prior to being placed in service or packaged for shipment.
   c. Equivalent spray-on or roll-on cabinet coating products will be considered upon Engineer's review and approval of product data, application data, and corrosion resistance data.

5. AIR DRY SPRAY ON COATING (Equipment, coils, fins, etc.) TYPE 4A and TYPE 4B
   a. Type 4A - Coating Material Adsil Micro Guard HVAC/R Coil and Fin Clear Protective Treatment AD35. Surface preparation, mixing and catalyzing, application, and clean-up shall be in strict accordance with the manufacturer's instructions. All recommended cleaning agents (Micro Kleen products) shall be utilized and applied per the manufacturer's instructions. Drying times and curing times shall be in accordance with the manufacturer's time schedule.
   b. Type 4B- Coating Material Husky Coil Coat from Bronz-Glow. Prior to spray coat application the coil shall be cleaned and in accordance with the coating manufacturer's specifications. Coil shall be allowed to dry thoroughly after cleaning prior to applying the coating. Coil shall receive corrosion protection treatment from a qualified coating vendor through application of vendor's in-house or field applied spray coating process. The coating material applied by this process shall have passed a minimum 3,000 hours salt spray test in accordance with ASTM B-117.85. Coating solution shall provide effective corrosion protection throughout the entire pH range of 1.0 to 14.0. Coating material shall consist of a synthetic polyelastomer material having properties of

a minimum 5,000 psi tensile strength, 400% or greater flexibility, 250% or greater elasticity to prevent chipping, cracking or flaking, have negligible (less than 1/2 of 1%) effect on heat transfer coefficients, coating shall contain a UV inhibitor rated at 10 year Florida sun protection. The unit to be disassembled to the point to where the face of the coil from both sides are exposed and can be coated. The vendor shall further ensure the "U" bend and header areas shall also be exposed to allow maximum coating coverage on both the inner and outer radius of the "U" bend and header surfaces. The protective coating shall be applied by spray application on both sides of the coil and using a method that ensures maximum coating penetration into the fin area. Following curing of the coating the dry mill thickness shall not greater than 1½ - 2 dry mills. Following coating the coil shall be cured in accordance with coating manufacturer's specification prior to restoring power to the unit. It is not recommended a coil of more than two rows be spray coated. Cabinet coating shall be Type 3B as described above.

c. Special care must be taken to follow coating manufacturer's instructions for coating coils to be sure that the entire surface of the fins and the tubes in the coil are coated. It is imperative that as much of the internal coil surfaces be coated as possible to prevent failure of the coil.

d. Equivalent spray-on coil coating products by Heresite (PC-2000 with PC-2000-C cabinet coating), Blygold (PoluAl coil coating with Type 3A or equal cabinet coating), Thermoguard (Total Coat), or equal will be considered upon Engineer's review and approval of product data, application data, and corrosion resistance data.

J. Coatings shall be factory applied by the equipment manufacturer/supplier. If this is not possible, coating shall be applied by a specialty shop under contract to the equipment manufacturer/supplier.

1. Corrosion protection shall be provided, by an authorized coating vendor for each applicable unit component as specified herein. A "Certificate of Coating Compliance" shall be issued by the coating vendor verifying use of the specified products and processes. Coating vendor shall supply owner a written "Owner's Coated Coil Cleaning Service and Maintenance Manual". Aforementioned certificate and manual shall be submitted upon completion of the project with all other closing documents.

2. Prior to shipment or installation of a coil into a cabinet coil shall be pressure tested to 110% of operating pressure and held for 45 minutes to ensure no leaks have occurred. Coil shall then be evacuated and placed under nitrogen blanket or installed in the cabinet.

3. When coil is being shipped as a single unit, vendor shall protect coil tubes from soil or moisture infiltration by shipping coil under a nitrogen blanket of not less than 5 psi on the fluid side. Coil shall be tagged advising coil is under nitrogen blanket and psi rating of the nitrogen blanket.

4. Following installation of coil into the cabinet coating vendor's a/c technician shall place coil under a 200-400 micron vacuum to ensure integrity of coil and absence of moisture within the coil.

5. Coil shall be issued a registration number and number shall be affixed to the coil by means of a non-removable polymer seal. Coating vendor shall maintain a job warranty file for each coil coated for the period of the warranty.

6. After coating application is completed, the equipment manufacturer/supplier shall test the equipment and certify system operation prior to releasing the equipment to the job site.

K. Any holidays, runs, sags, blisters, or inclusions in the coating are unacceptable and will be corrected. With the approval of the engineer, small areas no more than 4-in by 4-in may be corrected in the field. Larger faults shall be returned to the coater to be repaired. The faulty material shall be removed by sanding and in the case of blisters, the edges feathered. The material used for recoating shall be manufactured by the same manufacturer as the original coating and shall be suitable for field repairs. The touch up material shall have the same corrosion resistance as the original coating, and if the original coating required an ultraviolet protection, the same protection will be provided as part of the repair. The final mil thickness of the repaired coating shall be equal to the originally specified thickness. Where baked coatings have been damaged, the repair shall be made with heat applied to the repaired surface to cure the coating. After curing a solvent test as recommended by the manufacturer shall be used to confirm that the coating is cured.

L. The coating manufacturer shall supply direct to the engineer, a set of coupons showing the final appearance of the cured coatings. Any coating that does not match the supplied coupons will be rejected.

2.09 TESTING, ADJUSTING AND BALANCING

A. Furnish the services of an AABC or NEBB certified agency for the testing, adjusting and balancing of all HVAC air systems installed under this Section.

B. The testing, adjusting and balancing agency shall be independent of all suppliers, installers and contractors on the project.

C. Refer to Section 23 05 93 “Testing, Adjusting, and Balancing” for additional requirements.

2.10 INSULATION

A. Provide insulation adhesives, coatings and vapor barrier materials, which are compatible and recommended, for use by the insulation manufacturer. Submit a certified statement from the insulation manufacturer attesting to their approval of the adhesives, coatings, and vapor barrier materials. The following adhesives and coatings, as manufactured by Foster Div.; H.B. Fuller Co. or Childers Products Co. are representative of approved products that meet the above requirements. (Other manufacturers who demonstrate to the Engineer that their products are equivalent are acceptable.)

1. Lagging adhesive: 30-36, CP50, AMV-1.

2. Vapor barrier coating: 30-35, CP30.

3. Vaporseal adhesive: 85-75, CP82.

4. Duct adhesive: 85-20, CP82.

5. Sealing compound adhesive: 30-45, CP70.

6. Weatherproof mastic: 35-01, CP10-1.

B. Closed cell foam type insulation applications include, but are not limited to:

1. Refrigerant Piping – Suction Lines

2. Condensate Drain Piping – Air Conditioners

3. Insulation Material - Preformed flexible closed cell foam pipe insulation, minimum density 5.5 lbs/cu ft, maximum "K" factor of 0.27 at 75 degrees F mean temperature.

4. Provide a field applied 0.016-inch aluminum jacket secured with stainless steel straps for all piping.

5. Acceptable manufacturers shall be Armstrong Corp; Manville Corp.; or equal.

C. Blanket type duct insulation shall include but not be limited to the following:

1. Concealed round and rectangular single wall ductwork.

2. Exposed round single wall ductwork.
   a. Insulation Material - Fibrous glass insulation, minimum density 1 lb/cu ft and a maximum "K" factor of 0.29 at 75 degrees F mean temperature.
   b. Facing - Factory applied vapor barrier 0.10 perm consisting of glass fiber scrim reinforced laminated facing of 2 mil aluminum foil and kraft paper.

D. Fiberglass board type insulation shall include but not be limited to the following:

1. Exposed rectangular single wall ductwork and plenums.
   a. Insulation Material - Fibrous glass insulation, minimum density 3 lbs/cu ft and a maximum "K" factor of 0.24 at 75 degrees F mean temperature.
   b. Facing - Factory applied vapor barrier 0.02 perm, consisting of glass fiber scrim reinforced laminated facing of 2 mil aluminum foil and kraft paper.

E. Acceptable manufacturers shall be Armstrong Corp; Certain-Teed; Owens Corning; Manville or equal.

2.11 PIPE AND FITTINGS

A. Condensate Drains

1. Pipe - Copper tube ANSI H23.1 Type K or ANSI H23.6 Type DWV hard drawn. Fittings - Soldered cast brass or wrought copper drainage fittings ANSI B16.29.

2. Solder - 95 percent tin and 5 percent antimony per ASTM B32, Alloy 95TA.

B. Refrigerant Piping

1. Pipe - Type K soft drawn copper, precleaned, inert gas filled, and capped. Fittings - Soldered wrought copper.

2. Solder - Hard silver solder with a minimum melting point of 1,300 degrees F. Fit up and solder joints while using an inert gas purge.

2.12 AIR HANDLING UNITS

A. In general, all air handling units, package, through the wall type and split systems shall be factory assembled with cabinet fan, heating and/or cooling section, filters, dampers, access sections with hinged access doors, motor, motor base, drive, drive guard and vibration isolators.

1. Units shall be designed to provide an integrated assembly when all of the components are assembled. All transition sections and filler pieces required between sections are to be provided as part of the unit.

2. Support brackets or rails are to be provided with the unit. Type of support is to be as required by the schedules and as shown on the Drawings, e.g. hung, floor mounted, etc. All air handling units shall be provided with lugs, brackets or field supplied devices to allow the unit to be firmly bolted to the structure or fastened to specified vibration isolators. The lugs, brackets or field supplied devices shall be sized to withstand the expected seismic loads for the area and type of application. Location of the attachments shall be based on the equipment being hung or base mounted as shown on the Drawings and the schedules.

3. Self-contained package units shall also contain compressors, refrigerant piping system, condenser, condenser fans and drives, mounting curb and factory wired control panel.

4. Heat pump units shall use a refrigerant system for both heating and cooling. Units shall include reversing valves and defrost controls.

5. Units not mounted on vibration isolators shall have all rotating components internally isolated from the main unit with vibration isolators.

6. Ductwork connections to units that require corrosion resistant coatings shall be made with flanges. Flanges shall be factory drilled before coating. Resilient washers suitable for the environment shall be used to protect the coating from the bolts in the flange. The use of self-tapping screws or other fastening methods that will damage the coating are not acceptable.

B. Casings

1. Casings shall be galvanized sheet steel construction with structural framing members as required. Pressure class rating shall be for the total fan static pressure. All sections of the unit shall be of the same pressure class.

2. The housing shall be constructed of formed and reinforced metal panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed and continuous seam welded corners. Unit shall be double-wall construction with insulation sandwiched between the panels. Provide with structural framing as required. Interior of unit shall be flush with no internal standing seams or framing extending into the air stream. Seal all seams with high performance polyurethane sealant. Materials of construction shall be as called for in the schedules. The housing shall be coated internally and externally with a gray polyurethane enamel for corrosion resistance. Pressure class rating shall be for the total fan static pressure. All sections of the unit shall be of the same pressure class.

3. Where specified on the schedules, and in all units with heating and/or cooling sections, the unit shall be insulated. All sections including, but not limited to, return plenum, coils, filter, spacers, access sections, fan cabinet, mixing box and by-pass sections, shall be insulated. Insulation shall be 1-in mat faced or neoprene coated fiberglass liner, 1-1/2 pound minimum density, installed with stick clips and adhesives to prevent erosion of the insulation.

4. Provide gasketed access doors for servicing all components. Access doors shall have a positive-pressure locking latch to provide an airtight seal. Bolts, nuts and shafts for door latches, handles and hinges shall be stainless steel.

5. Where suspended from structure, horizontal units shall be supported on channel supports or provided with brackets.

6. Holes shall be provided in the base rails for rigging shackles to facilitate overhead rigging and forklift slots shall be provided to facilitate maneuvering.

7. Units for outdoor installation shall comply with the following:
   a. Materials of construction shall be corrosion resistant, or provided with a corrosion resistant coating system for weather protection.
   b. The casing shall enclose all components for weather protection, with gasketed access doors provided for all sections to facilitate maintenance. Doors shall have provision for key locking to prevent unauthorized tampering.
   c. Top of housing shall be constructed to prevent buckling and ponding of water.

C. Fan Section

1. Fans shall be centrifugal cabinet fans with belt or direct drive as scheduled. Extended external lubrication fittings shall be provided.

2. On belt driven fans, mount motor on an adjustable slide base, equipped with jack screws.

3. Where scheduled, backwardly curved wheels shall be air foil type.

4. All fans shall be statically and dynamically balanced before shipment.

5. Whenever possible, fans shall be AMCA certified for sound and air performance, per AMCA 210-85 and AMCA 330-86.

6. Where called for on the schedules, fans shall be of spark resistant construction. On spark resistant fans, bearings shall not be placed in the air stream. Construction shall conform to AMCA 99-0401-82 Classification.

7. Fan bearings shall be furnished as specified elsewhere in this Section.

D. Cooling Section

1. Cooling coil section shall be insulated, and provided with drain pan, coil support slide rails and coil closure plate. Coil mounting shall minimize air by-pass around the coil. Provide insulated drain pan with a corrosion resistant lining and drain connections on both ends of the drain pan.

2. Refrigerant cooling coils shall be cartridge type with copper tubes, aluminum fins, galvanized steel frame, copper suction header and distribution tubes. Fins shall be mechanically attached to the tubes. Coils shall be pressure and leak tested at 300 psig with air under water. Coils shall be certified per ARI Standard 410.

E. Heating Sections

1. Heating section shall be insulated. Where heating is provided by coils, coil support slide rails and closure plates shall be provided.

2. Location of heating sections, preheat and reheat, shall be as shown on the schedules or Drawings.

3. Electric Heating Coils
   a. Electric heating coils shall be open resistance heating type with coil and unit UL listed. Coils and coil controls shall meet NEC requirements. Coil frame shall be galvanized steel with vertical element supports. Elements shall be insulated from the supports with ceramic bushings.
   b. Electric heating coils shall be sheathed elements type with coil and unit UL listed. Coils and coil controls shall meet NEC requirements. Elements shall consist of 80-20 nickel- chromium coil within a steel tubular sheath filled with compacted magnesium oxide powder. The tubular elements shall have steel edgewound fins copper brazed to the tubular sheath. The entire assembly shall be coated with high temperature aluminum paint. Ends of elements shall be closed with a ceramic washer and a threaded terminal.
   c. Factory wired controls shall be provided in the unit control panel. Panels shall include all safety controls and interlocks, step control relays and devices and terminal strip for remote wired devices. Step control sensors and step controller will be provided under the temperature control portion of the specification. Control voltage shall not exceed 120V.
   d. Electric heaters must comply with the latest NEC and UL requirements and shall include the following:
      1) Primary overtemperature, thermal cut-out (automatic reset).
      2) Secondary thermal protection (manual reset).
      3) Zero clearance construction. Maximum current of 48 Amps per circuit.
      4) Interlock between fan and heater control circuit.
      5) A disconnect switch at or within sight of magnetic contactors.
      6) Factory dielectric test of electrical insulation.

7) Fusible links (heat limiters) for thermal protection will not be accepted.
8) All three phase duct heaters shall have balanced three phase circuits. Where duct heaters draw more than 48 Amps, each circuit must have fused or circuit breaker protection.
9) Pressure type minimum airflow switch.
10) The following built-in accessories and controls, in addition to the NEC and UL required safety controls, shall be housed in the terminal box, magnetic contactors for automatic temperature control, control circuit transformers and a fusible disconnect switch with visible break and external operating handle with direct linkage to disconnect switch.

F. Filters

1. See makeup and air handling unit schedules for filter types by unit.

2. Filter Box shall have tracks for the specified filter types, except roll filters, to allow filter replacement from either side. Sealing material shall be provided at tracks and ends to prevent air by-passing the filters.

3. Disposable Filters shall be framed filters, 1-in or 2-in thickness (as scheduled). Filter pressure drop for clean filters at 300 fpm face velocity shall be 0.2-in wg for 1-in thick and 0.15-in wg for 2-in thick filters. Filter shall have 30 to 35 percent efficiency on ASHRAE test standard 52-76. Manufacturers and type shall be American Air Filter Co., Am Air 300X; Farr Co., 30/30 Disposable or equal.

4. A total of three complete sets of filter media shall be provided for each unit.

G. Gauges

1. For all types of filters, each filter section shall be provided with a differential static pressure gauge across the filter. Where more than one filter is used in series, each filter shall be provided with a separate gauge. Each gauge shall be provided with shut off-vent valves similar to Dwyer A-301A vent valves on each side of the gauge to permit zeroing of the gauge without disconnecting the gauge. Tubing shall be stainless steel. Static pressure sensors, valves and fittings shall be stainless steel. Pressure range of gauges shall be three times the clean pressure loss of filters provided.

2. Gauges for local indication of indoor units shall be magnehelic gauges accurate to within plus/minus 2 percent of full scale. Gauges shall have a zero adjustment screw and an adjustable set point indicator. Fluid shall be a low specific gravity oil. Oil shall remain functional to minus 20 degrees F. Casing shall be cast aluminum. The unit shall be able to withstand an over pressure of 15 pounds per square inch. Gauges shall be by Dwyer Magnehelic Series 2000 or equal.

3. Gauges for local indication of outdoor units shall be combination vertical/inclined manometer type. Gauges shall have zero adjustment screw and set point indicator. Casing shall be one piece plastic and epoxy coated aluminum scale. A weatherproof housing shall be provided for protection of the unit from direct sun light. Gauges shall be Dwyer Mark II No. 25 inclined manometer or equal.

4. Remote indication of pressure differential shall be provided by a transmitter using silicon strain gauge transducer. Casing shall be cast aluminum. The unit shall be able to withstand an over pressure of 15 pounds per square inch. Unit shall have zero and span adjustment. The transmitters shall be provided with an LCD readout on the face of the transmitter. Transmitters shall be Dwyer Series 603A differential pressure transmitter.

H. Condensing Unit

1. Condensing unit shall consist of casing, two-stage compressor(s), refrigerant piping system, condenser, condenser fans and drives and factory wired controls and panel.

2. All rotating components shall be internally isolated with vibration isolators from the main unit.

3. Condenser section for self-contained package units shall be an integral part of the unit and shall be part of a complete factory assembled unit.

4. Condensing unit for split systems shall be designed and constructed for mounting remote from its associated air handler with field fabricated interconnecting refrigerant piping, including associated specialties.

5. Refrigerant compressors shall be of the type, number, and capacity specified on the schedules. Compressors shall be provided with unloading or hot gas by-pass as required by the schedule. Compressor shall include suction strainer, crank case oil sight glass, oil strainer and oil heater and forced feed lubrication. Compressor controls shall include three-phase manual reset overload protection, hi-low refrigerant pressure cutout, manual reset low oil pressure cutout, non-cycle pump down relay. In addition, multiple compressor units shall have a compressor sequence switch.

6. Air cooled condenser shall have propeller or centrifugal fans as shown on the schedules. Exposed fans shall be provided with fan guards. Coils shall have copper tubes, aluminum fins, galvanized steel frame and copper headers. Fins shall be mechanically attached to the tubes. Coils shall be pressure and leak tested at 425 psig with air under water.

I. A complete refrigerant piping system shall be factory fabricated and installed in the unit. Each compressor shall be provided with a complete and independent refrigerant piping system.

1. Piping shall be Type K copper tubing with joints silver brazed. Brazing shall be done with an inert gas purge. Suction lines shall be insulated with closed cell foam insulation. Hot gas piping shall be insulated to protect personnel as required.

2. Valves shall be bronze body brazed connection and shall include compressor and condenser relief valves, condenser liquid line service valve, refrigerant charging valve, compressor discharge, suction service valves, liquid line solenoid and thermal expansion valve.

3. Complete refrigerant system shall be cleaned, leak tested and charged with refrigerant.

4. Size of field fabricated piping for split systems shall be determined by the equipment manufacturer.

5. Refrigerant shall be ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

J. Unit Control Panel

1. For self-contained package units, split systems and fuel burning units, factory wired control panel shall be furnished and mounted on the unit. Panels shall include all controls required in other sections and all safety controls and interlocks, heavy duty fused visible break disconnect, control devices, motor starters and terminal strip for remote wired devices. Control type and sequence shall be as specified in other related Sections or on the Drawings. Control voltage shall not exceed 120 Volts. Control panel door shall be provided with a keyed lock. A complete wiring diagram shall be permanently attached to the inside of the panel door. Step control sensors and step controller will be provided under the temperature control portion of the specification unless specified with unit on the equipment schedule.

2. Furnish electric heater section controls as scheduled and in accordance with the controls specified under Electric Duct Heaters, elsewhere in this Section.

3. Where specific area classifications are called for or shown on the electrical drawings, all equipment and wiring shall be in conformance with the requirements for that classification.

4. The type of enclosure shall be as specified in Division 26.

K. Accessory Sections

1. Accessory sections shall be as shown on the Drawings and Schedules, and as required for the unit type.

2. Mixing boxes shall be of the configuration shown on the Drawings. Deflection plates shall be provided if required to maintain even air flow over coils and prevent stratification.

3. Spacer and access sections will be provided where specified or required. Access sections shall have hinged doors on each end except for filters.

4. Inlet and discharge louvers for outdoor mounted units shall be weatherproof design.

5. Factory fabricated insulated curbs shall be provided where shown on the schedule and/or Drawings. Curbs shall be galvanized steel construction with corrosion resistant coating. Unless otherwise specified, curbs shall include provisions for supply and return air duct and piping connections to the area below. Where the roof is pitched the curb shall be constructed to match the pitch and provide a level surface at the top of the curb for the unit to mount on.

2.13 FANS

A. General:

1. Fans shall be factory assembled, complete with fan wheel, fan housing or cabinet, bearings, drives, drive guard, motor, motor base, unit base and vibration isolators, dampers and bird screens unless otherwise specified. All fans shall be provided with lugs, brackets or field supplied devices to allow the fan to be firmly bolted to the structure or fastened to specified vibration isolators. The lugs, brackets or field supplied devices shall be sized to withstand the expected seismic loads for the area and type of application. Location of the attachments shall be based on the equipment being hung or base mounted as shown on the Drawings and the schedules.

2. All fans shall be statically and dynamically balanced before shipment.

3. Where belt drives are used, motors shall be provided with adjustable slide bases. Adjustable sheaves and slide bases shall be selected so that the midpoint of the adjustable range matches the fan schedule data. Drives selected shall have a safety factor of 1.5 times motor horsepower.

4. All fans shall be AMCA rated for sound and air performance per AMCA 210-85 and 330-86.

5. Where belt drives are used, motors shall be provided with adjustable slide bases. Adjustable sheaves and slide bases shall be selected so that the midpoint of the adjustable range matches the fan schedule data. Drives selected shall have a safety factor of 1.5 times motor horsepower.

6. Fans shall be assembled with OSHA shaft and motor guards. Provide access for greasing bearings, tachometer readings of fan and motor speed without removing the cover. Cover shall be properly ventilated to prevent motor overheating.

7. Where shown on the Drawings and Schedules, fans shall be of spark resistant construction. Bearings shall not be placed in the air stream. Construction shall conform to AMCA 99-0401-82 Classifications. All electrical components shall be explosion proof.
   a. TYPE A - All parts in contact with the gas stream shall be non-ferrous material.
   b. TYPE B - Aluminum wheel and non-ferrous ring around shaft openings.
   c. TYPE C - Non-ferrous ring on inlet bell and shaft opening.

8. Inlet or discharge screens shall be provided for fans that are not directly duct connected.

9. Unless sparkproof construction or other materials of construction are scheduled fans shall be of steel construction.

10. Electric motors and electrical disconnects shall be provided as specified elsewhere in this Section.

11. Fans shall be UL listed when noted in the schedules or when code required for the specific application.

B. Inline Centrifugal Fans:

1. Inline centrifugal fans shall have flanged inlet and discharge, wheel inspection door, and variable belt drives. Belt drive shall have a shroud over the belt in the air stream. Wheel shall be backward inclined airfoil type. Mounting brackets shall be provided per specific fan mounting orientation. Unless spark resistant construction or other materials are specified on the schedule, fan shall be of steel construction with steel or aluminum wheel. Manufacturers shall be Greenheck Fan Co.; Loren Cook Co.; or equal.

2.14 DUCTWORK

A. Sheet metal ductwork shall be constructed of the materials specified using the gauges or thicknesses and reinforcing called for by SMACNA for the material specified. Unless otherwise specified, all components of duct systems shall be constructed of the same material as the ductwork. This is to include braces and turning vanes.

1. Galvanized steel ductwork shall be constructed of hot-dip galvanized sheet steel, per ASTM, A525 and A527.

2. Aluminum ductwork shall be constructed of 3003H-14 alloy B&S Gauges.

3. Stainless steel ductwork shall be constructed of Type 316 stainless steel.

B. Ductwork shall be constructed of the following materials and to the following standards:

System	Location	Static Pressure	Construction Material	SMACNA Standard
Supply & Return	Electrical Room	±2-in WG	GS/AL (See Dwgs)	M&F
Toilet Exhaust	Toilet Room	±2-in WG	AL	M&F

Abbreviations

M&F - SMACNA HVAC Duct Construction Standards - 1st Ed. - Metal & Flexible

** except where listed otherwise in this table*
AL = Aluminum
GS = Galvanized Steel
SS = Stainless Steel

C. Design of ductwork shall include all loads applied to the ductwork, in addition to the load of the duct. These loads include but are not limited to wind, snow and internal dirt or liquid buildup.

D. Construction

1. All ductwork shall be substantially built with joints and seams smooth on the inside and given a neat appearance on the outside. Inside surfaces and joints shall be smooth and free from pockets, burrs and projections. All joints shall be substantially air tight with laps made in the direction of air flow and no flanges projecting into the air stream. All changes in direction and duct transitions shall be shaped to permit the easiest possible air flow.

2. Pressure Classes
   a. Pressure classes for determination of sheet metal gauge and reinforcing shall be as defined by the latest issue of the SMACNA standards for duct construction.
   b. For ductwork with a static pressure higher than 2-in water gauge, pressure class shall be as shown on the Drawings. For ductwork with a static pressure 2-in water gauge or less pressure class shall be equal to the maximum pressure indicated for the fans or air handling units on the Schedules and the pressure class shall be the same for the entire length, including branches, of the specific duct system.

3. Rectangular Ductwork
   a. Ductwork shall be constructed as shown on the Drawings in accordance with the specified SMACNA Construction Standard, latest edition.
   b. Cross-breaking shall conform to SMACNA Standard. Cross-breaking shall be applied to the sheet metal between the standing seams or reinforcing angles. The center of the cross-break shall be of the required height to assure rigidity for each panel.
   c. All square elbows for rectangular ductwork shall be provided with turning vanes unless otherwise noted on the Drawings. Turning vanes shall be as detailed in the SMACNA Manual and or as shown on the Drawings.
   d. Alternate Construction (Rectangular Only) - Factory-fabricated joint systems may be offered as an alternate form of construction. The system offered shall meet all requirements of SMACNA including SMACNA TDC and TDF systems. Alternate joint systems shall be "Ductmate System" as manufactured by Ductmate Industries, Inc., installed in accordance with the manufacturer's recommendations. The system shall be sealed for zero leakage and angle attachment to the main duct section shall be by tack welding. The use of screws is not allowed.

4. Double Wall (Acoustical Lined) Ductwork – Round, Rectangular, and Flat-Oval
   a. For all ductwork shown on the Drawings as double wall, both duct and fittings shall be lined with fiberglass with a thermal conductivity of 0.27 BTU/hr/sq ft at 75 degrees F mean temperature. Insulation lining shall be 2-inches thick (exterior) and 1-inch thick (interior).
   b. The lining shall be covered with a solid aluminum liner for aluminum ductwork, and a solid Type 316 stainless steel liner for stainless steel ductwork. See the drawings for ductwork material.
   c. Lining adhesives, cloth and coatings, shall have a fire and smoke hazard rating conforming to ASTM E84, NFPA 255 and UL 723 with a flame spread rating not exceeding 25, and smoked developed rating not exceeding 50.

d. Lining shall be odorless, shall not shed or dust and shall not support mold growth.
e. Duct shall be similar to United McGill Sheet Metal ACOUSTI-K27 (Solid welded seam Acousti-line with anti-microbial agent) and Rectangular-K27 (Acousti-line with anit microbial agent) type lined duct, or equal.

5. Round Ductwork
   a. Ductwork shall be constructed as shown on the Drawings in accordance with the specified SMACNA Construction Standard latest edition.
   b. Round Ductwork
      1) Round ductwork shall be either lock type, welded longitudinal seam construction or spiral ductwork.
      2) Gauges of ductwork and fittings shall be as specified in SMACNA. Draw bands will not be permitted. Slip joint shall be used on ductwork up to 36-in in diameter and the "loose flange" or Vanstone joint shall be used on ducts over 36-in in diameter.
      3) All seams and joints shall be continuously welded.
      4) Round ductwork shall be manufactured by United Sheet Metal; SEMCO or equal.

6. Round Ductwork Fittings
   a. All 90-degree turns shall be made of five piece mitered welded construction made by the manufacturer of the conduit. Fittings less than 90 degrees in the riser shall be made of multiple pieced mitered welded construction.
   b. All fittings in the round duct system shall be of the male and female type and in assembling these together, there shall be applied an approved synthetic rubber sealing compound on the joint. Also, on the outside of the duct apply this synthetic rubber sealing compound in order to further make these joints air tight. Mechanically fasten the conduits together using sheet metal screws not less than four per fitting 6-in on centers maximum and equally spaced around the circumference of fitting.
   c. Round duct fittings shall be manufactured by United Sheet Metal; SEMCO or equal.

7. Insulated Round Flexible Ducts
   a. Round flexible ducts shall comply with specified SMACNA Construction Standards and be constructed of corrugated ductile aluminum that can be bent and rebent by hand and is self-supporting. 1-in insulation shall be applied around the outside and be finished with a vinyl cover.
   b. Thermal conductivity of the insulation shall not exceed 0.27 BTU/hr/sq ft/1 degree F at 75 degree mean temperature. Duct shall be Class I, per UL 181.
   c. Maximum length shall be 5-ft. The remainder shall be galvanized sheet metal. Duct run shall be as short and straight as possible to minimize static resistance.

8. Volume Dampers
   a. Dampers shall be standard opposed or parallel multi-blade type on 2-in channel frame, flanged connection with external damper position indicator, manual adjustment, and position locking arrangement. Damper blades shall not exceed 6-in in width. Dampers shall be constructed of the same material as the ductwork, or of a material of equal corrosion resistance. Balancing and

balancing/shutoff dampers shall be opposed blades and shutoff dampers shall be parallel blade.

b. Locking quadrants shall have a positive method of holding the damper in its selected position such as a bolt through both the quadrant and the lever arm. Systems using springs or other devices that can vibrate loose are not acceptable.

c. Where manual dampers are used for shut-off service, dampers shall have a replaceable butyl rubber or bulb vinyl seals provided with the damper. Install seals along the top, bottom and sides of the frame and along each blade edge.

9. Access Doors

a. Access doors shall be 24-in by 24-in minimum, except where the duct size is less than 26-in, where the largest door that will fit the duct will be used. Unhinged access panels are not acceptable, except where shown on the Drawings. Access doors shall be of the same material as the duct, pan type construction for metal ductwork, with smooth edges and fitted seals, constructed and installed for air-tight fit with ease of opening and closing. Doors shall be substantially butt hinged, with heavy sash locks and substantial door pulls. Door openings and door frames shall be reinforced with bar stock or angle. Where ductwork is installed with duct liner or exterior duct insulation, the access door shall be of the insulated type. Access doors may be factory fabricated. Where ductwork is constructed of aluminum or stainless steel, access door hardware shall be of similar material.

10. Fasteners

a. Sheet metal screws, drive cleats, cinch bands and other fasteners shall be fabricated from materials with an equal of greater corrosion resistance than the ductwork in which they are installed. Where a material other than the duct material is used, it shall be approved by the Engineer before installation.

2.15 FIRE AND SMOKE DAMPERS

A. Fire and smoke dampers shall meet local codes and the requirements of the NFPA Pamphlet No. 90A. Dampers in systems constructed of materials other than galvanized steel shall be constructed of Type 316 stainless steel.

B. Dampers shall be designed and tested for their specific application in the system. Dampers shall be suitable for the following services:

1. Fire dampers for systems that are automatically shut down in the event of a fire.

2. Fire dampers for systems that are operational in the event of a fire.

3. Smoke dampers activated by smoke sensors.

4. Combination fire and smoke dampers where both types of dampers are required in the same location.

C. Dampers shall be sized so that the free air space is not less than the connected duct free area. Location shall be as shown on the Drawings and required by code.

D. Fire dampers shall have a minimum 1-1/2 hour standard fire protection rating in accordance with NFPA Pamphlet No. 252 and UL-555. Where the fire protection rating of the partition exceeds 2 hours, multiple dampers in series may be used to provide a rating equal to the partition. Dampers with fusible links shall be arranged to close automatically and remain tightly closed upon the operation of a UL approved fusible link or other approved heat actuated device, located where readily affected by an abnormal rise of temperature in the duct. Fusible links shall have a temperature rating of 50 degrees F above the maximum normal duct operating temperature, but not less than 165 degrees F.

E. Smoke dampers shall be located on the HVAC drawings and shall interface with the smoke detection system on the electrical drawings. Dampers shall comply with UL 555S.

F. Workmanship - Install dampers in sleeve unless noted otherwise on the Drawings or in the case of dampers listed for installation without sleeves after specific approval from the Engineer. Fire and smoke dampers shall be installed to provide a positive barrier to passage of air when in a closed position. Dampers shall be installed so they will be self-supporting in case of duct destruction due to heat. Care shall be exercised that the frame be set so that the closing device will not bind. Damper operators for fire and smoke dampers shall be spring to close and shall be as specified in the automatic control systems.

G. Factory fabricated, steel-curtain type, UL approved fire dampers, with damper blades out of the air stream. These fire dampers shall be tested and installed in accordance with the manufacturer's instructions and the latest editions of UL 555 and UL 555S. Damper operators shall be factory installed and tested. Operators shall not be removed and reinstalled or installed in the field.

H. Access Doors - Tight fitting access doors shall be provided for accessibility to dampers and fusible links for inspection and maintenance.

I. All fire and smoke dampers shall have written approval from local authorities.

J. Instrument ports and mounting holes for sensors, indicators, flow switches, detectors, gauges and other items to be mounted on the ductwork by the automatic control contractor shall be coordinated with the ATC Equipment provided under this Section. Mounting shall be in accordance with the automatic control contractor’s and the manufacturer’s instructions.

2.16 DIFFUSERS, REGISTERS AND GRILLES

A. General

1. All diffusers, registers and grilles shall be of the shape, sizes, capacity and type as shown on the Drawings. Refer to the Air Distribution Device Schedule on the Drawings.

2. On all duct openings that do not have a specific diffuser, register, grill or mesh covers, provided a wire mesh cover.

3. Finish – Unless, otherwise specified, diffusers, registers and grilles shall have the following finish. All diffusers, registers and grilles located in ceilings shall have a baked white enamel finish except where the ceiling system has an exposed aluminum support grid. Where the ceiling has an exposed aluminum support grid the diffusers, registers and grilles shall have a baked aluminum enamel finish. All diffusers, registers and grilles not located in ceilings shall have baked aluminum enamel finish.

B. Wire Mesh Covers

1. Where wire mesh covers are called for on the Drawings, the wire mesh and support frame shall be the same material as the duct where the cover is installed. Unless otherwise noted the wire mesh shall be 0.5-in mesh.

2. The wire mesh shall be contained in a metal frame. The mesh shall be firmly attached to the frame to prevent it being pulled out of the frame by casual contact. The frame shall be a minimum of 16 gauge sheet metal or the minimum gauge for a flange based on SMACNA, whichever is greater. The frame shall be on both sides of the mesh creating a sandwich with the mesh in the middle. Fastenings shall go through the frame on both sides of the cover.

2.17 ROOF CURBS

A. Roof curbs shall be furnished for all roof mounted HVAC equipment including fans and relief vents.

B. Roof curbs shall be pre-fabricated type, minimum 12-in height and sized to match the dimensions of the equipment base supported. Curbs shall provide a horizontal mounting surface for the equipment and shall be designed to allow for roof slope where applicable.

C. Curbs shall be straight sided type of all aluminum welded construction with nominal 2-in thick acoustical/thermal insulation in curb walls. A perforated metal liner shall be provided to protect the insulation. Epoxy coated steel curbs are acceptable if required to meet seismic or wind loads.

D. Curb interiors shall be provided with protective coatings when a coating is specified for a particular fan. Refer to Fan Schedules for applicable units.

E. Roof curbs shall be as manufactured by Greenheck Fan Co. or equal.

2.18 ATC EQUIPMENT

A. Area Classification

1. Where specific area classifications are called for or shown on the electrical drawings, all equipment and wiring shall be in conformance with the requirements for that classification as specified in Division 26. Special attention shall be given to hazardous areas specifically "Class I Div. 1 Group D" and "Class I Div. 2 Group D" to comply with code requirements for equipment selection and installation procedures.

B. Room Thermostats

1. Electric room thermostat shall be of the heavy duty all metal type, provided with concealed adjustment and exposed thermometer.

2. Temperature sensors shall be of the wire-wound resistive element type (RTD) using either nickel or platinum alloy as the resistive element. All temperature sensors shall have an end to end (element to readout display) accuracy of plus or minus 0.5 degree F.

3. Room thermostat and temperature sensors mounted on exterior walls shall be provided with insulated mounting plates.

4. All room thermostats and sensors shall be mounted 5-ft-6-in above finish floor except where otherwise indicated on the Drawings or specified herein.
   a. All room thermostats located in Administrative areas shall be mounted 4-ft-0-in above finish floor or as required by the ADAAG and the Applicable Local Accessibility Code.

5. Electric thermostats in corrosive areas shall be installed in electric boxes with remote stainless steel bulbs.

C. Static Pressure Sensors - Shall be adjustable, set point proportional type, with adjustable range in inches of water to meet the performance or function specified.

D. Smoke Detectors (Four Wire Type)

1. Furnish and install smoke duct detectors in the supply air duct and return air duct or plenum of all air handling unit and the supply air duct for all make-up air units. Furnish and install smoke duct detectors in the exhaust air duct of exhaust systems as shown on the Drawings.

2. Smoke detector type shall be as shown on the Drawings and listed in the Control Component Schedule on the Drawings.

3. The detector housing shall be listed per UL 268A specifically for use in air handling systems. The detector shall operate at air velocities of 500 to 4000 feet per minute. The detector housing shall be equipped with an integral mounting base capable of accommodating either photo electronic or ionization detector heads. It shall be capable of local testing via remote testing station. The duct detector housing shall incorporate an airtight smoke chamber in compliance with UL 268A, Standard for Smoke Detectors for Duct Applications. The housing shall be capable of mounting to either rectangular or round ducts without brackets. An integral filter system shall be included to reduce dust and residue effects on detector and housing, thereby reducing maintenance and service.

4. Detectors shall be provided with two sets of contacts to provide smoke alarm signals. One is to be used by the ATC systems, and the second is for use in Division 26 for interface to fire alarm system.

5. Remote test switch and alarm indicator stations shall be furnished for all duct smoke detectors as specified above. The installation and wiring of the remote stations will be provided under this Section. The remote test stations shall be wall mounted within the visible location of the smoke detector and easily accessible from the floor. Alarm indicator stations shall activate a visible and audible signal upon smoke detector activation. Alarm indicator stations shall also activate a visible or audible signal identified as AIR DUCT DETECTOR TROUBLE upon smoke detector trouble conditions. Alarm indicator stations shall be mounted in a location approved by the Authority having jurisdiction.

6. Provide all necessary relays, transformers and other devices as required.

7. Where multiple units serve the same space, the smoke detectors shall be wired such that any smoke detector will shut down all units serving the space.

E. Dampers

1. Automatic dampers shall be parallel or opposed blade as specified under “Sequence of Operation.”

2. All damper frames are to be constructed of the same material as the duct or a material with greater corrosion resistance sheet metal and shall have flanges for duct mounting. Damper blades shall not exceed 6-in in width. All blades are to be of corrugated type construction, fabricated from two sheets metal, spot welded together. Blades are to be suitable for high velocity performance. Maximum blade length in any section shall be 48-in. Additional stiffening or bracing shall be provided for sections exceeding 48-in in height. Multi-section dampers shall be provided with sufficient interconnecting hardware to provide unison operation of blades in the entire assembly.

3. All damper bearings shall be made of nylon.

4. Replaceable butyl rubber or bulb vinyl seals are to be provided with the damper. Seals are to be installed along the top, bottom and sides of the frame and along each blade edge. Seals shall provide a tight closing, low (1 percent) maximum leakage damper.

5. Dampers shall be selected for the velocity and pressure differential required without excessive deflections.

6. Modulating dampers shall be of opposed blade construction. Dampers for two position operation may be single direction multiple-leaf type.

7. Dampers may be furnished for in duct mounting and with face linkages if the following conditions are met.
   a. Service is for supply or makeup air in either process or non-process areas or service is for return or exhaust of non-corrosive air.
   b. Space is available to install a 24 by 24 (minimum) access door in the duct on the linkage side of the damper.

8. Dampers shall be furnished for flange mounting with exposed jamb mounted blade linkages for any of the following applications:
   a. Where installation clearances do not allow the installation of full size access doors to allow inspection and adjustment of face linkages.
   b. For corrosive, dirty or particle laden air service.
   c. Where called out on the Drawings.

F. Electronic Damper Actuators

1. Electronic actuators, less than 600 in-lb of rated torque, shall have ISO 9001 quality certification and be UL listed under standard 873, CSA C22.2 No. 24 and have CE certification. Electronic actuators used on dampers shall be designed to directly couple and mount to a stem, shaft or ISO style-mounting pad. Actuator mounting clamps shall be a V-bolt with a toothed V-clamp creating a cold weld, positive grip effect. Single point, bolt or single screw actuator type fastening techniques or direct-coupled actuators requiring field assembly of the universal clamp is not acceptable.

2. Actuators shall be fully modulating/proportional, pulse width, floating/tri-state, or two position as required and be factory or field selectable. Actuators shall have visual position indicators and shall operate in sequence with other devices if required. Proportional actuators shall be capable of digital communication, as built.

3. Two sets of DPDT switches with fully adjustable set points shall be provided to activate panel indicators and provide signals for equipment operation.

4. Actuator shall have an operating range of minus 22 to 122 degrees F.

5. Proportional actuators shall accept a 0 to 10 VDC or 0-20 mA input signal and provide a 2 to 10 VDC or 4-20 mA (with a load resistor) operating range.

6. Actuators shall be capable of operating on 24, 120 or 230 VAC or 24 VDC and Class 2 wiring as directed by the application. Power consumption shall not exceed 10 VA for AC, including 120 VAC actuators and 8 watts per actuator for applications

7. NEMA 2 rated actuators shall be provided with a three foot (minimum), prewired, electrical cable. Actuators requiring removal of the actuator cover for access to wiring terminals, exposing electronics, printed circuit boards to damage, are unacceptable.

8. Actuators shall have electronic overload protection or digital rotation sensing circuitry to prevent actuator damage throughout the entire rotation. End switches to deactivate the actuator at the end of rotation or magnetic clutches are not acceptable.

9. For power-failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Spring return actuators shall be capable of CW or CCW mounting orientation. Spring return models >60 in-lb will be capable of mounting on shafts up to 1.05-in diameter. Spring return actuators with more than 60 in-lb of torque shall have a manual override metal crank. Upon loss of control signal, a proportional actuator shall fail open or closed based on the

minimum control signal. Upon loss of power, a non-spring return actuator shall maintain the last position.

10. Actuators using “on-board” chemical storage systems, capacitors or other “on-board” non-mechanical forms of fail-safe operation are unacceptable.

11. Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required. Dampers requiring greater torque or higher close off may be assembled with multiple low torque actuators. Dual mounted actuators using additional anti-rotation strap mechanical linkages or special factory wiring to function are not acceptable. Actuators in a tandem pair must be “off the shelf” standard actuators ready for field wiring.

12. Dampers actuators will not produce more than 62 dbA when furnished with a mechanical fail-safe spring. Non-spring return actuators shall conform to a maximum noise rating of 45 dbA with power on or in the running or driving mode.

13. Proportional actuators shall be fully programmable. Control input, position feedback and running time shall be factory or field programmable. Diagnostic feedback shall provide indications of hunting or oscillation, mechanical overload, mechanical travel and mechanical load limit. The actuators shall also provide actuator service data, at a minimum, number of hours powered and number of hours in motion.

14. Where special classifications are shown on the electrical drawings damper actuators shall be provided with suitable enclosures.

15. NEMA 4X enclosures shall be Type 304 stainless steel and shall have a shaft seal and all electrical connections shall be suitable for the space classification. Enclosure shall be UL listed.

16. Explosion-proof enclosure shall be suitable for Class I, II and III. A suitable shaft seal must be provided. Housing shall be cast copper fill aluminum with stainless steel fasteners and shall be UL listed. Housing shall be suitable for NEMA 4, 7 and 9.

G. Local ATC Panels

1. Where shown on the Drawings or required by the control sequence, provide local ATC panels.

2. All controllers, relays, switches, etc., for equipment shall be mounted within ATC cabinets with hinge lock type doors where shown on the Drawings. All temperature settings, adjustments and calibrations shall be made at the system control panel.

3. Submit details of each ATC panel for approval prior to fabrication. Locations of each panel are to be convenient for adjustment and service. Provide engraved nameplates beneath each panel mounted control device clearly describing the function of said device and range of operation. All manual switches and dial thermometers shall be flush mounted on the hinged door, with permanent labels showing the function of each item. All other devices shall be located within the cabinet mounted to a sub panel.

4. All electrical devices within the panels shall be factory pre-wired to a numbered terminal strip. All wiring within the panel shall be in accordance with NEMA and UL standards and shall meet all local codes.

5. Unless otherwise specified herein or shown on the Drawings, control panels shall meet the requirements for Electrical Products specified elsewhere in this Section.

6. Electrical power supplied to automatic temperature control panels shall be 120V, single phase, 60Hz. Where 24V power is required, a 120/24 transformer shall be provided. The transformers shall be sized for their control system electrical loads. Transformers shall be mounted in the local control panel.

7. Provide a 110V power receptacle in each panel.

8. Provide a copy of the wiring and control diagram for all work in each panel. The diagram is to be stored in a pocket on the door.

H. Miscellaneous Devices - Provide all the necessary relays, limit switches, positioners, clocks, transformers, etc., to make a complete and operable system. Locate these devices on local ATC panel unless specified otherwise.

I. Name Tags - All sensing devices, transmitters, controllers, not mounted in a clearly labeled panel, or which are not an obvious part of a clearly labeled device, shall be provided with an engraved plastic plate containing the name, function and system or system number for the device.

J. Set points on thermostats and temperature controllers, shown on the Drawings are indicative only and devices shall be adjustable above and below such set points. If a set point is not stated, the control range of devices shall be suitable for the intended service. Range of devices shall be approximately 50 percent greater in both directions than span of variable, with a minimum of 25 degrees and a maximum of 110 degrees F for air systems.

K. Thermometers - Thermometers shall be flush mounted on local panels. These thermometers shall be of the dial type, minimum 3-in diameter.

L. Short Cycle Timers - Timers shall be electric operated with two sets of normally open, normally closed contacts with manual time adjustment from 1 to 15 minutes.

M. Flow Sensors

1. Flow sensors shall be thermal dispersion type sensors using a heated and RTD sensor probe to define flow. Housing shall be aluminum construction NEMA 4X and all parts of the sensor in contact with the measured air stream shall be Type 316 stainless steel. Units shall be powered by 120 Volt, single phase, 60 Hz power taken from the control panel. The unit set point shall be field adjustable and shall have a field configurable power supply of 24 VDC, 115 VAC, or 240 VAC. Flow sensors shall be Model FLT 9 3B manufactured by Fluid Components, Inc San Marcos, CA or equal. Each duct airflow sensor for system status shall provide flow indication by LED and activate two SPDT 6 amp dry contacts located in its respective control panel for status indication. Provide panel indicator lights for system “normal” and

"failure" status indication and provide "failure" annunciation. The flow sensor shall have a built-in calibration circuit for testing and calibrating the flow sensors. Sensor alarm points shall be set after the system has been balanced.

N. Field Wiring

1. All field wiring, other than power wiring, between control cabinets (A.T.C. control), control devices, unitary control panels and control terminals in motor control centers shall be furnished under this Section and shall conform to the requirements of Division 26.

2. 120V line voltage wiring to suspended and cabinet unit heaters and their thermostats shall be considered power wiring. All interlocking wiring within MCC shall be installed under Division 26.

3. Refer to the electrical drawings for NEMA enclosure types, other than NEMA 1, by room or location designation such as "Damp", "Wet", "Corrosive", "Class - Div. - Group -".

4. Installation of all conduit, wire, sleeves, outlet boxes, insulating bushings, system cabinets, terminal boxes, pull boxes, junction boxes, inserts, anchors, system devices, etc., shall be in accordance with the appropriate requirements of Division 26 and in accordance with the requirements of the current edition of the local codes for signal systems and electrical systems.

5. Run wiring in rigid steel conduit except in dry locations above ceilings and wood or metal stud framed partition walls, where EMT may be used. Conduit, boxes and fittings and their installation and testing shall be as specified in Section 26 05 33.

6. Wire, with the exception of DDC cable and thermostat wire, shall be copper type THHN/THWN insulated for 600 Volts. Wire and its installation and testing shall be as specified in Section 26 05 10.

7. In the event of any conflict among referenced codes, current editions of the applicable local codes shall take precedence for interpretation of "Signal System" installation requirements.

8. Installation of sensor wiring in finished areas shall be concealed whenever possible. Where concealed wiring is not possible, written approval for exposed work must be obtained from the Engineer prior to installation.

9. A power supply 115V, single phase, 60 Hz, 20 Amp circuit for ATC, requirements will be available at each local control panel. Power shall not be taken from the control power transformers of the motor control center.

10. Coordination Issues
    a. When motors are manually or automatically controlled from the HVAC ATC panels, the panels shall include a set of normally dry (unpowered) contacts (for connection to the motor started) which close when the motor is to operate. The ATC contractor will wire these contacts to the motor starter and make

connections to the terminals provided. Contacts shall be rated 120 Volts, 10 Amperes, 60 Hz for inductive and resistive loads.

b. A set of normally open dry (unpowered) contacts (for connection to the HVAC ATC panel) which close when the motor starter has pulled in, shall be provided under Section 26 00 00. The ATC contractor will make connections to the terminals provided and wire these contacts from the motor starter to the HVAC ATC panel to signal the motor is operating.
c. Line voltage thermostats will be furnished under this Section and installed and wired under Division 26.
d. The electrical contractor will provide a 120V circuit to all control panels shown on the Drawings. Power for the control systems is to be taken from the panels and no other source.
e. Flow alarms that require line voltage electric power to operate are to be furnished and installed under this Section. Units shall be powered by 120 Volt, single phase, 60 Hz power taken from the control panel. The flow alarms shall be provided with two sets of contacts. One set will be wired by the electrical contractor for the instrumentation system. The second contact will be used to provide an HVAC signal which will be wired under this Section.
f. Alarms from the HVAC systems that provide a signal to the central control system will be furnished and installed under this Section. The alarms shall be provided with two sets of contacts. One set will be wired by the electrical contractor for the instrumentation system. The second contact will be used to provide an HVAC signal which will be wired under the Section.
g. The following wiring is to be done under this Section:
    1) Between ATC panels and MCCs.
    2) Between ATC panels and control panels on equipment provided by the HVAC contractor.
    3) Between alarm devices provided by the other trades and ATC panels.
    4) Power wiring from the ATC panels to smoke detectors and flow sensors.
h. Wiring from smoke detectors provided under this Section to the building fire alarm systems will be provided under Division 26.
i. Refer to electrical drawings for details of wiring at motor control panels. Provide all interconnecting wiring to start and stop motors.

O. Software licensing and user agreements shall be based on a one time fee. Agreements that remove all responsibility for the software and its performance are not acceptable.

2.19 SEQUENCE OF CONTROLS

A. General

1. HVAC equipment will operate with the following sequences of operation.

2. The following will apply to all sequences.
    a. All sequences are reversible unless otherwise noted.
    b. Manual reset of control functions with manual reset will be at the local control panel unless otherwise noted.
    c. Where required to prevent nuisance shut downs of systems, provide time delay of sensors to allow system start up before the sensors are activated. This would

include, but not be limited to low temperature freeze protection on 100 percent outdoor air units.

d. For fan systems with shut off dampers, air flows greater than 2000 cfm and fan operating static pressure greater than 1-in water gauge, fans shall be stopped and started by damper end switches. When the sequence calls for the fan to run, the control system shall open the respective damper. When the damper is open as indicated by an end switch on the damper the fan shall start.
e. Where control sequences refer to activation of an alarm indicator, it will be understood to mean activation of a labeled pilot light at the local ATC panel. A dedicated pilot light will be provided for each alarm unless a common alarm light is specified.

3. Exhaust Fan with Motion Sensor Control
   Exhaust Fan EF-1
   a. When the motion sensor is not activated, the fan shall be off, and the exhaust damper shall be closed.
   b. When the motion sensor is activated, the fan shall run, and the exhaust damper shall be open. After a field adjusted run time, the fan shall stop, and the motion sensor shall return to inactive condition

B. Control Sequences for Constant Volume Direct Expansion Units

1. Electrical Room - Air Conditioning Unit with Space Thermostat Control

   System is designed for Intermittent Operation to provide space cooling for the Electrical Room to protect the equipment from the effects of heat and humidity. Unit can be operated with the supply fan operating continuously. However, the design intent is for the supply fan to cycle on/off with the cooling/heating functions.

   Units AHU-1/ACCU-1, AHU-2/ACCU-2
   a. When smoke is sensed by the smoke sensor, all other control functions shall be overridden, and the supply fan shall be off, and an alarm light in the smoke sensor shall be activated. Smoke sensors shall be manually reset. When multiple air handling units serve the same space, any smoke detector shall shut all units down in that space.
   b. When the unit thermostat on/off switch is placed in the off position, the temperature controls shall be inactivated, the supply fan and condensing unit shall be off.
   c. When the unit thermostat is placed in the on position and the system fan on/auto switch is in the on position, the temperature controls shall be activated, and the fan shall run continuously.
      1) When the space temperature sensed by the space thermostat is above the cooling set point, the condensing unit shall be on in cooling mode.
      2) When the space temperature sensed by the space thermostat is below the cooling set point, the condensing unit shall be off.
      3) When the space temperature sensed by the space thermostat is below the heating set point, the condensing unit shall be off, and the electric heat shall be activated.
      4) When the space temperature sensed by the space thermostat is above the heating set point, the condensing unit shall be off, and the electric heater shall be off.

d. When the unit thermostat is placed in the on position and the system fan on/auto switch is in the auto position, the temperature controls shall be activated.
   1) When the space temperature sensed by the space thermostat is above the cooling set point, the condensing unit shall be on in cooling mode, and the supply fan shall be on.
   2) When the space temperature sensed by the space thermostat is below the cooling set point, the condensing unit shall be off, and the supply fan shall be off.
   3) When the space temperature sensed by the space thermostat is below the heating set point, the supply fan shall be on, the condensing unit shall be off, and the electric heat shall be activated.
   4) When the space temperature sensed by the space thermostat is above the heating set point, the condensing unit shall be off, the supply fan shall be off, the condensing unit shall be off, and the electric heater shall be off.

e. The space thermostat shall have an adjustable set point. The initial cooling set point for Primary (AHU-1) unit shall be 80ºF. The initial cooling set point for Secondary (AHU-2) units shall be 85°F. The initial heating set point for Primary units shall be 50°F. The initial heating set point for Secondary units shall be 45°F. The Contractor shall instruct the Owner to alternate set points in order to alternate primary (70% of time)/secondary (30% of time) unit operation. Thermostats shall have automatic changeover from heating to cooling.

f. Dual (or two-speed) compressors shall have two stages of cooling.

g. Provide a space temperature sensor. Space temperature sensor shall have an adjustable high limit set point with an initial setting of 95°F. Sensor shall send a high space temperature alarm signal to the instrumentation system. See Electrical and Instrumentation drawings for additional details. Coordinate interface with instrumentation system supplier.

C. Control Sequences for Unit Heaters

1. Unit Heaters with Package Controls

Unit EUH-1

a. Unit heaters shall be controlled by integral or remote controls supplied with the unit heater.

b. All sequences are reversible except as noted.
   1) When the space temperature as sensed by the integral thermostat is below the space thermostat set point (50°F), the unit heater shall be activated.
   2) When the space temperature as sensed by the integral thermostat is above the space thermostat set point (50°F), the unit heater shall be off.

PART 3 EXECUTION

3.01 INSTALLATION

A. The Contractor shall start up each piece of equipment and system and shall make all adjustments so that the system is placed in proper operating condition.

B. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

C. Equipment

1. Install equipment in accordance with manufacturer's recommendation. Provide piping and ductwork connections in accordance with the requirements as specified elsewhere in this Section.

2. When units are shipped disassembled, field connect all sections together as shown on the Drawings to form single air handling unit. Seal all joints with gaskets and/or sealants.

3. Do not operate equipment without filters. Do not run equipment with dirty filter pressure drop more than twice clean filter pressure drop. A total of three complete sets of filters shall be provided. The first set is to be installed for start-up, test and balancing. The second set shall be installed after final cleanup and acceptance by the Owner. The third set shall be turned over to the Owner as a spare.

4. The Contractor shall start up each piece of equipment and system and shall make all adjustments so that the system is placed in proper operating condition.

D. Insulation - General

1. Do not apply insulation prior to testing and acceptance of piping, ductwork and/or equipment. Insulation shall not be applied to damp or frosty surfaces. Clean dust, dirt, grease and moisture from surfaces of pipe and ducts before applying insulation or insulation adhesives. Install all insulation in a neat and workmanlike manner. Nameplates and equipment certification and data tags affixed to any piece of apparatus must remain exposed to view. Where two layers of insulation are used, stagger all joints both ways. Secure each layer independently. Continue insulation through walls, partitions, floors and pipe sleeves.

2. The recommendations and instructions of the manufacturers of products used in the work are hereby made part of this Section except as they may be superseded by other requirements of this Section.

3. Adhesives, coatings and vapor barrier materials shall be applied as specified by the manufacturer. Do not apply these materials when ambient temperature is above or below the maximum and minimum ambient temperature respectively, specified as limits by the manufacturer. In general, these limits are 90 degrees F and 40 degrees F, however, the limitations are to be checked for each product.

4. All penetrations through a vapor barrier for hangers, instruments, etc, shall be sealed to provide a complete vapor barrier. The use of staples or other fasteners that penetrate the vapor barrier shall not be permitted.

5. Insulation systems that require a vapor barrier shall be installed with an intact vapor barrier that covers the entire pipe, duct, or piece of equipment to be insulated. All edges of insulation that do not abut another piece of insulation shall have the vapor

barrier extended and sealed to the item being insulated. All penetrations through the insulation such as for thermowells, test ports, dampers, nameplates, or other items shall have the vapor barrier extend over the edges of the insulation and sealed to the item being insulated. Where items are mounted on ductwork a standoff shall be provided to protect the vapor barrier. The vapor barrier shall be sealed to the standoff.

6. For insulated items exceeding 100 square feet, or 20 feet in length, extend the vapor barrier to the item being insulated to reduce the area or length within a single enclosed area to the dimensions listed above.

E. Piping Insulation Cold Piping Closed Cell Foam

1. Apply insulation in thicknesses indicated. Joints shall be sealed using self-sealing seams or adhesive.

2. Fittings shall be covered with the same insulation, mitered to fit.

3. Installation - Apply insulation in the thickness indicated. Attach insulation to sheet metal duct. Joints shall be made to have compression fit with the joints sealed with adhesive. Manufacturer's installation instructions shall be followed. Adhesives and coatings shall be provided by the insulation manufacturer and shall be compatible with the insulation. Insulation shall be provided with a protective finish for outdoor use in accordance with manufacturer's recommendations.

Service	Pipe Size	Insulation Thickness
Refrigerant Piping	All sizes	1 – in.
Condensate Drain Piping – Air Conditioners	All sizes	1 – in.

F. Ductwork Insulation

1. For purposes of insulation, flexible ductwork shall be treated as sheet metal ductwork.

2. Provide all cold ductwork with a vapor barrier. Where the method of attachment causes penetrations of the vapor barrier, seal such penetrations with vaporseal adhesive and vapor barrier tape.

3. Clips, pins, washers, staples, and other metal components shall be of the same material as the duct to be insulated. Where items of the same material are not available, a material of equal corrosion resistance may be used. If a different material of equal corrosion resistance is to be used, it must be approved by the Engineer.

4. All outside corners of ductwork in the traffic level shall be protected by sheet metal angles. Angles shall be 22 gauge galvanized steel with 2-in legs. When the duct is constructed of materials other than galvanized steel, the protective angle shall be fabricated of the same material as the duct, or of equal corrosion resistance. If a

different material of equal corrosion resistance is to be used, it must be approved by the Engineer. Angles shall be attached to the outside of the vapor barrier with adhesive. The entire inside surface of the corner angle shall be coated with adhesive before being installed.

5. All joints in insulation shall be compressed 0.25-in. Corner insulation shall be lapped with the overlap extending over the full thickness of the insulation layers. Open spaces in joints are not acceptable. A minimum of two layers of insulation shall be used when the required insulation thickness is greater than 2-in. Joints in adjacent layers shall be staggered a minimum of 3-in.

6. All ductwork, except as specifically noted below, shall be insulated unless approved in writing by the Engineer.
   a. Process Area Exhaust Ductwork. Toilet exhaust ductwork shall be insulated.
   b. Double Wall Insulated Ductwork.

G. Ductwork Insulation - Blanket Type

1. Concealed Round and Rectangular Single Wall Ductwork and Exposed Round Single Wall Ductwork
   a. Installation - Apply insulation in the thickness listed below. Adhere insulation to the duct surface with adhesive applied in strips 6-in wide on 12-in centers. Butt all joints and lap jacket 2-in over adjoining jacket. Seal all lap joints with vaporseal adhesive and staples. For ducts 30-in wide and over, additionally support insulation on bottom of duct with rows of welded or adhesive clips and washers on 18-in centers. Seal penetrations, staples and terminations of vapor barrier with vapor barrier coating.
   b. Insulation Thickness - Concealed Round and Rectangular Single Wall Ductwork and Exposed Round Single Wall Ductwork.
      1) All ducts 2-in

H. Ductwork Insulation - Fiberglass Board Type

1. Exposed Rectangular Single Wall Ductwork and Plenums.
   a. Installation - Apply insulation in the thickness listed below. Fasten insulation to sheet metal duct with weld pins or approved adhered pins and clip washers. Place pins on 12-in centers located near edge of insulation and with a minimum of two rows per side. Impale insulation on pins. Attach clip washers so that they rest on the surface of the insulation without indent. Cut off pins flush with surface of washers. Seal penetrations with aluminum vapor barrier coating. Groove insulation to cover standing seams or stiffeners. Extend vapor barrier facing continuously over standing seams or stiffeners to provide continuous seal. Seal joints and edges with 4-in wide strip of factory furnished vapor barrier facing adhered with vapor barrier adhesive or approved vapor barrier duct sealing tape to provide a continuous vapor barrier.
   b. Insulation Thickness - Exposed Rectangular Single Wall Ductwork and Plenums.
      1) All ducts 2-in

I. Ductwork Insulation - Closed Cell Foam Type

1. Installation - Apply insulation in the thickness listed below. Attach insulation to sheet metal ductwork with a full coverage coat of adhesive. Make joints to have a compression fit with the joints sealed with adhesive. Cut insulation at standing joints and seams in the ductwork and apply additional layers of insulation over the standing joint or seam to obtain an insulation thickness equal to that on the surface of the duct. Follow all manufacturers' installation instructions. Adhesives and coatings shall be provided by the insulation manufacturer and shall be compatible with the insulation. Insulation shall be provided with a protective finish for outdoor use in accordance with manufacturer's recommendations.

2. Insulation Thickness
   a. Outdoor mounted round and rectangular single wall ductwork.
      1) All air ducts 1-in

J. Installation of Ductwork

1. Fabricate and erect all ductwork where shown on the Drawings, as specified herein and in accordance with SMACNA requirements. Rigidly support and secure ductwork in an approved manner. Install hangers plumb and securely suspended from supplementary steel or inserts in concrete slabs. Sufficiently thread lower ends of hanger rods to allow for adequate vertical adjustment. Do not use building siding and metal decking to hang ductwork.

2. Wherever ducts are divided, maintain the cross-sectional area. All such changes must be approved and installed as directed by the Engineer or as approved on shop or erection drawings.

3. During installation, close the open ends of ducts to prevent debris and dirt from entering. Install work in accordance with the overall approved progress schedule and in cooperation with all other trades so there will be no delay to other trades.

4. Provide the unused portion of external louvers (where it is not used as a fresh air intake or exhaust) with a blank-off constructed of 0.0625-in aluminum. Provide blank-off panels with aluminum reinforcing angles to prevent buckling and secured to the exterior wall with aluminum angles and rustproof fasteners on not more than 12-in centers. Provide caulking completely around the outside edge of the angle and the aluminum.

5. Install automatic dampers when supplied by other trades.

6. Cross-break sheet metal in accordance with SMACNA duct construction standard. Apply cross-breaking to the sheet metal between the standing seams or reinforcing angles. The center of the cross-break shall be of the required height to assure each panel section being rigid.

7. Cross-break streamlined ducts on top only and adequately brace internally.

8. Beading as specified in SMACNA will be acceptable in lieu of cross-breaking.

9. The Drawings of the air ducts and air risers show the general location for installation of the ducts and risers. Should additional offsets or changes in direction be made,

these changes must be considered in the original bid and shall be installed at no additional cost to the Owner.

10. All necessary allowances and provisions shall be made in the installation of the ducts for the structural conditions of the building. Ducts shall be transformed or divided as may be required. Wherever this is necessary, maintain the cross-sectional area. All of these changes, however, must be approved and ducts installed as directed by the Engineer or as approved on shop or erection drawings.

11. The taper of all transformations shall be not more than 15 degrees.

12. Secure casing to curbs according to SMACNA Duct Construction Standards.

13. Provide baffle plates as required to prevent stratification and to provide proper operation of controls.

14. Where ducts are constructed of materials other than galvanized steel the reinforcing members shall be of the same material as the ductwork.

15. For PVC ductwork where reinforcing members of material other than PVC are required, totally encase the reinforcing member in PVC.

16. The use of button punching or snap locks on ductwork constructed of aluminum shall not be permitted.

K. Hangers

1. The use of wire to hang flexible ductwork shall not be permitted.

2. Ductwork shall not come in contact with any of the ceiling construction or any other equipment in the ceiling cavity.

L. Sealing of Ductwork

1. General – Unless, otherwise indicated, seal all ductwork joints and seams using sealant in accordance with the instructions of the sealant manufacturer and this Section. All transverse seams, joints and fitting connections, both shop and field assembled, shall be sealed in accordance with this Section. Not more than one longitudinal seam shall be unsealed in each section of duct.

2. Application of Sealant - Thoroughly clean all seams, joints, etc., of dirt, oil, grease, or other coatings which might interfere with the adhesion of the duct sealant before the sealant is applied.

3. Uncured sealant may be forced into the slotted side of the seam or joint before shop or field assembly, and the joint or seam completed while the sealant is still uncured. Excess sealant shall be removed from both the inside and outside of the duct before it sets.

4. Duct Tape - Use of duct tape alone for sealing ductwork is prohibited. Duct tape may be used primarily for the purpose of retaining the uncured duct sealant in seams and

joints until it has cured. Duct tape shall not be applied to the inside of any duct nor shall it be applied to standing type joints at any time. All duct tape used shall be compatible with the sealant.

5. Sealant shall be either in liquid form or a mastic with a maximum flame spread of 25 and a maximum smoke developed rating of 50 when tested in accordance with ASTM E84, NFPA 255 and UL 723.

6. Sealing systems shall be suitable for the environment. The following schedule is to be used to select the sealant.
   a. Indoor, dry galvanized round and rectangular duct is to be sealed with Iron Grip 601 or equal.
   b. Indoor, dry, stainless steel, aluminum and PVC coated is to be sealed with FTA 20 adhesive and DT-Tape gypsum or equal.
   c. All other areas unless otherwise noted are to be sealed with FTA 50 adhesive and DT-Tape gypsum or equal.
   d. All sealers listed or manufactured by Hardcast Inc. and are to define the type of sealer. Other equal sealants are acceptable.

M. Ductwork Fittings and Accessory Items

1. Duct Elbows - Rectangular ductwork where full radius elbows cannot be installed, provide abrupt elbows equipped with shop-installed hollow, air foil turning vanes.

2. Flexible Connectors
   a. Install flexible connectors at all duct connections to fans, fan units or blowers, air handling units and air conditioning units. Make connections substantially air tight at all seams and joints.
   b. Where the construction of the flexible connection or vibration isolator results in a cross-sectional area of the connection which is less than 90 percent of the adjacent ductwork, the size of the connection shall be increased to provide a cross sectional area equal to or greater than 90 percent of the adjacent duct.
   c. Provide flexible duct connections at both the intake and discharge connections for all fans and air handling units except as noted below:
      1) Wall and roof fans that have integral motor/fan wheel isolation.
      2) Air handling units where the fan is isolated from the intake and discharge connections by internal flexible connections or separations, and the unit is mounted without vibration isolators between the unit and the support structure.

3. Dampers
   a. Install manual volume control dampers wherever it may be necessary to regulate air volume for system air balancing and where shown on the Drawings.
   b. Install splitter dampers, where shown on the Drawings, to regulate air volume for system air balancing. Splitter dampers shall be single blade, end pivoted type, manual adjustment and position locking arrangement.
   c. Factory-fabricated volume extractors shall be used at all supply air diffusers.
   d. An access door, of ample size to permit maintenance and resetting of damper blades, shall be installed at each opposed blade damper, splitter damper and volume extractor so located for easy access to the damper blades.

4. Access Doors
   a. Provide access doors at the following locations (minimum requirements):
      1) Automatic dampers - linkage side.
      2) Duct mounted temperature controllers.
      3) Freeze-stats.
      4) Fire dampers.
      5) Smoke detectors.
      6) Filter banks.
      7) Flow sensors.
   b. Where access doors are required in ductwork located above ceilings, coordinate the location of the access doors to clear the ceiling support system and to be accessible through the ceiling grid.

N. Grilles, Registers and Diffusers

1. The location of diffusers, registers and grilles shall be as shown on the Reflected Ceiling Plans. Where diffusers, registers and grilles are not located in the ceiling, there are no Reflected Ceiling Plans provided, the location shall be as shown on the ductwork drawings. The exact location of these devices shall be determined in the field in cooperation with the other trades.

2. Install all devices in an approved manner in accordance with the manufacturer's recommendation.

O. Flexible Ductwork

1. Make connections, joints and terminations air tight as recommended by the manufacturer. Where joints are made to rigid sheet metal ductwork, apply 3M Company EC-800 sealer and the joint shall be drawn tight with a drawband. Collars shall be 2-in long minimum and sleeves shall be 4-in long minimum.

2. Install flexible ducts with one duct diameter-radius elbows and cut as short as possible. Duct shall not be compressed, and the length shall be kept short so minimum hangers or supports are required, and static pressure losses are kept to a minimum. Sag in flexible duct shall not exceed 1/2-in/ft between duct supports.

P. Filling in Space Around Ductwork

1. To prevent sound passing through the area between the duct and the framed or cut opening in the floors, walls or partitions, pack mineral wool to completely fill the space the full depth of the opening. Whenever a fire-rated wall or floor is penetrated, fill the space around the duct with a locally approved type of fireproof rope.

2. At firewalls, apply galvanized sheet metal escutcheon plates on both faces of the wall to close the gap between the structure and the sides of the insulated or bare duct.

Q. Duct Supports Through Floors

1. Where vertical ducts pass through floor openings, rigidly attach supporting angles to the ducts and anchor with expansion bolts to the floor or curb. Angles shall be of

the same material as the duct for metal duct and stainless steel for nonmetallic ducts, placed on the two long sides of the duct extending 3-in over edge of opening, and shall not be less than the sizes recommended by SMACNA. Remaining open areas shall be filled in with a plate of the same material as the angles.

R. Supporting Outdoor Ducts

1. Provide the ducts installed above roof with angle iron supports. Sizes of angles shall be as shown on the Drawings.

2. The vertical supporting angles shall be continuous full height of the duct and shall be bolted to same. These, together with intermediate supporting angle as required, shall be provided with bottom plates which shall be welded to the vertical angles. Attach the plates with anchor bolts to sleepers, which shall be placed on scraped roofing. Weld all of these angles together to form a stiff continuous supporting unit for the duct. Paint angles with oxide primer after installation.

3. Slope ducts to shed water.

4. Duct supports shall be designed and installed to meet wind loading requirements as described in Part 2.

S. Ductwork at Masonry

1. Where ducts connect to, or terminate at masonry openings, or along the edges of floors where concrete curbs are not being provided, place a continuous 2-1/2-in by 2-1/2-in by 3/16-in galvanized angle of the same material as the duct around the ductwork. Then bolt the angle to the construction and make airtight to same by applying caulking compound on the angle before it is drawn down tight to construction.

2. Fasten plenums to concrete curbs with 3-in by 3-in by 1/4-in thick continuous angle. Concrete curbs will be provided under another Division. This angle shall sit on a continuous bead of caulking compound and be anchored to the curb at 16-in centers. Terminate the sheet metal at the curb and bolt to the angle. Seal the sheet metal to the curb with a continuous bead of caulking compound.

3. When exposed ducts pass through finished floors, walls or ceilings, provide angle collars completely covering space around duct.

T. Quality of Ductwork Installation

1. All ductwork shall be free from pulsation, chatter, vibration or objectionable noise. After system is in operation, should these defects appear, correct by removing, replacing or reinforcing the work. Sound levels shall not exceed the minimum requirement as specified in ASHRAE 1980 Systems Volume, page 35.16, Table 23. No discreet tones will be allowed.

2. The maximum allowable leakage of low pressure system shall be 5 percent of air volume.

U. Plenums

1. Seal fresh air inlet and exhaust air plenums at louvers or otherwise subject to weather entrainment watertight at all bottom joints and seams and up all vertical seams for a minimum of 12-in. After application, remove excess sealant before it sets hard. Where possible, pitch fresh air inlet and exhaust air plenums down towards the louver. Where it is not possible to pitch the plenum, provide a 1-in capped drain connection at the low point of the plenum.

V. Test Ports

1. Where shown on the Drawings and where required for testing and balancing, provide instrument insertion ports. Size and location of ports shall be coordinated with the Contractor performing air balancing. Seal ports with plastic snap lock plugs. When the ductwork will be insulated, extend the port to the face of the insulation and seal the vapor barrier to the port. When the ductwork is lined, extend the port into the duct to the inner surface of the duct liner.

2. In round ductwork provide 2 ports 90 degrees on centers. In rectangular ductwork provide ports are required by AABC or NEBB for a full traverse measurement.

3. As a minimum, ports shall be provided in the following connections:
   a. All duct mains.
   b. All duct branches unless all connections are diffusers, registers, or grilles and the total can be calculated by summing the readings for all of the connections.
   c. All connections to tanks or hoods where there is no other access for taking a measurement.

4. A main duct is defined as one of the following:
   a. A duct serving five or more outlets.
   b. A duct serving two or more branch ducts.
   c. A duct emanating from a fan or plenum.
   d. All remaining ducts are considered branch ducts.

W. Piping

1. Pipe and Fittings
   a. Install piping in a neat manner with lines straight and parallel or at right angles to walls or column lines and with risers plumb. Run piping so as to avoid passing through ductwork or directly under electric light outlets and/or interference with other lines or extending beyond furring lines as determined by Architectural Drawings. Accomplish all work using the best methods and procedures of recognized pipe fabrication in a good and workmanlike manner in accordance with the latest revision of applicable ANSI Standards, ASME Codes and PFI Standards.
   b. Cut pipe square, not upset, undersize or out of round. Carefully ream ends and clean before installing.
   c. Bending of pipe shall not be permitted. Use fittings for all changes in direction.
   d. Do not remove end caps on pre-cleaned pipe until immediately before assembly. Cap all open ends immediately after completion of installation.

e. Thoroughly clean all piping interiors after installation and keep them clean by approved temporary closures on all openings until the system is put in service. Closures shall be suitable to withstand the hydrostatic test.

2. Soldering (Copper Tubing)
   a. After cutting, thoroughly clean all surfaces to be soldered to a metal-bright finish, free from dirt, grease or other material before fluxing and soldering. Perform this cleaning by using emery cloth, sandpaper or steel wool. Clean the outside end of the tubing for a length of 1/2-in greater than the depth of the fitting. Clean the inside of the fittings in a similar manner. Apply non-corrosive flux and assemble the joint. Acid solder or acid flux will not be accepted.
   b. Heat the surfaces to be joined slowly and uniformly to the melting point of the solder. Maintain the surface being soldered above the melting point of the solder for sufficient time to draw the solder completely into the joint. When the solder congeals to a plastic state, remove the excess metal with a cloth brush, leaving a fillet around the end of the fitting. Full penetration of the solder uniformly throughout the entire socket is required. Allow the soldered joints to cool in still air until only warm to the hand, after which the work may be quenched.
   c. Any type of crack, pinhole, area of incomplete penetration, or similar defect will not be accepted. Peening for closing up defects shall not be permitted.
   d. Use heating torches of sufficient size for heating of large fittings prior to soldering. Multiple tips or ring burners for use on combination torches may be used.
   e. Remove all external and internal loose solder and flux after joint cools.

3. Refrigerant Piping
   a. Before and during silver soldering refrigerant piping, purge the assembly of pipe and fittings with dry nitrogen, to avoid formation of oxidation scale on inside of pipe during soldering.
   b. Where specially prepared, Type R, cleaned or charged refrigerant piping is not available for equipment interconnection, with the [Engineer's] [Owner's Representative's] approval, the following procedure must be completed. Clean the interior of field assembled refrigerant piping after joining in four steps as follows:
      1) Draw a clean lintless cloth through the piping to remove coarse dirt and dust.
      2) Draw clean lintless trichlorethylene saturated cloth through the piping until cloth is not discolored with dirt.
      3) Draw a clean cloth saturated with compressor oil through the piping.
      4) Complete cleaning by drawing a clean, dry, lintless cloth through the piping.
   c. Pressure test and charge immediately after cleaning.

3.02 FIELD TESTING

A. Testing and Balancing

1. General - Test, adjust and balance all HVAC systems. If required by the Engineer, tests shall be made during the progress of the work to demonstrate the strength, durability and fitness of the installation. Furnish all instruments, ladders, lubricants, test equipment and personnel required for the tests; including manufacturer's

representatives for testing and start-up of all Contractor supplied equipment. Before testing and balancing, all systems shall be cleaned as specified. Submit four copies of records of all tests, measurements, settings of throttling devices and nameplate data to the Engineer.

2. Final Tests - Perform tests of all systems as required by the Engineer prior to final acceptance of the systems for the purpose of demonstrating satisfactory functional and operating efficiency as well as adjustment. During this period, check the setting of all automatic controls and take sufficient measurements to ensure that conditions are correct and that capacities are adequate to meet the specified requirements. Systems will not be considered complete until all tests have been concluded to the satisfaction of the Engineer and all other parties having jurisdiction. In event of leakage or defects, repeat tests until all faults are corrected. Perform the general operating tests under as near design conditions as possible.

3. Perform all testing, adjusting and balancing under the supervision of a qualified heating, ventilating and air conditioning engineer employed by the air balance and testing agency. Reporting forms for testing and balancing shall be as recommended by the AABC or NEBB.

4. Coordination of the test shall be the responsibility of the balancing sub-contractor. Access to the site, availability of service representatives, and tenant acquiescence will be considered in the determination of both the testing schedule and the witnessed recheck of the balancing.

5. Refer to Section 23 05 93 for additional requirements.

B. Piping Pressure Testing

1. Pipe Testing Procedure
   a. The equipment to which any piping system is attached shall not be subject to any line tests. Either remove or blank off items which may be damaged by the test pressure. The test pressures apply to the piping materials as specified, but shall not be assumed to apply to piping specialties, accessories, or equipment including safety heads, rupture discs, relief valves, expansion joints, instruments or filters.
   b. Prior to pressure testing, take the following precautions:
      1) Do not apply insulation over piping prior to completion of testing.
      2) Lines containing check valves shall have the source of test pressure located on the upstream side. Set the control valves in the open position for the duration of the test.
      3) Block up all piping supported by springs temporarily to a degree sufficient to sustain the test liquid load.
   c. Test the piping system at the pressure indicated in the individual pipe material specification section or 1-1/2 times normal working pressure, whichever is greater for the respective systems. Leakage or loss of head will not be acceptable.

2. Condensate Drains Testing

Test Press.	Medium	Duration	Allowable Loss

10 Feet Column	Water	2 hrs	None
10 Inch Mercury	Air	15 min.	None

3. Refrigerant Piping Testing

Test Press.	Medium	Method
To suit Refrigerant used	Inert gas and refrigerant	Electronic leak detector

4. Following the completion of acceptable leak testing, evacuate and charge the completed refrigeration system in accordance with the manufacturer's recommendations.

3.03 START-UP AND TEMPORARY OPERATION

A. Properly maintain and service all equipment and systems until the particular equipment or the system has been accepted by the Owner.

3.04 BALANCING OF ROTATING EQUIPMENT

A. All machines shall be balanced both statically and dynamically by the manufacturer within the limits of best commercial practices. The term machine, as used above, is to be considered as any piece of equipment, which contains rotating components. All machines furnished shall have operating speed not exceeding 80 percent of the first critical speed.

3.05 PAINTING

A. The Contractor shall be responsible for the repair of all defects, blemishes, holidays and the like apparent in manufacturer's coatings and shall ensure that materials used for such repair shall match or be compatible with the manufacturer's standard color, coatings and practices. Do not paint over nameplates.

B. Paint black the louver side of all louver blank off panels and the interiors of unlined plenums and ductwork where connected to louvers.

3.06 ACCEPTANCE OF AUTOMATIC CONTROL SYSTEM

A. During the acceptance inspections, the manufacturer shall provide the required personnel to operate the system and show complete functionality. The manufacturer will also provide the required communication devices to allow simultaneous observations at multiple points. In general, each system will be run through its complete operating sequence.

B. Systems that are found to be operating incorrectly will be bypassed and not corrected during the inspection. If multiple systems are found to not be operating, the inspection will be canceled and rescheduled at the manufacturer's expense.

3.07 CLEANING

A. Leave all piping, ductwork and equipment in a thoroughly cleaned condition. Thoroughly flush all piping to remove all foreign materials prior to any cleaning procedure. All flushing and cleaning shall be to the satisfaction of the Engineer. Furnish, install and remove all temporary piping and equipment used in the cleaning and flushing operations.

B. Maintain all ductwork, fans, coils, air filters, outlets and other parts of the ductwork systems in a clean condition during installation.

C. Clean complete ductwork systems prior to testing and air balancing. Secure cheese cloth over all openings of the ductwork system for entrapment of dirt during the cleaning operation.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish the necessary labor, materials, instruments, transportation and devices required and test, adjust and balance the total heating-ventilating-cooling systems and air systems. Each as specified and detailed herein, or as required to cause the systems to perform in accordance with the intent of the Drawings and this Section. Systems to be tested, adjusted and balanced include all systems installed by the HVAC Contractor and the additional systems provided and installed by others as listed below.

B. Testing, balancing and operation of the systems shall be performed by competent and experienced personnel, having formerly done similar work and whose qualifications and performance shall be subject to the approval of the Engineer. Test and balance air system and submit testing and balancing reports to the Engineer for review and approval. Re-balance when required by the Engineer, incorporating all changes and certify the systems have been tested and balanced to meet specified requirements.

C. The tests shall demonstrate the specified capacities and operation of equipment and materials comprising the systems. Such tests other than as described herein, which are deemed necessary by the Engineer to indicate the fulfillment of the Contract, shall be made.

D. Systems serving odorous areas shall be balanced for both flow and pressure as defined herein.

E. Data required by this Section shall receive complete approval before final payment is made.

F. If, in the opinion of the Engineer, the Contractor has not, will not, or cannot comply with the testing, balancing and adjusting requirements of this Section, he may advise the Owner to employ a qualified firm to perform such work at Contractor's sole expense. Refer to Sections 23 00 00 for additional requirements.

G. Refer to the Drawings for additional requirements.

1.02 RELATED WORK

A. Refer to Section 23 00 00.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, the following:

1. Qualifications and experience information and data as detailed under Paragraph 1.04 below.

2. Proposed testing schedules and procedures.

3. Results of periodic field inspections as specified under Paragraph 3.01 below.

4. Preliminary draft "system" balancing reports as systems are completed and tested.

5. Final systems and Project balancing reports as final system adjustments are made as systems are accepted by the Owner.

6. All submittals shall contain a statement that Sections 23 00 00, 23 05 93 and all other referenced Sections have been read and complied with. The certification statement shall be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved and shall be included with every submittal and resubmittal.

B. In general, corrections or comments or lack thereof, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.04 QUALITY ASSURANCE

A. Qualifications standards for this work - Affiliation with manufacturers, installing contractors or engineering firms will not preclude acceptability. Submit qualifications within 60 days after Contract award. Membership in the AABC or NEBB for air and water testing is required. The testing balancing contractor shall not be affiliated with the on-site contractors.

B. To perform required professional services, the balancing agency shall have a minimum of two test-and-balance engineers certified by the AABC or NEBB.

C. This certified test-and-balance engineer shall be responsible for supervision and certification for the total work specified herein.

D. The balancing agency shall submit records of experience in the field of air system balancing or any other data as requested by the Engineer. The supervisory personnel for the firm shall have at least 5 years’ experience and all the employees used in this project shall be qualified technicians in this specific field.

E. The balancing agency shall furnish all necessary calibrated instrumentation to adequately perform the specified services. An inventory of all instruments and devices in possession of the balancing agency may be required by the Engineer to determine the balancing agency's performance capability.

1.05 ENGINEERING SERVICES

A. When engineering services are specified to be provided by the Contractor, the Contractor shall retain a licensed professional engineer to perform the services. The engineer shall be licensed at the time the work is done and in the State in which the

project is located. If the State issues discipline specific licenses, the engineer shall be licensed in the applicable discipline. In addition, the engineer shall be experienced in the type of work being provided.

B. All work is to be done according to the applicable regulations for professional engineers, to include signing, sealing and dating documents. When submittals are required by a professional engineer, in addition to state required signing and sealing, a copy of the current wallet card or wall certificate indicating the date of expiration shall be included with the submittal.

1.06 SCHEDULE AND PROCEDURES

A. A complete schedule of balancing procedures for each of the buildings or systems shall be submitted in sufficient time in advance so that the Engineer might arrange to observe these procedures as they progress. Before commencing with the balancing of the systems submit the methods and instruments proposed to be used to adjust and balance the air systems.

B. Submit proposed testing programs at least 2 weeks prior to the scheduled test to assure agreement as to personnel and instrumentation required and scope of each testing program.

1.07 DRAWING REVIEW

A. The balancing organization shall thoroughly review the location of all fresh air dampers, return dampers, spill dampers, quadrant dampers, splitter dampers, bypass dampers, face dampers, fire dampers, registers, grilles, diffusers, VAV boxes, troffers, etc. The purpose of the review is to finalize the optimum locations for dampers, test ports and balancing valves shown on the Drawings.

B. The balancing organization shall thoroughly review the location of all balancing valves, test ports, gauge cocks, thermometer wells, and flow control devices. The purpose of the review is to finalize the optimum locations for these components.

1.08 EQUIPMENT CURVES

A. Fan Characteristics Charts: The HVAC and General Contractors shall provide to the Balancing Organization any required characteristic curve charts for all fans to include air conditioning units and air handling units. Characteristic curve charts shall be not less than 8-1/2-in by 11-in and shall show the static pressure, capacity horsepower and overall efficiency for operating conditions from no load to 130 percent of specified load. The minimum size of the actual fan curve shall be no less than 6-in by 8-in. The use of faxed copies of curves is not acceptable.

1.09 GUARANTEE

A. The balancing work shall be guaranteed to be accurate and factual data, based on readings in the field. All typewritten data shall be submitted within 14 working days of the performance of the test. Test data shall not be held until final completion, but shall be

submitted on an interim basis as soon as the test or appropriate groups of tests are finished.

PART 2 PRODUCTS

2.01 MATERIALS

A. Furnish gaskets, lubricants and other expendable materials required to be replaced during the execution of this work.

B. Fixed-pitched pulleys required for fan adjustments shall be furnished on an exchange basis by the party responsible for the fan installation.

C. Where test results indicate that air quantities at any system fan are below or in excess of the specified amount, the HVAC and General Contractors, at their own expense, shall change driving pulley ratio or shall make approved changes to obtain the specified or scheduled air quantities.

D. Testing apparatus: Furnish plugs, caps, stops, valves, pumps, compressors, blowers and similar devices required to perform this work.

1. Furnish anemometers, thermometers, gauges, voltmeters, ammeters, lachometers and similar instruments, not part of the permanent installation, but required to record the performance of the equipment and systems.

2. Testing apparatus, not part of the permanent installation, shall remain the property of the Contractor, but made available to the Engineer.

3. Instruments used for testing shall be certified accurate to within plus or minus 0.10 degrees F for temperature or plus or minus 0.10-in wc for pressure. Calibration of the instruments shall be done within 7 days of testing for this project and henceforth every 30 days thereafter for the duration of the testing period. Certification of calibration shall be submitted to the engineer prior to starting the work.

2.02 TESTING REPORTS

A. Forms: Furnish test report data on 8-1/2-in by 11-in bond AABC or NEBB form paper in accordance with Section 01 33 23. Submit format for recording data and receive approval prior to use.

B. Reports shall be Excel spreadsheets format and shall be submitted in both hard copy and as a data file.

C. The report shall contain the following general data in a format selected by the balancing agency:

1. Project number

2. Contract number

3. Project title
4. Project location
5. Project architect
6. Project mechanical engineer
7. Test and balance agency
8. Test and balance engineer
9. General contractor
10. Mechanical subcontractor
11. Dates tests were performed
12. Certification

D. At a minimum, the report shall include:

1. Preface. A general discussion of the systems, any abnormalities and problems encountered.

2. Instrumentation list. The list of instruments including type, model, manufacturer, serial number and calibration dates.

3. System Identification. In each report, the VAV boxes, zones, supply, return and exhaust openings and traverse points shall be numbered and/or lettered to correspond to the numbers and letters used on the report data sheets and on the report diagrams.

E. Prepare 11-in by 17-in single line diagrams or 12-in by 18-in half size drawings showing all duct systems indicating all terminal air outlets including diffusers, grilles and registers, perforated plates, nozzles and other types of air supply, exhaust or return outlets. The minimum scale for diagrams showing the measurement points shall be 1/8-in=1-ft-0-in in the final form as submitted. The use of faxed copies of diagrams is not acceptable. Location of test points shown on the diagrams shall be clear and easy to locate on the diagram. The identification mark of the test points shall be the same as is shown on the test report showing the test data. The identification for test points shall include indication of the units served, and shall not have a duplicate in the project. All supply outlets shall be adjusted so that there are no drafts. Grille and register readings may be made by a vane anemometer, but diffuser readings shall be made by a flow hood or a velometer, using the tip recommended by the diffuser manufacturer. Each test sheet shall include the following data:

1. Job name and address.

2. Name of HVAC Contractor.

3. Name of balancing organization.

4. Instruments used to perform the test.

5. Name of test technician or test engineer.

6. Fan system and/or zone number.

7. Room number or area name.

8. Size of outlet.

9. Type outlet.

10. Manufacturer of outlet.

11. The cfm at each outlet on system and corresponding cfm at each outlet as noted on the plans.

12. Percent deviation of the measured flow versus the design flow.

13. Indication of the branch and terminal that are the open/low that are the basis for balancing the remainder of the system.

PART 3 EXECUTION

3.01 INSPECTIONS

A. During construction, the balancing agency shall inspect the installation of pipe systems, sheet metal work, temperature controls, and other component parts of the heating, ventilating and air conditioning systems. The inspections shall be performed periodically as the work progresses. A minimum of two inspections are required as follows: (1) when 60 percent of the duct work is installed: (2) when 90 percent of the equipment is installed. The balancing agency shall submit a brief written report of each inspection to the Engineer.

3.02 START OF BALANCING

A. The General Contractor shall notify the Balancing Organization and Engineer when systems become operational and ready for preliminary and final testing, adjusting and balancing.

B. Final balancing shall not begin until system has been installed complete and is capable of normal operation. Provide personnel to assist in rough balance and calibration.

C. All grilles, dampers, fans, coils, pumps, valves and linkages shall be verified to be installed and operating.

D. System shall be capable of operating under control as specified on Drawings and/or contained herein.

E. Visually inspect all fire dampers on branch take-offs to each floor to ensure that they are fully open.

F. Verify with straight edge that fan/pump and motor shafts are parallel and that sheaves are in proper alignment.

G. Verify that belts are properly tensioned when unit is operating with no excessive squeal at startup. If not correct, adjust sheaves or motor base accordingly.

H. Start fans and pumps and verify that rotation is correct. If rotation is incorrect coordinate with electrical contractor to switch power leads such that the motor rotates correctly.

I. Check nameplate voltage on motor, compare to scheduled voltage. Notify the Engineer immediately of any discrepancies. Measure and record actual voltage across all power leads. Notify the Engineer of discrepancies immediately.

J. Check motor nameplates full load amps, measure and record amperage across all power leads. If there are marked discrepancies in amperage draws between legs, notify the Engineer immediately.

K. Measure and record fan/pump and motor rpm. Check that motor rpm agrees with nameplate and scheduled rpm.

L. If, upon commencing the work, the balancing contractor finds that the systems are not ready, or if a dispute occurs as to the readiness of the systems, the balancing agency shall request an inspection to be made by the Engineer. This inspection shall establish to the satisfaction of the represented parties whether or not the systems meet the basic requirements for testing and balancing. Should the inspection reveal the notification to have been premature, all costs for the inspection and work previously accomplished by the balancing agency shall be paid for by the General Contractor. Furthermore, such items that are not ready for testing and balancing shall be completed and placed in operational readiness before testing and balancing services shall be recommenced.

M. Leaks, damage and defects discovered or resulting from startup, testing and balancing shall be repaired or replaced to like-new condition with acceptable materials. Tests shall be continued until system operates without adjustments or repairs.

3.03 REQUIRED ACCURACY

A. Systems shall be balanced to be within the following limits of the capacity shown on the Drawings. Limits shall be applied to both individual components and to the system totals.

1. General Systems (plus/minus 10 percent)

3.04 TESTING

A. HVAC Air Systems (Air Handling Units, Exhaust Fans, etc.)

1. Balance the supply return and exhaust air systems in accordance with AABC or NEBB Standards by the use of direct reading instruments such as an "anemotherm" or velometer which has been properly calibrated.

2. Temporarily add static pressure to the system, to simulate the effect of dirty filters, by blanking off portions of the filter section, covering filter section with cheesecloth or other suitable means. Confirm static has been added with new static pressure reading across fan. Remove cheesecloth, etc., after traverses are complete.

3. If so instructed by the Engineer, further balancing of temperature shall be made either by thermometer or by temperature recorder.

4. The sequence of air balancing shall be as follows:
   a. First, establish air flow quantity at supply fan by main duct traverse.
   b. Next, establish air flow quantities in main ducts and branches.
   c. Finally, establish air flow quantities at outlets, using proportional balancing among branch outlets. All multiple opening systems shall be left with at least one "open low" inlet or outlet, to which all other system openings shall be proportionally balanced. The "open low(s)" on each system shall be indicated in the report.
   d. Grille and register readings may be made by a vane anemometer, but diffuser readings shall be made by a flow hood or a velometer using the tip recommended by the diffuser manufacturer. All supply outlets shall be adjusted so that there are no drafts.
   e. After all outlets are adjusted to within the tolerances specified elsewhere in this Section, remeasure all system outlets, and retraverse all branch and main ducts to establish final "as balanced" flows.
   f. All main air ducts shall be traversed, using a Pitot tube and manometer. The manometer shall be calibrated to read two significant figures in all velocity pressure ranges. The static pressure reading at the traverse point shall be recorded for each successive traverse.
      1) A main duct is defined as either of the following:
         a) A duct serving five or more outlets.
         b) A duct serving two or more branch ducts.
         c) A duct emanating from a fan or plenum.
      2) All other ducts are branch ducts.
      3) The intent of this operation is to measure by traverse, the total air quantity handled by the fan and to verify the distribution of air to zones and to adjust system pressure to minimum level required to satisfy the farthest air outlet.
   g. Adjust fan speeds if results of system capacity tests are not within tolerances specified and repeat Paragraphs 3.04.A.4.c, d, and e above, as required.
   h. Mark all final balancing damper positions with a permanent marker.
   i. For systems which modulate between different flow modes (e.g. minimum outside air to 100 percent outdoor air or 100 percent return air to 100 percent exhaust) measure and report system flow under both extremes of modulation and check for excessive system flow deviation above design, when system is modulating between its end points.

5. Furnish data in excel spread sheet format tabulating the following:
   a. Opening number, type, size and design flow rate.
   b. Quantity of air in cfm at each air outlet and inlet.
   c. Dry and wet bulb temperature in each room.
   d. Dry and wet bulb temperature of the supply air.
   e. Dry and wet bulb temperature of the return air.

f. Outdoor dry and wet bulb temperature at the time the above tests are conducted.
g. Total, sensible, and latent capacity in BTUH.

6. Adjust belts, sheaves and the alignment of air handling equipment.

7. Where various combinations of sheaves must be installed on fan systems to achieve the correct air delivery, change the sheaves and continue to take successive readings until the correct combinations are installed.

8. Furnish data in excel spread sheet format taken at each air moving device, to include fans, packaged units and air handling units, tabulating the following:
   a. Manufacturers, model number and serial number of units.
   b. All design and manufacturer's rated data.
   c. Total quantity of supply air in cfm.
   d. Total quantity of return air in cfm.
   e. Total quantity of exhaust or relief air in cfm.
   f. Total quantity of outside air in cfm.
   g. Outlet velocity - fpm.
   h. The rpm of each fan or blower.
   i. Maximum tip speed - fpm.
   j. The rpm of each motor.
   k. Voltage and ampere input of each motor (one reading for each phase leg on 3 phase motors).
   l. Pressure in inches w.g. at inlet of each fan or blower.
   m. Pressure in inches w.g. at discharge of each fan or blower.
   n. Pressure drops across system components such as louvers, filters, coils and mixing boxes.
   o. Submit the actual fan operating point on a copy of the fan shop drawing showing operating curve.
   p. List the following data from all fan motors installed.
      1) Manufacturer model and size.
      2) Motor horsepower, service factor and rpm.
      3) Volts, phases, cycles and full load amps.
      4) Equipment locations.
   q. Pressure in inches w.g. at inlet to unit cabinet.
   r. Pressure in inches w.g. at discharge from unit cabinet.
   s. Outdoor air and return air damper position.
   t. List the following data for all coils installed in the unit:
      1) Airflow rate in cfm.
      2) Number of rows.
      3) Number of fins per inch.
      4) Face area in square feet.
      5) Tube size in inches.
      6) Tube and fin materials.
      7) Outdoor-air, wet- and dry-bulb temperatures in deg F.
      8) Return-air, wet- and dry-bulb temperatures in deg F.
      9) Entering-air, wet- and dry-bulb temperatures in deg F.
      10) Leaving-air, wet- and dry-bulb temperatures in deg F.
      11) Refrigerant expansion valve and refrigerant types.
      12) Refrigerant suction pressure in psig.

13) Refrigerant suction temperature in deg F.
14) Inlet steam pressure in psig.
15) Number of stages.
16) Actual operating current and voltage for all legs.

B. Heat Pump Units and Condensing Units

1. Furnish typewritten data, tabulating as follows:
   a. Manufacturer, model number, size and serial number of all units.
   b. All design and manufacturer's rated data.
   c. Suction and condensing temperatures, and pressures.
   d. Temperatures of entering and leaving air.
   e. Voltage and ampere input of motors under full load (one for each phase leg).
   f. Total, sensible, and latent capacity in BTUH.

C. Heating Coils (Electric Unit Heater and Air Handling Units)

1. Furnish typewritten data tabulating the following:
   a. Manufacturer and model number.
   b. All design and manufacturer's rated data.
   c. Actual operating current and voltage for all legs.
   d. Coil location and identification.
   e. Dry bulb inlet and outlet coil temperatures.
   f. Number of stages.
   g. Air flow in CFM.
   h. Face area in square feet.
   i. Capacity in BTUH.

3.05 STANDBY EQUIPMENT

A. Where systems are provided with standby equipment, the system shall be balanced for operation in standby as well as normal operation.

3.06 FINAL ACCEPTANCE

A. At the time of final inspection, the balancing agency shall recheck, in the presence of the Engineer, specific and random selections of data recorded in the certified test-and-balance report.

B. Points and areas for recheck shall be selected by the Engineer.

C. Measurements and test procedures shall be the same as the original test and balance.

D. Selections for recheck, specific plus random, shall not normally exceed 15 percent of the total number tabulated in the report, except where special air systems require a complete recheck for safety reasons.

E. If the specific rechecks are more than 5 percent deviation from the report or specified flows, all of the systems, that require specific recheck, shall be rebalanced. If 5 percent or 5 of the random checks, whichever is less, exceeds a 10 percent deviation from the specified flows, the report shall be rejected. In the event the report is rejected, all systems

shall be readjusted and tested, new data recorded, a new certified test-and-balance report submitted, and a new inspection test made, all at no additional cost to the Owner.

3.07 OPPOSITE SEASON TEST

A. The balancing agency shall perform an inspection of the HVAC system during the opposite season from that in which the initial adjustments were made. The balancing agency shall make any necessary modifications to the initial adjustments to produce optimum system operation.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. This Section specifies the basic materials and methods of installation for insulation for process piping, valves, and fittings as specified herein and where shown on the Drawings.

B. Heat tracing tape and systems are specified in Section 40 41 13.

1.02 DESCRIPTION OF SERVICE

A. The pipe insulation system shall comprise preformed insulation and aluminum sheathing with stainless steel banding. Coordinate with heat tracing tape system where required.

B. In piping systems to be insulated, all pipe, fittings, and valves shall be insulated. Valve operators and any other parts of the system designated in the field by the Engineer shall be left exposed for operation and/or observation.

C. The finished appearance of the insulation sheathing shall be cylindrical with no irregular dents, bulges, depressions, soft spots, or uneven edges. Workmanship shall be of first quality. All openings shall be covered and all joints sealed with matching colored sealant.

1.03 RELATED WORK

A. Pipe testing, cleaning and disinfection is included in Section 01 45 28.

B. Pipe hangers and supports are included in Section 40 05 75.

C. Electrical heat tracing is included in Section 40 41 13.

1.04 SUBMITTALS

A. Submit to the Engineer, in accordance with Sections 01 33 23 and 01 78 23, the following for each insulation by System: Manufacturer's product data showing conformance with this Section for all required insulation, jackets, covers, coatings, adhesives, fasteners, supports and appurtenances; complete manufacturer's instructions for installation of all required items.

B. All submittals shall contain a statement that Sections defining specific insulation types and thickness and all other referenced Sections have been read and complied with. The certification statement shall specify the specific Sections and be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.

C. All materials deliveries must have accompanying manufacturer's certifications attesting to satisfactory results of product testing showing conformance with this Section.

D. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.

E. In general, corrections or comments or lack thereof, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.05 REFERENCE STANDARDS

A. National Fire Protection Association (NFPA)

B. Occupational Safety and Health Administration (OSHA)

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.06 DEFINITIONS

A. Particular terminology used under this Section is defined as follows:

1. Outdoor Piping - Piping that is not within a building and which is exposed to the weather.

PART 2 PRODUCTS

2.01 GENERAL

A. The materials supplied shall conform to all governing codes, standards, and specifications. If any departures from the specification are deemed necessary, departures shall not be made without prior written approval of the Engineer.

B. All materials and integrated insulation assemblies furnished shall have flame spread ratings of not over 25 (fire resistive), smoke developed rating of not over 50 and fuel contributed rating of not over 50, as established by tests conducted in accordance with Interior Federal Standard No. 00136B, entitled 'Interior Federal Standard Flame-Spread Properties for Materials' and the National Fire Code of the NFPA. The treatment of jackets or facings to impart flame and smoke safety must be permanent. (The use of water-soluble treatment is prohibited.) Exception allowed for closed cell foam insulation and PVC fitting covers.

C. The toxicity of the solvents used shall not exceed a maximum allowable concentration of 200 ppm or the latest value published by the American Conference of Governmental Industrial Hygienists and OSHA.

D. Adhesives, coatings and vapor barrier materials shall be compatible with the insulation as recommended by the insulation manufacturer. Submit a certified statement attesting to the approval of the materials by the insulation manufacturer. Adhesives and coatings shall be manufactured by Foster Div.; H.B. Fuller Co.; Childers Products Co. or equal. H.B. Fuller and Childers Products Numbers are listed below by adhesive/coating types.

1.	Lagging adhesive:	30-40, CP50, AMV-1.
2.	Vapor barrier coating:	30-35, CP30.
3.	Vaporseal adhesive:	85-75, CP82.
4.	Duct adhesive:	85-20, CP82.
5.	Sealing compound adhesive:	30-45, CP70.
6.	Weatherproof mastic:	35-01, CP10-1.

2.02 INSULATION FOR PIPING

A. Piping insulation shall be closed cell foam type insulation. Insulation material shall be rigid cellular glass and flexible closed cell foam sheet.

B. Insulation Material – Formed flexible closed cell foam pipe insulation, minimum density 5.5 lbs/cu ft, maximum "K" factor of 0.27 at 75 degrees F mean temperature. Insulation thickness shall be 2 inches.

C. Jacket

1. Outdoor Piping - Jacket shall be kraft paper bonded to aluminum foil reinforced with fiberglass yarn and self-sealing lap with field applied 0.016-in thick aluminum jacket. Secure jacket with removable stainless steel bands, 24-in on center, and a minimum of two bands securing each section of aluminum jacketing.

D. Fittings Covers

1. Outdoor Piping - Preformed aluminum covers.

E. Acceptable manufacturers shall be Armstrong Cork, Manville Corp. or equal.

2.03 HEAT TAPE FOR PIPING

A. Supply and installation of heat tape shall be as specified in Section 40 41 13.

2.04 SCHEDULE FOR PIPING INSULATION

A. Insulation shall be provided for:

1. All exposed outdoor piping that is size 8 inches and smaller.

2. Additional systems as shown on the Drawings.

B. Heat tracing shall be provided as indicated on the Drawings and specified in Section 40 41 13.

C. Jacketing shall be as specified in this Section.

PART 3 EXECUTION

3.01 GENERAL

A. Do not apply insulation prior to testing and acceptance of piping, tanks, ductwork and/or equipment. Insulation shall not be applied to damp or frosty surface. Clean dust, dirt, grease and moisture from surfaces of pipe and ducts before applying insulation or insulation adhesives. Nameplates and equipment certification and data tags affixed to any piece of apparatus shall not be covered. Where two layers of insulation are used, stagger all joints both ways. Secure each layer independently. Continue insulation and jacketing through walls, partitions, floors and pipe sleeves. Insulation shall be sized to include the thickness of the heat tracing and other piping irregularities.

B. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

C. Insulation, adhesives, coatings and vapor barrier materials shall be applied in accordance with manufacturer’s recommendations. Do not apply these materials when ambient temperature is above or below the maximum and minimum ambient temperature respectively, specified as limits by the manufacturer. In general, these limits are 90oF and 40oF. However, the limitations are to be checked and complied with for each product.

D. All penetrations through a vapor barrier for hangers, instruments, etc. shall be sealed to provide a complete vapor barrier. The use of staples or other fasteners that penetrate the vapor barrier is not permitted.

E. Insulation systems that require a vapor barrier shall be installed with an intact vapor barrier that covers the entire pipe, duct, or piece of equipment to be insulated. All edges of insulation that do not abut another piece of insulation shall have the vapor barrier extended, and sealed to the item being insulated. All penetrations through the insulation such as for thermowells, test ports, dampers, nameplates, or other items shall have the vapor barrier extend over the edges of the insulation and sealed to the item being insulated. Where items are mounted on ductwork a standoff shall be

provided to protect the vapor barrier. The vapor barrier shall be sealed to the standoff.

F. For insulated items exceeding 100 square feet, or 20 feet in length, extend the vapor barrier to the item being insulated to reduce the area or length within a single enclosed area to the dimensions listed above.

3.02 INSTALLATION OF PIPING INSULATION

A. Preformed sectional insulation and jacketing shall be used where possible. The use of blanket insulation will be limited to fittings that cannot be insulated with sectional insulation. All joints on preformed and fabricated insulation shall be accurately fitted to eliminate voids. Voids shall be eliminated by refitting or replacing the insulation. End joints shall be firmly butted to adjoining sections of insulation. Use rigid insulation with a protective metal shield of a thickness and length as specified in MSS Bulletin SP-69 Table 4. Secure the shield with at least three 1/2-inch aluminum bands. Where piping is supported by roller hangers, insulation saddles shall be installed.

B. Outdoor piping insulation shall be installed so as to keep the insulation dry, shall be completely watertight, and shall not allow the entry of rainwater or washdown water. Joints shall be located to prevent the entrance of water. Breaks in jacketing caused by vertical connections or instruments shall be protected by hoods or cones. Where there are breaks in the jacket, plastic moisture barriers shall be provided under the jacketing to protect the insulation. Insulation and jacketing of valves shall be waterproofed. Insulation and jacketing of the valve shall be removable to allow servicing of the valve.

C. Vapor seal adhesive shall be used to seal seams and to butt sections on all cold piping if self-sealing laps are not provided. The use of staples or any other fastening method that would penetrate the vapor barrier will not be permitted on cold piping systems. Staples may be used on hot piping systems where there is no potential for condensation.

D. Metal or plastic jacketing shall have its joints staggered from those of the insulation. Joints between jacketing and insulation shall be a minimum of 3-in.

E. Metal or plastic jacketing shall have a minimum 3-in overlap on longitudinal joints and end joints. Longitudinal joints in horizontal piping shall have the outer lap of the joint pointed down to shed water. The end of the outer lap shall be located at the 5 or 7 o'clock positions.

F. Where piping is provided with electric or steam heat tracing the insulation shall not be installed until the heat tracing has been tested and accepted. Insulation shall be sized to allow for the heat tracing line without deforming the insulation.

G. Where supports, anchors or guides are in direct contact with cold piping, insulate the item in contact a distance of four times the insulation thickness. Clamps and non-welded support devices shall be contained within the insulation. The space within insulating saddles at pipe hangers shall be filled with insulation.

H. On vertical risers exceeding 15-ft in height, provide intermediate support for the insulation. For carbon steel pipe, this support shall consist of angle clips or other suitable devices welded to the pipe at about 15-ft on centers and concealed by the pipe covering. On non-carbon steel piping, clamps or other non-welded devices shall be used.

I. Unless otherwise specified insulate all valves, control valves, fittings, pipe specialties and all other components that could be construed as being part of the piping system. Insulate valve bonnets to a point just below the stuffing box.

J. Bridge flanges, unions, and pipeline strainers with block or sectional insulation wired in place. Wire shall be black steel, annealed. Stop the pipe insulation a sufficient distance to allow removal of flange bolts without disturbing the pipe insulation and extend the block, at least 2-in over the adjacent pipe insulation. Flange covers shall be designed for removal without damaging the pipe insulation. Fill voids with dry insulating cement or blanket insulation.

K. Insulation manufacturer's installation instructions are to be considered a part of this specification. In the event of a conflict, the more stringent requirement shall prevail.

3.03 INSTALLATION OF HEAT TAPE

A. See Section 40 41 13 for specifications regarding materials and installation for heat tracing tape.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish, fabricate and install all fiberglass reinforced plastic (FRP) ductwork including fittings, accessories, dampers, hangers and any incidental work or components required and provide complete air supply, return and exhaust ductwork systems as shown on the Drawings and as specified herein.

B. Design, furnish and install seismic restraints and braces for all ductwork and accessories.

C. In general, ductwork shall consist of any passageway made of FRP substantially air-tight, used for the conveying of air, gas or materials. Included are fittings, transitions, bracing, fasteners, sealers, supports and accessories such as access panels, access doors, turning vanes and manual air balancing dampers. All ductwork shall be of size and material as specified herein and as shown on the Drawings. All duct sizes indicated on the Drawings are clear, inside dimensions.

D. Any change in duct sizes, offsets, transitions and fittings required to accommodate job conditions shall be submitted to Engineer for approval.

E. All ductwork, piping, and equipment shown on the Drawings is intended to be approximately correct to scale, but figured dimensions and detailed drawings of the actual equipment furnished shall be followed in every case. The Drawings shall be taken in a sense as diagrammatic. Size of ductwork and piping are shown, but it is not the intent to show every offset or fitting, nor every hanger or support, or structural difficulty that may be encountered. To carry out the intent and purpose of the Drawings all necessary parts to make a complete working system ready for use shall be furnished without extra charge. The Contractor shall be responsible to coordinate the system installation and routing with the work of all trades.

1.02 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, the following:

1. Ductwork shop drawings shall include typical details of discharge nozzles, transitions, elbows, fittings, accessory items such as access panels or access doors, turning vanes, volume control and splitter dampers, volume extractors, hangers, joining methods, bracing and material gauges. Drawings of general layouts of individual systems shall be submitted, scale shall be 1/4-in = 1-ft-0-in minimum.

B. The following additional data shall be submitted.

1. Manufacturer's qualification and experience data, specifications and installation instructions, factory and field quality control procedures, catalog data, brochures,

descriptive matter, illustrations, diagrams and color charts of ductwork to be selected.

2. Specific handling and storage requirements for ductwork, joint kits and resin systems.

3. For units that will be shipped exposed, provide a description of the protective packaging that will be used during transit.

4. All submittals shall contain a statement that Sections 23 00 00, 23 31 16 and all other referenced Sections have been read and complied with. The certification statement shall be made by all of the following that are applicable; the Contractor, sub-contractor and the vendor. The statement shall be an individual statement for each party involved, and shall be included with every submittal and resubmittal.

5. Sample coupons of laminate not less than 1-ft square. Provide sample laminate coupons for each method of manufacture and for both round and rectangular duct manufacturing methods.

6. Resin system data, including chemical environment service test data, case history data of similar installations (with contact addresses), resin pot life and time versus temperature data required for complete resin cure for laminate thicknesses actually proposed.

7. Submit design calculations signed and sealed by a professional engineer and fabrication procedures for record purposes only. Also submit a letter certifying that the laminates fabricated with the proposed resin system will give satisfactory performance under the specified service conditions and stating the service conditions for which certification is provided and indicating compliance with specified pressure and vacuum design criteria.

8. Submit construction details for flexible connectors, expansion joints, elbows, transitions, junctions and flanged fittings including dimensioned laminate cross sections and flange fabrication and assembly details.

9. Submit results of factory readings taken with "Barcol Hardness Impressor" and provide procedure to field check for complete cure of resin.

10. Certified service tables for the resins being used and the expected contaminants showing satisfactory services for the required design conditions.

11. Detailed instructions for field joining of the ductwork to include quality control procedures.

12. Submit shop test reports for fiberglass reinforced plastic dampers.

13. Submit product data for dampers, access doors, labels, flexible connectors, gaskets, hangers, supports, and anchors. Include performance data such as pressure drop, leakage, etc.

C. In general, corrections or comments or lack thereof, made relative to submittals during review shall not relieve the Contractor from compliance with the requirements of the drawings and specifications. Submittals are for review of general conformance with the design concepts of the project and general compliance with the contract documents. The Contractor is responsible for the final design conforming and correlating all quantities and dimensions, selecting fabrication processes and techniques of construction, coordinating the work of all trades, and performing the work in a safe and satisfactory manner.

1.03 REFERENCE STANDARDS

A. ASTM International (ASTM):

1. ASTM C581 - Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service.

2. ASTM D2996 - Standard Specification for Filament-Wound “Fiberglass” Glass-Fiber Reinforced Thermosetting Resin Pipe

3. ASTM D3982 - Standard Specification for Contact Molded “Fiberglass” Glass-Fiber Reinforced Thermosetting Resin Ducts

4. ASTM C582 - Standard Specification for Contact Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion Resistant Equipment

B. National Fire Protection Association (NFPA):

1. NFPA 90A - Standard for the Installation of Air Conditioning and Ventilation Systems.

2. NFPA 91 - Standard for Exhaust Systems for Air Conveying of Materials.

3. NFPA 252 - Standard Methods of Fire Tests of Door Assemblies.

C. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE)

D. American National Standards Institute (ANSI):

1. ANSI RTP-1 - Reinforced Thermoset Plastic Corrosion Resistant Equipment.

E. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.04 QUALITY ASSURANCE

A. All FRP duct and fittings shall be from a single manufacturer.

B. All materials shall be supplied by a manufacturer experienced in the fabrication of materials similar to those specified. Design and engineering shall be performed by

personnel regularly employed by the manufacturer who are experienced in the design of FRP systems similar to those specified.

C. The manufacturer shall provide factory trained personnel for training of installers and for supervision and inspection of the installation. The use of local sales representatives for this service is not acceptable.

D. Corrosion resistance data shall be based on ASTM C581.

E. Inspection by the Engineer's representative or failure to inspect shall not relieve the Contractor of responsibility to provide materials and perform the work in accordance with the documents.

F. The Owner and Engineer reserve the right to sample and test any materials after delivery and to reject all components represented by a sample that fails to comply with the specified requirements.

G. The Engineer reserves the right to reject acceptance of delivery of any or all pieces of equipment found upon inspection to have any or all of the following defects in the laminate:

1. Blisters.
2. Chips.
3. Crazing.
4. Exposed glass.
5. Cracks.
6. Burned areas.
7. Dry spots.
8. Foreign matter.
9. Surface porosity.
10. Sharp discontinuity.
11. Trapped air.
12. Any item which does not satisfy the tolerances as specified.

1.05 DELIVERY, STORAGE AND HANDLING

A. Equipment, material and spare parts shall be shipped complete except where partial disassembly is required by transportation regulations or for protection of components. No ductwork or components shall be shipped prior to complete resin cure.

B. Inspection of the duct and components will be made by the Engineer or other representative of the Owner after delivery. Materials shall be subject to rejection at any time on account of failure to meet any of the specified requirements. Material rejected after delivery shall be marked for identification and shall be immediately removed from the job site.

C. All materials shall be inspected for size, quality and quantity against approved shop drawings upon delivery.

D. Delivery schedule of all equipment shall be coordinated with the Contractor. Equipment ready for shipment prior to the agreed on shipping date shall be stored without cost to the Owner by the manufacturer.

E. All materials shall be suitably packed for shipment and long term storage. Each package shall be labeled to indicate the project and the contents of each package. Where applicable, equipment numbers shall be marked on the container.

F. All equipment shipped that is exposed such as on a flatbed truck shall be protected during transit. The equipment shall be protected from moisture, road salt, dirt and stones or other materials thrown up from other vehicles. Electrical components shall be protected as above, but with special attention to moisture. The method of shipment protection shall be defined in the submittals.

G. All materials shall be stored in a covered dry location off of the ground. When required to protect the materials they shall be stored in a temperature-controlled location.

1.06 COORDINATION

A. The drawings indicate the extent and general arrangement of the systems. If any departures from the drawings or specifications are deemed necessary, details of such departures and the reasons therefore shall be submitted as soon as practical for review. No such departures shall be made without the prior written concurrence of the Engineer.

B. The Contractor shall coordinate the location and placement of all concrete inserts, duct supports and welding attachments with the structural engineer.

C. The Contractor shall assume full responsibility for coordination of the HVAC systems, including scheduling and verification that all structures, ducts, piping and the mounting of equipment are compatible.

D. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

1.07 SPARE PARTS

A. Spare parts shall include all special items on the manufacturer's standard list of spare parts.

B. In addition to special items, the following spare parts shall be provided:

1. Furnish all special tools required for normal operation and proper servicing of the equipment.

2. All materials in kit form to make or repair joints. Kits shall be supplied sufficient to repair 10 percent of the joints. Include material safety data sheets for all components.

3. Names and addresses of all manufacturers of fiberglass reinforcements, resins, hardeners and components used to repair and maintain the FRP duct system.

C. Pack spare parts in containers suitable for extended storage without deterioration of the parts. Containers shall be clearly labeled designating contents, pieces of equipment for which intended and equipment identification numbers.

1.08 STANDARDS OF CONSTRUCTION AND INSTALLATION

A. All ductwork construction and installation details shown on the Drawings and specified herein are based on acceptable methods of construction and installation and are intended to define the quality of construction and installation to be furnished. Alternate details may be submitted for approval.

1.09 ENGINEERING SERVICES

A. When engineering services are specified to be provided by the Contractor, the Contractor shall retain a licensed professional engineer to perform the services. The engineer shall be licensed at the time the work is done and in the State in which the project is located. If the State issues discipline specific licenses, the engineer shall be licensed in the applicable discipline. In addition, the engineer shall be experienced in the type of work being provided.

B. All work is to be done according to the applicable regulations for professional engineers, to include signing, sealing and dating documents. When submittals are required by a professional engineer, in addition to state required signing and sealing, a copy of the current wallet card or wall certificate indicating the date of expiration shall be included with the submittal.

PART 2 PRODUCTS

2.01 MATERIAL

A. Design Conditions:

1. Temperature: minus 30 to 125 degrees F.

2. Pressure: 12-in w.g. positive; 12-in w.g. negative.

3. Flow medium and velocity: air at 2500 fpm.

B. The following materials are expected to be in the air stream or surrounding area. The resins used shall be suitable for all of the following:

1. Derakane 510-B-400

2. Cor VE 8401

3. AOC Vipel K022

4. Reichold's Dion Impact 9303-54

2.02 FIBERGLASS REINFORCED PLASTIC (FRP) DUCTWORK

A. FRP ductwork shall be of contact molded or filament wound construction, or a combination of these methods, to meet design criteria.

B. Indoor FRP ductwork shall have a flame spread rating of 25 or less and a smoke developed rating of not more than 50 in accordance with ASTM E84. Sprinklers shall not be used for internal fire suppression. Coat indoor ductwork with moisture-resistant intumescent paint if necessary to achieve the required ratings.

C. The ductwork corrosion barrier shall consist of a 20-mil (finished thickness) minimum chemical resistant interior liner with an apertured synthetic surface veil embedded in a resin rich surface. The inner surface shall be free of cracks and crazing with a smooth finish and with an average of not over two pits per square foot, providing the pits are less than 1/8-inch diameter and not over 1/32-inch-deep and are covered with sufficient resin to avoid exposure of inner surface fabric. Some waviness is permissible as long as the surface is smooth and free of pits. The interior liner shall be reinforced with an 80 mil interior layer consisting of 1.5 oz per square foot non-continuous chopped strand mat. The combined glass content of the interior liner and interior layer shall be 25 percent.

D. The ductwork structural layer shall consist of Type E filament winding glass or alternating layers of chopped strand mat and woven roving. The glass content of the structural layer shall be 55-65 percent. Calculations for wall thickness determination shall be based on the structural fiberglass reinforced wall only. Long term deflection shall not exceed 1 percent of duct diameter or duct width for rectangular ducts. Round and rectangular FRP ductwork shall be designed using a safety factor of 10 to 1 for pressure and 5 to 1 for vacuum service.

E. The ductwork exterior surface layer shall be resin rich C-veil not less than 20 mils thick. Outside finish shall be a pigmented, paraffinated gel coat with an ultraviolet inhibitor.

F. Ductwork shall be designed to resist specified loadings but in no case shall it be less than the following total thicknesses:

Diameter* (inches)	Filament Wound Thickness (inches)
0-23	0.225
24-30	0.275
36-42**	0.375
48-60**	0.525
66-72**	0.625

*Where rectangular duct is used the longest dimension shall be considered equivalent to the diameter.

**Rectangular duct may be reinforced with angles or tees to meet the required pressure or vacuum service.

G. Resins used in the laminate shall be premium corrosion resistant and fire retardant vinyl ester resins without additives. The resin system utilized shall not require any additives such as antimony which detract from visual inspection or deplete corrosion resistance. Resin system utilized in the liner and structure shall yield a completely translucent laminate.

H. Fittings and Joints: All fittings such as elbows, laterals, tees and reducers shall be of the same resin as the adjacent duct section; shall be equal to or superior in strength to the adjacent duct section; and shall have the same internal dimensions as the adjacent duct section. Non-flanged duct joints shall be butt wrapped or bell and spigot joints. Total width of overlay for butt-wrap joints shall be not less than 6-in for diameters from 6-in up to and including 30-in, and not less than 10-in for diameters 36-in and larger. Bell and spigot joints shall be sealed with a standard butt joint overlay as per ASTM D3982 Table 1. The interior opening between the bell and spigot shall be sealed with a resin paste so that no glass fibers are exposed and all voids are filled. Field cut duct ends and exposed glass fibers shall be resin coated prior to joint assembly to maintain a continuous interior corrosion barrier. Coat all exterior surfaces of joints with a paraffinated resin-rich gel coat with UV inhibitors.

I. Round Standard Elbows:

1. Standard elbow centerline radius shall be equal to 1-1/2 times the diameter.

2. Standard elbows up to 24-in diameter shall be smooth radius molded elbows. Standard elbows 30-in diameter and greater may be mitered sections as specified below.

3. 0 to 44 degree elbows shall contain one mitered joint and two sections. 45 to 80 degree elbows shall have a minimum of two mitered joints and three sections. Elbows greater than 80 degrees shall have a minimum of four mitered joints and five sections.

J. Rectangular Fittings:

1. Fittings shall be factory manufactured to meet the specified design criteria and in accordance with approved submittals. Factory install reinforcing ribs as required

to meet the specified deflection requirements and to provide a system free from pulsing, warpage, sagging and undue vibration.

2. Provide turning vanes in all mitered rectangular elbows. Rectangular elbow turning vanes shall be of FRP construction, solid or double wall construction with an airfoil shaped profile.

K. Reinforcing:

1. Round duct reinforcing shall be factory installed with spacing between reinforcing located to avoid all hangers and support saddles.

2. Rectangular duct and fitting reinforcing shall be factory located and installed to avoid duct hangers, support saddles, bracing, branch take-offs and entries, and plenum connections. Routine field cutting and field relocation of factory installed reinforcing is not acceptable.

L. Tolerances:

1. Out-of-roundness of duct shall be limited to plus or minus 1/8-in or plus or minus 1 percent of duct inside diameter, whichever is greater for duct sizes 6-in diameter and greater.

2. Rectangular duct tolerances shall be 3/16-in for duct dimensions up to 18-in and plus or minus 1 percent for dimensions of over 18-in.

3. All unflanged duct shall be square on the ends in relation to the duct axis plus or minus 1/8-in up to and including 24-in diameter and plus or minus 3/16-in for all diameters greater than 24-in.

4. Fittings:
   a. The tolerance on angles of all fittings shall be plus or minus 1 degree, up to and including 24-in diameter and plus or minus 1/2 degree for 30-in diameter and above.

5. Flanges:
   a. Flange faces shall be perpendicular to the axis of the duct within 1/2 degree.
   b. Flange faces shall be flat to within plus or minus 1/32-in, up to and including 18-in diameter and flat within plus or minus 1/16-in for 20-in diameter and larger.
   c. Provide custom filler pieces as required to mate flanges squarely.

M. All connections to expansion joints, dampers, tanks, or other equipment shall be flanged. Gaskets shall be chlorobutyl, EPDM, or other material as recommended by the manufacturer for the specific service, pressure, and temperature. Flanges shall be hand laid up to thickness specified in ASTM D3982 Table 1 except that minimum thickness shall be 3/4-in. Each flange face shall be ground flat and a new 100 mil corrosion barrier shall be applied. The flange shall be anchored to a waxed table to ensure the flatness tolerance outlined above. The face shall be textured for use with full face gaskets, 1/8-in minimum thickness. Flange drilling shall be as per ASTM D3983

Table 1. All bolt holes shall be back spot faced for a washer seat. All flange bolts shall be torqued to values as recommended by manufacturer.

N. Fasteners: Furnish all bolts, nuts, washers and other fasteners required. Material of metallic fasteners shall be Type 316 stainless steel.

O. There shall be not less than a 1/4-in buildup of FRP over the duct at each support and as shown on the Drawings.

P. Provide laminated ring or lug in ducts that will be supported by hangers or wall brackets in a vertical orientation.

Q. Acceptable manufacturers shall be Ancor, Belco Manufacturing, Daniel Company, Diamond Fiberglass, Ershigs, or Spunstrand.

2.03 FLEXIBLE CONNECTORS

A. Flexible connections shall be integral flange molded U type units constructed of Hypalon or EPDM rubber reinforced with a strong synthetic asbestos-free fabric suitable for corrosive service. The flexible connections shall be designed to minimize the transmission of vibration from the fans to the ductwork at the suction and discharge connections. Flexible connections shall be designed to allow 1-in lateral offset movement. Ends shall be flanged with flanges matching duct connection flanges. Corners on rectangular expansion joints shall be molded and free of patches or splices. The flexible connections shall be suitable for outdoor service and temperature ranges from minus 10 up to 125 degrees F, and pressure to 2 psig. Specially fabricated 3/8-inch Type 316 stainless steel retaining back-up bars shall be supplied to prevent damage to the flexible connector when the fasteners are tightened.

B. Acceptable manufacturer shall be Holz Rubber Company, Mercer Rubber Company, Proco Products Inc., or equal.

2.04 FIBERGLASS REINFORCED PLASTIC DAMPERS - ROUND BALANCING

A. Rating Conditions:

1. Pressure Rating: 12-in water column.

B. Materials:

1. Bearings: Teflon.

2. Blade: FRP.

3. Frame: FRP.

4. Axle: Solid Type 316 stainless steel.

5. Operator: Type 316 stainless steel or FRP lever with locking quadrant, Epoxy coated worm gear operator for dampers over 12” diameter.

6. Fasteners: Type 316 stainless steel.

7. Linkage: Type 316 stainless steel.

8. Angles: FRP.

9. Flanges: Drilled to match adjacent duct.

C. Acceptable manufacturer shall be Daniel Company, Swartwout, or equal.

2.05 FIBERGLASS REINFORCED PLASTIC DAMPERS – ROUND ISOLATION

A. Rating Conditions:

1. Pressure Rating: 12-in water column.

2. Allowable Leakage: Zero cfm/sf of face area at 30-in water column.

B. Materials:

1. Bearings: Teflon.

2. Blade: FRP.

3. Frame: FRP.

4. Axle: Solid Type 316 stainless steel.

5. Operator: Type 316 stainless steel or FRP lever with locking quadrant. Epoxy worm gear operator (manual damper applications) for dampers over 12” diameter or extended axle and mounting flange or body (motorized damper applications). Coordinate mounting requirements with the damper actuator supplier.

6. Fasteners: Type 316 stainless steel.

7. Shaft seals: O-ring housed in an FRP packing gland, or as required to achieve the specified leakage performance.

8. Blade seals: Embedded elastomer

9. Linkage: Type 316 stainless steel.

10. Angles: FRP.

11. Flanges: Drilled to match adjacent duct.

C. Acceptable manufacturer shall be Daniel Company, Swartwout, or equal.

2.06 FRP TRANSITION PIECES

A. Provide transition pieces as shown on Drawings and specified herein.

B. Construction:

1. Thickness of transition pieces shall be designed using a safety factory of 10 to 1 for pressure and 5 to 1 for vacuum service with the pressure classification listed below.

2. Custom flanges shall be designed as required to connect to fans, coils, dampers and duct work. Coordinate flange sizes to match approved equipment dimensions.

C. Pressure Classification: Manufacturer shall design transition pieces so that they shall be free from buckling, pulsing, warpage and sagging at design pressures.

2.07 LABELS

A. The service of each duct along with an arrow indicating direction of flow shall be provided on each duct system.

B. Labels shall contain the service spelled out, the duct size, and the equipment number of the equipment served. Service identifications shall be as follows:

C. EXHAUST AIR DUCT

D. Numbers and letters shall be die-cut from 3.5 mil vinyl film and pre-spaced on carrier film. Adhesive and finish shall be protected with one piece removable liners. Colors shall be white letters on black backgrounds. Label construction shall be suitable for the environment in which it is installed (wet, corrosive, exterior, etc.).

E. The system for preparation and application of letters shall be Type B a.s.i./2 by ASI Sign Systems; Architectural Graphics Inc., Brady, Pipemarker, Seton, or equal. Letters shall be 3-in high Optima Bold, upper case using Grid 2 spacing. Direction arrows are to match. The instructions of the manufacturer shall be followed in respect to storage, surface preparation and application of letters.

2.08 ACCESS DOORS

A. Access doors shall be 24-in by 24-in minimum. Where the duct size is less than 26-in, the largest door that will fit the duct shall be used. Unhinged access panels are not acceptable except where so specified on the Drawings. Access doors shall be of the same material as the duct. Doors shall be substantially butt hinged with heavy sash locks and substantial door pulls. Door openings and door frames shall be reinforced and gasketed to minimize leakage. Access door hardware shall be Type 316 stainless steel.

PART 3 EXECUTION

3.01 INSTALLATION

A. All ductwork shall be fabricated and erected where shown on the Drawings or as specified herein.

B. The Contractor shall not install any equipment or materials until the Owner and Engineer have approved all submittals. If any equipment or materials are installed prior to approval of the submittals, it shall be at the Contractor's risk.

C. During installation the open ends of ducts shall be closed to prevent debris and dirt from entering. Work shall be installed in accordance with the overall approved progress schedule and in cooperation with all other trades so there will be no delay to other trades.

D. The Drawings of the air ducts and air risers indicate the general location for installation of the ducts and risers. Should additional offsets or changes in direction be made, these changes must be considered in the original bid and shall be installed at no additional cost to the Owner.

E. All necessary allowances and provisions shall be made in the installation of the ducts for the structural conditions of the building. Ducts shall be transformed or divided as may be required. Wherever this is necessary, the cross-sectional area shall be maintained. All of these changes, however, must be approved and ducts installed as directed by the Engineer or as approved on shop or erection drawings.

F. The taper of all transformations shall be not more than 15 degrees unless otherwise shown on the Drawings.

G. Do not remove or alter factory installed duct reinforcing ribs except as required to accommodate duct alterations due to unexpected field conditions. Notify the Owner’s representative prior to starting any field modifications involving ductwork structural reinforcing members. Submit additional design calculations to demonstrate structural design integrity of ductwork and fittings requiring reinforcing modifications in the field.

H. Ductwork connections to units that require corrosion resistant coatings shall be made with flanges. Flanges shall be factory drilled before coating. Resilient washers suitable for the environment shall be used to protect the coating from the bolts in the flange. The use of self-tapping screws or other fastening methods that will damage the coating are not acceptable.]

I. Provide 1-in minimum PVC pipe duct drains in the bottom of all main, branch and riser ducts to allow removal of condensate as indicated in the drawings.

J. Ducts shall be sloped at 1% or as noted on the Drawings to facilitate condensate removal.

K. The maximum allowable leakage of low pressure system shall be 5 percent of air volume. The maximum allowable leakage of high pressure systems shall be one

percent of air volume when tested at 100 percent of the operating static pressure. Construct and install the ductwork in a manner that minimizes system leakage. If excessive leakage is suspected, test the system at 2-inch w.g. Visual leaks under test conditions shall be not allowed.

3.02 HANGERS AND SUPPORTS

A. Ducts shall not be supported from furring, hung ceilings or from another duct or pipe.

B. Ductwork shall not come in contact with any of the ceiling construction or any other equipment in the ceiling cavity.

C. Fiberglass ductwork shall be properly anchored and supported from building structure where indicated on the Drawings. Support anchoring for horizontal ducts shall be according to ASTM D3982 or 10-ft-0-in on center, maximum spacing. All material shall be 316SS.

D. All fittings, expansion joints, and similar items shall be supported within 18-in of the joint unless otherwise noted.

E. Hangers shall not be supported from roof decking or bulb tees. Where required, provide supplemental hangers to span between the building structures.

F. Ductwork shall be rigidly supported and secured in an approved manner. Bracing and vibration isolators shall be installed, where necessary, to eliminate vibration, rattle and noise. Hangers shall be installed plumb and securely suspended from supplementary steel or inserts in concrete slabs. Lower ends of hanger rods shall be sufficiently threaded to allow for adequate vertical adjustment. Building siding and metal decking shall not be used to hang ductwork.

G. All ductwork support design shall be provided by the Contractor with a PE seal from an engineer licensed in the State of Tennessee.

H. Outdoor ducts shall be provided with 316 SS structural steel angles; pre-engineered, prefabricated support systems; and/or equipment rails and straps. Signed and sealed structural calculations from an engineer Licensed in the State of Tennessee shall be provided by the contractor.

3.03 DUCTWORK FITTINGS AND ACCESSORY ITEMS

A. Duct Fittings - Changes in direction and offsets shall be made in a gradual manner to facilitate streamline flow of air.

B. Dampers:

1. Manual volume control dampers shall be installed wherever it may be necessary to regulate air volume for system air balancing and where shown on the Drawings.

C. Access Doors:

1. Hinged access doors shall be installed where listed below, wherever shown on the Drawings and wherever access may be required for service, maintenance and adjustment.

2. Provide access doors at the following locations (minimum requirements):
   a. Automatic dampers - linkage side.
   b. Duct mounted temperature controllers.
   c. Freeze-stats.
   d. Manual balancing dampers.
   e. Turning vanes.
   f. Inlet side of centrifugal fans.
   g. Inlet and outlet sides of tubular axial-flow fans.
   h. As necessary or required.

D. Flexible Connectors:

1. Furnish flexible connectors at each inlet and outlet of fan and in the duct runs where required for expansion, contraction and movement.

2. Ductwork spacing and alignment for flexible connections shall be aligned to the tolerances of the flexible connection manufacturer, or plus/minus 1/4-in whichever is less. Bolts shall be torqued to the manufacturer's recommendations. Do not over tighten.

3. Where flexible connections are used as expansion joints, the manufacturer's pre-compression recommendations shall be followed. When the temperature at installation differs from the temperature in the pre-compression recommendation, a correction shall be made.

3.04 DUCTWORK AT MASONRY

A. Where ducts connect to or terminate at masonry openings fasten the duct flange to the masonry. Seal the connection airtight with caulk.

B. Plenums connected to concrete curbs shall be fastened to create an airtight seal. Concrete curbs shall be provided under another Division. The plenum flange shall sit on a continuous bead of caulking compound and be anchored to the curb at 16-in centers.

C. When exposed ducts pass through finished floors, walls or ceilings, provide angle collars completely covering space around duct.

3.05 NOISE

A. All ductwork shall be free from pulsation, chatter, vibration or objectionable noise. After system is in operation, should these defects appear they shall be corrected by removing, replacing or reinforcing the work. Sound levels shall not exceed the minimum

requirement as specified in ASHRAE - Systems Volume. No discreet tones will be allowed.

3.06 CLEANING OF DUCTWORK

A. All ductwork, fans, outlets and other parts of the ductwork systems shall be maintained in a clean condition during installation.

B. Complete ductwork systems shall be cleaned prior to testing and air balancing. Cheese cloth shall be secured over all openings of the ductwork system for entrapment of dirt during the cleaning operation.

3.07 PAINTING

A. Louver blank-off panels and ductwork visible through louvers in exterior walls are to be painted black. Painting shall be performed under this Section and shall be as specified in Division 09.

3.08 PLENUMS

A. Fresh air inlet and exhaust air plenums at louvers or otherwise subject to weather entrainment shall be sealed water tight at all bottom joints and seams and up all vertical seams for a minimum of 12-in. After application excess sealant shall be removed before setting hard. Where possible fresh air inlet and exhaust air plenums shall pitch down towards the louver. Where it is not possible to pitch the plenum a 1-in capped drain connection shall be provided at the low point of the plenum.

3.09 TEST PORTS

A. Where shown on the Drawings and where required for testing and balancing, instrument insertion ports shall be provided. Size and location of ports shall be coordinated with the contractor performing air balancing.

B. In round ductwork provide 2 ports 90 degrees on centers. In rectangular ductwork provide ports as required by AABC or NEBB for a full traverse measurement.

C. As a minimum, ports shall be provided in the following connections:

1. All duct mains.

2. All duct branches unless all connections are diffusers, registers, or grilles and the total can be calculated by summing the readings for all of the connections.

3. All connections to tanks or hoods where there is no other access for taking a measurement.

D. A main duct is defined as one of the following:

1. A duct serving five or more outlets.

2. A duct serving two or more branch ducts.

3. A duct emanating from a fan or plenum.

4. All remaining ducts are considered branch ducts.

3.10 LABELS

A. Labels shall be located not more than 26 linear feet apart and shall also be provided at both sides of wall and floor penetrations and each equipment connection.

B. Label locations shall have unobstructed view from normal viewing locations.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials and equipment required and install complete and make operational, electrical and process instrumentation systems at the Dupont Pump Station Basin in Chattanooga, Tennessee as shown on the Drawings and as specified herein.

B. The work shall include furnishing, installing and testing the equipment and materials specified in other Sections of the Division 26 Specifications and shown on the Drawings, including:

1.

Section No		Title
26 00 00	-	Electrical - General Provisions
26 00 01	-	Electrical System Analysis
26 05 10	-	Wires and Cables (600 Volt Maximum)
26 05 33	-	Raceways, Boxes, Fittings and Supports
26 05 40	-	Motors Low Voltage
26 08 10	-	Electrical System Testing and Settings
26 18 00	-	Wiring Devices
26 19 00	-	Miscellaneous Equipment
26 23 00	-	Low-Voltage Switchgear
26 24 16	-	Panelboards
26 24 20	-	Low Voltage MCCs
26 29 23	-	Variable Frequency Drive (Low Voltage)
26 32 13	-	Diesel Engine Driven Generator
26 41 13	-	Lightning Protection System
26 43 00	-	Surge Protection Devices
26 51 00	-	Lighting System
33 71 19	-	Underground System
33 79 00	-	Grounding System

C. The work shall include furnishing and installing the following:

1. Electrical service from the Power Company.

2. Conduit, wire and field connections for all motors, motor controllers, control devices, control panels and electrical equipment furnished under other Divisions of these specifications.

3. Conduit, wiring and terminations for all field-mounted instruments furnished under other Divisions of these specifications, including process instrumentation primary elements, transmitters, local indicators and control panels. Lightning and surge protection equipment wiring at process instrumentation transmitters. Install vendor furnished cables specified under other Divisions of these specifications.

4. A complete raceway system for the Data Highway Cables and specialty cable systems. Install the Data Highway Cables and other specialty cable systems, furnished under other Divisions of these Specifications, in accordance with the system manufacturers' installation instructions. Review the raceway layout, prior to installation, with the computer system supplier and the cable manufacturer to ensure raceway compatibility with the systems and materials being furnished. Where redundant cables are furnished, install cables in separate raceways.

5. Conduit, wiring and terminations for variable frequency drives and transformers furnished under other Divisions of these specifications.

6. Precast handholes and light pole bases.

7. Handhole frames and covers.

8. Telecommunications service from the service provider.

9. It is the intent of these Specifications that the electrical system shall be suitable in every way for the service required. All material and all work which may be reasonably implied as being incidental to the work of this Section shall be furnished at no extra cost.

D. Each bidder or their authorized representatives shall, before preparing their proposal, visit all areas of the existing site, buildings and structures in which work under this Division is to be performed and inspect carefully the present installation. The submission of the proposal by this bidder shall be considered evidence that their representative has visited the site, buildings and structures and noted the locations and conditions under which the work will be performed and that he/she takes full responsibility for a complete knowledge of all factors governing his/her work.

E. Temporary power connections as required shall be provided by the Contractor at no additional expense to the Owner. All temporary wiring shall be in accordance with the NEC. Any temporary equipment feeders (4160V, 480V, 120V, etc.) shall be installed in conduit. The Contractor shall provide to the Engineer details, methods, materials etc. prior to making temporary connections. Furnish and install all equipment and materials including control equipment, motor starters, branch and feeder circuit breakers, panelboards, transformers, etc., for temporary power.

F. Field verify all existing underground electrical conduit, concrete duct banks, manhole, pull boxes, etc. and mechanical piping. The Contractor shall include in his bid all costs associated with relocation or removal of underground equipment as required for construction of the new facilities.

G. The Contractor shall prepare and furnish electrical and instrumentation conduit layout shop drawings for yard electrical, within and under all roads, buildings and structures to the Engineer for approval prior to commencing work. Layouts shall include but not be limited to equipment, pull boxes, manholes, conduit routing, dimensioning, methods and locations of supports, reinforcing, encasement, materials, conduit sizing, equipment access, potential conflicts, building and yard lighting, and all other pertinent technical specifications for all electrical and instrumentation conduits and equipment to

be furnished. All layouts shall be drawn to scale on 24 x 36 sheets. Refer to the SUBMITTALS paragraph within this specification for additional requirements.

H. The work shall include complete testing of all equipment and wiring at the completion of work and making any minor correction changes or adjustments necessary for the proper functioning of the system and equipment. All workmanship shall be of the highest quality; substandard work will be rejected.

I. A single manufacturer shall provide switchgear, motor control center, transformers, panelboards and disconnect switches. This manufacturer shall also provide the power system study as specified herein.

J. Contractor shall provide their own temporary power for miscellaneous power (drills, pumps, etc.). No facility circuits shall be used unless approved in writing by the Engineer. Any temporary added shall be removed at job completion.

K. Complete coordination with other contractors. Contractor shall coordinate with all other contractors' equipment submittals and obtain all relevant submittals.

L. Mount transmitters, process instruments, operator stations, etc. furnished under other Divisions of these specifications.

M. Concrete electrical duct encasement, including but not limited to excavation, concrete, conduit, reinforcement, backfilling, grading and seeding is included in Division 26. All work shall be done in accordance with Divisions 2 and 3 of these specifications.

N. Excavation, bedding material, forms, concrete and backfill for underground raceways; forms and concrete for electrical equipment furnished herein is included in Division 26. All work shall be done in accordance with Divisions 2 and 3 of these specifications.

O. Perform testing of the electrical equipment in accordance with the requirements of the individual specification sections and in accordance with Section 26 08 10.

P. Set the electrical protective devices in accordance with NETA standards and in accordance with the protective coordination study.

Q. Review the electrical underground system and the civil yard piping. Install the electrical underground system in a manner that avoids conflicts with manholes, catch basins, etc. provided under other Divisions of the specifications.

R. Sequencing and Scheduling

1. Coordinate electrical equipment installation with other trades.

2. Arrange for chases, slots and openings in the building structures during the progress of construction to allow for the electrical installation.

3. Coordinate installing required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

4. Sequence, coordinate and integrate the installation of electrical materials and equipment for efficient flow of the work. Coordinate the installation of large equipment requiring position prior to closing in the building.

5. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

1.02 RELATED WORK

A. Excavation and backfilling, including gravel or sand bedding for underground electrical work is included in Division 2.

B. Cast in place concrete work, including concrete encasements for electrical duct banks, equipment pads, light pole bases and reinforcing steel, is included in Division 3.

C. Instrumentation and control equipment is included under Division 13.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, shop drawings for equipment, materials and other items furnished under Division 26.

B. As a minimum all equipment specified in each Section of Division 26 shall be submitted at one time. As an example, all lighting fixtures shall be submitted together, all motor control centers shall be submitted together, etc. Submittals that do not comply will be returned disapproved.

C. Shop drawings shall be submitted for the following equipment and materials:

1. Raceways, Boxes, Fittings and Hangers

2. Wires and Cables

3. Miscellaneous Equipment (as specified in Section 26 19 00)

4. Panelboards

5. Switchgear

6. Motor Control Centers

7. Lighting Fixtures and Lamps

8. Switches, Receptacles and Covers

9. Lightning Protection System

10. Precast Manholes and Handholes, Frames and Covers

11. Grounding Hardware and Connections

12. Variable Frequency Drives

13. Diesel Engine Driven Generator

D. Submittals shall be required for the following items:

1. Qualifications of Electrical Contractor Superintendent

2. Preliminary Short Circuit Study

3. Final Power System Study

4. Training Plans

5. Testing and Service Reports

6. Seismic Restraint calculations and details

E. Installation working drawings shall be submitted for all conduit routing layouts. Contractor shall utilize the Contract AutoCAD drawings for base files and show conduit routing using the layers described herein. Colors, line type and line widths shall be appropriate for plotting using AIA standards. Dashed lines shall indicate the conduit is concealed or buried. Solid lines shall indicate the conduit is exposed. The conduits and any major pulling points shall be drawn in model space. The associated text shall be drawn in paper space at a size not less than 0.1-inch. Provide associated type written conduit schedules for easy cross check. Schedules may be included on the drawings or in a separate spreadsheet/table. Layers shall be:

1. E-POWR-CDT: 480-volt power

2. E-LITE-CDT: 120/208/240-volt power or lighting

3. E-CNTRL-CDT: 120-volt control, instrumentation, signal, communication or fiber

4. E-ANNO-TEXT: Annotation text

5. Layouts shall be shown at an appropriate scale for clarity. If the Contract drawings need to be re-scaled to adequately represent the conduit routing, the Contractor shall do so. Contractor may submit separate drawings for power, lighting and control for one area to avoid re-scaling of drawings.

6. Layouts shall include locations of process equipment, motor control centers, transformers, panelboards, control panels and equipment, motors, switches, motor starters, large junction or pull boxes, instruments and any other electrical devices connected to concealed or buried conduits.

7. Contractor layouts of conduit routing shall comply with installation specifications 26 05 33 and 33 71 19 for raceway and underground systems. It is expected for major conduit corridors that there would be two separate ductbanks, with a minimum spacing of 12-inches between the two different ductbank systems. One ductbank would contain 480-volt and 120-volt power and control while the other

ductbank would contain fiber optic, Ethernet, shielded instrumentation wiring or other signal / communication wiring.

8. Submittal shall include a file with the AutoCAD drawings along with full size (36-inch by 24-inch) hardcopy prints on high quality paper.

9. Concrete floors and/or walls containing concealed conduits shall not be poured until conduit layouts are approved.

F. The manufacturers name and product designation or catalog numbers shall be submitted for the following material utilized:

1. Testing Equipment

2. Ground System Resistance Test Equipment

G. Operation and Maintenance Data

1. Submit operations and maintenance data for equipment furnished under this Division, in accordance with Section 01730. The manuals shall be prepared specifically for this installation and shall include catalog data sheets, drawings, equipment lists, descriptions, parts lists, etc, to instruct operating and maintenance personnel unfamiliar with such equipment.

2. Manuals shall include the following as a minimum:
   a. A comprehensive index.
   b. A complete "As Built" set of approved shop drawings.
   c. A complete list of the equipment supplied, including serial numbers, ranges and pertinent data.
   d. A table listing of the "as left" settings for all timing relays and alarm and trip setpoints.
   e. System schematic drawings "As Built", illustrating all components, piping and electric connections of the systems supplied under this Section.
   f. Detailed service, maintenance and operation instructions for each item supplied.
   g. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.
   h. The operating instructions shall also incorporate a functional description of the entire system, with references to the systems schematic drawings and instructions.
   i. Complete parts list with stock numbers, including spare parts.

H. Mark submittals to clearly identify proposed equipment including accessories, options, and features and to exclude parts not applicable to the project. When manufacturer's cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submittal piece of literature and each submittal drawing shall clearly reference the Project Specification and/or Contract Drawing that the submittal is to cover. General catalogs will not be accepted as cut sheets to fulfill submittal requirements.

I. Check shop drawings for accuracy prior to submittal. Shop drawings shall be stamped with the date checked and a statement indicating that the shop drawings conform to this Section and the Drawings. This statement shall also list all exceptions to this Section and the Drawings. Mark submittals to identify proposed equipment including accessories, options and features being proposed for approval and exclude parts not to be used. Shop drawings not so checked and noted shall be returned marked NOT APPROVED.

J. The Engineer's check shall be for conformance with the design concept of the project and compliance with this Section and the Drawings. Errors and omissions on approved shop drawings shall not relieve the Contractor from the responsibility of providing materials and workmanship required by this Section and the Drawings.

K. All dimensions shall be field verified at the job site and coordinated with the work of all other trades.

L. Material shall not be ordered or shipped until the shop drawings have been approved. No material shall be ordered or shop work started if shop drawings are marked " No Exceptions Taken," " Make Corrections Noted ", “Amend and Resubmit”, or " Rejected - See Remarks."

M. Exceptions for Submittals

1. Exceptions to the Specifications or Drawings shall be clearly defined by the Electrical Subcontractor in a separate section of each submittal package. The submittal shall contain the reason for the exception, the exact nature of the exception and the proposed substitution so that a proper evaluation may be made by the Engineer. The acceptability of any device or methodology submitted as an "or equal" or "exception" to the Specifications shall be at the sole discretion of the Engineer.

2. Submittals for certain major items such as low voltage switchgear, generators and variable frequency drives shall include a complete copy of their specification section with each paragraph and sub-paragraph noted with the comment "compliance", "deviation", or "alternate".
   a. By noting the term "compliance", it shall be understood that the manufacturer is in full compliance with the item specified and will provide exactly the same with no deviations.
   b. By noting the term "deviation", it shall be understood that the manufacturer prefers to provide a different component in lieu of the one specified and in so doing, takes full responsibility for making the equipment work as specified and will provide any and all ancillary components to make the equipment work at no extra cost to the Owner.
   c. By noting the term "alternate", it shall be understood that the manufacturer proposes to provide the same operating function but prefers to do it in a different manner and in so doing, takes full responsibility for making the equipment work as specified and will provide any and all ancillary components to make the equipment work at no extra cost to the Owner. The alternate method shall be fully described with schematic diagrams and one-line diagrams as applicable.

1.04 REFERENCE STANDARDS

A. Electric equipment, materials and installation shall comply with the National Electrical Code (NEC) and with the latest edition of the following codes and standards:

1. National Electrical Safety Code (NESC)
2. Occupational Safety and Health Administration (OSHA)
3. National Fire Protection Association (NFPA)
4. National Electrical Manufacturers Association (NEMA)
5. American National Standards Institute (ANSI)
6. Insulated Cable Engineers Association (ICEA)
7. International Society of Automation (ISA)
8. Underwriters Laboratories (UL)
9. Factory Mutual (FM)
10. International Electrical Testing Association (NETA)
11. Institute of Electrical and Electronics Engineers (IEEE)

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 PRIORITY OF THE CONTRACT DOCUMENTS

A. If, during the performance of the work, the Contractor finds a conflict, error or discrepancy between or among one or more of the Sections or between or among one or more Sections and the Drawings, furnish the higher performance requirements. The higher performance requirement shall be considered the equipment, material, device or installation method which represents the most stringent option, the highest quality or the largest quantity.

B. In all cases, figured dimensions shall govern over scaled dimensions, but work not dimensioned shall be as directed by the Engineer and work not particularly shown, identified, sized, or located shall be the same as similar work that is shown or specified.

C. Detailed Drawings shall govern over general drawings, larger scale Drawings take precedence over smaller scale Drawings, Change Order Drawings shall govern over Contract Drawings and Contract Drawings shall govern over Shop Drawings.

D. If the issue of priority is due to a conflict or discrepancy between the provisions of the Contract Documents and any referenced standard, or code of any technical society, organization or association, the provisions of the Contract Documents will take

precedence if they are more stringent or presumptively cause a higher level of performance. If there is any conflict or discrepancy between standard specifications, or codes of any technical society, organization or association, or between Laws and Regulations, the higher performance requirement shall be binding on the Contractor, unless otherwise directed by the Engineer.

E. In accordance with the intent of the Contract Documents, the Contractor accepts the fact that compliance with the priority order specified shall not justify an increase in Contract Price or an extension in Contract Time nor limit in any way, the Contractor's responsibility to comply with all Laws and Regulations at all times.

1.06 ENCLOSURE TYPES

A. Unless otherwise required, electrical enclosures shall be NEMA Types as follows:

1. NEMA 1 in dry, non-process indoor locations. (i.e., administration areas, laboratories, control rooms, storage rooms, electric rooms).

2. NEMA 12 in "DUST" locations shown on the Drawings. (i.e. maintenance shops).

3. NEMA 4X in outdoor locations, rooms below grade including basements and buried vaults, “DAMP” and "WET" locations shown on the Drawings.

4. NEMA 4X in "CORROSIVE" locations shown on the Drawings.

5. NEMA 7 (and listed for use in the area classifications shown) for “Class I Division 1 Group D”, “Class I Division 2 Group D” and “Class II Division 1” NEC hazardous locations shown on the Drawings.

1.07 SERVICE AND METERING

A. The power company serving this project is EPB Electric Power. Service will be obtained at 480/277 Volts, 3 Phase, 4 Wire, 60 Hz to the service entrance equipment as shown on the drawings. Contractor shall be responsible to pay all fees and charges as required for temporary/construction power for Contractor’s use. Contractor shall be responsible to pay all fees and charges for permanent service via the bid allowance and submit invoices to Owner for substantiation. Coordinate with EPB Electric Power to provide and meet requirements for these services. EPB Electric Power contact is Brandon Culpepper, telephone 423-648-4643, email: culpepperbk@epb.net.

B. The power company will be responsible for the following work:

1. Furnishing and installing the primary conduits for the underground service from the riser pole to the utility transformer.

2. Furnishing and installing the primary conductors (overhead and underground) to the utility transformer.

3. Furnishing and installing the transformer pad and grounding.

4. Furnishing and installing transformer.

5. Termination of underground primary cables at the transformer.

6. Termination of underground secondary cables at the transformer.

7. Furnishing and installing metering current transformers (C.T.'s), meter and meter wiring.

C. The Contractor shall be responsible for the following work:

1. Make all arrangements with the power company for obtaining electrical service, pay all power company charges and furnish all labor and material required for the electrical service.

2. Furnishing and installing secondary underground conduits and cable.

3. Furnishing and installing an empty conduit with pull line from the metering C.T.'s to the meter enclosure. Conduit size and type shall be approved by the power company.

1.08 HAZARDOUS AREAS

A. Equipment, materials and installation in areas designated as hazardous on the Drawings shall comply with NEC Articles 500, 501, 502, 503 and NFPA 820.

B. Equipment and materials installed in hazardous areas shall be UL listed for the appropriate hazardous area classification.

1.09 CODES, INSPECTION AND FEES

A. Equipment, materials and installation shall comply with the requirements of the local authority having jurisdiction.

B. Obtain all necessary permits and pay all fees required for permits and inspections.

1.10 POWER SYSTEM STUDIES

A. Provide the power system studies in accordance with Section 26 00 01.

1. Provide a preliminary short circuit and coordination analysis prior to the initial submittal of the electrical service switchgear submittal to confirm the equipment being provided new and the existing equipment are appropriately rated for the short circuit duty available and to ensure that the protective devices being provided properly coordinate among themselves and with the existing installed equipment.

2. Provide a final short circuit, protective devices coordination and arc flash analysis to be used for setting the protective devices and for providing the appropriate safety arc flash labeling on all equipment, existing and new. In addition, the final

analysis report will be used by the Owner as a bench mark for setting and testing protective devices in the future.

1.11 ELECTRICAL SYSTEM TESTING AND SETTINGS

A. Test and provide settings for systems and equipment furnished under Division 26 in accordance with Section 26 08 10 "Electrical System Testing and Settings" and the individual equipment sections for additional specific testing requirements. If the testing results are not within acceptable limits repair or replace all defective work and equipment at no additional cost to the Owner.

B. Make adjustments to the systems furnished under Division 26 in accordance with the equipment manufacturers requirements/recommendations and the system coordination study specified in Section 26 00 01.

1.12 INTERPRETATION OF DRAWINGS

A. In general, the Drawings do not show conduit routing. The Contractor shall be responsible for the planning and routing of all conduits in compliance with the specifications and Drawing details.

B. Drawings noting equipment identification and associated circuitry is found on the following drawings:

1. One line power diagrams show power, grounding and control circuitry requirements associated with substations, switchgear, switchboards, motor control centers, distribution panels, transformers, and feeders to lighting panels.

2. Panelboard schedules show branch circuit conduit and wire requirements.

3. Riser diagrams show circuitry for instrumentation and control devices along with miscellaneous signal or communication wiring.

C. Unless specifically stated to the contrary, the Drawings do not show exact locations of conduit runs. Coordinate the conduit installation with other trades and the actual supplied equipment.

D. Install each 3-phase circuit in a separate conduit unless otherwise shown on the Drawings.

E. Unless otherwise approved by the Engineer, conduit shown exposed shall be installed exposed; conduit shown concealed shall be installed concealed.

F. Where circuits are shown as "home-runs" all necessary fittings and boxes shall be provided for a complete raceway installation.

G. Verify the exact locations and mounting heights of lighting fixtures, switches and receptacles prior to installation.

H. Except where dimensions are shown, the locations of equipment, fixtures, outlets and similar devices shown on the Drawings are approximate only. Exact locations shall be determined by the Contractor and approved by the Engineer during construction. Obtain information relevant to the placing of electrical work and in case of any interference with other work, proceed as directed by the Engineer and furnish all labor and materials necessary to complete the work in an approved manner.

I. Circuit layouts are not intended to show the number of fittings, or other installation details. Furnish all labor and materials to install and place in satisfactory operation all power, lighting and other electrical systems shown.

J. Redesign of electrical or mechanical work, which is required due to the Contractor's use of an alternate item, arrangement of equipment and/or layout other than specified herein, shall be done by the Contractor at his/her own expense. Redesign and detailed plans shall be submitted to the Engineer for approval. No additional compensation will be provided for changes in the work, either his/her own or others, caused by such redesign.

K. Surface mounted panel boxes, junction boxes, conduit, etc. shall be supported by ½-inch spacers to provide a clearance between wall and equipment.

L. All floor mounted electrical equipment shall be placed on a 4-inch thick (3/4-inch, 45 degree chamfer at all exposed edges) concrete pads, provide reinforcement, anchors, etc.

M. The Contractor shall harmonize the work of the different trades so that interferences between conduits, piping, equipment, architectural and structural work will be avoided. All necessary offsets shall be furnished so as to take up a minimum space and all such offsets, fittings, etc., required to accomplish this shall be furnished and installed by the Contractor without additional expense to the Owner. In case interference develops, the Engineer is to decide which equipment, piping, etc., must be relocated, regardless of which was installed first.

N. Raceways and conductors for the lightning protection systems are not shown on the Drawings. Provide raceways and conductors as required by the system manufacturer for a complete and operating system. Raceways shall be installed concealed in all finished spaces and may be installed exposed or concealed in process spaces.

O. Raceways and conductors for lighting, switches, receptacles and other miscellaneous low voltage power and signal systems as specified are not shown on the Drawings. Raceways and conductors shall be provided as required for a complete and operating system. Homeruns, as shown on the Drawings, are to assist the Contractor in identifying raceways to be run exposed and raceways to be run concealed. Raceways shall be installed concealed in all finished spaces and may be installed exposed or concealed in all process spaces. Raceways installed exposed shall be near the ceiling or along walls of the areas through which they pass and shall be routed to avoid conflicts with HVAC ducts, cranes hoists, monorails, equipment hatches, doors, windows, etc. Raceways installed concealed shall be run in the center of concrete floor slabs, above suspended ceilings, or in partitions as required.

P. It is the intent of these Specifications that the Electrical Systems shall be suitable in every way for the service required. All materials and all work that may be implied as being incidental to the work of this Section shall be furnished at no additional cost to the Owner.

1.13 SIZE OF EQUIPMENT

A. Investigate each space in the structure through which electrical equipment furnished under Division 26 must pass to reach its final location. Coordinate shipping splits with the manufacturer to permit safe handling and passage through restricted areas in the structure.

B. The equipment shall be kept upright at all times during storage and handling. When equipment must be tilted for passage through restricted areas, brace the equipment to ensure that the tilting does not impair the functional integrity of the equipment.

1.14 RECORD DRAWINGS

A. As the work progresses, legibly record all field changes on a set of Project Contract Drawings, hereinafter called the "Record Drawings."

B. Record Drawings shall accurately show the installed condition of the following items:

1. One-line Diagrams.
2. Equipment elevations (front views).
3. Raceways and pull boxes.
4. Conductor sizes and conduit fills.
5. Panel Schedules.
6. Control Wiring Diagrams.
7. Lighting Fixture Schedules.
8. Lighting fixture, receptacle and switch outlet locations.
9. Underground raceway and duct bank routing.
10. Plan view, sizes and locations of switchgear, distribution transformers, substations, motor control centers and panelboards.
11. CCTV system components, wiring and routing of raceways.
12. Fiber Optic Network system components, wiring and routing of raceways.
13. Lightning protection system.
14. Grounding system.

C. Submit a schedule of control wiring raceways and wire numbers, including the following information:

1. Circuit origin, destination and wire numbers.

2. Field wiring terminal strip names and numbers.

D. In addition to the schedule, provide point to point connection diagrams showing the same information submitted in the schedule of control wiring raceways including all designations and wiring numbers.

E. Submit the record drawings, schedule of control wiring raceways and wire numbers and the point-to-point connection diagrams to the Engineer. The schedule of control wiring raceways and wire numbers and the point-to-point connection diagrams shall be computer generated (i.e. no hand-written or drawn schedules, drawings or diagrams will be accepted).

1.15 EQUIPMENT INTERCONNECTIONS

A. Review shop drawings of equipment furnished under other Divisions and prepare coordinated wiring interconnection diagrams. Submit copies of wiring diagrams or tables with Record Drawings.

B. Furnish and install all equipment interconnections.

1.16 MATERIALS AND EQUIPMENT

A. Materials and equipment furnished under this contract shall be new, unless specifically called for on the Drawings.

B. All electrical equipment and materials shall be listed by Underwriter's Laboratories, Inc., and shall bear the appropriate UL listing mark or classification marking. Equipment, materials, etc. utilized not bearing a UL certification shall be field or factory UL certified prior to equipment acceptance and use.

C. Warrant all equipment furnished under Division 26 in accordance with Section 01 78 36. Refer to individual equipment sections for additional warranty items.

1.17 EQUIPMENT AND DEVICE IDENTIFICATION

A. Identify all electrical equipment furnished under Division 26 and all equipment control panels furnished under other Divisions with nameplates as described herein. Equipment includes switchgear, switchboards, motor control centers, panelboards, transformers, variable frequency drives, disconnect switches, separately mounted motor starters, transfer switches, control panels, control stations, named terminal cabinets, etc. The designation of the equipment shall correspond to the designation shown on the Drawings.

1. A minimum of two nameplates shall be required at electrical equipment. The first nameplate shall identify the equipment or the name of the equipment it serves.

For example, a panelboard identification nameplate would have the identification of “LP-1” while a local disconnect switch for a pump motor would have the identification of “EFFLUENT PUMP No. 4”. The second nameplate shall identify the power source, i.e. “FED FROM MCC-2”.

B. Nameplates shall be engraved, laminated plastic, not less than 1/16-in thick by 3/4-in by 2-1/2-in with 3/16-in high black letters on a white background.

C. Nameplates shall be screw mounted to NEMA 1 enclosures. Nameplates shall be bonded to all other enclosure types using an epoxy or similar permanent waterproof adhesive. Two-sided foam adhesive tape is not acceptable. Where the equipment size does not have space for mounting a nameplate the nameplate shall be permanently fastened to the adjacent mounting surface. Cemented nameplates shall not be drilled.

D. All voltages (e.g. 480 volts, 120 volts, etc.) within pull boxes, junction boxes etc. shall be identified on the front exterior cover. Signs shall be red background with white engraved lettering, lettering shall be a minimum of 1" high.

E. All receptacles, wall switches, lighting fixtures, photo cells, emergency lights, exit lights, instruments, etc. shall be identified with the panel and circuit to which it is connected. For example a receptacle fed from circuit 4 from panel LP-2 would have the label “LP-2/4”. Identification shall be with machine generated labels with ¼” high letters.

1.18 PROFESSIONAL ENGINEERING SERVICES

A. When engineering services are specified to be provided by the Contractor, the Contractor shall retain a licensed professional engineer to perform the services. The engineer shall be licensed at the time the work is done and licensed in the State in which the project is located. If the State issues discipline specific licenses, the engineer shall be licensed in the applicable discipline. In addition, the engineer shall be experienced in the type of work being provided.

B. All engineering work shall be done according to the applicable regulations for professional engineers to include signing, sealing and dating documents. When submittals are required by a professional engineer, in addition to state required signing and sealing, a copy of the current wallet card or wall certificate indicating the date of expiration shall be included with the submittal.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 SLEEVES AND FORMS FOR OPENINGS

A. Provide and place all sleeves for conduits penetrating floors, walls, partitions, etc. Locate all slots for electrical work and form before concrete is poured.

B. Exact locations are required for stubbing-up and terminating concealed conduit. Obtain shop drawings and templates from equipment vendors or other subcontractors and locate the concealed conduit before the floor slab is poured.

C. Where setting drawings are not available in time to avoid delay in scheduled floor slab pours, the Engineer may allow the installations of such conduit to be exposed. Requests for this deviation must be submitted in writing. No additional compensation for such change will be allowed.

D. Seal all openings, sleeves, penetration and slots as specified in Section 26 05 33.

3.02 CUTTING AND PATCHING

A. Cutting and patching shall be done in a thoroughly workmanlike manner and be in compliance with modifications and repair to concrete as specified in Section 01 73 29. Saw cut concrete and masonry prior to breaking out sections.

B. Core drill holes in concrete floors and walls as required.

C. Install work at such time as to require the minimum amount of cutting and patching.

D. Do not cut joists, beams, girders, columns or any other structural members.

E. Cut opening only large enough to allow easy installation of the conduit.

F. Patching to be of the same kind and quality of material as was removed.

G. The completed patching work shall restore the surface to its original appearance or better.

H. Patching of waterproofed surfaces shall render the area of the patching completely waterproofed.

I. Remove rubble and excess patching materials from the premises.

J. When existing conduits are cut at the floor line of wall line, they shall be filled with grout of suitable patching material.

3.03 INSTALLATION

A. Work not installed according to the Drawings and Specification shall be subject to change as directed by the Engineer at Contractor's expense.

B. Electrical equipment shall be protected against mechanical and water damage. Store all electrical equipment in dry permanent shelters. Do not install electrical equipment in place until structures are weather-tight.

C. Damaged equipment shall be replaced or repaired by the equipment manufacturer, at the Engineer's discretion and at the Contractor's expense.

D. Repaint any damage to factory applied paint finish using touch-up paint furnished by the equipment manufacturer. The entire damaged panel or section shall be repainted in accordance with the field painting requirements specified in Section 09 91 00 at the Contractor's expense.

3.04 MANUFACTURERS SERVICE

A. Provide manufacturer's services for testing and start-up of the following equipment:

1. Switchgear (__1__ days __1__ trips minimum)
2. Low Voltage Motor Control Center (__1__ days __1__ trips minimum)
3. Variable Frequency Drives (__1__ days __1__ trips minimum)
4. Diesel Engine Driven Generator (__2__ days __1__ trips minimum)

B. Testing and startup shall not be combined with training. Testing and start-up time shall not be used for manufacturer's warranty repairs.

C. Refer to associated specification Section for additional requirements.

3.05 TRAINING

A. Provide manufacturer's services for training of plant personnel in operation and maintenance of the equipment furnished under Division 26.

1. Switchgear (__1__ days __1__ trips minimum)
2. Low Voltage Motor Control Center (__1__ days __1__ trips minimum)
3. Variable Frequency Drives (__1__ days __1__ trips minimum)
4. Diesel Engine Driven Generator (__2__ days __1__ trips minimum)

B. The cost of training programs to be conducted with Owner's personnel shall be included in the Contract Price. The training and instruction, insofar as practicable, shall be directly related to the system being supplied.

C. Provide detailed O&M manuals to supplement the training courses. The manuals shall include specific details of equipment supplied and operations specific to the project.

D. The training program shall represent a comprehensive program covering all aspects of the operation and maintenance of each system.

E. All training schedules shall be coordinated with and at the convenience of the Owner. Shift training may be required to correspond to the Owner's working schedule.

F. Within 120 days of contract award to the Contractor, submit an overview of the proposed training plan. This overview shall include, for each course proposed:

1. An overview of the training plan.
2. Course title and objectives.
3. Prerequisite training and experience of attendees.
4. Recommended types of attendees.
5. Course Content - A topical outline.
6. Course Duration.
7. Course Location - Training center or job site.
8. Course Format - Lecture, laboratory demonstration, etc.
9. Schedule of training courses including dates, duration and locations of each class.
10. Resumes of the instructors who will actually implement the plan.

G. The Engineer will review the training plan submittal with the Owner.

3.06 POWER SYSTEM STUDY

A. Install arc flash warning labels at equipment identified in the final approved arc flash study.

3.07 CLEANING

A. Remove all rubbish and debris from inside and around electrical equipment and enclosures.

B. Remove dirt, dust or concrete spatter from the interior and exterior of equipment using brushes, vacuum clear or clean lint-free rags. Do not use compressed air.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Provide both a preliminary and a final short circuit, selective coordination and arc flash study of the complete electrical distribution system as specified herein and as shown on the Drawings. The study shall include motor starting/running calculations.

B. Obtain and pay for the services of the independent engineering specialty firm or low voltage motor control center manufacturer, subject to the approval of the Engineer, to provide a complete fault current, device evaluation, protective devices selective coordination and arc flash study. The selective coordination study shall begin with the utility company's feeder protective device and include all of the electrical protective devices down to and including the largest feeder circuit breaker and motor starter in the all low voltage motor control centers and power distribution panelboards. The study shall also include variable frequency drives, harmonic filters, Uninterruptible Power Supplies (UPS), power factor correction equipment, transformers and protective devices associated with emergency and standby generators, and the associated paralleling equipment and distribution switchgear. The arc flash study shall begin with the utility company's feeder protective device and include all of the electrical distribution equipment down to and including low voltage motor control centers and power distribution panelboards and lighting panels. All information required to perform the study shall be obtained by the entity performing the study.

C. Submit the preliminary short circuit, selective coordination and motor starting/running study prior to submittal of motor control centers, and panelboards shop drawings. The aforementioned shop drawings will not be reviewed until the preliminary power system study is approved by the Engineer. No exceptions will be allowed. The preliminary study shall include but not limited to:

1. Short circuit, protective device coordination and motor starting studies shall be performed on nationally recognized computer software such as SKM System Analysis, EDSA, ETAP, or approved equal.

2. Obtain and verify with the utility company all information needed to conduct the study. Obtain and verify with the Owner ratings of existing electrical equipment that shall be included in the study.

3. Current transformers' ratio and burden calculations shall be based on a 10 percent maximum ratio error per ANSI C57.13. Identify current transformers that will not allow the protective devices to operate within acceptable ANSI error margins and recommend corrective action.

4. The preliminary study shall verify equipment is being applied within their design ratings and electrical protective devices will coordinate.

5. Recommend changes and/or additions to equipment as required providing adequate protection and coordination based on the actual equipment supplied and the results of the short circuit and protective device selective coordination

studies. Submit any such changes and additions as a part of the study. Field settings of devices, adjustments, and minor modifications to equipment that are required to accomplish conformance with the approved short circuit and protective device selective coordination studies shall be carried out by the Contractor at no additional cost to the Owner.

D. After release of electrical equipment by the manufacturer, but prior to energizing the electrical equipment, submit the final short circuit and selective coordination study including all calculations, tabulations, protective devices coordination graphs, etc. as specified herein.

1. Provide a complete short circuit study and protective device selective coordination study for both the utility power distribution system and the emergency/standby power distribution system under the scope of this study. The study shall include but shall not be limited to:
   a. Full compliance with applicable ANSI and IEEE Standards.
   b. Performed on nationally recognized computer software such as EDSA, SKM System Analysis, ETAP, or equal.

2. Provide a report summarizing the selective coordination and motor starting/running study including: one-line diagram of the system, relay and breaker setting tabulation, coordination curves, relay curves, circuit breaker curves, motor starting/running curves, protective device coordination and short circuit calculation, all prepared by the specialty firm.

3. Recommend changes and/or additions to equipment as required providing adequate protection and coordination based on the actual equipment supplied and the results of the short circuit and protective device selective coordination studies. Submit any such changes and additions as a part of the study. Field settings of devices, adjustments and minor modifications to equipment that are required to accomplish conformance with the approved short circuit and protective device selective coordination studies shall be carried out by the Contractor at no additional cost to the Owner.

1.02 RELATED WORK

A. Section 26 08 10 "Electrical Systems Testing and Setting"

B. Variable frequency drives are included in Division 26.

C. Motors are included under other Divisions and are specified in Division 26.

D. Emergency/standby generator are included in Division 26.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 30 00, the following:

1. The number of years the specialty firm has been in the business of performing coordination studies.

2. Identification of each of the three qualifying projects for each of the past three years including:
   a. A brief description of each study.
   b. Name of owner of installation on which study was performed with address, telephone number, and contact person.
   c. Date of study.
   d. Any other information indicating the firm's experiences and ability to perform the work and business status.

B. Preliminary Short Circuit and Coordination Study Report shall include but not limited to:

1. The coordination study report shall be bound in a standard 8-1/2-in by 11-in size report.

2. Electrical distribution system one-line diagram. One line diagrams shall be legible on printed paper and shall not exceed 11 x 17-in in size unless required to clearly illustrate the system and related data.

3. Provide detailed “Input Data” report that identifies all input parameters associated with the equipment depicted on the system one line diagrams including but not limited to Utility data, conductor sizes and lengths, protective device sizes and rating, transformer sizes and ratings, motor types and sizes, etc.

4. Provide current transformers' ratio and burden calculations to confirm that the current transformers will not saturate prior to operation of the protective relays and confirming the current transformers used with differential protection will not saturate under any fault condition.

5. Tabulation of each protective device, its short circuit rating, the available fault current available at the device and an indication whether or not the device is adequately rated for the available fault current and voltage at which it is applied.

6. Preliminary graphic time-current curves showing how the protective devices proposed by the equipment suppliers will coordinate as being applied. TCC’s shall be produced and printed in color to assist the reviewing engineer in the graphical analysis of the protective device coordination. Each device on a TCC shall be a different color and where devices are shown on multiple TCCs the color for the device shall be constant on each TCC that the devices are shown on.

C. Final Short Circuit and Selective Coordination Study Report shall include but not limited to:

1. The coordination study report shall be bound in a standard 8-1/2-in by 11-in size report. The selection of all protective relays types, current transformers, fuse types and ratings shall be the responsibility of the manufacturer and shall be based on the preliminary coordination study, which shall be submitted prior to the equipment shop drawings in accordance with Section 01 30 00. The complete study shall be approved by the Engineer before any equipment is shipped. The report shall include the following sections and information:

2. An executive summary outlining the distribution system, the information received from the power company, assumptions made to complete the report, statement of the adequacy of the distribution equipment to safely clear any fault currents, the adequacy of the distribution equipment to close in on a fault, identify any problem areas with recommendations for resolving the problem.

3. Electrical distribution system one-line diagram. One line diagrams shall be legible on printed paper and shall not exceed 11 x 17-in in size unless required to clearly illustrate the system and related data.

4. Provide detailed “Input Data” report that identifies all input parameters associated with the equipment depicted on the system one line diagrams including but not limited to Utility data, conductor sizes and lengths, protective device sizes and rating, transformer sizes and ratings, motor types and sizes, etc.

5. Provide current transformers' ratio and burden calculations to confirm that the current transformers will not saturate prior to operation of the protective relays and to confirm the current transformers used with differential protection will not saturate under any fault condition.

6. Transformer differential protection calculations including current transformer mismatch relay setting and charts. Provide differential current transformer wiring schematics including polarity and wiring connections based on the winding configuration of the actual power transformers being supplied.

7. Tabulation of all protective devices, circuit breakers, fuses, current transformers, etc. The tabulation shall indicate the device, manufacturer, catalog number, recommended setting, etc.

8. Industry standard graphic time current, protective relay and protective device curves, showing equipment and material damage curves, relay, circuit breaker, fuse curves, available fault currents at the equipment, transformer inrush currents, etc., for each piece of equipment. TCC’s shall be produced and printed in color to assist the reviewing engineer in the graphical analysis of the protective device coordination. Each device on a TCC shall be a different color and where devices are shown on multiple TCCs the color for the device shall be constant on each TCC that the devices are shown on.

9. Tabulation of each protective device, its short circuit rating the available fault current available at the device and an indication whether or not the device is adequately rated for the available fault current and voltage at which it is applied.

10. Calculations and required documentation including copies of correspondence with involved entities such as utility fault contribution coordination.

D. Preliminary Arc Flash Study Report shall include but not limited to:

1. The Arc Flash study report shall be bound in a standard 8-1/2-in by 11-in size report.

2. An executive summary outlining the distribution system, the information received from the power company, assumptions made to complete the report and recommendations to reduce the arc flash values.

3. Recommendations to reduce the arc flash incident energy levels

E. The Final Arc Flash Study report shall be bound in a standard 8-1/2-in by 11-in size report. The report shall include the following sections and information:

1. An executive summary outlining the distribution system, the information received from the power company, assumptions made to complete the report and recommendations to reduce the arc flash values.

2. Provide a detailed bus label for each fault location. Each label shall include a listing of the protective device settings and incident energy at several different working distances.

3. Provide a NFPA 70 E work permit form for each fault location.

4. Provide labels for each fault location.
   a. Provide two labels for the service entrance motor control center (MCC). One label shall indicate the arc flash values for the line side of the main breaker. The second label shall indicate the arc flash values for the load side of the main breaker.

5. PPE Table – Provide a PPE table that defines the Personnel Protective Equipment classes and clothing descriptions identified in the reports and labels.

F. Submittal of Digital Data and System Model

1. Following final approval of any of the above mentioned studies, the Contractor shall provide a digital copy of all reports submitted as part of the project. Reports shall not be password protected and shall be free manipulated by the engineer or owner.

2. Following final approval of any of the above studies, the Contractor shall provide the complete digital system model and system library used to build the model and complete the studies. All files needed to accurately recreate the study completed by the Contractor must be furnished and a backup of the system library used to define all system components must be provided.

1.04 REFERENCED STANDARDS

A. Institute of Electrical and Electronic Engineers, Inc. (IEEE):

1. Standard 141, Recommended Practice for Electrical Power Distribution for Industrial Plants

2. Standard 241, Recommended Practice for Electrical Power Systems in Commercial Buildings

3. Standard 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Systems

4. Standard 399, Recommended Practice for Industrial and Commercial Power System Analysis

5. IEEE Std. 519- Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems, 1992

6. IEEE Std. 1584- IEEE Guide for Arc Flash Hazard Calculations, 2002

7. NFPA 70E 2012.

8. IEEE Std. 242-2001

B. American National Standards Institute (ANSI):

1. Standard C37.90, IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus

2. Standard C37.91, IEEE Guide for Protective Relay Applications to Power Transformers

3. Standard C37.95, IEEE Guide for Protective Relaying of Utility-Consumer Interconnections

4. Standard C37.96, IEEE Guide for AC Motor Protection

5. Standard C57.12.59, IEEE Guide for Dry-Type Transformer Through-Fault Current Duration

6. Standard C57.13, IEEE Standard Requirements for Instrumentation Transformers

7. Standard C57.109, IEEE Guide for Liquid-Immersed Transformer Through-Fault-Current Duration

1.05 QUALITY ASSURANCE

A. Independent Engineering Specialty Firm's Experience

1. Specialty firm shall have been in the business of the type of work specified, for at least the past five years.

2. The specialty firm shall have a minimum of three projects of equal or greater size, service, with the type of equipment specified for each of the past three years.

B. Specialty firm shall be incorporated in the State, Commonwealth or District, in which the equipment will finally reside and shall have a licensed, in the same jurisdiction, professional engineer as a full time employee, to supervise and seal the report.

C. The specialty firm shall be an independent organization, which can function as an unbiased authority, professionally independent of the manufacturers, suppliers and installers of equipment or systems evaluated by the specialty firm.

D. All electrical studies shall be stamped and signed by a professional electrical engineer. The engineer shall be registered in the State, Commonwealth or District in which the equipment will finally reside.

1.06 SHORT CIRCUIT STUDY

A. Perform a short circuit study in accordance with ANSI Standards C37.010 and C37.13 to check the adequacy and to verify the correct application of circuit protective devices and other system components within the construction package. The study shall address the case when the system is being powered from the utility source as well as from the on-site generating facilities, normal and alternate (bus tie closed) modes of operation. Minimum and maximum possible fault conditions shall be covered in the study. It shall be the responsibility of the Contractor performing the study to determine the operating parameters of the system and to derive the worst case fault conditions. Assumptions of plant operation shall not be allowed.

B. Consider the fault contribution of all motors operating during the maximum demand condition of the motors.

C. Calculate short-circuit momentary duties and interrupting duties on the basis of an assumed bolted 3 phase short circuit at each high and medium voltage switchgear bus and controller, low voltage switchgear bus, switchboard, motor control center, distribution panelboard, pertinent branch circuit panelboard and other significant locations throughout the systems. The short circuit tabulations shall include X/R ratios, asymmetry factors, KVA and symmetrical fault-current. Provide a ground fault current study for the same system areas. Include in tabulations fault impedance, X/R ratios, asymmetry factors, motor contribution, short circuit KVA, and symmetrical and asymmetrical fault-currents.

D. The studies shall include representation of the site power system, the base quantities selected, impedance source data, calculation methods and tabulations, one-line diagrams, conclusions and recommendations.

E. Provide the following:

1. The available fault current at each bus within the limits of the study shall be identified and listed.

2. The momentary and interrupting rating of all elements of the distribution system shall be listed. The maximum available fault current available at each element shall be calculated

3. Determine the adequacy of the electrical protective devices to withstand the maximum available fault at the terminals of the equipment. Provide an equipment list, the equipment rating (both momentary and withstand), the maximum available fault rating and the adequacy of the equipment to withstand the fault. The results shall be tabulated in the form of a PASS/FAIL device

evaluation table Equipment that does not have adequate ratings shall be identified immediately and brought to the attention of the Engineer.

4. The short circuit portion of the report shall include:
   a. Executive summary describing the distribution system, the procedures used to develop the study, utility related information furnished by the utility company including the name and telephone number of the individual supplying the information, identify all assumptions made in the preparation of the study, identify any problem areas and provide a definitive statement concerning the adequacy of the distribution system to interrupt and withstand the maximum possible fault current.
   b. Computer printout of the input data.
   c. Computer printouts for the three phase and ground fault studies. Printouts shall indicate the fault current available at each major equipment, distribution bus within the high, medium and low voltage distribution systems.
   d. Table listing all the electrical distribution and utilization equipment (including VFDs), the equipment interrupting and withstand ratings, the available fault current at the terminals of the equipment and the ability of the equipment to interrupt and/or withstand the fault.
   e. The short circuit study shall be prepared using approved computer software and must include complete fault calculations as specified herein for each proposed and ultimate source combination. Source combinations may include present and future Power Company supply circuits, large motors, or generators.

F. Automatic Load Transfer

1. Provide a detailed study demonstrating the interrupting capacity of automatic transfer bus ties and switches, as well as the fault withstand capabilities. The following shall be considered:
   a. X/R ratio fault-current of circuit at point of transfer.
   b. X/R ratio and fault-current rating of the transfer device.
   c. Length of time fault may persist prior to protective device opening.
   d. Magnetic stress withstand rating.
   e. I2t withstand rating.
   f. Transfer device maximum interrupting duty compared to load interrupting duty.

1.07 PROTECTIVE DEVICE COORDINATION

A. Provide a protective device time-current coordination study in accordance with ANSI/IEEE Std. 242, with coordination plots of protective devices plus tabulated data, including ratings and settings selected. In the study, balance shall be achieved between the competing objectives of protection and continuity of service for the system specified, taking into account the basic factors of sensitivity, selectivity and speed.

B. Provide separate plots for each mode of operation: (1) "singled ended mode" (single incoming utility feeder energized all motor control centers single ended); (2) "stand-by mode" (on-site generation solely providing power to the system. Show maximum and

minimum fault values in each case. Multiple power sources shown in one plot is not acceptable.

C. Each primary protective device required for a delta-to-wye-connected transformer shall be selected so the characteristic or operating band is within the transformer parameters, which, where feasible, shall include a parameter equivalent to 58 percent of the ANSI C37.91 withstand curve to afford protection for secondary line-to-ground faults. Separate low voltage power circuit breakers from each other and the associated primary protective device, by a 16 percent current margin for coordination and protection in the event of line-to-line faults. Separate the protective relays by a 0.3-second time margin for the maximum 3 phase fault conditions to assure proper selectivity. The protective device characteristics or operating bands shall be terminated to reflect the actual symmetrical and asymmetrical fault-currents sensed by the device. Provide the coordination plots for 3 phase and phase-to-ground faults on a system basis. Include at least all devices down to largest branch circuit and largest feeder circuit breaker in-each motor control center and/or power distribution panelboard. Include all adjustable setting ground fault protective devices.

D. Select relay types (i.e., inverse, very inverse, extremely inverse, over current with or without voltage restraint, timers, etc.), current transformer ratings and types, fuse, residually or zero sequence connected ground faults protection, etc., that will allow the system to be protected to within the equipment fault ratings and provide the maximum possible coordination between the protective devices.

E. Multifunction Solid State Relays

1. Where multifunction solid state relays are already installed, it shall be the responsibility of the Contractor to obtain the current and complete list of software setpoints programmed into the device. These setpoints shall be evaluated for potential impacts on the protective device coordination.

2. Where multifunction solid state relays are being install, it shall be the responsibility of the Contractor to provide all setpoints needed for the specified operation of the relay. These settings include but are not limited to:
   a. The complete pickup settings of all protective elements specified by the designer and shall not be limited to only the overcurrent pickup settings. Settings for protective elements such as reverse power, synchronization, frequency and voltage control, etc. shall be provided in full.
   b. Differential pickup and zone settings necessary for the relay to operate as specified and designed and to protect the zone it is intended for. Zone of protection calculations and balance equations shall be completed entirely by the Contractor based on the equipment as furnished and designed.
   c. The complete protective relay logic map and logic equations. The relay logic is responsible for translating the pickups of the protective elements into relay output events and device trips. All logic necessary to create the specified output of the relay based on the specified protective elements shall be furnished with the protective device coordination report.
   d. Any and all miscellaneous settings necessary for the relay to communicate with the installation systems and the mirroring of data to other installation systems as specified or designed.

3. Contractor shall be responsible for the programming of relays prior to the field testing and start up requirements of this contract. The Contractor shall be responsible for all time needed to complete the relay settings in order to furnish a completely functional system as specified and required by the approved protection device settings.

F. Arc Flash Mitigation and Reduction Modes

1. Where devices are furnished with alternative trip settings intended to mitigate arc flash hazards, the Contractor shall coordinate these alternative pickup settings and provide representation of their tripping characteristics via TCC's. The alternative pickup settings shall be coordinate with the associated load and shall be set to provide the fastest device response time while avoiding nuisance trips during normal plant operation.

G. Generator Protective Devices

1. The study shall address all of the protective devices provided for generator protection.

2. Protective relays requiring settings shall be included.

3. The Electrical Contractor shall obtain all necessary generator information to perform this study.

H. Motor Protection and Coordination

1. Provide a complete and independent set of current-time characteristic curves for all motors 50 HP and above indicating coordination between the protective relays and the thermal and starting characteristics of the motor.

2. The Contractor shall obtain from the motor supplier the necessary information to perform the study. Certified curves for "Safe Time vs. Current at 100% Voltage" and "Accelerating Time vs. Current at 100% Voltage" are necessary and shall become part of the final report.

I. Call discrepancies to the attention of the Engineer in the conclusions and recommendations of the report.

J. The Time current Characteristic Curves shall include:

1. The coordination plots shall graphically indicate the coordination proposed for the several systems centered on full-scale log forms. The coordination plots shall include complete titles, representative one-line diagrams and legends, associated upstream power system relays, fuse or system characteristics, significant motor starting characteristics, significant generator characteristics, complete parameters for power, and substation transformers, complete operating bands for low voltage circuit breaker trip devices, fuses, and the associated system load protective devices. The coordination plots shall define the types of protective devices selected, together with the proposed coil taps, time-dial settings and pick-up settings required. The short-time region shall

indicate the relay instantaneous elements, the magnetizing inrush, and ANSI transformer damage curves, the low voltage circuit breaker and instantaneous trip devices, fuse manufacturing tolerance bands, and significant symmetrical and asymmetrical fault-currents.

2. No more than six devices shall be shown on one coordination plot. Of these six curves, two (the largest upstream device and the smallest downstream device) shall repeat curves shown on other coordination plots in order to provide cross-reference. Give each curve in the study a study-unique number or letter identifier to permit cross-reference between plots.

3. The coordinating time interval between primary and back-up protective devices shall be as per Table 15-3, Section 15.6, IEEE Std. 242-2001.

4. Include a detailed description of each protective device identifying its type, function, manufacturer, and time-current characteristics. Tabulate recommended device tap, time dial, pickup, instantaneous, and time delay settings. A tabulation shall include settings for every overcurrent protective device, timer, power system relays (e.g., ANSI 25, 27, 32, 67, 87, etc.), circuit breaker, recommended fuse and current transformer ratings, etc. Include C.T. ratio, burden and all other calculations required for the determination of settings. Provide recommended settings for all protective devices furnished under Division 26 and furnished with those furnished with Variable Frequency Drives and associated transformers, generators and associated paralleling and distribution switchgear.

1.08 ARC FLASH

A. Provide an arc flash study that utilizes the fault current values calculated in the short circuit study and the maximum clear times of the upstream protective device selected in the coordination study to calculate the incident energy at each fault location.

B. The Arc Flash study shall be in accordance with the procedure outlined in IEEE Standard 1584.

C. Calculate the incident energy levels at each faulted bus for each mode of operation: (1) "singled ended mode" (single incoming utility feeder energized all motor control centers single ended); (2) "stand-by mode" (on-site generation solely providing power to the system. Determine arc flash incident energy values for both maximum and minimum fault values in each case.

1. Maximum values shall be calculated with 100% motor load.

2. Minimum values shall be calculated with no motors running (startup condition).

D. Extent of Study

1. The arc flash study shall include analysis for all equipment that would normally be serviced while energized and cannot be easily shut down during maintenance periods. The contractor shall coordinate with the owner to ensure

that all equipment that is expected to be analyzed is included in the study. The extent of the analysis includes but is not limited to:

a. MCC's and distribution equipment

E. Arc Flash Labels

1. The arc flash study shall produce a single set of label templates that shall not be printed until the final arc flash study has been approved.

2. A single set of labels shall be printed and affixed to the equipment analyzed if the equipment is continuous. Double ended equipment shall have individual labels for each side of the gear. Equipment that is not continuous shall have a single label placed on each piece of continuous gear.

3. Where applicable, LINE and LOAD labels shall be produced for equipment. Examples of equipment that require these labels include the main breakers of the MCC. In these cases, the LINE side breakers shall be affixed to indicate the hazard associated with the line side of the equipment and the LOAD label shall be affixed to indicate the hazard associated with the rest of the gear.

4. Labels shall be affixed where they are clearly identifiable with the equipment they depict. Labels shall not obscure any other signage on the equipment unless they are used to completely cover a previous arc flash label.

5. Labels shall meet the following requirements:
   a. Labels shall be indoor/outdoor rated weather resistant vinyl or polyester with a UV resistant over laminate. The label shall have a minimum thickness of 5 mil. Labels shall be backed with pressure sensitive permanent cold temperature adhesive rated for a minimum 5 year life in the environment in which they are installed.
   b. All lettering shall be black and printed via thermal transfer. Backgrounds shall be orange for hazard risk categories 1-4 and red for "Dangerous" areas.
   c. Where subjected to degrading or corrosive environments, the labels shall be provided with a tinted fiber glass cover.
   d. The label shall match any pre-existing facility or client specified formatting. The contractor shall be responsible for obtaining this formatting information prior to submitting label templates.
   e. A single label for equipment is acceptable where equipment is continuous. In the event of split busses or equipment not arranged in a continuous fashion, multiple labels shall be provided.
   f. Line side labels for equipment main breakers shall be included in addition to load side labels.
   g. Labels shall be DANGER/WARNING type conforming to the NFPA 70E and ANSI Z534.4 standards. Labels are required to have the minimum information specified by these standards printed on them. Labels shall be legible and standard throughout the plant.
   h. Labels templates shall be provided to the engineer and client for final approval and shall be printed and affixed by the contractor. Contractor shall be responsible for all work required to print and affix the labels to the

equipment. Labels shall be affixed in accordance with the direction of the client.

6. Contractor shall produce all arc flash labels and coordinate affixing them onto all equipment.

F. Arc Flash Mitigation and Reduction Devices

1. Where devices are furnished with alternative trip settings intended to mitigate arc flash hazards, the Contractor shall provide an alternative arc flash lookup table associated with these alternative settings.

2. Labels shall have only the worst case hazard risk category (without the arc flash reduction settings) depicted. Multiple labels for different device settings shall not be accepted.

3. Devices such as differential protection relays which limit incident energy by limiting the magnitude of the available fault and/or minimizing the fault clearing time may be used to calculate hazard risk categories. The use of these devices in the calculations shall only be permitted where permitted by the standards and code guidelines used to complete the arc flash analysis. If not explicitly stated by the standard as an acceptable method for calculating arc flash hazard, it shall not be permitted.

G. Arc Flash Hazard Mitigation

1. Acceptable hazard risk categories shall be coordinated by the contractor between the owner and engineer. Contractor shall list all areas greater than category 2 in the conclusion of the report and shall give reasons for the high incident energy.

2. The Contractor shall be responsible for proposing and evaluating arc flash mitigation measure including but not limited to:
   a. Adjustment of protective devices (without interfering with breaker coordination) in an attempt to better balance the system coordination and the incident energy available to an arcing fault.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 QUALITY ASSURANCE

A. Adjust relay and protective device settings according to values established by coordination study. Setting shall be made in accordance with Section 26 08 10.

B. Make minor modifications to equipment as required to accomplish conformance with the short circuit and protective device coordination studies.

C. Notify Consulting Engineer in writing of any required major equipment modifications.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish, install and test all wire, cable and appurtenances as shown on the Drawings and as specified herein.

B. Install data highway, fiber optic, coaxial and I/O cables furnished under Division 13.

1.02 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, product data of proposed wire.

B. Installed unapproved wire shall be removed and replaced at no additional cost to the Owner.

1.03 DELIVERY, STORAGE AND HANDLING

A. Carefully handle all conductors to avoid kinks and damage to insulation.

1.04 WARRANTY

A. Manufacturer shall warrant cable against defects for a period of one years from date of Substantial Completion and shall remove and replace defective cables at its own expense during this warranty period.

PART 2 PRODUCTS

2.01 GENERAL

A. Wires and cables shall be of annealed, 98 percent conductivity, soft drawn copper.

B. Conductors shall be stranded, except that lighting and receptacle wiring may be solid.

C. Except for control, signal and instrumentation circuits, wire smaller than No. 12 AWG shall not be used.

D. Wire shall have 600 Volt insulation except where indicated otherwise.

E. Conductors installed in plenums shall be marked PLENUM RATED.

F. Wire of a given type shall be the product of a single manufacturer.

2.02 BUILDING WIRE

A. Wire for lighting, receptacles and other circuits not exceeding 150 Volts to ground shall be NEC type XHHW-2 as manufactured by The Okonite Co.; General Cable.; Encore Wire Corporation; Southwire Co.; or equal.

B. Wire for circuits over 150 Volts to ground within buildings and structures shall be NEC type XHHW-2 as manufactured by The Okonite Co.; General Cable.; Encore Wire Corporation; Southwire Co.; or equal.

C. Wire for circuits over 150 Volts to ground used underground or for service entrance shall be NEC type RHW-2, flame retardant and CT rated per IEEE 1202 as manufactured by The Okonite Co.; General Cable.; Encore Wire Corporation; Southwire Co.; or equal.

D. Bare copper ground wire shall be stranded, annealed copper wire ASTM B.

E. Multi-conductor power cables shall have stranded conductors with type XLP insulated, nylon conductor covering, and an overall PVC jacket covering over individual wires. Number of conductors shall be as indicated on the Drawings. Cable shall be TC rated meeting UL 1277 and IEEE 383 Standards. Cable shall be flame resistant, non-propagating and shall be suitable for installation in a Class I, Division II hazardous location and for direct burial in earth. Multi-conductor power cables, sizes #12 AWG and larger, shall be furnished with a green ground conductor and a white neutral conductor where required to serve phase to neutral loads. Cable shall be as manufactured by The Okonite Co.; Southwire Co.; General Cable; or equal.

F. Equipment grounding conductors shall be NEC Type THW green and sized in accordance with NEC Table 250-122. Ground grid conductors shall be insulated unless shown otherwise on the Drawings.

2.03 CONTROL, STATUS AND ALARM WIRE

A. Wire shall be No.14 AWG NEC type XHHW, stranded as manufactured by The Okonite Co.; General Cable.; Encore Wire Corporation; Southwire Co.; or equal.

B. Multi-conductor control cable, where shown on the Drawings, shall be stranded, No. 14 AWG, 600 Volt, XLP insulated, nylon jacket over insulation, polyvinyl chloride jacket overall, Type TC as manufactured by The Okonite Co.; General Cable; Southwire Co.; or equal. Number of conductors shall be as shown on the Drawings.

2.04 INSTRUMENTATION WIRE

A. Wire for process instrumentation signals (i.e., 1-5 VDC, 4-20 mADC), R.T.D., potentiometer and similar signals shall be:

1. Single pair cable:
    a. Conductors: 2 No. 16 stranded and twisted on 2-in lay.
    b. Insulation: XLP with 600 Volt, 105 degrees C rating.
    c. Shield: 100% Aluminum/polyester foil with drain wire.

d. Jacket: PVC with UL Subject 1277 TC, UL 1581 and manufacturers' identification.
e. Max overall diameter: 0.296-in.
f. Miscellaneous: UL Listed as Instrument Tray Cable/Power Limited Tray Cable (PLTC) for use in accordance with Article 727 and Article 725 of the NEC.
g. Manufacturers: Belden Cable; Manhattan; General Cable; The Okonite Co.; Rockbestos Company; or equal.

2. Three conductor (triad) cable:
a. Conductors: 3 No. 16 stranded and twisted on 2-in lay.
b. Insulation: XLP with 600 Volt, 105 degrees C rating.
c. Shield: 100% Aluminum/polyester foil with drain wire.
d. Jacket: PVC with UL Subject 1277 TC, UL 1581 and manufacturers' identification.
e. Max overall diameter: 0.310-in.
f. Miscellaneous: UL Listed as Instrument Tray Cable/Power Limited Tray Cable (PLTC) for use in accordance with Article 727 and Article 725 of the NEC.
g. Manufacturers: Belden Cable; Manhattan; General Cable; The Okonite Co.; Rockbestos Company; or equal.

3. Multiple pair cables (where shown on the Drawings):
a. Conductor: Multiple 2 No. 16 stranded and twisted on a 2-in lay.
b. Insulation: XLP with 600 Volt, 105 degrees C rating.
c. Shield: Individual pairs shielded with 100 percent mylar tape and drain wire.
d. Jacket: PVC with UL Subject 13, UL 1581 manufacturers' identification.
e. Misc: UL Subject 13, Type PLTC.
f. Manufacturers: Belden; Manhattan; General Cable; Rockbestos Company or equal.

4. Local Area Network (LAN) Ethernet cable: Unshielded twisted pair cable shall be designed for use with a high speed (10/100/1000 Mbps) Ethernet 10/100/1000 BASE-T/TX communications network. Twisted pair cable shall have a nominal impedance 100 ohms at one MHz, a maximum attenuation of 8 dB per 1000 feet at one MHz. Twisted pair cable must have frequency tested up to 250 MHz or more. Twisted pair cable shall be plenum rated and shall have a minimum of four 23 AWG solid copper conductor pairs. All 10/100/1000 BASE-T/TX (RJ-45) terminations on twisted pair cable shall be done in a professional and workman like manner. Terminations shall provide for proper strain relief on cable jacket. Strain relief on wire and/or wire insulation shall not be acceptable. Category 6 cable shall be as manufactured by Belden; Phoenix; or equal.

B. Splices (Power Conductors)

1. Unless otherwise indicated on the Drawings, splices shall not be made in cables without prior written approval of Engineer. Where splicing is approved by Engineer, splicing materials for 600 Volt splices shall be made with long barrel, tin plated copper compression (hydraulically pressed) connectors and insulated with heavy wall heat shrinkable tubing. Conductivity of completed connections shall be not less than that of uncut conductor. Insulation resistance of completed

connections of insulated conductors shall be not less than that of uncut conductor.

C. Wire lugs shall be tin plated copper, long barrel compression type (hydraulically pressed) for wire sizes No. 8 AWG and larger. Lugs for No. 10 AWG and smaller wire shall be locking spade type with insulated sleeve. Lugs shall be as manufactured by the Thomas and Betts Co.; Burndy; Amp; or equal.

D. Compression type connectors shall be insulated with a heat shrink boot or outer covering and epoxy filling. Splice kits shall be as manufactured by Raychem (Tyco); Ideal Industries; 3M Co. or equal.

E. Solderless pressure connectors shall be self-contained, waterproof and corrosion-proof units incorporating prefilled silicone grease to block out moisture and air. Connectors shall be sized according to manufacturer's recommendations. Connectors shall be UL listed and CSA approved, as manufactured by King Innovation; Ideal Industries, Inc., or equal.

2.05 MOTOR CONNECTIONS

A. Motor connections shall be ring type mechanical compression terminations installed on branch circuit wires and motor leads and secured with bolt, nut and spring washer. Connections shall be insulated with a Raychem Type RVC, roll-on stub insulator; Thomas & Betts, Shrink-Kon MSCV20; or equal. For wire sizes No. 8 and larger, long barrel, tin plated copper compression (hydraulically pressed) type connections Burndy Co., or equal) shall be installed on branch circuit wires and motor leads. Connections shall be insulated with heavy duty heat shrinkable material (Raychem Corp., or equal.

2.06 TERMINATION AND SPLICES (CONTROL, STATUS AND ALARM CONDUCTORS)

A. Termination connectors shall be of locking fork-end (upturned leg ends) type as manufactured by Ideal Industries; 3M Co.; Panduit Corp. or equal.

B. Insulated compression type connectors shall be of the expanded vinyl insulated parallel or pigtail type as manufactured by Ideal Industries; 3M Co.; Panduit Corp., or equal.

C. Solderless pressure connectors shall be self-contained, waterproof and corrosion-proof units incorporating prefilled silicone grease to block out moisture and air. Connectors shall be sized according to manufacturer's recommendations. Connectors shall be UL listed and CSA approved, as manufactured by King Innovation; Ideal Industries, Inc., or equal.

2.07 TERMINATIONS (INSTRUMENTATION CABLES)

A. Termination connectors shall be of locking fork-end (upturned leg ends) type as manufactured by Ideal Industries; 3M Co.; Panduit Corp., or equal.

2.08 WIRE AND CABLE MARKERS

A. Wire and cable markers shall be "Omni-Grip" as manufactured by the W.H. Brady Co.; Thomas & Betts Co., SMS; 3M Co., STD-TAG; or equal.

B. Wire and cables with diameters exceeding the capacity of the "Omni-Grip" shall be marked with pre-printed, self-adhesive vinyl tapes as manufactured by the W.H. Brady Co.; Panduit Corp.; 3M Co.; or equal.

2.09 WALL AND FLOOR SLAB OPENING SEALS

A. Wall and floor slab openings shall be sealed with UL approved expanding material which equals or exceeds fire rating of wall or floor construction such as "FLAME-SAFE" as manufactured by the Thomas & Betts Corp.; Pro Set Systems; Neer Mfg. Co.; Specified Technologies, Inc.; or equal.

2.10 TERMINAL CONNECTORS (FIBER OPTIC)

A. Terminal connectors shall be Type ST2 compatible design with ceramic ferrule and strain relief boot. Epoxy used to attach connectors to individual fibers shall be a heat cure type featuring an accelerated cure cycle and color change upon cure completion. Connector specifications shall be as follows:

1. Insertion loss (typical): 0.5 dB.

2. Durability (mating cycles): 1000 (minimum).

3. Repeatability: Less than 0.2 dB.

4. Operating Temperature: minus 40 to plus 80 degrees C].

PART 3 EXECUTION

3.01 INSTALLATION

A. Uniquely identify wires, cables and each conductor of multi-conductor cables (except lighting and receptacle wiring) at each end and in manholes, hand holes, and pull boxes with wire and cable markers.

B. Use lubrications to facilitate wire pulling. Lubricants shall be UL approved for use with the insulation specified.

C. Provide multi-conductor control and signal cables within the underground system. Cables shall be installed continuous from building to building without splices. Individual control conductors and twisted shielded pairs signal cables will not be allowed in underground systems.

D. Crimping tools used in securing the conductor in compression type connectors or terminal lugs shall be those made for that purpose and for conductor sizes involved.

Crimping tool shall be ratchet type which prevents tool from opening until crimp action is completed. Such tools shall be a product of connector manufacturer.

E. Install an equipment grounding conductor in raceways.

F. Seal openings in slabs and walls through which wires and cables pass.

G. Pull cables from direction that requires least tension. Use a feed-in tube and sheave designed for cable installation. Use sheaves with radii that exceed cable manufacturer's recommended minimum bending radius. Use a dynamometer and constant velocity power puller. Velocity should not be less than 15-ft./min. or more than 50-ft./min. Do not exceed cable manufacturer's maximum recommended tension.

H. If cable cannot be terminated immediately after installation, install heat shrinkable end caps.

I. Fireproof exposed cables in manholes, vaults, pullboxes, switchgear and other areas not protected by conduit where medium voltage cables are present. Use fire-proofing tape and glass tape in accordance with manufacturer's instructions. Fire-proofing tape shall be installed with one half-lapped layer of Scotch Brand 77 Electric Arc and Fireproofing Tape (3M Corp., or equal). Tape shall be secured with a two-layer band of Scotch Brand 69 Glass Electrical Tape (3M Corp., or equal) over the last wrap.

J. Fiber Optic Cables

1. Provide material, equipment, and labor to install fiber optic cables indicated and as specified herein.

2. Installation shall be in accordance with the NEC.

3. Install cables in raceway systems as indicated. Inspect raceways prior to pulling in cables. Notify the Engineer of any conditions which would prevent installation of specified cables before proceeding with the installation.

4. Lubricate cables with lubricants specially formulated for fiber cabling jackets during installation. Do not exceed cable manufacturers' specifications for tensile strength and bending radius. Pulleys used to aid in installation of fiber optic cable shall be sized according to minimum bending radius. Pulling tension of fiber cables during installation shall be recorded using a strip recorder. Printout of strip recorder shall be submitted to the Engineer.

5. For fiber optic cable systems provided under Division 26, provide breakout kits, splice closures, signal transceivers, power supplies, patch panels, pigtails and jumpers to install a complete data highway communications network. Patch panels and splice enclosures shall be wall mounted.

6. Splices shall be made in designated enclosures above ground only. Provide adequate put-up lengths on cable reels to make termination-to-termination runs without splices. Where splices are indicated, provide mechanical splices with attenuation losses of 0.3 dB or less. Make splices watertight and provide mechanical protection equal to cable jacket.

7. Support cables in riser conduits at intervals as required by the NEC.

8. Installation tools and materials shall be approved by cable manufacturer.

9. Polishing process of terminal connectors shall be a two stage wet process using 3.0 micron lapping film for an initial polish followed by 0.3 micron lapping film for final polish.

10. Label each termination point.

11. Tag each cable in junction boxes, manholes and handholes. Provide permanent nylon/plastic tie-wrap type tags with waterproof markings.

12. Make the following field tests after cable installation:
    a. Visually inspect terminal connectors for out-of-round conditions and surface defects such as micro-chips and cracks using a 100X (minimum) inspection microscope.
    b. Check optical continuity of each fiber from terminal to terminal.
    c. Verify calculated attenuation power losses of each fiber from transmit and receive terminals at source of each data communications loop. Light source and operating wavelength of test equipment shall be representative of actual operating equipment.]

3.02 WIRE COLOR CODE

A. Wire shall be color coded or coded using electrical tape in sizes where colored insulation is not available. Where tape is used as the identification system, it shall be applied in junction boxes, manholes, and other accessible intermediate locations as well as at each termination.

B. The following coding shall be used:

System	Wire	Color
240/120 Volts Single-Phase, 3 Wire	Neutral	White
	Line 1	Black
	Line 2	Red
208Y/120, Volts 3 Phase, 4 Wire	Neutral	White
	Phase A	Black
	Phase B	Red
	Phase C	Blue
240/120 Volts 3 Phase, 4 Wire delta, center tap ground on phase coil A-C	Neutral	White
	Phase A	Black
	Phase B (High)	Orange
	Phase C	Blue
480Y/277 Volts 3 Phase, 4 Wire	Neutral	White
	Phase A	Brown
	Phase B	Orange
	Phase C	Yellow

C. Neutral or ground wires that terminate in a Panelboard and require color tape shall have color tape extend at least 6 inches from termination point.

3.03 TERMINATIONS AND SPLICES

A. Power conductors: Unless otherwise indicated on the Drawings, no splices may be made in cables without prior written approval of the Engineer. Where splicing is approved, terminations shall be die type or set screw type pressure connectors as specified. Splices (where allowed) shall be die type compression connector and waterproof with heat shrink boot or epoxy filling for copper conductors # 4 AWG and larger. Splices shall be solderless pressure connectors with insulating covers for copper conductors # 6 AWG and smaller. Aluminum conductors (where specified) shall employ terminations and splices specifically designed for aluminum conductors.

B. Control Conductors: Termination on saddle-type terminals shall be wired directly with a maximum of two conductors. Termination on screw type terminals shall be made with a maximum of two spade connectors. Splices (where allowed) shall be made with insulated compression type connectors.

C. Instrumentation Signal Conductors (including graphic panel, alarm, low and high level signals): terminations same as for control conductors. Splices allowed at instrumentation terminal boxes only.

D. Except where permitted by the Engineer no splices will be allowed in manholes, handholes, or other below grade located boxes.

E. Splices shall not be made in push button control stations, control devices (i.e., pressure switches, flow switches, etc.), conduit bodies, etc.

3.04 INSTRUMENTATION CABLES

A. Instrumentation cables shall be installed in rigid aluminum raceways as specified. Circuits shall be installed as twisted pairs or triads. In no case shall a circuit be made up using conductors from different pairs or triads. Triads shall be used wherever three wire circuits are required.

B. Terminal blocks shall be provided at instrument cable junction and circuits shall be identified at such junctions.

C. Shielded instrumentation wire, coaxial, data highway, I/O and fiber optic cables shall be run without splices between instruments, terminal boxes, or panels.

D. Ground shielding on instrumentation wires at one end only as recommended by instrument manufacturer and isolated at other locations. Terminal blocks shall be provided for inter-connecting shield drain wires at junction boxes. Where individual circuit shielding is required, each shield circuit shall be provided with its own block.

E. Install shielded instrumentation wire in conduit and pull boxes that contain only shielded instrumentation wire. Instrumentation cables shall be separated from other (i.e., power,

control, etc.) cables in manholes by enclosing them within rigid aluminum raceways and boxes.

F. Shielded cable terminations at each end shall be provided with heat shrinkable tubing placed over the exposed shield and conductors. Tubing shall extend 1 inch minimum over jacket end and extend 0.5 inch minimum from jacket end over exposed conductors.

3.05 FIELD TESTING

A. Test 600 Volt wire insulation with a mega-ohm meter after installation and prior to termination. Make tests at not less than 1000 Volts DC. Test duration shall be one minute. Submit a written test report of results to the Engineer. Notify the Owner in writing 48 hours prior to testing.

B. Field testing and commissioning shall be done in accordance with latest revision of the "Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems" published by the International Electrical Testing Association (NETA Standard ATS-2017) unless otherwise modified by this Section. Minimum wire insulation resistance shall not be less than 250 Mega-ohms.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install complete raceway systems as shown on the Drawings and as specified herein.

B. Home runs indicated are to assist the contractor in identifying raceways to be installed concealed or exposed. Raceways identified to be installed exposed on the Drawings shall be run near the ceilings or along the walls of the areas through which they pass and shall be routed to avoid conflicts with HVAC ducts, cranes and hoists, lighting fixtures, doors and hatches. Raceways indicated to be run concealed shall be run in the center of concrete floor slabs, in partitions, or above hung ceilings, as required.

C. Raceways and conductors are not shown completely on the Drawings, including but not limited to raceways and conductors: between lighting, switches, receptacles, other miscellaneous low voltage and signal systems, except where they are required to pass through restricted or designated spaces. Conduit and wiring descriptions are indicated on the riser diagrams for the Instrumentation Systems. Home runs indicated, are to assist the Contractor in identifying raceways to be installed concealed or exposed. Raceways and conductors shall be provided for complete and operating systems. Raceways indicated to be run exposed on the Drawings shall be run near the ceilings or along the walls of the areas through which they pass and shall be routed to avoid conflicts with HVAC ducts, cranes and hoists, lighting fixtures, doors and hatches, etc. Raceways indicated to be run concealed shall be run in the center of concrete floor slabs, in partitions, or above hung ceilings, as required.

D. Furnish all labor, materials, equipment, accessories and components and install a complete seismic restraint and support system for raceway systems as indicated on the Drawings and as specified herein.

1. All supports, hangers, bracing and appurtenances shall conform to the latest applicable requirements of the NEC except as supplemented or modified by the requirements specified in this Section.

E. The electrical subcontractor shall engage the services of an independent professional engineer registered in the State of Tennessee, with specific experience in the design of seismic restraints and supports for electrical supporting systems hereinafter referred to as support engineer.

1.02 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, the manufacturers' names and product designation or catalog numbers with marked cut sheets of all materials specified.

PART 2 PRODUCTS

2.01 RACEWAYS AND FITTINGS

A. Rigid Aluminum Conduit and Fittings (NEC Type RMC):

1. Rigid aluminum conduit, couplings, factory elbows and fittings shall be 6063 alloy and shall comply with ANSI C80.5.

2. Acceptable manufacturers:
   a. American Conduit by SAPA.
   b. AFC Co.
   c. Wheatland Tube.
   d. Or equal.

B. PVC Coated Rigid Aluminum Conduit and Fittings:

1. PVC coated rigid aluminum conduit shall be 6063 alloy with a minimum 0.040-in thick, polyvinyl chloride coating permanently bonded to it and an internal chemically cured urethane or enamel coating. The rigid aluminum conduit shall comply with ANSI C80.5 prior to coating.

2. PVC coated couplings, factory elbows and fitting shall be furnished with a PVC coating bonded to aluminum the same thickness as used on the PVC coated conduit. The ends of all couplings, fittings, etc. shall have a minimum of one pipe diameter in length of PVC overlap.

3. Acceptable manufacturers:
   a. "Ocal" as manufactured by Thomas & Betts.
   b. "Plasti-Bond Red" as manufactured by Robroy Industries.
   c. Perma-Cote.
   d. Or equal.

C. Non Metallic Conduit and Fittings:

1. PVC conduit shall be rigid polyvinyl chloride schedule 40 or 80. Rigid PVC conduit shall comply with NEMA TC-2 and UL/651 and shall be sunlight resistant, rated for use with 90 degree C conductors in exposed and direct or concrete encased applications.

2. Underground utility duct, 4-in trade size and above, shall be type EB conduit encased in concrete, rated for use with 90 degree C conductors and shall comply with UL/651A and NEMA TC-6 and 8.

3. Connectors, couplings, fittings and ancillary materials shall be supplied by the conduit manufacturer. Connectors, fittings and ancillary materials shall be rated for the environment for which they are installed.

4. Acceptable manufacturers:
   a. Carlon Corp.

b. Certained Corp.
c. Conux Pipe Systems, Inc.
d. Or equal.

D. Liquid-tight Flexible Metal Conduit, Couplings and Fittings:

1. Liquid-tight flexible metal conduit shall be square locked, galvanized steel flexible conduit with a moisture proof, flame resistant, polyvinyl chloride jacket, for use with rigid metal conduit systems. Sealtite, Type UA, manufactured by the Anaconda Metal Hose Div.; Anaconda American Brass Co.; American Flexible Conduit Co., Inc.; Universal Metal Hose Co., or equal.

2. Liquid-tight conduit fittings shall be hot-dipped mechanically galvanized, positive grounding, screw in type. Provide external bonding lugs on sizes 1-1/4-in and larger. Box connectors shall have insulated throats as manufactured by the Thomas & Betts Co.; Crouse-Hinds Co., or equal.

3. Acceptable Manufacturers:
   a. American Flexible Conduit Co.
   b. Anaconda Metal Hose/ANAMET Inc.
   c. Electri-flex Co.
   d. Thomas & Betts.
   e. O-Z Gedney.
   f. Or equal.

E. Flexible Metallic Tubing:

1. Flexible metallic tubing shall be for use under the provisions of NEC Article 360.

2. Flexible metallic tubing shall be hot-dipped galvanized steel strips shaped into interlocking convolutions firmly joined to one another assuring a complete lock.

3. Flexible metallic tubing shall be used only indoors for connection to lighting fixtures in NEMA 1 administration and office areas.

4. Furnish and install insulated bushings at terminations for conductor protection.

5. Acceptable manufacturers:
   a. Tristeel as manufactured by Triangle - PWC, Inc.
   b. Or equal.

2.02 BOXES AND FITTINGS

A. Wet Location Boxes and Fittings:

1. NEMA 4X terminal boxes, junction boxes, pull boxes, etc, shall be sheet Type 316 stainless steel unless otherwise shown on the Drawings. Boxes shall have continuously welded seams and mounting feet. Welds shall be ground smooth. Boxes shall be flanged and shall not have holes or knockouts. Box bodies shall not be less than 14 gauge metal and covers shall not be less than 12 gauge metal. Covers shall be gasketed and fastened with stainless steel clamps.

Terminal boxes shall be furnished with hinged doors, terminal mounting straps and brackets. Terminal blocks shall be NEMA type, not less than 20 Amps, 600 Volt.

2. Cast or malleable iron device boxes shall be Type FD. Boxes and fittings shall have cadmium-zinc finish with cast covers and stainless steel screws.

3. Cast aluminum boxes and fittings shall be copper free aluminum with cast aluminum covers and stainless steel screws as manufactured by the Killark Electric Co..; Crouse-Hinds Co.; Appleton Electric Co.; or equal.

4. Cast aluminum device boxes shall be Type FD. All cast aluminum boxes and fittings shall be copper free aluminum with cast aluminum covers and stainless steel screws as manufactured by the Killark Electric Co.; Crouse Hinds Co.; L. E. Mason Co. or equal.

5. Cast aluminum fittings (C's, T's, LB's, etc.) shall be of the mogul design (with rollers) as manufactured by Appleton Electric Co.

6. Acceptable Manufacturers:
   a. Appleton.
   b. Crouse-Hinds.
   c. Steel City.
   d. Hoffman.
   e. Electromate - Division of Robroy Ind.
   f. Or equal.

B. Corrosive Location Boxes:

1. NEMA 4X PVC coated outlet boxes shall be used with PVC coated conduit shall be furnished with a PVC coating bonded to the metal, the same thickness as used on the coated steel.

2. Acceptable manufacturers:
   a. "OCAL" as manufactured by Thomas & Betts.
   b. "Plasti-Bond Red" as manufactured by Robroy Industries.
   c. Triangle PWC Inc.
   d. Or equal.

3. NEMA 4X terminal boxes, junction boxes and pull boxes shall be fiberglass reinforced plastic with stainless steel hardware and gasketed covers. Terminal boxes shall be furnished with hinged doors, terminal mounting straps and brackets. Terminal blocks shall be NEMA type, not less than 20 Amps, 600 Volt.

4. Acceptable Manufacturers:
   a. Hoffman.
   b. Stahlin - Division of Robroy Ind.
   c. English Electric.
   d. Or equal.

C. Hazardous (Classified) Location Boxes:

1. Explosion-proof boxes shall be designed for Class 1, Group D, Division 1 hazardous locations, and shall also have O-ring seals to meet NEMA 4 requirements. Boxes and covers shall be aluminum, with stainless steel hinges and stainless steel bolts; Type EJB-N4 as manufactured by the Crouse-Hinds Co.; Appleton Electric Co.; Adalet-PLM, or equal.

D. Miscellaneous Fittings:

1. Flexible couplings shall be type ECGJH as manufactured by the Crouse-Hinds Co.; Appleton Electric Co.; Killark Electric Manufacturing Co. or equal.

2. Conduit hubs shall be as manufactured by Myers Electric Products, Inc. or equal.

3. Conduit wall seals for new concrete walls below grade shall be O.Z./Gedney Co., Type WSK; Linkseal; Spring City Electrical Manufacturing Co., Type WDP, or equal.

4. Conduit wall seals for cored holes shall be Type CSMC as manufactured by the O.Z./Gedney Co., or equal.

5. Conduit wall and floor seals for sleeved openings shall be Type CSMI as manufactured by the O.Z./Gedney Co., or equal.

6. Combination expansion-deflection fittings embedded in concrete shall be Type XD as manufactured by the Crouse-Hinds Co.; Type DX as manufactured by O.Z./Gedney Co.; Type DF as manufactured by Appleton Electric Co., or equal.

7. Combination expansion-deflection fittings installed exposed shall be Type XD as manufactured by Crouse-Hinds Co.; Type DX as manufactured by O.Z. Gedney Co.; Type DF as manufactured by Appleton Electric Co., or equal.

8. Explosion proof fittings shall be as manufactured by the Crouse-Hinds Co.; Appleton Electric Co.; O.Z./Gedney Co., or equal.

9. Conduit sealing bushings shall be O.Z./Gedney, Type CSB, or equal.

10. Grounding bushings shall be malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs as manufactured by Crouse Hinds/Cooper, Series HGLL; Appleton, Series GIB; O.Z./Gedney, Type HBLG, or equal.

2.03 HARDWARE

A. Conduit Mounting Equipment:

1. In dry, non-corrosive, indoor areas, hangers, rods, backplates, beam clamps, channel, etc. shall be hot-dipped galvanized steel.

2. 316 Stainless steel channel with 316 stainless steel hardware (hangers, rods, backplates, beam clamps, fasteners, anchors, nuts, washers, etc.) shall be used in process areas, as shown on the drawings, in areas designated "WET", "DAMP" and "CORROSIVE" on the Drawings and in outdoor locations. All channel and hardware shall be resistant to the chemicals present in the area in which it is used.

3. Furnish any and all necessary supports, brackets, conduit sleeves, racks and bracing as required.

4. Expansion anchors (minimum 3/8" diameter) shall be equal to Kwik Bolt as manufactured by the McCullock Industries, Minneapolis, MI; Wej it by Wej it Expansion Products, Inc., Bloomfield, CO; or Kwik-Bolt II as manufactured by the Hilti Fastening Systems, Inc, Tulsa, OK. The length of expansion bolts shall be sufficient to place the wedge portion of the bolt a minimum of 1 in behind the steel reinforcement. Apply anti-seize compound to all nuts and bolts. Supports installed without the approved compound shall be dismantled and correctly installed, at no cost to the Owner.

B. Conduit Identification Plates:

1. Conduit identification plates shall be embossed stainless steel with stainless steel band, permanently secured to the conduit without screws.

2. Identification plates shall be as manufactured by the Panduit Corp., or equal.

C. Wall and Floor Slab Opening Seals:

1. Wall and floor slab openings shall be sealed with a UL approved expending material which equals or exceeds the fire rating of the wall or floor construction as manufactured by the Thomas & Betts Corp.; Pro Set Systems; Neer Mfg. Co.; Specified Technologies, Inc., or equal.

PART 3 EXECUTION

3.01 RACEWAY APPLICATIONS

A. Refer to Table 26 05 33-1 for specific raceway application requirements.

B. All conduit of a given type shall be the product of one manufacturer.

C. Refer to Section 33 71 19 for underground applications.

3.02 BOX APPLICATIONS

A. Unless otherwise specified herein or shown on the Drawings, all boxes shall be metal.

B. Exposed switch, receptacle and lighting outlet boxes and condulet fittings shall be cast or malleable iron, except that cast aluminum shall be used with aluminum conduit and non-metallic PVC shall be used with PVC.

C. Concealed switch, receptacle and lighting outlet boxes shall be pressed steel.

D. Terminal boxes, junction boxes and pull boxes shall have NEMA ratings suitable for the location in which they are installed, as specified in Section 26 00 00.

E. Boxes flush in block, brick or tile walls shall be located at a course line and provided with square tile covers. Flush boxes shall not project beyond the finished surfaces nor shall surfaces project more than 1/8-in beyond the box enclosure. Wiring devices located in close proximity to each other shall be installed in one solid gang box with single cover.

F. All conduit bodies and pulling outlets shall comply with NEC wire bending space requirements. Mogul type fittings shall be used for sizes 2-1/2-in and larger.

TABLE 26 05 33-1
Raceway Application Guidelines

Location/Circuit Type	Raceway Type
All locations - raceways containing circuits above 600 Volts.	Exposed - Rigid aluminum (RAC) conduit. Concealed - Do not embed within structure. If this is not possible, use Schedule 40 PVC conduit. Underground – Schedule 40 PVC duct (as specified) in concrete reinforced duct bank. Avoid running through corrosive locations.
All locations Class 2 and 3 signal wiring and 4-20 mA instrumentation cables, non-fiber (copper) data highway. Fire alarm, security, and communications system wiring	Exposed - Rigid aluminum (RAC) conduit. Use PVC coated rigid aluminum conduit in corrosive areas. Concealed - Rigid aluminum (RAC) conduit. Underground - Rigid aluminum (RAC) conduit in concrete reinforced ductbank. Use PVC coated aluminum conduit for single conduit direct burial applications.
All locations Fiber Optic wiring systems (Fire alarm, security, and communications system wiring)	Exposed - Rigid aluminum (RAC) conduit. Concealed - Schedule 80 PVC conduit. Underground – Schedule 40 PVC conduit in concrete reinforced duct bank. Direct Burial applications (where specifically shown on the Drawings) - Schedule 80 PVC

TABLE 26 05 33-1 Raceway Application Guidelines	
Location/Circuit Type	Raceway Type
Process areas - non-corrosive, non-hazardous locations designated as DAMP or WET on the Drawings.	Exposed conduit for power wiring, lighting, switch, and receptacle circuits - Rigid aluminum (RAC) conduit. Concealed conduit for power wiring, lighting, switch, and receptacle circuits - Schedule 40 PVC conduit when embedded within concrete floor slabs.
Corrosive areas - chemical storage and handling areas, underground vaults, within tanks or clearwells, filter pipe galleries and locations where designated corrosive on the Drawings.	Exposed conduit for power wiring, lighting, switch, and receptacle circuits - PVC coated rigid aluminum. Concealed conduit for power wiring, lighting, switch, and receptacle circuits - Schedule 40 PVC conduit when embedded within concrete floor slabs or structures.
Hazardous areas - all locations - Class 1, Division 1 and 2.	Exposed conduit for power wiring, lighting, switch, and receptacle circuits - Rigid aluminum (RAC) conduit. Concealed conduit for power wiring, lighting, switch, and receptacle circuits - Rigid aluminum (RAC) conduit.
Outdoor areas - all locations.	Exposed conduit for power wiring, lighting, switch, and receptacle circuits – Rigid aluminum (RAC) conduit. PVC conduit shall not be used exposed. Concealed conduit for power wiring, lighting, switch, and receptacle circuits - Schedule 40 PVC conduit when embedded within concrete structures.

3.03 FITTINGS APPLICATIONS

A. Combination expansion-deflection fittings shall be used where exposed conduits cross structure expansion joints or in straight runs where expansion is anticipated. Combination expansion-deflection fittings shall be installed where embedded conduits cross structural expansion joints. Refer to Structural Drawings for expansion joint locations. Provide bonding jumpers around fittings.

B. All underground conduit penetrations at walls or other structures shall be sealed watertight. Conduit wall seals and sleeves shall be used in accordance with the manufacturer's installation instructions and the details shown on the Drawings.

C. Conduit sealing bushings shall be used to seal conduit ends exposed to the weather and at other locations shown on the Drawings.

D. Gas Containment Area Sealing:

1. Internally and externally seal each conduit entering or leaving any area containing noxious gases to prevent contamination into clean areas via the conduit system. Areas requiring this protection are rooms where chlorine, ammonia and ozone are stored, generated or handled. Caulking material for conduit internal use shall be synthetic elastomer type, 3M, Series CP25 or equal. External sealing shall be in accordance with the typical details shown on the Drawings.

E. Insulated throat grounding bushings shall be used where specified herein, in Section 33 79 00 and where conduits stub up into electrical equipment such as MCC's, switchgear, etc.

3.04 INSTALLATION

A. No conduit smaller than 3/4-in electrical trade size shall be used, nor shall any have more than the equivalent of three 90-degree bends in any one run. Pull boxes shall be provided as required by the NEC after every 270 degrees of bends and for straight run not to exceed 200 feet or as directed.

B. No wire shall be pulled until the conduit system is complete in all details; in the case of concealed work, until all rough plastering or masonry has been completed; in the case of exposed work, until the conduit system has been completed in every detail.

C. All conduit which may under any circumstance contain liquids such as water, condensation, liquid chemicals, etc., shall be arranged to drain away from the equipment served. If conduit drainage is not possible, conduit seals shall be used to plug the conduits. The ends of all conduits shall be temporarily plugged to exclude dust, moisture and debris from entering during construction.

D. Conduit ends exposed to the weather shall be sealed with conduit sealing bushings.

E. Conduits noted as spare shall be capped or plugged at both ends with easily removable fittings.

F. Conduit terminating in NEMA 3R, 4, and 4X enclosures shall be terminated with Myers type conduit hubs.

G. Conduit terminating in pressed metal boxes shall have double locknuts (aluminum) and insulated bushings.

H. Conduits containing equipment grounding conductors and terminating in sheet metal boxes shall have insulated throat grounding bushings.

I. Conduits shall be installed using threaded fittings except for PVC.

J. The use of running threads is prohibited. Where such threads are necessary, a 3-piece union shall be used.

K. All conduits entering or leaving a motor control center, switchboard or other multiple compartment enclosure shall be stubbed up into the bottom horizontal wireway or other manufacturer's designated area, directly below the vertical section in which the conductors are to be terminated. The 3-in extension of conduit above the floor slab or concrete equipment pad may be reduced to a dimension that suits the equipment manufacturer's installation requirements if the 3-in stub-up interferes with the equipment being provided.

L. PVC coated rigid aluminum conduit and elbows shall be used for pad-mounted transformer stub-ups.

M. In hazardous locations, conduits terminating at boxes enclosing circuit opening equipment shall be sealed at the entrance to the enclosure with approved compound filled sealing fittings to prevent passage of explosive or combustible gases through the conduits. All conduits leading from or entering hazardous locations shall be similarly sealed at points of exit or entrance. Exposed conduits passing through hazardous locations shall be sealed at both the entrance to and the exit from the hazardous locations. A sealing compound installation schedule shall be presented to the resident engineer (RE) for approval. Each installation shall be signed off by the Contractor and the RE and each fitting shall be legibly marked with red paint to indicate that the sealing compound has been installed.

N. Conduit sealing and drain fittings shall be installed in all hazardous (classified) areas designated Class 1, Division 1, and Class 1, Division 2.

O. Liquid-tight flexible metal conduit shall be used for all motor terminations, the primary and secondary of transformers, generator terminations and other equipment where vibration is present or may require removal. The length of liquid-tight flexible metal conduit shall not exceed 36" when used for vibration isolation, and shall not exceed 72" in length when attaching to luminaires.

P. Flexible couplings shall be used in hazardous locations for all motor terminations and other equipment where vibration is present.

Q. Aluminum fittings and boxes shall be used with aluminum conduit. Aluminum conduit shall not be imbedded in concrete containing chlorides, unwashed beach sand, sea water, or coral bearing aggregates. Aluminum conduit shall be isolated from other metals with heat shrink tubing (Raychem or equal) or plastic-coated hangers. Strap wrenches shall be used for tightening aluminum conduit. Pipe wrenches, channel locks, chain wrenches, pliers, etc. shall not be used.

R. All threads on aluminum conduit and fittings shall be cleaned and coated with “No-Oxide” compound before installing.

S. Aluminum conduit installed in concrete or below grade shall be completely covered with two (2) coats of bitumastic paint or with heat shrink tubing (Raychem or equal).

T. Aluminum conduit entering manholes and below grade pull boxes shall be terminated with grounding type bushings and connected to a 3/4" x 10' rod with a #6 bare copper wire.

U. Flexible metallic conduit (Type MC cable) shall be used for recessed fluorescent fixtures in hung ceilings to connect fixtures to the conduit system.

V. PVC coated aluminum conduit shall be used as a transition section where concrete embedded conduit stubs out of floor slabs or through below grade walls or where conduit installed under building slabs on grade stub out of floors. The PVC coated aluminum conduit shall extend a minimum of 3-in into and out of the floor slab, concrete pad, or wall to allow for proper threading of the conduit.

W. PVC conduit to non-metallic box connections shall be made with PVC socket to male thread terminal adapters with neoprene O-ring and PVC round edge bushings.

X. PVC conduit shall be supported with non-metallic clamps, PVC coated steel racks and stainless steel hardware.

Y. Expansion fittings shall be used on exposed runs of PVC conduit where required for thermal expansion. Installation and number of fittings shall be as recommended by manufacturer.

Z. PVC boxes, conduit fittings, etc., with integral hubs shall be solvent welded directly to the PVC conduit system.

AA. Non-metallic boxes with field drilled or punched holes shall be connected to the PVC conduit system with threaded and gasketed PVC Terminal Adapters.

BB. Conduit supports, other than for underground raceways, shall be spaced at intervals not exceeding the distance required by the NEC to obtain rigid construction.

CC. Single conduits shall be supported by means of one-hole pipe clamps in combination with one-screw back plates, to raise conduits from the surface. Multiple runs of conduits shall be supported on fabricated channel trapeze type racks with stainless steel horizontal members and threaded hanger rods. The rods shall be not less than 3/8-in diameter. Surface mounted panel boxes, junction boxes, conduit, etc, shall be supported by spacers to provide a minimum of 1/2-in clearance between wall and equipment.

DD. Conduit Supports (Other than Underground Raceways):

1. Trapezes:
    a. Conduit support trapezes shall be vertically supported every 10-ft or less, as required to obtain rigid conduit construction.
    b. Lateral seismic restraints (Sway Bracing) shall be spaced 30-ft or less.
    c. Horizontal seismic restraints shall be spaced at 40-ft or less. There shall be at least one horizontal restraint per horizontal run.
    d. Attachment to structural steel shall be by beam clamps or welded beam attachment. C-clamps will not be allowed for vertical hangers. Side beam clamps with beam hooks shall be used for seismic restraint only.
    e. Attachment to concrete shall be cast-in-place inserts, cast-in place welded plates with welded studs or stainless steel adhesive anchors.

2. Flush Mounted Supports:

a. Support shall be spaced 10-ft or less, as required to obtain rigid conduit construction.
b. Attachment to concrete shall be with cast-in-place inserts, cast-in place welded plates with welded studs or stainless adhesive anchors.

3. Conduit Racks:
   a. Support shall be spaced 10-ft or less, as required to obtain rigid conduit construction.
   b. Horizontal seismic restraints shall be spaced at 30-ft or less.
   c. Attachment to concrete shall be with cast-in-place inserts, cast-in place welded plate with welded studs or stainless adhesive anchors.

4. Conduit Hangers;
   a. Conduit hangers shall be vertical supported 10-ft or less, as required to obtain rigid conduit construction.
   b. Lateral seismic restraints (Sway Bracing) shall be spaced 20-ft or less.
   c. Horizontal seismic restraints shall be spaced at 30-ft or less. There shall be at least one horizontal restraint per horizontal run.
   d. Attachment to structural steel shall be by beam clamps or welded beam attachment. C-clamps will not be allowed for vertical hangers. Side beam clamps with beam hooks shall be used for seismic restraint only.
   e. Attachment to concrete shall be cast-in-place inserts, cast-in place welded plates with welded studs or stainless steel adhesive anchors.

5. All reinforcing bars shall be located by the Electrical Subcontractor with the use of a rebar locator prior to installing adhesive capsule type anchors. Mark the location of all reinforcing bars in an area bounded by a line drawn at least 18-in from the edge of the support bearing/weld plates on all four sides of the bearing/weld plates prior to fabricating and installing bearing/weld plates.

6. Where interference occurs, adjust anchor locations to clear reinforcing bars and alter support configuration at no additional cost to the Authority.

EE. Miscellaneous stainless steel for the support of fixtures, boxes, transformers, starters, contactors, panels and conduit shall be furnished and installed. Channel supports shall be ground smooth and fitted with plastic end caps.

FF. Stainless steel channels, flat iron and channel iron shall be furnished and installed for the support of all electrical equipment and devices, where required, including all anchors, inserts, bolts, nuts, washers, etc, for a rigid installation. Channel supports shall be ground smooth and fitted with plastic end caps.

GG. All conduits on exposed work, within partitions and above suspended ceilings, shall be run at right angles to and parallel with the surrounding wall and shall conform to the form of the ceiling. No diagonal runs will be allowed. Bends in parallel conduit runs shall be concentric. All conduits shall be run perfectly straight and true.

HH. Where conduits pass through openings in walls or floor slabs, the remaining openings shall be sealed against the passage of flame and smoke in accordance with UL requirements and the details shown on the Drawings. The sealing method shall have

a UL fire rating, which equals or exceeds the fire rating of the wall or floor construction.

II. Conduits shall not cross pipe shafts, access hatches or vent duct openings. They shall be routed to avoid such present or future openings in floor or ceiling construction.

JJ. Conduits passing from heated to unheated spaces, exterior spaces, refrigerated spaces, cold air plenums, etc, shall be sealed with "Duxseal" as manufactured by Manville or seal fitting to prevent the accumulation of condensation.

KK. Conduits shall be located a minimum of 3-in from steam or hot water piping. Where crossings are unavoidable, the conduit shall be kept at least 1-in from the covering of the pipe crossed.

LL. Mandrels shall be pulled through all existing conduits which will be reused and through all new conduits 2-in in diameter and larger prior to installing conductors.

MM. 3/16-in polypropylene pull lines shall be installed in all new conduits noted as spares or designated for future equipment. Conduit noted as spare shall be capped or plugged at both ends with easily removable fittings

NN. Emergency (generator) source and normal EPB source feeders shall not be run through the same pull box.

OO. Where no type or size is indicated for junction boxes, pull boxes or terminal cabinets, they shall be sized in accordance with the requirements of NEC Article 314. Enclosure type and material shall be as specified herein.

PP. Pull or junction boxes shall be furnished and installed where shown on the Drawings, in every 200 feet of straight conduit runs or in runs where more than the equivalent of four 90-degree bends occur or at any point necessary for wire pulling and splicing. Splices shall not be made in pulling elbows.

QQ. A conduit identification plate shall be installed on all power, instrumentation, alarm and control conduits at each end of the run and at intermediate junction boxes, manholes, etc. Conduit plates shall be installed before conductors are pulled into the conduits. Exact identification plate location shall be coordinated with the Engineer at the time of installation to provide uniformity of placement and ease of reading. When a master conduit numbering system is used, the conduit tag numbers shall be exactly as shown on the drawings, if a master conduit numbering system is not used the conduit identification tags shall provide detailed "to" and "from" information.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. All motors shall be as called for in other Sections of these Specifications shall be in conformance with the requirements of this Section.

B. Motors connected to Variable Frequency Drive (VFD) Controllers shall be designed for inverter duty.

1.02 RELATED WORK

A. Section 26 29 23: Variable Frequency Drives

B. Section 26 24 20: Low Voltage Motor Control Centers

C. Section 26 05 33: Raceways, Boxes, Fittings, and Supports

D. Section 26 05 10: Wires and Cables (600 Volt maximum)

E. Section 26 08 10: Electrical System Testing and Settings

1.03 SUBMITTALS

A. Submit complete motor nameplate data and test characteristics per NEMA Standard MG1-12.54 "Report of Test Form for Routine tests on Induction Motors" in accordance with Section 01 33 23, including:

1. Efficiency at 1/2, 3/4 and full load
2. Power factor at 1/2, 3/4 and full load
3. Motor outline, dimensions and weight
4. Conduit entry points and sizes
5. Descriptive bulletins, including full description of insulation system
6. Bearing design data
7. Special features and accessories (i.e., space heaters, temperature detectors, etc.)
8. Power factor correction capacitor rating and type (when required).

B. Provide operation and maintenance manual in accordance with Section 01 78 23.

C. Provide equipment warranty in accordance with Section 01 78 36.

1.04 REFERENCE STANDARDS

A. American Bearing Manufacturers Association (ABMA)

B. American National Standards Institute (ANSI)

C. American Society for Testing Materials (ASTM)

D. Institute of Electrical and Electronics Engineers (IEEE)

E. International Organization for Standardization (ISO)

F. National Electrical Manufacturers Association (NEMA)

G. National Fire Protection Association (NFPA)

H. Underwriters Laboratories (UL)

I. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Motors shall be listed under UL recognized component file as applicable.

B. Motor manufacturer shall maintain authorized service centers capable of providing training, parts, and emergency maintenance and repairs.

C. Electric motors driving identical machines shall be identical.

D. Routine tests shall be performed on representative motors, and shall include the information described on NEMA MG1-12.54 “Report of Test Form for Routine Tests on Induction Motors”. Efficiency shall be determined in accordance with IEEE Publication No. 112, Method B. Power factor shall be measured on representative motors.

1.06 SYSTEM DESCRIPTION

A. To assure unity of responsibility, the motors shall be furnished and coordinated by the manufacturer of the driven equipment. The Contractor shall assume responsibility for the satisfactory installation and operation of the entire system as specified.

B. When electrically driven equipment differs from that indicated, adjust the motor size, wiring and conduit systems, disconnect devices, and circuit protection to accommodate the equipment actually installed, without additional cost.

1.07 DELIVERY, STORAGE AND HANDLING

A. When furnished, energize motor space heaters to prevent moisture condensation throughout the storage and construction period. Perform periodic motor insulation resistance tests per manufacturer's storage recommendation.

B. Maintain the bearings during storage and construction, and periodically rotate the motor shaft according to manufacturer's instructions.

PART 2 PRODUCTS

2.01 GENERAL

A. Unless otherwise noted, all motors ½ through 100 horsepower shall be rated 230/460 volt, three-phase, 60 Hertz A.C.; motors 125 horsepower and above shall be rated 460 volt, three-phase, 60 Hertz, and motors below ½ horsepower shall be rated 115/230 volt, single-phase, 60 Hertz A.C.

B. All motors used with variable frequency drives shall be rated for inverter duty and shall be in accordance with NEMA MG1, Section IV, Part 31.

C. All motors operating with variable frequency drives shall be equipped with winding temperature switches unless specified with another temperature sensing device.

D. All motors rated 50 horsepower and larger shall have a 120-volt space heater for moisture control.

E. Vertical motors shall be hollow or solid shaft as required by the equipment furnished under other Sections of these Specifications.

F. Submersible pump motor construction and accessories shall be as specified under the associated pump specification.

G. All motors shall be built in accordance with current NEMA, IEEE, ANSI and ABMA standards. Motors shall be of the type and quality described by this Section and other Divisions of the Specifications, and/or as shown on the Drawings, fully capable of performing in accordance with Manufacturer's nameplate rating, and free from defective material and workmanship.

H. Torque output: Minimum performance characteristics for locked rotor and breakdown torque with rated voltage and frequency applied as defined by NEMA MG1, to accelerate and operate the load throughout its operating speed range, including conditions imposed by reduced voltage starting methods.

I. Motors shall deliver the specified performance at rated load under the combinations of voltage and frequency variations and voltage unbalance specified in NEMA MG1.

J. Horsepower rating: Sized for operation within the full load nameplate rating without applying the service factor, throughout the full range of mechanical or hydraulic operating condition.

K. Service Factor: 1.15 service factor on sine wave power and 1.0 service factor on VFD power in a 40 degrees C ambient, unless otherwise noted.

L. Specific motor application data such as horsepower, speed, enclosure type, etc., is specified under the detailed driven mechanical equipment specification.

M. Enclosures: Conform to one of the NEMA standard enclosure designs as specified under the detailed driven mechanical equipment specification. If no enclosure type is specified, provide TEFC (Totally Enclosed Fan Cooled) enclosures.

N. Nameplates: Engraved or embossed on stainless steel fastened to the motor frame with stainless steel screws or drive pins with information per NEMA MG1.

O. Acceptable Manufacturers: Nidec (US Motors), Baldor, TECO-Westinghouse, Toshiba, WEG, or equal.

2.02 SINGLE-PHASE MOTORS

A. Application: Motors smaller than 1/2 Hp shall be 115/230 or 208 Volts single phase, continuous heavy duty, reversible, capacitor start. Small fan motors may be split-phase or shaded pole type if such are standard for the equipment. Wound rotor or commutator type single-phase motors are not acceptable unless their specific characteristics are necessary for the application.

B. Overload protection: Provide internal automatic thermal overloads unless otherwise noted.

C. Insulation: Class F or better, with Class B temperature rise, 1.15 service factor. Locked rotor current shall not be greater than specified in NEMA Standard MG1, Design "N".

D. Enclosure: Provide fully gasketed, totally-enclosed air over or fan cooled in conformance with NEMA Standard MG1. Small fan motors may be open type if suitably protected from moisture, dripping water and lint accumulation.

E. Washdown duty: Where motor is installed in wet or corrosive areas routinely exposed to washdowns, high humidity or caustic chemicals, provide stainless steel, paint free washdown motors with Inpro bearing isolators, stainless steel T-type condensation drains, nitrile conduit box gasket, and corrosion resistant fans.

F. Bearings: Sealed ball bearings permanently lubricated for 10 years' normal use, furnished with shaft slinger.

G. Class 1, Division 1 and 2 locations: Single phase motors installed in Class 1, Division 1 and 2 locations shall be explosion proof, marked with a T3B temperature code label, and UL listed for use in Class 1, Division 1, Groups C & D, and Class II, Groups E, F, & G hazardous location. The temperature code marking shall appear on the nameplate.

2.03 THREE-PHASE INDUCTION MOTORS (SQUIRREL-CAGE)

A. Applications

1. Energy efficiency: Meet or exceed requirements of NEMA MG1 Part 12 for NEMA Premium Efficient motors, for 1 Hp and larger.

2. Severe duty: Motors installed in process areas and wet or corrosive locations shall be of a type designated by the manufacturer as "Corro Duty", "Mill and Chemical", "Severe Duty", or similar quality designation.

3. Class 1, Division 2 locations: Motors in Class 1, Division 2 locations shall be marked with a temperature code label suitable for use in the hazardous area classification where installed. Motors shall also comply with the following additional requirements:
   a. The Class, Group and Temperature Code shall be one of the following:
   b. Class I Group D - T2B (260°C)
   c. Class I Group D, Class II Groups F and G - T3B (165°C)
   d. Class I Groups C and D, Class II Groups F and G - T3C (160°C)
   e. Thermostats: Where winding thermostats are used to obtain surface temperature limitation, the thermostats shall be connected in series with the starter holding coil (stop button). Winding temperature detectors and switches shall be UL listed for use in Class 1, Division 1 locations.
   f. The exposed surface of motor condensation heaters shall not exceed 80 percent of the nameplate temperature code value.
   g. Ventilation fan shall be constructed of corrosion-resistant, non-sparking material such as bronze.

4. Class 1, Division 1 locations: Motors installed in Class 1, Division 1 locations shall be explosion proof, temperature code T3C (160°C), listed for use in Class 1, Division 1, Group C & D locations in accordance with UL 674. The operating temperature or temperature range marking shall appear on the nameplate, indicating the maximum temperature for all conditions including overload, locked rotor and single-phasing.

5. Inverter Duty: Motors connected to Variable Frequency Drive Controllers shall be designed for inverter duty and shall comply with the following:
   a. Definite purpose: Motors operated on variable frequency drives shall be designed specifically for inverter duty, per NEMA MG1, Part 31, and comply with IEEE 841. Motors shall be designed for constant or variable torque over the speed range required by the driven equipment application. Motors shall be capable of across the line starting at the motor minimum terminal voltage with an acceptable maximum locked rotor current.
   b. Torsional critical speed: First or second torsional shall not be encountered within the operating speed range. Rotors shall be stiff shaft design, statically and dynamically balanced with the first lateral critical speed at least 15% above the maximum running speed.
   c. Thermal protection: Provide temperature winding switches, or other type of thermal protective device specified in the mechanical equipment section. Refer to the “Accessories” paragraph of this specification.
   d. Cooling provisions: Maintain temperature rises at design levels while operating throughout the speed range. Ventilation system shall be designed for maximum heat transfer including larger fans or auxiliary cooling fans to maintain proper low speed cooling.
   e. Inverter grade insulation system: Minimum Class F or better insulation materials with additional phase insulating material, extra end-turn bracing and Class H spike resistant wire. The resultant system shall withstand up

to 2000 volt transients without premature motor failure and have no cable limitations in motor application.

f. Motor shaft currents: Insulate the ODE bearing and provide a shaft grounding strap. Insulate bearing probes to prevent shorting out bearing insulation.

B. Construction

1. Stator core: Built up, fully processed, high grade, low loss silicon steel laminations keyed or dovetailed to the stator frame and securely held in place at each end.

2. Stator winding: Assembled using random wound copper coils. A split component epoxy insulation system shall be used in order to provide high resistance to moisture and other contaminates.

3. Insulation: Manufacturer's premium grade non-hygroscopic, chemical and humidity resistant insulation system consisting of Class F or H materials, operated at Class B temperature rise, with at least one impregnation cycle using solventless resin, and multiple additional dip and bake cycles using polyester varnish.

4. Motor leads: Non-wicking type, minimum Class F temperature rating and permanently numbered for identification.

5. Rotor shaft: Forged or rolled steel, accurately machined, smoothly finished, with sufficient strength to withstand all stresses resulting from normal operation at any speed up to and including a 25 percent overspeed condition. Coordinate shaft end details with driven equipment coupling.

6. Rotor core: Solid, built-up stack of fully processed and coated, high-grade, low-loss silicon steel laminations, with die cast aluminum or fabricated copper bars or their respective alloys. Rotors on frames 213T and above shall be keyed to shaft and rotating assembly dynamically balanced.

7. Cooling fan: Corrosion-resistant, bi-directional, keyed, clamped and shouldered on the shaft.

8. Rotor assembly: Coated with a corrosion resistant epoxy insulating varnish or other protective coating, thermally stable, statically and dynamically balanced. Balance weights shall be securely attached to the rotor resistance ring by welding or similar permanent method.

C. Bearings

1. Motors shall be equipped with vacuum-degassed anti-friction bearings made to ABMA Standards, and be of ample capacity for the motor rating. The bearing housing shall be large enough to hold sufficient lubricant to minimize the need for frequent lubrication, but facilities shall be provided for adding new lubricant and draining out old lubricant without motor disassembly. The bearing housing shall have long, tight, running fits or rotating seals to protect against the entrance

of foreign matter into the bearings, or leakage of lubricant out of the bearing cavity.

2. Bearings of high thrust motors will be locked for momentary up-thrust of 30 percent down-thrust. All bearings shall have a minimum L10 life rating of 100,000 hours in accordance with ABMA life and thrust values including rotor weight. For applications with higher thrust loads which cannot meet the L10 life, spring loaded spherical roller thrust bearings may be used.

3. Anti-backspin device: When specified or requested by the pump manufacturer, provide a shaft mounted, mechanical non-reverse ratchet rated at 100 percent of motor full load torque for immediate protection against reversing due to phase reversals or from backspin at shutdown. Ratchet shall be suitable for duty with variable frequency drives.

D. Enclosures

1. Motor frames: cast iron or welded heavy plate steel construction, stiff enough to withstand the rotating forces and torques generated and shall be designed to limit or avoid any undesirable harmonic resonances. Provide a threaded, forged steel, shouldered eyebolt blind tapped into the motor frame for lifting on all frames 254T and larger.

2. Condensate drain openings: locate drain holes at the low points in the end brackets to allow removal of accumulated moisture from enclosures. Provide corrosion resistant, breather drain plugs for severe duty motors.

3. Enclosure type: as specified in the mechanical equipment section, designed in accordance with NEMA MG1. All drip-proof and weather protected Type I and Type II motors (WPI and WPII) shall have epoxy encapsulated windings. Totally enclosed designs shall be provided with an upgraded insulation by additional dips and bakes to increase moisture resistance and shall not b encapsulated. Motors for outdoor service shall have vacuum pressure impregnated (VPI) epoxy insulation for moisture resistance.

4. Hardware: hex head, SAE Grade 5 or better, plated for corrosion protection.

5. Main terminal box: fabricated steel or cast iron, sized per the NEC for number and size of conduit connections and conductor bending and terminations as indicated on the drawings, arranged to accommodate conduit entry from any quadrant, with a grounding terminal and gaskets between the box and motor frame and between the box and its cover.

6. Bearing housings: provide machined surfaces for attaching a magnet mounted accelerometer in order to monitor the motor vibration in the vertical, horizontal, and axial directions at each bearing housing.

7. Frame grounding: provide motor frame grounding pad or threaded stud where supplemental grounding to frame is indicated on the drawings.

E. Accessories: provide where specified herein or under the detailed mechanical specifications for individual equipment:

1. Winding temperature switches: factory installed, embedded, bi-metallic, temperature actuated switches with leads terminating in the main conduit box. This device shall protect the motor against damage from overheating caused by single phasing, overload, high ambient temperature, abnormal voltage, locked rotor, frequent starts or ventilation failure. The switch shall have **normally closed** contacts. Not less than three switches shall be furnished with each motor.

2. Winding temperature relay: complete winding thermal protection system consisting of three PTC thermistors and a separately mounted, separately excited, 115 VAC, 1 phase, solid state control module with dual Form C contacts, mounted in a NEMA 4X enclosure.

2.04 SURFACE PREPARATION AND SHOP COATINGS

A. Cast and Fabricated Components

1. Motor cast iron and fabricated metal components shall be cleaned; free of grease, oil, dirt, or other contaminants; then oxide primed and painted with manufacturer’s standard finish coating.

2. Severe duty motors: surpass the 250-hour salt spray test per ASTM B117.

B. Internal Surfaces

1. Internal surfaces: shaft, rotor, end bells and parts shall be covered with a corrosion-resistant coating of epoxy paint or equal material of 2 mils minimum dry film thickness for increased life against adverse environmental conditions. The stator bore and end turns shall be coated with clear epoxy varnish in addition to the insulating varnish treatment.

2. Shaft extension: protected with a rust preventive strippable coating capable of being peeled off or unwrapped.

3. Machined joints and threaded parts: coated with rust-inhibiting compound.

2.05 FACTORY TESTING

A. Each motor shall be given an unwitnessed routine short commercial test per NEMA MG1 and IEEE 112.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install the motors per manufacturer's installation instructions.

1. Prepare rigid foundation or mounting surface to minimize vibration and maintain alignment between motor and load shaft.

2. Align the motor shaft with driven equipment according to manufacturer's written instructions. Adjust axial position of motor frame with respect to load shaft.

3. Accurately adjust flexible couplings for direct drive according to machine manufacturer's guidelines. Check alignment to minimize vibrations. Coupling spacing shall be according to coupling manufacturer guidelines.

4. Anchor motor base to load bearing surface with grade 5 steel bolts or better.

B. Electrical Connections

1. All motors shall be connected to the conduit system by means of a short section of liquid-tight flexible conduit to isolate the conduit system from motor vibration. Refer to Section 26 05 33.

2. Install motor branch circuit conduits and conductors in accordance with NEC and local code requirements.

3. Terminate the motor leads using products rated for vibration applications and per the manufacturer's connection diagrams. Refer to Section 26 05 10.

4. Install equipment grounding conductors per NEC and local code requirements.

5. Tighten electrical connections and terminals according to manufacturer's published torque values.

6. Install conduit and wiring between motor auxiliary devices and associated indicators, controllers and protective devices in accordance with shop drawings.

7. Connect electro-magnetic field sensitive devices such as RTDs, thermistors, thermal protector switches, and vibration sensors with twisted and shielded instrumentation wiring.

8. When furnished, mount power factor correction capacitor adjacent to the motor and connect to the motor junction box with liquid tight flexible conduit and code sized wiring. For explosion-proof motors, mount the capacitor in a non-hazardous area above or near the MCC.

C. Pre-Commissioning Inspection

1. Inspect for physical damage. Verify all shipping materials and braces are removed.

2. Compare equipment nameplate information with site conditions and report any discrepancies.

3. Inspect for proper mounting, grounding, and wiring connections. Check all hardware for looseness and re-tighten as necessary.

4. Verify that the motor and the coupled load are properly aligned. Inspect bearings for proper lubrication and rotate motor shaft by hand to check for binding. Oil lubricated bearing housings that have been filled with preservative oil shall be drained and re-filled with the proper grade of bearing oil before putting the machine into service.

5. Clean motor externally, on completion of installation. Vacuum dirt and debris; do not use blown compressed air to assist in cleaning.

D. Field Commissioning

1. All testing and commissioning shall be done in accordance with the latest revision of the “Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems” published by the InterNational Electrical Testing Association (NETA Standard ATS).

2. Perform insulation resistance (megger) tests in accordance with manufacturer's instructions. If the test fails consult the manufacturer and dry out the machine.

3. Perform a phase rotation test to ensure proper shaft direction with load uncoupled. The correction for wrong rotational direction shall be made at the motor terminal box.

4. Check all connections with wiring diagrams prior to energizing.

5. Inspect for unusual mechanical or electrical noise or signs of overheating during initial test run.

6. Measure running current and evaluate relative to load conditions and nameplate full load amperes.

7. The Contractor shall submit to the Engineer a typed list of all motors 1 hp and larger listing the no load motor current and voltage along with the current and voltage with the motor under load. Any phase current imbalance greater than 10% or greater than be flagged for corrective action.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. The Contractor shall engage the services of a recognized corporately- and financially-independent testing firm and the equipment manufactures as required for the purpose of performing inspections and tests as herein specified.

B. The testing firm shall provide all material, equipment, labor, and technical supervision to perform such tests and inspections.

C. It is the purpose of these tests to assure that all tested electrical equipment, both Contractor- and Owner-supplied, is operational and within industry and manufacturer's tolerances and is installed in accordance with design specifications.

D. The tests and inspections shall determine suitability for energizing equipment.

E. Test systems and equipment furnished under Division 26 and repair or replace all defective work and equipment. Refer to the individual equipment sections for additional specific testing requirements.

F. Field testing and commissioning shall be performed in accordance with the latest revisions of NETA Standard ATS "Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems" unless otherwise modified by these Sections.

G. A typed test report for each component tested shall be submitted to the Engineer for the project record files as indicated.

H. Make adjustments to the systems and instruct the Owner's personnel in the proper operation of the systems.

I. In addition to the specific testing requirements listed in the individual Sections, perform the additional testing, inspections and adjust settings as specified herein.

J. Testing shall be scheduled and coordinated with the Owner at least 2 weeks in advance.

K. Provide qualified test personnel, instruments and test equipment.

L. Provide a test report verifying compliance with the testing requirements included under Division 26.

M. Before proceeding with the energization of equipment, notify the Owner to schedule the start-up of the equipment.

1.02 RELATED WORK

A. Electric motors are provided with the driven equipment and are specified in the individual equipment specifications and section 26 05 40.

B. Variable Frequency Drive units are provided with the driven equipment and are specified in the individual equipment specifications and Section 26 29 23.

C. Control panels are provided with the driven equipment and are specified in the individual equipment specifications.

1.03 SUBMITTALS

A. Test Report

1. The test report shall include the following:
   a. Summary of project
   b. Listing of equipment tested
   c. Test results
   d. Recommendations

2. Furnish copies of the complete report to the owner/engineer's representative as directed in the contract documents.

B. The report shall include a Table of Content and a data sheet for each component tested. The Table of Content shall identify each component by a unique number. The Number shall appear on the technical data sheet for identification. Submit cable test results, grounding test results, circuit breaker, motor circuit protector, and protective device settings, fuse type and rating for each piece of equipment. Test report shall be submitted in a three ring binder. Three copies shall be furnished.

C. The report shall include a Table of Contents, a technical data sheet for each component (i.e., cable, circuit breaker, transformer, relay, etc.) tested. The Table of Content shall include the name of each component, location, the major piece of equipment the component is located within, and a sheet number on which the technical information is presented. Each data sheet shall include a unique sheet number, the name of the component under test, the major piece of equipment in which the component is located and the weather conditions at the time of the test including the temperature and relative humidity at the time of the test. The firm doing the testing shall include, in the report, their opinion whether or not the equipment being tested complies with the specification and recommended measures to correct the deficiency. Any discrepancies shall be noted in the concluding summary of the report. Test report forms shall be in compliance with NETA standards. Three complete copies shall be provided. Reports shall be signed by the person in responsible charge of the field testing, an officer of the firm performing the tests and an officer of the Electrical Contracting Firm.

D. The reports shall be submitted to the Engineer for review, comment and record purposes. Each report shall include a Table of Content, a technical data sheet, for each component (i.e., cable, circuit breaker, transformer, relay, etc.) tested. The

Table of Content shall include the name of each component, the major piece equipment the component is located within, and a sheet number on which the technical information is presented. Each data sheet shall include a unique sheet number, the name of the component under test, The major piece of equipment in which the component is located, the weather conditions at the time of the test (i.e., temperature, humidity, sunny, rain, etc) the tester's observation and findings, discrepancies, any remedial work performed or act to resolve problems, technical parameters obtained during the tests, as left settings of all devices, and a statement indicating the equipment is ready to be energized. The report shall contain a statement indicating the equipment was tested in accordance with the procedures outlined in the latest edition of The International Testing Association Acceptance Testing Specifications.

1.04 APPLICABLE CODES, STANDARDS AND REFERENCES

A. All inspections and tests shall be in accordance with the following codes and standards except as provided otherwise herein:

1. National Electrical Manufacturers Association - NEMA

2. ASTM International - ASTM

3. Institute of Electrical and Electronic Engineers - IEEE

4. InterNational Electrical Testing Association - NETA Acceptance Testing Specifications (ATS) - Latest Revision

5. American National Standards Institute - ANSI C2: National Electrical Safety Code

6. State and local codes and ordinances

7. Insulated Cable Engineers Association - ICEA

8. Association of Edison Illuminating Companies - AEIC

9. Occupational Safety and Health Administration - OSHA

10. National Fire Protection Association - NFPA
    a. ANSI/NFPA 70: National Electrical Code
    b. ANSI/NFPA 70B: Electrical Equipment Maintenance
    c. NFPA 70E: Electrical Safety Requirements for Employee Workplaces
    d. ANSI/NFPA 78: Lightning Protection Code
    e. ANSI/NFPA 101: Life Safety Code

B. All inspections and tests shall utilize the following references:

1. Project design specifications

2. Project design drawings

3. Project short-circuit, coordination and arc flash study

4. Manufacturer's instruction manuals applicable to each particular apparatus

5. Project list of equipment to be inspected and tested

1.05 QUALITY ASSURANCE

A. Qualifications of testing firm

1. The testing firm shall be a corporately- and financially-independent testing organization which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems evaluated by the testing firm.

2. The testing firm shall be regularly engaged in the testing of electrical equipment devices, installations, and systems.

3. The testing firm shall meet OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907, or be a Full Member company of the InterNational Electrical Testing Association.

4. The lead, on-site, technical person shall be currently certified by the InterNational Electrical Testing Association (NETA) or National Institute for Certification in Engineering Technologies (NICET) in electrical power distribution system testing.

5. The testing firm shall utilize engineers and technicians who are regularly employed by the firm for testing services. Resumes of key staff proposed for the project shall be submitted to the [Engineer][Construction Manager][Owner] for review.

6. The testing firm shall submit proof of the above qualifications with bid documents, when requested.

7. The terms used here within, such as test agency, test Firm, testing laboratory, or Contractor's test company shall be construed to mean the testing firm.

1.06 DIVISION OF RESPONSIBILITY

A. The Contractor shall perform routine insulation-resistance, continuity, and rotation tests for all distribution and utilization equipment prior to and in addition to tests performed by the testing firm specified herein.

B. The Contractor shall supply a suitable and stable source of electrical power to each test site. The testing firm shall specify the specific power requirements.

C. The Contractor shall notify the testing firm when equipment becomes available for acceptance tests. Work shall be coordinated to expedite project scheduling.

D. The project electrical engineer is responsible for obtaining and approving a short-circuit analysis and coordination study prepared by an independent testing firm or consulting engineer.

E. The project electrical engineer shall supply a short-circuit analysis and coordination study, a protective device setting sheet, a complete set of electrical plans, specifications, and any pertinent change orders to the testing firm prior to commencement of testing.

F. The testing firm shall notify the Owner/Engineer's representative prior to commencement of any testing.

G. Any system, material, or workmanship which is found defective on the basis of acceptance tests shall be reported to the owner/engineer's representative.

H. The testing firm shall maintain a written record of all tests and, upon completion of project, shall assemble and certify a final test report.

I. Safety and Precautions

1. Safety practices shall include, but are not limited to, the following requirements:
   a. Occupational Safety and Health Act (OSHA)
   b. Accident Prevention Manual for Industrial Operations, National Safety Council (NSC)
   c. Applicable state and local safety operating procedures
   d. Owner's safety practices (Lockout/Tagout)
   e. National Fire Protection Association - NFPA 70E
   f. National Fire Protection Association - NFPA 79
   g. American National Standards for Personnel Protection

2. All tests shall be performed with apparatus de-energized. Exceptions must be thoroughly reviewed to identify safety hazards and devise adequate safeguards.

3. The testing firm shall have a designated safety representative on the project to supervise the testing operations with respect to safety.

1.07 TEST EQUIPMENT REQUIREMENTS

A. Suitability of Test Equipment

1. All test equipment shall be in good mechanical and electrical condition.

2. Selection of metering equipment should be based on a knowledge of the waveform of the variable being measured. Digital multi-meters may be average or RMS sensing and may include or exclude the dc component. When the variable contains harmonics or dc offset and, in general, any deviation from a pure sine wave, average sensing and average measuring RMS scaled meters may be misleading. Use of RMS measuring meters is recommended.

3. Field test metering used to check power system meter calibration must have an accuracy higher than that of the instrument being checked.

4. Accuracy of metering in test equipment shall be appropriate for the test being performed.

5. Waveshape and frequency of test equipment output waveforms shall be appropriate for the test and tested equipment.

B. Test Instrument Standards

1. All equipment used for testing and calibration procedures shall exhibit the following characteristics:
   a. Maintained in good visual and mechanical condition
   b. Maintained in safe operating condition

2. Test equipment should have operating accuracy equal to, or better than, the following limits:
   a. Portable multi-meters should be true RMS measuring.
   b. Multi-meters should have the following accuracy limits, or better:
      1) AC voltage ranges: .75% +/-3 last single digits @ 60 Hz
      2) AC current ranges: .90% +/-3 last single digits @ 60 Hz, including adapters, transducers
      3) DC voltage ranges: .25% +/-1 last single digit
      4) DC current ranges: .75% +/-1 last single digit
      5) Resistance ranges: .50% +/-1 last single digit
      6) Frequency range: .10% +/-1 last single digit @ 60 Hz
   c. Clamp-on ammeters: ac current +/-3% of range +/-1 last single digit @ 60 Hz
   d. Dissipation/power factor field equipment
      1) +/-0.1% power factor for power factor values up to 2.0%
      2) 5% of the reading for power factor values above 2.0%
   e. Low-range dc resistance equipment: 1.0% of reading, +/-2 last single digits
   f. Transformer turns-ratio test equipment: 0.5% or better @ 60 Hz
   g. Ground electrode test equipment: +/-2% of range
   h. Insulation test sets: 0-1000V dc +/-20% of reading at mid-scale
   i. Electrical load survey equipment
      1) +/-5% total error, including sensors
      2) 1% resolution
      3) Current transformers +/-2% of range @ 60 Hz
      4) Voltage transformers +/-0.5% of range @ 60 Hz
   j. Liquid dielectric strength test equipment: +/-2% of scale
   k. Infrared scanning equipment: sensitivity of 2 degrees C
   l. Phase shifting equipment: +/-1.0 degree C over entire range
   m. High-current test equipment: +/-2% of range
   n. DC high potential test equipment: +/-2% of full scale
   o. AC high potential test equipment (60 Hz): +/-2% of full scale

C. Test Instrument Calibration

1. The testing firm shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy.

2. The accuracy shall be directly traceable to the National Institute of Standards and Technology.

3. Instruments shall be calibrated in accordance with the following frequency schedule:
   a. Field instruments: 6 months maximum
   b. Laboratory instruments: 12 months
   c. Leased specialty equipment: 12 months (Where accuracy is guaranteed by lessor)
   d. Dated calibration labels shall be visible on all test equipment.
   e. Records, which show date and results of instruments calibrated or tested, must be kept up-to-date and available upon request.
   f. Up-to-date instrument calibration instructions and procedures shall be maintained for each test instrument.
   g. Calibrating standard shall be of higher accuracy than that of the instrument tested.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PREPARATION

A. Testing shall be scheduled and coordinated with the Owner at least 2 weeks in advance.

3.02 ACCEPTANCE TESTING

A. Provide acceptance testing for all equipment provided under Division 26 in accordance with the individual specification sections.

B. Provided acceptance testing for all motors provided under Divisions 11, 33, 41 43, 44 and 46 and 22, 23, 40.

C. Tests all electrical equipment, both Contractor- and Owner-supplied, is operational and within industry and manufacturer's tolerances and is installed in accordance with design specifications prior to energizing equipment.

D. Test systems and equipment furnished under Division 26 and repair or replace all defective work and equipment. Refer to the individual equipment sections for additional specific testing requirements.

E. Make adjustments to the systems and instruct the Owner's personnel in the proper operation of the systems.

F. Mechanical inspection, testing and settings of circuit breakers, protective relays, disconnect switches, motor starters, overload relays, control circuits and equipment for proper operation.

G. Check and record the full load current draw of each motor. Where power factor correction capacitors are provided the capacitor shall be in the circuit at the time of the measurement. Check ampere rating of thermal overloads for motors and submit a typed record to the Engineer of the same, including MCC cubicle location and driven load designation, motor service factor, horsepower, and Code letter. If incorrectly sized thermal overloads are installed replace same with the correct size overload.

H. Check power and control power fuses for the correct type and ratings. Replace fuses if they are found to be of the incorrect size.

I. Check settings of the motor circuit protectors. Adjust settings to lowest setting that will allow the motor to be started when under load conditions.

J. Check motor nameplates for correct phase and voltage.

K. Check rotation of motors prior to testing the driven load. Disconnect the driven equipment if damage could occur due to wrong rotation. If the rotation of the motor shaft is not correct, for the driven equipment, change the motor connections at the motor terminal box.

L. Check interlocking, control and instrument wiring for each system and/or part of a system to prove that the system will function properly as indicated by control schematic and wiring diagrams.

M. Inspect each piece of equipment in areas designated as HAZARDOUS to ensure that equipment of proper rating is installed. In the case where HAZARDOUS rated equipment is installed outdoors or in "WET" locations, verify that equipment furnished is also rated for use in WET locations and that conduit and equipment drains are provided. If equipment is not properly rated advise the Engineer.

N. Verify proper phase sequence connection at transformers, equipment, and panels by producing a 1, 2, 3 / A, B, C phase rotation from left to right.

O. Verify all circuit breaker ratings and settings are as required by the Contract Documents or as amended during shop drawing review. Advise the Engineer of discrepancies and make changes as directed by the Engineer.

P. Verify proper operation of automatic and manual transfer switches, accessories devices and associated motor interlocks provided to either delay or prevent motor starting after transfer. Verify that the upstream protective device for each automatic and manual transfer switch is of the proper type and rating to achieve the specified short-circuit withstand rating. If a specific upstream protective device is required to obtain the proper short circuit withstand rating, verify that the proper signage is installed on the upstream protective device and on the automatic/manual transfer switch enclosures indicating the proper replacement parts. If signage is not installed on both the upstream protective device and the transfer switch advise the Engineer and provide the signage as specified in the transfer switch specification section.

Q. Assist in the testing of the emergency/standby engine generator(s). The Electrical Contractor shall provide a journeymen electrician for the duration of the test to assist in the setup and operation of the emergency/standby engine generator(s) test(s).

R. Verify grounding of instrumentation equipment and line surge protection equipment.

S. Test and calibrate protective relays and circuit breakers.

T. Perform over potential, high potential, insulation resistance and shield continuity test for all medium voltage cables. Megger test all low voltage power system cable.

U. Assist in performing a complete plant power outage test to will demonstrate that the automatic power transfer equipment, individual equipment programming and the plant's process control system reestablishes plant operations in the proper sequence once normal or standby power is established. The test shall be repeated until proper plant restoration is demonstrated.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and install wiring devices as shown on the Drawings and as specified herein.

B. Provide all interconnecting conduit and branch circuit wiring for receptacle circuits in accordance with the NEC.

1.02 RELATED WORK

A. Outlet boxes are included in Section 26 05 33.

1.03 SUBMITTALS

A. Submittals shall be in accordance with Section 26 00 00.

1.04 REFERENCE STANDARDS

A. Wiring devices shall comply with the requirements of the National Electric Code (NEC) and shall be Underwriters Laboratories (UL) labeled.

PART 2 PRODUCTS

2.01 MATERIALS

A. Wall switches shall be heavy duty, specification grade, toggle action, flush mounting quiet type. All switches shall conform to the latest revision of Federal Specification WS 896. Wall switches shall be suitable for the area classification indicated and shall be of the following types and manufacturer:

1. Single pole, 20 Amp, 120/277 Volt - Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc., or equal.

2. Double pole, 20 Amp, 120/277 Volt - Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc., or equal.

3. Three way, 20 Amp, 120/277 Volt - Cooper Wiring Devices, Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc., or equal.

4. Four way, 20 Amp, 120/277 Volt - Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc., or equal.

B. Explosion-proof single pole factory sealed switches shall be for 20 Amps, 120/277 volts, mounted in copper free aluminum or malleable iron cast boxes and be similar

and equal to Crouse-Hinds EDS Series, Appleton Electric Co. EDS; Hubbell HBL, or equal.

C. Receptacles shall be heavy duty, specification grade of the following types and manufacturer or equal. Receptacles shall conform to Fed Spec WC596-F.

1. Duplex, 20 Amp, 125 Volt, 2 Pole, 3 Wire; Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc., or equal.

2. Weatherproof/corrosion resistant single, 20 Amp, 125 Volt, 2 Pole, 3 Wire, with cover; Crouse-Hinds Co., Catalog No. WLRS-5-20; Appleton Electric FSKJ520; Pass & Seymour, or equal.

3. Corrosion resistant duplex, 20 Amp, 125 Volt, 2-pole, 3-wire, high visibility yellow nylon face, nickel plated brass or copper alloy power contacts, Cooper-Arrow/Hart Catalog No. 5362CRY; Hubbell Catalog No. HBL53CM62; Bryant-Electric Catalog No. BRY5362CR; or equal.

4. Weather & tamper resistant ground fault interrupter, duplex, 20 Amp, 125 Volt, 2-pole, 3-wire, gray nylon face, Cooper Wiring Devices Catalog No. TWRVG20GY; Hubbell Catalog No. GFTR20GY; Bryant-Electric Catalog No. GFTR20GY; or equal.

5. Ground fault interrupter, duplex, 20 Amp, 125 Volt, 2 Pole, 3 Wire, GFCI feed thru type with "test" and "reset" buttons. Cooper Wiring Devices; Hubbell Wiring Devices-Kellems; Pass & Seymour, Inc., or equal.

D. Device Plates

1. Plates for indoor flush mounted devices shall be of the required number of gangs for the application involved and shall be as follows:
   a. Administration type buildings: Smooth, high impact nylon of the same manufacturer and color as the device. Final color shall be as selected by the Engineer.
   b. Where permitted in other areas of the plant, flush mounted devices in cement block construction shall be Type 302 high nickel (18-8) stainless steel of the same manufacturer as the devices.

2. Plates for indoor surface mounted device boxes shall be cast metal of the same material as the box, Crouse-Hinds No. DS23G and DS32G; Appleton FSK1DRC, FSK1TSEC; Pass & Seymour or equal.

3. Oversized plates shall be installed where standard plates do not fully cover the wall opening.

4. Device plates for switches mounted outdoors or indicated as weatherproof shall be gasketed, cast aluminum with provisions for padlocking switches "On" and "Off", Crouse Hinds No. DS185; Appleton FSK1VS; Pass & Seymour, or equal.

5. Multiple surface mounted devices shall be ganged in a single, common box and provided with an adapter, if necessary, to allow mounting of single gang device plates on multi-gang cast boxes.

6. Engraved device plates shall be provided where required.

7. Weatherproof, gasketed cover for GFI receptacle mounted in a FS/FD box shall be Cooper Crouse-Hinds; RACO (Hubbell); Pass & Seymour, Inc., or equal.

8. Weatherproof non-metallic 'Not Attended/While-In-Use' cover, UV & corrosion resistant polycarbonate back & cover, deep cover, gasketed, horizontal or vertical mounting as required, single or double gang as required, lockable hasp, as manufactured by Thomas & Betts (Red Dot); Cooper Wiring Devices (Arrow Hart); Carlon; or equal.

9. Weatherproof metallic 'Not Attended/While-In-Use' cover, UV & powder die-cast metal construction, minimum 3-1/2 in deep cover, gasketed, horizontal or vertical mounting as required, single or double gang as required, lockable hasp, as manufactured by Thomas & Betts (Red Dot); TayMac; Orbit Electric; or equal.

10. Weatherproof (with plug NOT inserted) cover, lift-lid, single or double gang as required, corrosion resistant die-cast construction, self-closing stainless steel spring doors, screw attach to FS, FD or other device boxes, EPDM gasket on base of cover (not in lid) surrounding receptacle providing protection while plug is installed, as manufactured by Cooper Crouse-Hinds WLRS (or WLRD), Appleton FSK-WR1 (or –WRD); Arrow-Hart; or equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Switch and receptacles outlets shall be installed flush with the finished wall surfaces in areas with stud frame and gypsum board construction, in dry areas with cement block construction or when raceways are shown as concealed on the Drawings.

B. Do not install flush mounted devices in areas designated DAMP, WET or WET/CORROSIVE on the Drawings. Provide surface mounted devices in these areas.

C. Where individual ground fault interrupter type receptacles are shown on the Drawings connected to the same circuit, the Contractor shall provide all ground fault interrupter type receptacles. Use of one ground fault interrupter type receptacle to protect downstream conventional receptacles is unacceptable.

D. Provide corrosion resistant receptacles and 'While-In-Use' weatherproof covers in areas designated CORROSIVE on the Drawings.

E. Convenience outlets shall be 18-in above the floor unless otherwise required or shown on the Drawings.

F. Convenience outlets installed in rooms designated as WET or where equipment may be hosed down shall be mounted minimum 48-in above deck or grade (or as shown on the Drawings) and shall be weather & tamper resistant, ground fault circuit interrupter type, installed within a 'While-In-Use' weatherproof cover.

G. Convenience outlets mounted outdoors shall be mounted minimum 48-in above deck or grade (or as shown on the Drawings) and shall be weather & tamper resistant, ground fault circuit interrupter type, installed within a 'While-In-Use' weatherproof cover.

H. Switches and dimmer controls for lighting shall be mounted 48-in above the finished floor unless otherwise noted or required.

I. The location of all devices is shown, in general, on the Drawings and may be varied within reasonable limits so as to avoid any piping or other obstruction without extra cost, subject to the approval of the Engineer. Coordinate the installation of the devices for piping and equipment clearance.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install all miscellaneous equipment as shown on the Drawings and as specified herein.

1.02 EQUIPMENT LIST

A. This Section provides the requirements for miscellaneous equipment typically employed in a facility, however, not all components specified in this Section are necessarily utilized on this project.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, detailed catalog information or drawings describing electrical and physical characteristics of all equipment specified in sufficient detail to show compliance with the Drawings and Specifications.

1.04 REFERENCE STANDARDS

A. Equipment enclosures shall have NEMA ratings suitable for the location in which they are installed, as specified in Section 26 00 00.

PART 2 PRODUCTS

2.01 MATERIALS

A. Disconnect Switches

1. Disconnect switches shall be heavy-duty, quick-make, quick-break, visible blades, 600 Volt, 3 Pole with full cover interlock, interlock defeat and flange mounted operating handle. All current carrying parts shall be copper

2. NEMA 4X enclosures shall be stainless steel.

3. NEMA 7 enclosures shall be cast aluminum.

4. Switches shall be as manufactured by the Square D Co.; General Electric; Eaton Electrical, or equal.

B. Fused Disconnect Switches

1. Fused disconnect switches shall be heavy-duty, quick-make, quick-break, visible blades, 600 Volt, 3 Pole with full cover interlock, interlock defeat and flange mounted operating handle. All current carrying parts shall be copper.

2. Fuses shall be rejection type, 600 Volts, 200,000A.I.C., dual element, time delay, Bussman Low-Peak, Class RK-1, or equal.

3. NEMA 4X enclosures shall be stainless steel.

4. NEMA 7 enclosures shall be cast aluminum.

5. Switches shall be as manufactured by the Square D Co.; General Electric; Eaton Electrical, or equal.

C. Control Stations

1. Control stations shall be heavy-duty type, with full size (30mm) operators. Stop buttons shall have a lockout latch that can be padlocked in the open position.

2. NEMA 4X enclosures shall be stainless steel.

3. NEMA 7 enclosures shall be cast aluminum.

4. Control stations shall be Square D Class 9001, similar by Eaton Electrical; General Electric Co., or equal.

D. General Purpose Dry Type Transformers

1. Transformers shall be dry type, two-winding with kVA and voltage ratings as shown on the Drawings. Transformer shall incorporate a 220 degree C insulation system and be designed not to exceed 115 degrees C temperature rise above a 40 degree C ambient full load

2. Four full capacity taps shall be furnished, two 2-1/2 percent above and two 2-1/2 percent below rated primary voltage.

3. Windings shall be copper.

4. Transformers shall be built in accordance with ANSI C89.2, and shall be UL listed and suitable for non-sinusoidal current loads with a K-factor of 4.

5. Transformers shall be energy efficient type, meeting the efficiency levels specified in NEMA Standard TP1-2002. Efficiency shall be tested in accordance with TP1-2002.

6. Transformers shall be furnished in NEMA 1 enclosures unless otherwise noted on the Drawings or as required by Section 26 00 00. Areas where a NEMA 4X and/or stainless steel enclosure is required, the transformer shall be of the TENV type.

7. Transformers shall be furnished with hot-dipped galvanized mounting hardware. In NEMA 4X areas or where stainless steel enclosures are required, hardware shall be Type 316 stainless steel.

8. Transformers shall have common core construction with low hysteresis and eddy current losses. The core flux density shall be below the saturation point to prevent overheating caused by harmonic distortion.

9. Transformer impedance shall be a minimum of 3 percent and a maximum of 5 percent.

10. Provide vibration isolators for transformers rated 112.5 kVA and higher.

11. Provide ground lug on frame and strap ground core assembly to frame of enclosure.

12. Transformers shall be manufactured by Square D Co.; General Electric Co.; Eaton Electrical, or equal.

E. Transformer-Panel Assembly

1. Manufacturers
   a. Eaton Electrical, Mini-Power Center
   b. Square D, Mini-Power Zone
   c. General Electric, Servicenter
   d. or equal

2. Ratings
   a. kVA and voltage ratings shall be as shown on the Drawings.
   b. Units shall be designed for continuous operation at rated kVA, for 24 hours a day, 365 days a year operation, with normal life expectancy as defined in ANSI C57.96.
   c. Transformer sound levels shall not exceed the following ANSI and NEMA levels for self-cooled ratings.
   d. Transformer windings shall be copper.

3. Construction
   a. Each TPA shall include a main primary breaker, an encapsulated dry-type transformer, and a secondary panelboard with main breaker.
   b. Main primary, secondary, and feeder breakers shall be enclosed with a padlockable hinged door.

4. Bus
   a. Panelboard bus shall be copper sized to NEMA 65 degrees C rise.

5. Wiring/Terminations
   a. All interconnecting wiring between the primary breaker and transformer, secondary main breaker and transformer, and distribution section shall be factory installed.
   b. All transformers shall be equipped with a wiring compartment suitable for conduit entry and large enough to allow convenient wiring.

6. Main Devices
   a. Each TPA shall include a main primary breaker with an interrupting rating of 22 kA at 480 Volts; and a secondary panelboard with main breaker rated 10 kA interrupting rating at 240 Volts.

7. Feeder Devices
   a. The secondary distribution section shall accommodate one inch, plug-inbreakers with 10 kA interrupting capacity.

8. Enclosure
   a. The enclosure shall be made of heavy-gauge steel and the maximum temperature of the enclosure shall not exceed 90 degrees C.
   b. The enclosure shall be totally enclosed,stainless steel non-ventilated, NEMA Type 3R, with lifting eyes.

F. Surge Protective Devices (SPD)

1. Refer to Section 26 43 00.

G. Wireway

1. NEMA 1 wireway shall be painted steel with screw covers.

2. NEMA 4 and 4X wireway shall be stainless steel with gasketed screw covers and stainless steel screws.

3. NEMA 1 wireway shall be Square-Duct as manufactured by the Square D Co.; NEMA 4 and 4X shall be Bulletin F-22 as manufactured by the Hoffman Engineering Co.; Appleton; Killark, or equal.

H. Control Relays

1. Control relays shall be heavy duty machine tool type, with 10 Amp, 300 Volt convertible contacts. Number of contacts and coil voltage shall be as shown on the Drawings. General use relays shall be General Electric Co., Catalog No. CR120B; similar by Square D Co.; Allen-Bradley Co., or equal. Latching relays shall be General Electric Co., Catalog No. CR120BL; similar by Square D Co.; Allen-Bradley Co., or equal.

I. Detectable Warning Tape

1. Each ductbank section shall be marked by means of a detectable warning tape (tracer tape) as shown on the Drawings. The detectable warning tape shall be capable of being detected or located by either conductive or inductive location techniques.

2. The detectable warning tape shall consist of 5 mil (.005-in) overall thickness; five-ply composition; ultra-high molecular weight; virgin polyethylene; acid; alkaline and corrosion resistant; with 150 pounds of tensile break strength minimum per 6-in width.

3. The top side of the tracer tape shall be color banded red for electrical and high voltage lines, and orange for signal, communication, telephone and fire alarm lines. Tracer tape shall be 4-in wide with four color bands. The tape shall be inscribed with the warning message for the utility such as "CAUTION – ELECTRICAL LINED BURIED BELOW". Tape shall be as manufactured by Mutual Industries, Inc.; Terra Tape, Div. of Reef Industries Inc., or equal.

J. Terminal Blocks

1. Terminal blocks shall be NEMA type rated at 20 amperes minimum, 600 Volt, channel mounted, with tubular screw and pressure plate.

2. Terminal blocks shall be Bulletin 1492 as manufactured by the Allen-Bradley Co.; ABB; Kukla, or equal.

K. Photocells

1. The photocells shall be suitable for power duty with individual fixtures or for pilot duty with contactors as detailed on the Drawings. Enclosure shall be NEMA 3R or 4. Contacts shall be rated for 2,000 watts continuous at 120 Volts. The unit shall turn on at 1.5 footcandles and off at 5.5 footcandles.

2. Photocells shall be Tork, Model 2101; Intematic; Paragon, or equal.

L. On-Delay, Off-Delay Timers (Solid State)

1. On and off delay timers shall be microprocessor based, solid state type.

2. Timers shall have the following features:
   a. Adjustable timing ranges from 0.1 seconds to 99 hours, 59 minutes minimum.
   b. Setpoints entered by pressing membrane covered keyboard on unit.
   c. LCD readout of timing progress and setpoint.
   d. Adjustable for on-delay or off-delay modes.
   e. Standard sized plug-in case.
   f. Totally sealed face plate.
   g. Sealed battery backup power to retain memory for up to 30 days.
   h. Accuracy plus or minus 0.01 second.
   i. DPDT isolated instantaneous and timed output contacts rated 6 Amps minimum at 120 Volt.

3. Timers shall be Bulletin 651 Multi-range, solid state as manufactured by Tenor Co., Inc.; Eagle Signal, CS-300 Series, or equal.

M. Corrosion Inhibitors

1. All equipment enclosures, terminal boxes, etc., located in a corrosive rated area (where shown on the Drawings) that contains electrical or electronic equipment or terminal strips shall be furnished with an internally mounted, chemically treated corrosion inhibitor pad.

2. The corrosion inhibitor pads shall be as manufactured by Hoffman Engineering Co.; 3M; AGM Container Controls, or equal.

N. Equipment Identification Nameplates

1. All field mounted electrical equipment such as disconnects, push button stations, etc., shall be provided with a weather resistant engraved laminoid equipment identification nameplate screwed or bolted adjacent to the device. Nameplate shall identify the mechanical equipment controlled exactly as shown on the electrical singleline drawings (i.e, P-95 Cooling Water Pump No. 1).

O. Equipment Mounting Stands

1. Equipment mounting stands shall be custom fabricated from 1/4-in 316 stainless steel plate and 4-in 316 stainless steel channel, as shown on the Drawings.

P. Lighting Contactor

1. Lighting contactor shall be of the electrically operated, mechanically held type mounted in NEMA 1, enclosures (except where noted otherwise on the Drawings) with number of poles as noted on the Drawings. Operating coils shall be rated for 120 Volts unless otherwise indicated on the Drawings and shall be for momentary operation. Provide with "Hand Off-Auto" switch on cover where shown on the Drawings.

2. Contactors shall be rated for 20 Amps, 600 VAC and shall be Automatic Switch Co., Bulletin 917 RC, similar by Square D Co.; Eaton Electrical, or equal.

Q. Terminal Cabinets

1. Each cabinet shall be furnished with a minimum of 50 spare terminals.

2. All interiors shall be completely factory assembled with terminal blocks and insulating barriers. All 120 volt AC and DC terminal blocks shall be isolated from each other by insulating barriers or separate enclosures. Interiors shall be designed so that terminal blocks or control relays can be replaced or added without disturbing adjacent units.

3. All wiring within the cabinets shall be grouped together in harnesses and secured to the structure.

4. All shielded cables shall terminate in separate cabinets. A third terminal shall be provided for each twisted shield pair and the shield for each connected thereto, unless otherwise noted on manufacturer's shop drawings.

5. Terminal blocks shall be molded plastic, tubular screw type with pressure plates and shall be rated 600 volts. Terminals shall be double sided and supplied with removable covers. Terminal blocks shall be Allen Bradley; ABB; Kukla, or equal.

6. Boxes shall be made from 14 gauge galvanized steel and shall be of sufficient size to provide a minimum of 6-in of wiring space on all sides and between adjacent terminal blocks. A minimum of four mounting studs shall be provided on each cabinet. Cabinets shall be furnished without knockouts. Holes for raceways shall be drilled on the job.

7. A single hinged door shall cover the front of each terminal cabinet. Doors shall have a neoprene gasket, vault type handle, three-point hatch and lock. Two keys shall be supplied for each lock. All locks shall be keyed alike. A terminal block schedule shall be provided with each terminal point numbered and identified (typewritten) as to function.

8. All exterior and interior steel surfaces of the cabinets shall be properly cleaned and finished with white over a rust-inhibiting phosphatized coating conforming to ANSI A55.1. The finish paint shall be of a type to which field applied paint will adhere.

9. Cabinets shall be as manufactured by Hoffman Engineering Company; Hennessy Products; Lee, or equal, with latch kit hardware.

10. Boxes in wet, damp, corrosive and all outdoor locations shall be NEMA 4X, Type 316 stainless steel.

R. Electric Warning Sign

1. Provide and install using stainless steel fasteners a total a restrictive sign that conforms with OSHA regulations for accident prevention. Size of sign: 10-in high by 14-in wide. Sign shall state "DANGER HIGH VOLTAGE". Sign shall be constructed of High Performance Plastic (HPP) by the Seton Name Plate Corp.; Global Equipment Co.; World-wide Sign Co., or equal.

2.02 CONTROL SYSTEM

A. The Manufacturer shall provide a complete and fully functional control system to manually or automatically operate the control system as specified herein and in other applicable sections of these specifications. All Manufacturers recommended safety devices shall be furnished to protect operators. All control devices, unless specified otherwise, shall be mounted in the Control Panel.

B. Control Panel Construction

1. The control panel shall consist of a main circuit breaker, a motor circuit protector (MCP) and magnetic starter for each motor, and a 120-volt control power transformer (fused on primary and secondary). All control components shall be mounted in one common enclosure. Control switches shall provide means to operate each motor manually or automatically.

2. Unless specifically noted otherwise, the electrical control equipment shall be mounted within a NEMA 4X enclosure, constructed of not less than 14 gauge 316 stainless steel. Latches shall be quarter turn quick release type and all hardware shall be 316 stainless steel. Where NEMA 3R or 12 enclosures are

specifically required, the door shall be provided with a pad-lockable vault type 3-point latch. The enclosure shall be equipped with a door and shall incorporate a removable back panel on which control components shall be mounted. Back panel shall be secured to enclosure with collar studs. Door(s) shall be interlocked with main circuit breaker and provided with pad-locking provision.

3. All motor branch circuit breakers, motor starters and control relays shall be of highest industrial quality, securely fastened to the removable back panels with screws and lock washers. Back panels shall be tapped to accept all mounting screws. Self-tapping screws shall not be used to mount any component.

4. A thermal-magnetic air circuit breaker, Type FH as manufactured by the Square D Company, or equal, shall be furnished for the main breaker. All circuit breakers shall be sealed by the manufacturer after calibration to prevent tampering. Each circuit breaker shall be adequately sized to meet the equipment operating conditions. Motor Circuit Protectors (MCP) shall be molded case with adjustable magnetic trip only, "Mag-Gard" as manufactured by the Square D or equal.

5. An open frame, across-the-line, NEMA-rated magnetic motor/starter, Class 8536 as manufactured by the Square D Company, or equal, shall be furnished for each motor. All motor starters shall be provided with motor circuit protectors and equipped to provide under-voltage release and overload protection on all three phases. Motor starter contacts shall be easily replaceable without removing the motor starter from its mounted position. Overloads shall be of the melting alloy or bi-metallic type, adjustable overloads are not acceptable, Class 10 quick trip overloads shall be provided for all submersible motors. Overload reset push-buttons shall be located on the exterior of the door. Normally open and normally closed auxiliary motor overload contacts wired to terminal blocks shall be provided for each motor starter within the control panel.

6. Fused space heater with thermostat to minimize condensation shall be powered internally from control power transformer.

7. Auxiliary contacts shall be provided for remote run indication and indication of each status and alarm condition. Additional controls shall be provided as specified herein and as required by Divisions 40, 43 and as shown on the drawings.

8. All operating control and instruments shall be securely mounted on the exterior door. All controls and instruments shall be clearly labeled to indicate function. All exterior mounted equipment shall be NEMA 4X.

9. Mode selector switches shall be Hand-Off-Auto or Local-Off-Remote type to permit override of automatic control and manual actuation of shutdown. Switches shall be NEMA 4X (800H) as manufactured by Allen-Bradley, or equal, providing three (3) switch positions, each of which shall be clearly labeled according to function.

10. Indicator lamps shall be LED (indoors) or Incandescent (outdoors) full voltage type and mounted in NEMA 4X (800H) modules, as manufactured by Allen-

Bradley. Lamp modules shall be equipped to operate at 120 volt input. Lamps shall be easily replaceable from the front of the control compartment door without removing lamp module from its mounted position. Indicators shall be provided for individual motor run and an indicator for each failure condition.

11. A six (6) digit, nonreset elapsed time meter shall be connected to each motor starter to indicate the total running time of each motor in "hours" and "tenth of hours". The elapsed time meters shall be Series T50 as manufactured by the ENM Company or equal.

12. A failure alarm with horn and beacon light shall be provided. Silence and reset pushbuttons shall also be furnished. A common failure reset pushbutton shall be provided to reset the alarm conditions (reset shall occur only if fault condition has been cleared). The alarm horn shall be weatherproof rated with gasket (Federal Signal Corporation, Cat. #350 or equal). The alarm beacon shall be NEMA 4X rated, red lens and solid state flasher (Ingam Products Inc. LRX-40).

13. The control panel shall operate on a power supply of 480 volts, 3-phase, 60 hertz unless otherwise noted.

14. The control diagrams and overload tables shall be laminated to the inside of the door except where door space is limited the laminated documents shall be in the print storage pocket.

15. Print storage pockets shall be provided on the inside of each panel. Pocket shall be of sufficient size as required to hold all prints necessary to service the equipment. A set of reduced drawings shall be provided for each panel, fixed to fit in the storage pocket.

16. A duplex GFCI utility receptacle (circuit breaker protected) providing 120 volts, 60 Hertz, single phase current shall be mounted on the side of the enclosure.

17. The control panel shall include an adjustable time delay relay to prevent any two motors from starting simultaneously. All timing relays shall be solid state, with pin (octal) and bases, relays shall be T-series as manufactured by Diversified Electronics Inc. or equal.

18. Alternators shall be provided to sequence motors, alternators shall be 008-120-13SP or 009-120-23AP as manufactured by Sta-con, or equal.

19. A phase monitor shall be provided for the control panel, monitors shall be model SUA-440-ASA as manufactured by Diversified Electronics Inc., or equal.

20. All exterior mounted equipment shall be rated NEMA 4X. Hinged NEMA 4X 316 stainless steel viewing windows will be permitted where such equipment is not available with a NEMA 4X rating.

21. The control panel shall be provided with lightning and surge protection. Protection devices shall be mounted within the control panel enclosure. Lead lengths shall not be longer than 12 inches from the main circuit breaker. Protection shall be rated for peak current 80kA per phase, non-modular design.

Advanced Protection Technologies series TE/XF or equal. Exact model number per voltage and phase power system used.

22. All control panel wiring shall be numbered at both ends with type written heat shrinkable wire markers.

23. Wiring shall be stranded copper, minimum size #14 AWG (except for shielded instrumentation cable), with 600 volt, 90 degree C, flame retardant, Type MTW thermoplastic insulation.

24. The control panel shall be provided with nameplates identifying each component, selector switches, pilot lights, etc. Nameplates shall be permanently affixed using an epoxy process (inner door nameplates shall be fastened with stainless steel screws). Nameplates shall be laminated plastic, engraved black letters with a white background.

25. All control panels shall be provided with a master nameplate located on the exterior door.

26. Where applicable provide a nameplate which reads as follows "CAUTION - THIS PANEL CONTAINS A VOLTAGE FROM AN EXTERNAL SOURCE." Letters shall be black on a high visibility yellow background.

27. Corrosion Inhibitor Emitter: Inclusion of an industrial corrosion inhibitor emitter that shall protect internal components of control panel from corrosion for up to one year. One spare emitter shall be provided for each control panel.

28. All control relays shall have 10 amp rated contacts (minimum), 11 pin with mounting base, 3PDT (minimum), with LED indicators to show relay status, relays shall be manufactured by Potter Brumfield or equal.

29. Terminal blocks shall be 600 volt heavy duty rated, tubular clamp type. Terminal strips shall be Allen Bradley catalog #1492-CA-1 or equal. Each terminal shall be individually labeled.

30. The completed control panel assembly shall be U.L. certified. The minimum overall short-circuit withstand rating of the completed control panel hall be 65,000 Amperes RMS symmetrical at 480 volts.

31. Intrinsically safe relays shall be solid state type with 5 amp output contacts, suitable for use on 120 volt, 60 hertz power supply and shall be Factory Mutual approved for devices in Class 1, Division 1 hazardous atmospheres. Intrinsically safe relays shall be Gems Solid State Safe-Pak as manufactured by Gems Sensors, Division of Transamerica Delaval, Inc. or equal.

32. All electronic control equipment (i.e. controllers, isolators, signal boosters, transmitters, PLC's, etc.) shall be as specified in Division 40.

33. A copper ground bar with sufficient terminals for all field and panel ground connections shall be provided.

34. All signal wiring entering and exiting the control panel shall be provided with surge protection. Surge protection shall be as specified in Division 40.

35. An 8-inch (minimum) clear space within the enclosure shall be provided horizontally along the entire top and bottom of the control panel. A 4-inch (minimum) clear space within the enclosure shall be provided vertically along the entire sides of the control panel. No devices, terminals, etc. shall be installed within this space, the space shall be provided for field conduit and wiring access only.

36. Incoming phase conductor terminals shall be clearly identified. All wiring within the control panel shall be color coded or coded using electrical tape in sizes where colored insulation is not available. The following coding shall be used.

System	Wire	Color
Incoming line voltage	Phase conductors	Black
	Ground	Green
	Neutral (As Required)	White
Less than line voltage (individual conductors)	AC	Red
	DC	Blue
	Foreign	Yellow

C. Spare Parts

1. The following number of spare parts shall be furnished for each control panel.
   a. 1 Indicator light assembly
   b. 2 control relays for each type furnished
   c. 5 fuses for each type/size furnished
   d. 1 set thermal overloads for each size furnished
   e. 1 selector switch for each type furnished
   f. 1 starter coil for each size furnished

PART 3 EXECUTION

3.01 INSTALLATION

A. Mounting Stands

1. Field mounted disconnects, pushbutton control stations, alarm panels, enclosed starters and circuit breakers, transformers, automatic transfer switches, wireways, contactors, terminal boxes, junction and pull boxes shall be mounted on stainless steel stands as specified. Where clearance requirements for stands may not be maintained, the Engineer may direct electric control equipment to be wall-mounted adjacent to the driven equipment, but in no case shall the distance from the drive motor to the control station exceed 3-ft, all at no additional cost to the Owner.

2. All floor mounting stands, bracing, anchor bolts and appurtenances furnished to support equipment loads, dynamic loads, wind loads and seismic forces shall conform to the latest applicable requirements of the State Building Code in effect at the time of Bid.

3. All wall mounted brackets, bracing, bolts and appurtenances to support equipment loads dynamic loads, wind loads and seismic forces shall conform to the latest applicable requirements of the State Building Code in effect at the time of Bid.

4. Channel supports shall be ground smooth and fitted with plastic end caps.

3.02 FIELD TESTING

A. Before supplying power to the alarm panels, the following tests shall be done: Verify that all wiring connection interfaces that are required are present. Check for secure connections. Using a continuity device, verify that all discrete inputs and output to and from the control panel are wired in correct polarity and are operating in the correct state of operation (normally open or closed state). Check for any direct short circuits across all voltage supply sources. As each of the above tests are performed, the Electrical Contractor shall highlight and initial each circuit that is tested. This set of prints shall be signed and left inside the enclosure.

B. Check mechanical interlocks for intended operation. Make any adjustments required.

C. In the event of an equipment fault in the panel, notify the Engineer immediately. After the cause of the fault has been identified and corrected, a joint inspection of the equipment shall be conducted by the Contractor and Engineer. Repair or replace the equipment as directed by the Engineer prior to placing the equipment back into service at no additional cost to the Owner.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor and materials required and installed. Complete as shown on the Drawings and as specified herein.

B. Furnish and install the low voltage switchgear equipment as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A. Power system studies are included in Section 26 00 01.

B. Diesel engine generator set is included in Section 26 32 13.

C. Concrete for equipment pad is included in Division 03.

1.03 SUBMITTALS

A. Submit shop drawings and product data in accordance with Section 01 33 23.

B. Shop drawings shall include the following information:

1. Master drawing index.
2. Front elevation view.
3. Floor plan layout.
4. Top view.
5. Dimensions, weight, and shipping splits.
6. Single line diagrams.
7. Schematic diagrams.
8. Nameplate schedules.
9. Component list including metering, protective relays, accessories and control equipment.
10. Conduit entry/exit locations.
11. Assembly ratings including
    a. Short-circuit rating
    b. Voltage

c. Continuous current
d. Bus material and ratings.

12. Major component ratings including:
    a. Voltage
    b. Continuous current
    c. Interrupting ratings.

13. Cable terminal lug sizes.

14. Product data sheets and catalog numbers for circuit breakers and fused switches. List all options, trip adjustments and accessories furnished specifically for this project.

C. Submit the following additional information where applicable:

1. Busway connection.

2. Connection details between close-coupled assemblies.

3. Composite floor plan of close-coupled assemblies.

4. Key interlock scheme drawing and sequence of operations.

D. Design Data

1. Submit the preliminary short circuit and selective coordination study prior to submittal of equipment shop drawings. The equipment shop drawings will not be reviewed until the preliminary power system study is approved by the Engineer.

2. Provide manufacturer's published time-current curves of the main breaker and feeder devices per Section 26 00 01.

E. Test reports

1. When requested, submit design test reports. Furnish documentation showing the results of design tests on a product of the same series and rating as that provided by this specification.

2. Submit production test reports showing results of testing performed on the actual equipment for this project. These tests include:
    a. 60-hertz dielectric tests
    b. Mechanical operation tests
    c. Electrical operation and control wiring tests
    d. Ground fault sensing equipment test.

3. Submit field test reports showing results of testing performed on the actual equipment for this project.

F. Submit manufacturer's installation instructions for the complete assembly and each major component:

1. Shipping, storage, and handling instructions.

2. Installation bulletins.

3. Supplemental instruction bulletins.

4. Application software.

5. Instructions necessary for proper seismic mounting of the equipment.

G. Statement of Qualifications

1. When requested, submit qualifications of factory service representatives for approval.

2. When requested, submit an acceptable list of installations with similar equipment to demonstrate compliance with this specification.

H. Manufacturer's Field Report

1. When requested, submit manufacturers field inspection reports.

I. Project Record Documents

1. Submit record document information in accordance with Section 01 33 23.

2. Submit the following information for record purposes
   a. A complete set of manufacturers "As Built" shop drawings incorporating all changes made during the manufacturing process.
   b. "As Built" point-to-point compartment wiring diagrams for metering, relay and control circuits. Show wire and terminal numbers.
   c. Field wiring interconnection drawings illustrating all field components and electric connections to the systems supplied under this Section.
   d. Confirm and record all protective device settings.

3. Furnish electronic copies of switchgear drawings, single line diagrams, and wiring diagrams in AutoCAD native file format. Drawings shall include any field modifications or changes to reflect actual as built conditions after completion of start-up and final acceptance by the Owner.

J. Operation and Maintenance Data

1. Submit operation and maintenance manuals in accordance with Section 01 78 23.

2. Provide equipment operation and maintenance manuals with each shipped assembly including instruction leaflets, instruction bulletins and renewal parts lists for the complete assembly and each major component.

3. Manuals shall include the following as a minimum
   a. A comprehensive index.
   b. A list of the equipment supplied, including serial numbers, ranges and pertinent data.
   c. Full product specifications for each item.
   d. Service, maintenance and operation instructions for each item.
   e. Special maintenance requirements particular to this system shall be clearly defined, along with set up and test procedures.
   f. Renewal parts list with stock numbers.

1.04 REFERENCE STANDARDS

A. American National Standards Institute (ANSI)

1. ANSI C37.20.1 - Metal Enclosed Low Voltage Power Circuit Breaker Switchgear

2. ANSI C37.20.1A - Metal Enclosed Low Voltage Power Circuit Breaker Switchgear-Amendment 1: Short Time and Short Circuit Withstand Current Tests Minimum Areas for Multiple Cable Connections.

3. ANSI C37.13.1 - Definite Purpose Switching Devices for Use in Metal-Enclosed Low-Voltage Switchgear

4. ANSI C37.17 - Trip Devices for AC and General Purpose DC Low Voltage Power Circuit Breakers

5. ANSI C37.50 - Test Procedures for Low Voltage AC Power Circuit Breakers Used In Enclosures.

6. ANSI C37.90.1 - Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus

B. National Electrical Manufacturers Association (NEMA)

1. NEMA SG3 - Low voltage power circuit breakers.

2. NEMA SG5 - Switchgear assemblies.

C. Underwriters' Laboratories (UL)

1. UL1558 - Metal Enclosed Low Voltage Power Circuit Breaker Switchgear

2. UL 1066 - Low Voltage AC and DC Power Circuit Breakers Used in Enclosures

D. National Fire Protection Association (NFPA)

1. NFPA 70 - National Electric Code

E. International Electrical Testing Association (NETA)

1. NETA ATS - Acceptance Testing Specifications.

F. Where reference is made to one of the above standards, the revision in effect at the time of the bid shall apply.

1.05 QUALITY ASSURANCE

A. The equipment furnished under this Section shall be the product of a manufacturer who has produced this same type of equipment for a period of at least 10 consecutive years.

B. The switchgear equipment shall be designed, assembled and tested by the manufacturer of the major components and circuit protective devices used within the switchgear assembly.

C. All section and devices shall be UL listed and labeled. Service equipment shall be UL labeled as suitable for use as service entrance equipment.

1.06 SYSTEM DESCRIPTION

A. General

1. It is the intent of these Contract Documents that the Contractor furnish and install, where indicated, free-standing, dead-front type low voltage metal-enclosed switchgear equipment, utilizing drawout power circuit breaker devices as specified herein, and as shown on the contract Drawings.

2. Provide auxiliary cable pull section for transition from underground cable feed as shown on the Drawings. Provide bus extensions and compression lugs for number and size of incoming cables.

3. Provide auxiliary sections with provision for cable or busway entrance as shown on the Drawings.

4. Provide automatic source transfer controls as specified herein and as shown on the contract Drawings.

5. Switchgear shall be coordinated with the engine generator set controls as specified in Section 26 32 13 to make a complete and operational system.

B. System Responsibility

1. Equipment specified under this Section shall be furnished as an integrated assembly by the manufacturer who shall have sole responsibility for furnishing all the parts and components required for a complete and operable system; however, all equipment need not be manufactured by a single manufacturer.

2. The source transfer controls shall be designed and manufactured by the Switchgear Manufacturer. No subcontracting or third-party will be permitted to design or furnish the switchgear controls.

C. Design Requirements

1. The switchgear shall be arranged so that the uppermost operating handle shall not exceed 6-ft 6-in from the floor when the switchgear is mounted on a 4-in high equipment pad.

2. Equip useable blank spaces and spaces indicated on the Drawings for future devices with all hardware necessary for the future addition of a protective device including doors, bus, device supports, mounting plates, and connections.

3. Provide key interlocks as indicated on the Drawings.

D. Performance Requirements

1. Minimum short circuit interrupting rating:
   a. The assembly shall be rated to withstand mechanical forces exerted during short-circuit conditions when connected directly to a power source having available fault current of 65,000 amperes symmetrical at rated voltage unless otherwise shown on the Drawings.

2. Voltage and current ratings: as indicated on the Drawings.

3. Surge Withstand Capability: per ANSI/IEEE C62.41 without damage.

4. The equipment and components shall operate continuously at its rated current under the following environmental conditions without damage or degradation of operating characteristics or life:
   a. Operating Ambient Temperature: 0 degrees C to 40 degrees C maximum ambient temperature
   b. Storage Temperature: -40 degrees C to 65 degrees C
   c. Relative Humidity: 0 to 95%, non-condensing
   d. Altitude: Operating to 6500 ft, de-rate for higher elevations

5. Metering accuracy: minimum accuracy of the complete system, including current sensors, auxiliary CTs, and the meter display, shall be +/- 1% of full scale for current values, and +/- 2% of full scale for power and energy values.

E. Power System Coordination and Protection

1. Provide a coordinated power system as specified in Section 26 00 01.

2. The switchgear and protective devices shall be fully rated for the specified short circuit current. Systems employing series connected ratings shall not be used.

3. Power circuit breaker: provide the following minimum independent time-current curve shaping adjustments for each power circuit breaker:
   a. Adjustable long time pick-up and delay.
   b. Adjustable short time pick-up, delay, and I2t settings.
   c. Adjustable ground fault pick-up, delay, and I2t settings.
   d. Adjustable instantaneous pickup.

4. Protective features: provide the following adjustable protective features at each main breaker location. This protection may be integral to the manufacturers standard trip unit offering, or may be provided via separate protective relays, however it shall be furnished as a complete and functional package:
   a. Voltage phase loss.
   b. Current phase loss.
   c. Line voltage phase unbalance, selectable from 5 to 40 percent of nominal in 5 percent increments.
   d. Voltage phase reversal.
   e. Overvoltage, selectable from 105 to 140 percent in 5 percent increments.
   f. Undervoltage, selectable from 95 to 60 percent in 5 percent increments.
   g. Time delay (adjustable from 0 to 8 seconds in 1 second intervals) for overvoltage, undervoltage, and phase unbalance trip and alarm settings.

F. Metering Requirements:

1. Basic metering: display the following minimum metered values at each breaker location. This metering may be integral to the manufacturers standard trip unit offering, or may be provided via separate metering devices, however it shall be furnished as a complete and functional package:
   a. Instantaneous value of phase current
   b. Instantaneous value of line-to-line voltage

2. Enhanced metering: meter and display the following values at each incoming main circuit breaker location:
   a. AC Phase Amperes +/- 0.5%
   b. AC Phase Voltage +/- 0.5%
   c. Watts +/- 1.0%
   d. VA +/- 1.0%
   e. Vars +/- 1.0%
   f. Power Factor +/- 2.0%
   g. Frequency +/- 0.1 Hz
   h. Watthours +/- 1.0%
   i. Varhours +/- 1.0%
   j. VA hours +/- 1.0%
   k. Watt Demand (10-, 15-, 20-, 25-, 30-, 45-, 60-minute interval)
   l. Voltage (minimum/maximum)
   m. Current (minimum/maximum)
   n. Power (minimum/maximum)
   o. Power Factor (minimum/maximum)
   p. Frequency (minimum/maximum)
   q. Peak Demand

3. Power quality monitoring: display the following values at each incoming main circuit breaker location:
   a. %THD (through 31st harmonic)
   b. Peak % THD

G. Source Transfer Controls:

1. Provide open transition, automatic source transfer controls as shown on the Drawings and as specified herein.

2. The alternate source may be a utility or a generator.

3. The controls shall monitor the condition of each power source and shall initiate a tripping condition when voltage or frequency has been lost (or reduced to a predetermined level) for a period of time sufficient to confirm that the loss is not transient.

4. The transfer scheme shall include the following features and controls:
   a. Drawout type voltage transformers with primary and secondary fuses on the line side of each incoming main.
   b. AUTO-MANUAL mode selector switch. In the MANUAL mode, automatic switching shall be inhibited and local electrical manual operation using the circuit breaker control switches shall be permitted.
   c. Three phase undervoltage, open/reverse phase and negative sequence voltage sensing relays or devices.
   d. Electrical interlocks to prevent parallel connection of the two incoming sources.
   e. A switch to permit either source to be selected as the preferred source.
   f. A switch to permit either automatic or manual return to the preferred source.
   g. Field adjustable 10 second time delay between transfer, either direction.
   h. Source voltage available indicator lights, push to test, each source.
   i. Manual retransfer pushbutton.
   j. Safety interlocks.
   k. Provisions for operational testing and simulation.

5. System operation shall be as follows:
   a. The source transfer control shall utilize the split bus primary selective system. The normal condition shall be with one main and tie circuit breakers closed and with the generator main circuit breaker open, so that each section of main bus is energized by the same source. The source transfer control shall monitor the condition of both power sources and shall initiate automatic switching when voltage is not available. The automatic switching shall open the circuit breaker associated with the affected source and then close the bus tie circuit breaker to restore power to the affected section of the main bus.
   b. When normal voltage returns to the affected source for a preset time, the source transfer control shall initiate retransfer to the original configuration if in the automatic return mode or shall await manual retransfer if in the hold return mode. In the hold return mode, if the source in use fails and if voltage to the other source has been restored, the source transfer control shall initiate automatic retransfer to the restored source.

1.07 DELIVERY, STORAGE AND HANDLING

A. Packing and Shipping

1. Equipment shall be handled and stored in accordance with manufacturer's instructions and NEMA PB 2.1.

B. Acceptance at Site

1. The assembly shall be provided with adequate lifting means for moving into the installation position.

C. Storage and Protection

1. Refer to Section 26 00 00.

1.08 MAINTENANCE

A. Maintenance Service:

1. Service-inspection during the first year of operation at Owner's request exclusive of repair, malfunction, or other trouble-shooting service calls.

B. Provide the following materials in the quantity specified. Materials shall match those installed in all respects and where possible shall come from the same production lot. Materials shall be properly packaged for long storage and containers shall be clearly and indelibly labeled on the exterior.

1. One quart of touch-up paint.

2. One dozen each of cover bolts, spring nuts and door fasteners.

C. Spare Parts

1. Provide the following spare parts in the quantities specified:
   a. 10 Fuses of each type and size.
   b. 10 Pilot lamps of each type.
   c. 2 replacement set of (three) breaker current limiters of each size.

2. Spare parts shall be boxed or packaged for long term storage and clearly identified on the exterior of package. Identify each item with manufacturers name, description and part number.

D. Tools

1. Provide a traveling type circuit breaker lifter, rail-mounted on top of switchgear.

2. Crank for racking breakers.

3. Manual charging handle for electrically operated breakers.

4. Maintenance slow closing device (if required by the equipment manufacturer) or other means to determine circuit breaker contact wear.

5. Provide a single hand- held portable test kit capable of testing each of the microprocessor-based trip device functions. Provide a single full function portable test set and accessories for complete field checking of calibration performance of circuit breaker trip units using secondary current injection testing. Include a ground defeat cable for trip units to allow for primary current injection testing, if necessary.

1.09 NOMENCLATURE AND IDENTIFICATION

A. Provide engraved laminated plastic nameplates on all doors for unit load description and for each control or indicating device. Nomenclature shall be as shown on the Drawing or as directed, using lettering approximately 3/8-in high for unit identification nameplates and 1/4-in high elsewhere. The nameplates shall use black letters on a white background. The engraving shall extend through the black exterior lamination to the core. Nameplates shall be screw fastened.

B. The manufacturer shall fasten a master NEMA nameplate to the front of the switchgear indicating model number, serial number, order number, manufacturing date, bus amperes, volts, overall short circuit rating, etc.

C. Provide permanent electrical hazard warning signs marked per OSHA requirements.

D. Provide permanent arc flash PPE signs marked per Section 26 00 01 requirements.

1.10 MANUFACTURERS' SERVICES

A. Provide services of a manufacturer's service representative for testing and start-up, as required in Section 26 00 00.

B. Provide services of a manufacturer's service representative for training, as required in Section 26 00 00.

C. Furnish the services of a manufacturer's representative for a minimum period of one 8-hour days for setup and programming of the power management system and metering devices. The manufacturer's representative shall be factory-trained and shall have a thorough knowledge of the software, hardware, and system programming.

PART 2 PRODUCTS

2.01 GENERAL

A. The use of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired.

B. Products of the following manufacturers are acceptable.

1. Eaton / Cutler-Hammer

2. General Electric

3. Square D

C. Like items of materials/equipment shall be the end products of one manufacturer in order to provide standardization for appearance, operation, maintenance, spare parts, and manufacturer's service.

2.02 MATERIALS

A. Wiring:

1. Low voltage instrument and control wiring: Stranded copper, minimum size No. 14 AWG, with 600 Volt, 90 degree C, flame retardant, Type SIS, bundled and secured with nylon ties. Provide wire markers at each end of all control wiring.

2. Control wiring terminations: provide insulated locking spade terminals, except where saddle type terminals are provided integral to a device. Current transformer secondary leads shall first be connected to conveniently accessible shorting type terminal blocks before connecting to any other device.

3. Terminal blocks: Groups of control wires leaving the motor control center shall be provided with terminal blocks with numbering strips.

4. Wiring identification: provide heat shrinkable wire markers at each termination point, marked with identification corresponding to appropriate designations on manufacturer's wiring diagrams, color coding per NEMA standards and the NEC.

5. Component identification: fuse blocks, relays, pushbuttons, switches, etc., shall be marked with identification corresponding to appropriate designations on manufacturer's wiring diagrams.

6. Line and load terminations: mechanical type terminals, suitable for 75 or 90 degrees C, copper or aluminum cable of the size indicated on the Drawings.

7. Grounding lugs: provided in the incoming line section for connection of the main conductor with additional lugs for supplemental grounding conductors as indicated on the Drawings.

B. Buses:

1. Buses: non-tapered, tin plated copper. Breaker primary connections and load side run backs shall be silver plated copper. All bolted connections shall be plated. Provide a fully rated neutral bus where a neutral bus is required or indicated on the Drawings.

2. Bus bracing: exceed the specified equipment short circuit current rating, but not less than 100,000 amperes RMS symmetrical.

3. Bus joints: welded connections or accessible bolted joints with high-tensile strength, zinc-plated hardware and conical spring-type washers.

4. Ground bus: provide a copper ground bus extending throughout the entire length of the switchgear, firmly secured to each vertical section structure and equipped with lugs for external ground connections, sized for cables shown on the Drawings.

C. Control and Metering Transformers:

1. Potential transformers: Two-winding, encapsulated type with primary and secondary fuses. Voltage ratings shall be as required for the application. Thermal rating and metering accuracy per ANSI Standard C57.13.

2. Current transformers: 600 volt rated, toroidal type with accuracy class per ANSI Standard C57.13 requirements for the specified metering application.

3. Control power transformers: Two-winding dry type with primary fuses, secondary circuit breaker, sized for the application per NFPA 70 (NEC).

2.03 EQUIPMENT

A. Switchgear shall consist of the required number of vertical sections bolted together to form a rigid framework of preformed steel channels or angles covered with bolted steel sheets. Each individual breaker/metering cell shall be completely segregated from adjacent compartments and sections by steel barriers at top, bottom, rear and sides. All edges of front covers or hinged front panels shall be formed. Provide adequate ventilation within the enclosure.

B. All sections of the switchgear shall be front and rear aligned with depth as shown on drawings. Devices shall be front removable and load connections front and rear accessible. Rear access shall be provided.

C. Rear cable compartments: isolated from the main and riser bus by insulated or grounded steel barriers with cable supports in each vertical section. Cable compartments shall be of sufficient depth to accommodate the number and size conduits shown on the drawings, with bending space in accordance with the NEC.

D. Enclosure:

1. NEMA 1 enclosure consisting of side, top and rear covers bolted to steel frame structure members. Front doors shall be hinged and gasketed with captive quarter turn fasteners.

E. Customer Metering:

1. Where indicated on the drawings, provide a separate customer metering compartment with a front facing hinged door and include the following:
   a. Current transformers for each meter. Current transformers shall be wired to shorting-type terminal blocks.
   b. Fused potential taps as the potential source for metering as shown on the Drawings.

F. Main Section:

1. Main section: consists of an incoming cable compartment with main lugs and a main disconnecting device as shown on the Drawings. Provide adequate space for the type and size and quantity of cable as indicated on the Drawings.

2. Main breaker: individually mounted, drawout, air power circuit breaker as indicated on the Drawings.

G. Distribution Sections:

1. The distribution sections shall consist of individually mounted, drawout, air power circuit breakers as indicated on the Drawings. Feeder sections shall be isolated from main section, and from adjacent feeder sections. Feeder devices shall be mounted in individual compartments with an external operating handle located on the compartment door.

H. Drawout cells: equip each breaker cell with drawout rails and primary and secondary disconnecting contacts, and safety interlocks.

1. Power disconnecting means: moving finger contacts on the power circuit breaker studs to engage stationary contacts extending through a glass polyester insulating support barrier only in the connected position. Provide multiple silver-to-silver full floating high-pressure point contacts with uniform pressure on each finger maintained by springs.

2. Secondary control power disconnecting means: gold-plated and pin and socket type plug-in connectors mounted on the removable unit and engaging floating plug-in connectors at the front of the compartment. Maintain contact engagement in the CONNECTED and TEST positions.

3. Racking mechanism: provide a mechanism with a removable lever crank to place the breaker into the CONNECTED, TEST, DISCONNECTED or REMOVED position, all of which permit closing the compartment door. Padlocking shall secure the breaker in the CONNECTED, TEST, or DISCONNECTED position by preventing levering.

4. Position indicator: color-coded visual indication of the CONNECTED, TEST, and DISCONNECTED breaker cell position.

5. Interlocks: provide interlocks to prevent the following operations:
   a. Racking a closed breaker into or out of the CONNECTED position.
   b. Closing a circuit breaker until it is fully racked into the TEST or CONNECTED position.
   c. Withdrawing a circuit breaker from the cubicle while the closing springs are charged.
   d. Insertion of a circuit breaker of incorrect frame size or inadequate interrupting capacity.

6. Removable element auxiliary switch contacts: provide 4 normally open and 4 normally closed, break-before-make auxiliary contacts wired to terminal blocks to indicate breaker position in the cell.

I. Provide a mechanical Kirk Key interlocking system to allow the following manual breaker operations:

1. With the bus tie breaker open, opening either main breaker shall release a key to allow manual closing of the tie breaker.

2. With the bus tie breaker closed, the key shall remain captive to prevent parallel operation of the main sources. Opening the tie shall release the key to allow the open main to be restored.

2.04 POWER CIRCUIT BREAKERS

A. Power circuit breakers: constructed and tested in accordance with ANSI C37.13, C37.16, C37.17, and C37.50 standards, and listed per UL 1066 for application in their intended enclosures for 100% of their continuous ampere rating.

1. Type: low voltage power air-circuit breakers.

2. Mounting: draw-out style with integral handles on the side of the breaker to facilitate lifting.

3. Closing time: maximum 3 cycles.

4. Primary contacts: easily accessible wear indicator to indicate contact erosion.

5. Operator: *manually or electrically operated as required or as indicated on the Drawings.

6. Breaker control interface: color-coded visual indicators to indicate contact open or closed positions as well as mechanism charged and discharged positions. Provide manual control pushbuttons on the breaker face for opening and closing the breaker. Breaker flag shall read "Closed" if the contacts are welded and the breaker is attempted to be tripped or opened.

7. Current limiting fuses: integrally mounted, isolated until the breaker is withdrawn, and coordinated such that the breaker trip device operates before the current limiters. Provide an anti-single-phase device that will trip the breaker in the event of a blown limiter, indicate from the front of the breaker which limiter is blown, and prevent the breaker from being re-closed on a single-phase condition due to missing or blown limiters.

B. Minimum symmetrical interrupting capacity: not less than overall switchgear interrupting rating, with 30-cycle short-time withstand ratings equal to their symmetrical interrupting ratings through 85,000 amperes, without relying on instantaneous trip protection. Provide current limiting circuit breakers or fuses where indicated or required to meet the specified short circuit rating.

C. Trip units: adjustable, electronic overcurrent trip device with true three phase RMS sensing of sinusoidal and non-sinusoidal currents, and the following minimum features and functions:

1. Interchangeable current sensors with their associated rating plug shall establish the continuous trip rating of each circuit breaker.

2. Trip mode indicators for ground fault, overload and short circuit.

3. An operator interface display panel showing diagnostic information and metering information.

4. Ground fault zone interlocking: provide a complete zone selective ground fault protection system for the main and feeder protective devices.

5. Arc flash reduction technology: allow a preset maintenance mode with an accelerated instantaneous override trip to reduce arc flash energy.

6. The trip unit shall communicate via a twisted pair to the network system provided in the equipment for remote monitoring and control. All monitored parameters shall be transmitted.

D. Electrically operated breakers: provide close/open pushbuttons, plus red and green indicating lights to indicate breaker contact position. 120 Vac motor operators; motor charging time shall not exceed 6 seconds.

1. Control power: AC and DC sources shall be supplied from control power transformers or DC power supplies internal to the switchgear assembly.

2. Circuit breaker control switches: 600 Volt switchgear rotary type, rated 20 Amps continuous, momentary contact, spring return type having mechanical target or flag and a fixed, pistol grip handle.

3. Indicator lights: Provide green, red and amber pilot lights for each circuit breaker OPEN, CLOSED and TRIP indication.

2.05 METERING AND CONTROL

A. Digital Metering:

1. Type: UL listed, CUL, CSA and CE certified microprocessor based, solid state, door mounted digital line meter device with accuracy per ANSI C12.16.

2. Surge withstand rating: meet ANSI standard C37.90.1 for surge withstand.

3. Monitored parameters: display values for each metered parameter and automatically range between units, kilo units and mega units for all displayed values.

4. Inputs: Provide external current transformers with rating as indicated on the drawings. Fused internal self-contained potential transformers for voltages up to 600 volts. Control power shall be supplied internally from the switchgear.

5. Operator interface: faceplate shall be membrane type, rated NEMA 12, with a durable backlit display to allow simultaneous viewing of multiple parameters. The meter shall be completely programmable using the display keypad or via network communications. All set points and recorded minimum and maximums shall be stored in non-volatile memory.

6. Operating temperature range: 0 to 70 degrees C, and 0 to 95 percent relative humidity non-condensing.

B. Digital Metering and Protection Device:

1. Type: UL listed, CUL, CSA and CE certified microprocessor based, solid state, door mounted digital line meter and protective device with accuracy per ANSI C12.16.

2. Surge withstand rating: meet ANSI standard C37.90.1 for surge withstand.

3. Inputs: Provide external current transformers with rating as indicated on the drawings. Fused internal self-contained potential transformers for voltages up to 600 volts. Control power shall be supplied internally from the switchgear.

4. Operator interface: faceplate shall be membrane type, rated NEMA 12, with a durable backlit display to allow simultaneous viewing of multiple parameters. The meter shall be completely programmable using the display keypad or via network communications to allow the user to disable undesired values/functions and to later reactivate them if required. The display screen shall indicate trip and alarm conditions.

5. Non-volatile memory: All set points and recorded minimum and maximums shall be stored in non-volatile memory and not require battery backup. In the event of a power failure, the meter shall retain all preset parameters, accumulated watthours and watt demand. Data at time of power loss and cause of trip shall be stored.

6. Synchronous pulse input: when activated shall override the preset watt demand interval and let the utility control the demand window.

7. Trip and alarm outputs: provide separate programmable contacts that actuate when a protective function exceeds its setpoint. The contacts shall have ratings of 10 Amps at 115/240 VAC and shall be NO/NC.

8. kWh pulse output: provide a separate field programmable NO/NC contact for a kilowatt hour pulse.

9. Operating temperature range: 0 to 70 degrees C, and 0 to 95 percent relative humidity non-condensing.

10. Reset function: a built-in reset button shall allow manual reset of a trip or alarm condition. Watt-hours and watt demand shall be resettable.

C. Electronic Trip Unit Monitor:

1. Provide a microprocessor-based device designed to monitor and display parameters of the circuit breaker electronic trip units. The monitor shall have the following features:
   a. Alphanumeric display.
   b. Indication of circuit breaker status; tripped, open, closed.
   c. Cause of circuit breaker trip.
   d. Phase, neutral, and ground current for each breaker.
   e. Energy parameters for each breaker.

2.06 INTEGRATED EQUIPMENT

A. The switchgear manufacturer shall integrate and assemble programmable controllers, surge protection, and uninterruptible power supplies into the switchgear as shown on the drawings.

1. Programmable controllers.

2. Uninterruptible power supplies.

3. Transient voltage surge suppression: as specified in Section 26 43 00.

B. Interrupting ratings of integrated equipment shall be coordinated with the overall interrupting ratings of the switchgear.

2.07 NETWORK COMMUNICATIONS

A. Provide interface hardware, cabling, and software to enable the following microprocessor-based devices to communicate with the plant-wide ETHERNET/IP network.

1. Metering devices

2. Circuit breaker trip units

B. Communicate metering and trip device data to a plant-wide power management network.

C. Communications gateway: Provide a distributed data logging gateway, interface hardware, power supplies, cabling, and software to connect local microprocessor-based devices to a plant-wide Ethernet TCP/IP communications network.

D. Network adapter modules: each local device shall communicate as a single node on the network via a terminal adapter with field-settable fixed IP addresses. 24 VDC power to the adapter shall be from a DC power supply internal to the switchboard, with a power sensing circuit to indicate to the network when the device does not have 24

VDC power, signaling a fault condition. Modbus/TCP Ethernet, PROFIBUS DP and ETHERNET/IP addressing shall be configured using software via a laptop computer. Provide all software for configuring advanced features.

E. Hardware shall communicate with third party hardware via RS-232 Modbus RTU. The system hardware shall have the ability to map up to 10,000 Modbus RTU read registers. Any computer user on the Local Area Network shall be able to activate the COM port or COM ports into Modbus gateways communicating via RS-232 Modbus RTU. Support for digital as well as analog registers and boolean statements shall be provided.

2.08 SURFACE PREPARATIONS AND SHOP COATINGS

A. All exterior and interior steel surfaces of the switchgear shall be properly cleaned and provided with a rust-inhibiting phosphatized coating. Color and finish of the switchgear shall be manufacturer's standard light gray.

B. Unpainted non-current carrying parts shall be galvanized to prevent corrosion.

2.09 SHOP TESTING

A. Perform manufacturers standard production testing and inspection in accordance with NEMA and UL standards. If requested by the Engineer, the manufacturer shall submit certified copies of test results to indicate proof of compliance with NEMA and UL Standards.

PART 3 EXECUTION

3.01 GENERAL

A. Install the switchgear as shown on the Drawings and in accordance with manufacturer's instructions and approved shop drawings.

B. Install the equipment in accordance with NEMA PB 2.1.

3.02 FIELD CONNECTIONS

A. Provide driven ground rods as specified in Section 33 79 00. Connect ground conductors to the upper end of the ground rods by exothermic weld or compression connector. Provide compression connectors at equipment ground bus.

B. Provide bare copper cable not smaller than No. 4/0 AWG not less than 24 -inches below grade connecting to the grounding electrode system.

C. Make wiring interconnections between shipping splits.

D. Install bus splice plates and torque the connections.

E. Install field wiring per Section 26 05 10. Field wiring shall be grouped by circuit and tie wrapped. Terminations shall not be stressed.

3.03 INSTALLATION

A. Remove temporary lifting angles, lugs and shipping braces. Remove all current transformer shunts after completing secondary circuits.

B. Mount indoor switchgears on a four-inch-thick concrete slab, unless otherwise indicated. Edges shall have 1/2-inch chamfer. The slab shall extend at least four inches beyond the equipment.

C. Unless otherwise indicated, the thickness of the concrete slab shall be increased to eight inches thick for outdoor applications, reinforced with 6-in by 6-in No. 6 mesh placed uniformly 4-in from the top of the slab. Slab shall be placed on a 6-in thick, well-compacted gravel base.

D. The assembly shall be bolted directly to floor sills set level in concrete per manufacturer's recommendations. Floor sills are not required if the floor is level to 1/8-inch per 3-foot distance in any direction. Provide all necessary hardware to secure the assembly in place.

E. Locate conduit and cable entrances in the space designated by the equipment manufacturer. Install conduits to prevent water from entering the enclosure. Bond all conduits including stubs to the equipment ground bus. Seal voids around conduit openings in the slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits three inches above slab surface.

F. Where field painting of enclosures is required to correct damage to the manufacturer's factory applied coatings, provide manufacturer's recommended coatings and apply in accordance with manufacturer's instructions.

G. Repair damage to galvanized coatings using zinc rich paint.

3.04 FIELD TESTING

A. Perform physical, electrical, and mechanical inspections in accordance with the manufacturer's recommendations and the following. Provide all temporary power for testing.

1. Compare equipment nameplate data with specifications and approved shop drawings.

2. Inspect physical, electrical, and mechanical condition.

3. Confirm correct application of manufacturer's recommended lubricants.

4. Verify appropriate anchorage, required area clearances, and correct alignment.

5. Inspect all doors, panels, and sections for paint, dents, scratches, fit, and missing hardware.

6. Verify that fuse and circuit breaker sizes and types correspond to approved shop drawings.

7. Verify that current transformer ratios correspond to approved shop drawings.

8. Confirm correct operation and sequencing of electrical and mechanical interlock systems.

9. Inspect insulating materials and structure for evidence of physical damage, reduced clearances, or contaminated surfaces.

10. Verify that field wiring is adequately separated from live busses. Physically secure the field wiring to withstand the effects of fault currents.

11. Check all devices for damage and make all necessary repairs or replacements, prior to energizing.

12. Verify correct barrier and shutter installation and operation.

13. Exercise all active components.

14. Inspect all mechanical indicating devices for correct operation.

15. Verify that vents are clear.

16. Test operation, alignment, and penetration of disconnecting contacts.

17. Inspect control power transformers.

18. Verify all ground connections have been made.

19. Verify operation of space heaters.

B. Perform the following electrical acceptance tests on the switchgear in accordance with NETA ATS.

1. Conduct an electrical insulation resistance test to verify that the equipment and field wiring are free from short circuits and grounds. Test phase-to-ground, phase-to-phase, and phase-to-neutral, with the switches or circuit breakers opened.

2. Over-potential tests.

3. Insulation-resistance test on control wiring; do not perform this test on wiring connected to solid-state components.

4. Control wiring performance test.

5. Primary current injection tests on the entire current circuit in each section of assembly.

6. Phasing check on double-ended switchgear to ensure correct bus phasing from each source.

7. Conduct earth resistance ground testing.

C. Perform the following electrical acceptance tests on circuit breakers with solid state trips in accordance with NETA ATS.

1. Contact resistance tests.

2. Insulation resistance tests.

3. Long-time delay time-current characteristic tests.

4. Determine short-time pickup and delay by primary current injection.

5. Determine ground-fault pickup and time delay by primary current injection.

6. Determine instantaneous pickup current by primary injection.

7. Verify correct operation of any auxiliary features such as trip and pickup indicators, zone interlocking, electrical close and trip operation, trip-free, and anti-pump function.

D. Perform the following before energizing the equipment

1. Retighten all accessible electrical connections to the manufacturer's torque values.

2. Retighten the wire clamping members of all accessible mechanical (pressure wire) type connectors to the values specified by the manufacturer.

3. Retighten conical spring washers according to manufacturer's instructions.

4. Turn all circuit breakers and fusible switches to the OFF position before energizing the bus.

5. Adjust ground fault and instantaneous protective devices to their most sensitive settings during start-up. Reset the devices after startup is complete and the equipment has been successfully energized.

6. Reinstall all parts and barriers removed to facilitate wiring and installation.

7. Before closing the enclosure, remove all metal chips, scrap wire, and other debris from the switchgear interior. Remove accumulated dust and dirt by using a brush, vacuum cleaner or clean, lint-free rags.

8. Install covers, close doors, and make certain that no wires are pinched and that all enclosure parts are properly aligned and tightened.

E. Performance Test

1. Verify complete system operation including all hardware, software and communication devices.

2. Verify networking performance with all interfacing systems by other manufacturers.

3.05 ADJUSTMENT

A. The Contractor shall perform field adjustments of the protective devices as required to place the equipment in final operating condition. The settings shall be in accordance with the approved short circuit and protective device coordination study.

B. The manufacturer's representative shall provide the following services for starting up and programming of the power management system and metering devices:

1. Set all the adjustable or programmable parameters of all devices in the equipment.

2. Coordinate startup with other manufacturer’s equipment.

3. Verify the integrity of the data communications network and troubleshoot as necessary.

4. Set all the network addresses of all devices in the equipment.

3.06 CLEANING

A. Remove all rubbish and debris around the switchgear. Remove dirt, dust, and concrete spatter from the exterior of the equipment using brushes, vacuum cleaner, or clean, lint free rags.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install all panelboards as shown on the Drawings and as specified herein.

B. All panelboard wiring shall include wiring numbers and terminal point numbers cross referenced to shop drawing and subsequent record drawing submittals.

1.02 RELATED WORK

A. Refer to Section 26 00 00 for nameplate identification requirements.

1.03 SUBMITTALS

A. Submit to the Engineer, in accordance with Section 01 33 23, shop drawings and product data, for the following as a minimum:

1. Equipment outline drawings showing elevation and plan views, dimensions and weight. Indicate all options, special features, ratings and deviations from this Section.

2. Bus arrangement drawings.

3. Product data sheets and catalog numbers for circuit breakers, etc. List all options, trip adjustments and accessories furnished specifically for this project.

4. Instruction and renewal parts books.

5. Test and inspection reports.

6. Complete bill of materials list.

7. The equipment drawings, summary tables, and bill of materials list shall be computer generated (i.e. no hand-drawn drawings, sketches, lists will be accepted).

1.04 REFERENCE STANDARDS

A. Panelboards shall be in accordance with the Underwriter Laboratories (UL) "Standard for Panelboards" and "Standard for Cabinets and Boxes" and shall be so labeled where procedures exist. Panelboards shall also comply with NEMA Standard for Panelboards and the National Electrical Code (NEC).

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 MANUFACTURERS

A. 120/240 Volt, single phase, 3 Wire and 120/208 Volt, 3 Phase, 4 Wire panelboards shall be Type NQ as manufactured by Schneider Electric; Type Pow R Line by Eaton; or Type AQ by General Electric.

B. 277/480 Volt, 3 Phase, 4 Wire panelboards shall be; Type NF as manufactured by Schneider Electric; Type Pow R Line by Eaton; or Type AE by General Electric.

C. 480 Volt, 3 Phase, 3 Wire panelboards shall be; I Line series as manufactured by Schneider Electric; Type Pow R Line by Eaton; or Type Spectra by General Electric.

D. Refer to additional requirements for manufacturers in Section 26 00 00. Alternate suppliers must be submitted for approval to the Engineer in writing four weeks prior to the original bid date with supporting documentation to confirm all aspects of the specifications.

PART 2 PRODUCTS

2.01 GENERAL

A. Rating

1. Panelboard ratings shall be as shown on the Drawings. All panelboards shall be rated for the intended voltage.

2. Circuit breaker panelboards shall be fully rated for the specified circuit breaker fault current interrupting capacity. Series connected short circuit ratings will not be acceptable.

2.02 MATERIALS (NEMA 1)

A. Interiors

1. All interiors shall be completely factory assembled with circuit breakers, wire connectors, etc. All wire connectors, except screw terminals, shall be of the anti-turn solderless type and all shall be suitable for copper wire of the sizes indicated.

2. Interiors shall be so designed that circuit breakers can be replaced without disturbing adjacent units and without removing the main bus connectors and shall be so designed that circuits may be changed without machining, drilling or tapping.

3. Branch circuits shall be arranged using double row construction except when narrow column panels are indicated. Branch circuits shall be numbered by the manufacturer.

4. A nameplate shall be provided listing manufacturer's name, panel type and rating.

B. Buses

1. Bus bars for the mains shall be of tin plated copper. Full size tin plated copper neutral bars shall be included where neutral bus is required. Bus bar taps for panels with single pole branches shall be arranged for sequence phasing of the branch circuit devices. Bussing shall be braced throughout to conform to industry standard practice governing short circuit stresses in panelboards. Phase bussing shall be full height without reduction. Cross connectors shall be tin plated copper. Each panel shall be provided with a ground bus bar, with removable link/jumper between neutral and ground bus. The ground bus shall be sized to the maximum number of circuit breakers that can be installed in the panelboard.

2. Neutral bussing shall have a suitable lug for each outgoing feeder requiring a neutral connection.

3. Spaces for future circuit breakers shall have busses sized for the maximum device that can be fitted into them and any hardware attached to the bus so the addition of a future breaker only required the addition of the breaker itself and no other hardware.

4. Tin plated copper equipment ground bars shall be furnished.

C. Boxes

1. Recessed or flush mounted boxes shall be made from galvanized code gauge steel having multiple knockouts, unless otherwise noted. Boxes shall be of sufficient size to provide a minimum gutter space of 4-in on all sides.

2. Surface mounted boxes and trims shall have an internal and external finish as specified in Paragraph 2.04D4 below.

3. At least four studs for mounting the panelboard interior shall be furnished.

4. All conduit entrances shall be field punched.

D. Trim

1. Hinged doors covering all circuit breaker handles shall be included in all panel trims.

2. Doors shall have semi flush type cylinder lock and catch, except that doors over 48-in in height shall have a vault handle and 3-point catch, complete with lock, arranged to fasten door at top, bottom and center. Door hinges shall be concealed. Furnish two keys for each lock. All locks shall be keyed alike; directory frame and card having a transparent cover shall be furnished on each door.

3. The trims shall be fabricated from code gauge sheet steel.

4. All exterior and interior steel surfaces of the panelboard shall be properly cleaned and finished with ANSI Z55.1, No. 49 or No. 61 light gray paint over a rust-inhibiting phosphatized coating. The finish paint shall be of a type to which field applied paint will adhere.

5. Trims for flush panels shall overlap the box by at least 3/4-in all around. Surface trims shall have the same width and height as the box. Trims shall be fastened with quarter turn clamps.

6. Door-in-door type construction shall be provided so that trim may be opened to access wire ways without removing the trim from the panel

2.03 CIRCUIT BREAKERS

A. Panelboards shall be equipped with circuit breakers with frame size and trip settings as shown on the Drawings.

B. Circuit breakers shall be molded case, bolt-in type.

C. Each circuit breaker used in 120/208 Volt, 3 phase, 4 wire panelboards shall have an interrupting capacity of not less than 10,000 Amps, RMS symmetrical.

D. Each circuit breaker used in 120/240 Volt, single phase, 3 wire panelboards shall have an interrupting capacity of not less than 10,000 Amps, RMS symmetrical.

E. Each circuit breaker used in 277/480 Volt 3 phase, 4 wire panelboards shall have an interrupting capacity of not less than 65,000 Amps, RMS symmetrical.

F. Each circuit breaker used in 480 Volt, 3 phase, 3 wire Power panelboards shall have an interrupting capacity of not less than 65,000 Amps, RMS symmetrical.

G. Each circuit breaker used in 480 Volt, 3 phase, 3 wire Distribution panelboards shall have an interrupting capacity of not less than 65,000 Amps, RMS symmetrical.

H. GFCI (ground fault circuit interrupter) shall be provided for circuits where shown on the Drawings. GFCI units shall be 1 Pole, 120 Volt, molded case, bolt-on breakers, incorporating a solid-state ground fault interrupter circuit insulated and isolated from the breaker mechanism. The unit shall be UL listed Class A Group I device (5 milliamp sensitivity, 25 millisecond trip time) and an interrupting capacity of 10,000 Amps, RMS.

I. GFCI for ground fault protection on heat trace equipment shall be provided for branch circuits where shown on the Drawings. GFCI units shall be rated properly for the intended voltage and trip setting indicated on the drawings and shall be molded case, bolt-on breakers, incorporating a solid state ground fault interrupter circuit insulated and isolated from the breaker mechanism. The unit shall be UL listed Class A Group I device (30 milliamp sensitivity, 25 millisecond trip time) and an interrupting capacity of 10,000 Amps, RMS.

J. Circuit breakers shall be as manufactured by the panelboard manufacturer.

2.04 FACTORY TESTS

A. Standard factory testing shall be performed for the equipment furnished under this section and these tests shall be in accordance with the latest version of NEMA and UL standards. Certified copies of these tests shall be provided to the Engineer upon request.

PART 3 EXECUTION

3.01 PREPARATION

A. Verify location at site before installing enclosure or conduits.

B. Provide minimum access and working space, as described in NEC Article 110.26, for all electric equipment.

3.02 INSTALLATION

A. Provide complete and perfect installation for all items of equipment included in this Section. Provide all miscellaneous bolts, washers, nuts, clips, lockwashers, small hardware, etc., of equal rust resistant material, to make installation complete.

B. Mount cabinet level and plumb, flush or surface as scheduled.

C. Mount boxes for surface mounted panelboards so there is at least 1/2-in air space between the box and the wall.

D. Unless otherwise noted on the Drawings, top of cabinets shall be mounted 6-ft 0-in above the floor, properly aligned and adequately supported independently of the connecting raceways.

E. Properly align panel in cabinet.

F. Connect panelboard branch circuit loads so that the load is distributed as equally as possible between the phase busses.

G. All wiring in panelboards shall be neatly formed, grouped, and identified to provide a neat and orderly appearance.

H. Paint all scratches, mars, etc., resulting from installation. Use matching paint.

I. All unused or abandoned openings in panelboards shall be sealed using a knockout closure or similar device.

J. All circuit wires removed from panels shall be disconnected completely with no cut off wire stubs left on the circuit breaker, ground, and neutral bar terminals.

K. Splices in panelboards are not permitted, except for shunt trip connections.

L. All panelboards shall be protected from physical damage, water damage, moisture, corrosion, dirt and dust during construction. Any panelboard judged to be unacceptable by the Engineer shall be replaced by the Contractor at no additional cost to the Owner

3.03 IDENTIFICATION

A. Branch circuit wires shall be labeled with associated pole number using vinyl cloth wrap around labels.

B. Provide typed as built circuit directories giving location and nature of load served. Install circuit directories in each panelboard.

C. Each panelboard shall be provided with two nameplates. The first shall be provided by the panelboard manufacturer and shall identify the panel. The second shall be field installed by the Contractor to identify the panel's upstream power source. Refer to Section 26 00 00 for additional information.

3.04 TESTING

A. Field testing and commissioning shall be done in accordance with the latest revision of the "Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems" published by the InterNational Electrical Testing Association (NETA Standard ATS) unless otherwise modified by this Section.

B. Record normal base load phase voltages and currents for each phase and the total neutral current and submit to the Engineer for review.

3.05 CLEANING

A. Remove all rubbish and debris from inside and around the equipment. Remove dirt, dust or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner or clean lint-free rags. Do not use compressed air.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish, install and test the motor control centers as shown on the Drawings and as specified herein.

B. Motor control centers shall be sized to include all equipment, spares and spaces shown on the Drawings.

1.02 RELATED WORK

A. Concrete for equipment pad is included in Division 03.

1.03 SUBMITTALS

A. Submit to the Engineer, in accordance with Section 01 33 23, shop drawings and product data, for the following as a minimum:

1. Equipment outline drawings showing elevation and plan views, dimensions, weight, shipping splits and metering layouts. Indicate all options, special features, ratings and deviations from this Section.

2. Conduit entrance drawings.

3. Bus arrangement drawings.

4. Unit summary tables showing detailed equipment description and nameplate data for each compartment.

5. Product data sheets and catalog numbers for overcurrent protective devices, motor starters, control relays, control stations, meters, pilot lights, etc. List all options, trip adjustments and accessories furnished specifically for this project.

6. Provide control systems engineering to produce custom unit elementary and compartment wiring diagrams for metering, relay, power and control circuits in accordance with the NEMA wiring class specified. Elementary drawings shall show interwiring and interlocking between units and to remotely mounted devices. Show all field devices, switches, lights, wire, terminal numbers, etc., and indicate special identifications for electrical devices per the Drawings.

7. Instruction and renewal parts books.

8. Itemized list of spare parts furnished specifically for this project, including quantities, description and part numbers.

9. Test and inspection reports.

10. Complete bill of materials list.

11. Provide seismic anchoring details, coordinated with the equipment mounting provision, prepared and stamped by a licensed professional engineer. Mounting recommendations shall be based upon manufacturer's shake table tests used to verify the seismic design of the equipment.

12. The equipment drawings, summary tables, elementary drawings/diagrams, spare parts list and bill of materials list shall be computer generated (i.e. no hand-drawn drawings, sketches, lists will be accepted).

1.04 REFERENCE STANDARDS

A. Motor control centers shall be designed, built and tested in accordance with the latest editions and revisions of NEMA Standard ICS-2 and Underwriters Laboratories (UL) Standard No. UL-845. Equipment shall conform to ANSI C19.3 test standards and the requirements of the National Electrical Code (NEC).

1.05 QUALITY ASSURANCE

A. The motor control centers shall be the product of a manufacturer who shall also be the manufacturer of all the circuit breakers, fused switches and motor starters included in the motor control center and who has produced the same type of equipment for a period of at least 15 consecutive years.

B. Motor control centers shall be designed, assembled and tested by the manufacturer of the motor control equipment included in the control center assembly.

C. All units and sections shall be UL labeled. Motor control centers containing service entrance equipment shall be UL labeled "Suitable for Use as Service Equipment."

D. Regulatory Requirements

1. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 (NEC) unless more stringent requirements are specified or indicated.

2. The equipment and major components shall be suitable for and certified to meet all applicable seismic requirements of the International Building Code (IBC) for zone 4 application. Guidelines for the installation consistent with these requirements shall be provided by the manufacturer and be based upon testing of representative equipment. The test response spectrum shall be based upon a 5% minimum damping factor, IBC: a peak of 2.45g's (3.2-11 Hz), and a ZPA of 0.98g's applied at the base of the equipment. The tests shall fully envelop this response spectrum for all equipment natural frequencies up to at least 35 Hz.

E. Certifications

1. The manufacturer shall maintain a documented ISO 9001 or 9002 quality assurance program implementing suitable procedures and controls to monitor all aspects of production and testing.

2. All sections and devices shall be UL listed and labeled. Service equipment shall be UL labeled as suitable for use as service entrance equipment.

3. The equipment manufacturer shall certify that the equipment will function following a seismic event, including both vertical and lateral required response spectra referenced in the specified codes.

1.06 OPERATING AND MAINTENANCE MANUALS

A. Operating and maintenance manuals shall be furnished in accordance with Division 01 and Section 26 00 00.

B. The manuals shall be bound and shall also include:

1. A list of "as left" settings for all motor circuit protectors and circuit breakers.

2. A table listing cubicle number, load description, installed overload heater size and motor horsepower, Amps, service factor and starting code letter.

1.07 MANUFACTURERS

A. The general arrangement of the motor control centers is shown on the Drawings. Motor control centers shall be one of the following products:

1. Eaton.

2. Square D.

3. General Electric Co.

1.08 SPARE PARTS

A. Provide the following spare parts in the quantities specified:

1. One dozen each size of cover bolts, cage nuts and door fasteners.

2. 2 cans of aerosol touch-up paint.

3. 50 percent replacement fuses, all types and sizes.

4. 24 replacement lamps for pilot lights.

5. 6 of each color replacement lens caps for pilot lights.

6. 2 starter coils for each size furnished.

7. 2 replacement overload heaters of each size/type used.

8. 2 overload relays for each size used.

9. 2 motor circuit protectors for each size used.

10. 2 circuit breaker rating plugs for each size used.

B. Spare parts shall be boxed or packaged for long term storage. Identify each item with manufacturers name, description and part number on the exterior of the package.

PART 2 PRODUCTS

2.01 RATING

A. Service: 480 Volt, 3 Phase, 3 Wire, 60 Hz.

B. The overall short circuit withstand and interrupt rating of the equipment and devices shall be not less than 65,000 Amps, RMS symmetrical at 480 Volts unless otherwise shown on the Drawings. Main and feeder circuit protective devices shall be fully rated for the specified short circuit duty. Systems employing series connected ratings for main and feeder devices shall not be used. Motor starter units shall be tested and UL labeled for the specified short circuit duty in combination with the motor branch circuit protective device.

C. The continuous current rating of the main horizontal bus shall be as shown on the Drawings. Vertical busses shall be sized for the structure load and shall have a minimum rating of 300 Amps. Bus bracing shall equal or exceed the specified equipment short circuit rating.

D. Motor control centers, including devices, shall be designed for continuous operation at rated current in a 40-degree C ambient temperature.

2.02 CONSTRUCTION

A. Enclosure

1. Enclosure type shall be NEMA 1 unless otherwise noted on the drawings.

B. Structure

1. Motor control centers shall consist of a series of metal enclosed, free-standing, dead front vertical sections bolted together to form double wall construction between sections. Individual vertical sections shall be nominally 90-in high, 20-in wide and 20-in deep unless otherwise shown on the Drawings. Bottom channel sills shall be mounted front and rear of the vertical sections extending the full width of each shipping split. Top of each section shall have removable plates with lifting angle. Make provisions for field installation of additional sections to each end and provide full depth cover plates (rodent barriers) at each end of the motor control center channel sills.

2. Provide continuous top and bottom horizontal wireways extending the full width of the line-up, isolated from the horizontal bus. Provide a 4-in wide, full height, vertical wireway in each section, equipped with a hinged door and cable supports. Vertical wireway shall be isolated from the bus and device compartments. Wireways openings shall have rolled edges or protective grommets.

3. Provide individual, flange formed, pan type door with concealed hinges and quarter turn latches for each device compartment and future space. Doors shall be removable. Door removal shall not be required to withdraw starter units or feeder tap devices.

4. Motor control centers shall be designed for against-the-wall or back-to-back mounting. All wiring, bus joints and other mechanical parts requiring tightening or other maintenance shall be accessible from the front or top.

C. Unit Compartments

1. Provide individual compartments for each removable combination starter and feeder tap device unit. Each vertical section shall accommodate a maximum of six compartments. Each size 1 or 2 combination starter shall be a minimum of 18 inches high. Steel barriers shall isolate the top, bottom and sides of each compartment from adjacent units and wireways. Removable units shall connect to the vertical bus in each section with tin plated, self-aligning, pressure type copper plug connectors. Size 5 and larger starter units may be wired directly to the bus. Removable units shall be aligned in the structure on guide rails or shelves and secured with a cam latch mechanism or racking screw.

2. Provide individual, isolated compartments for all fixed mounted devices including circuit breakers, cable lugs, metering, relaying and control devices. Main and bus tie circuit breakers shall be wired directly to the main horizontal bus. All bus connections shall be fully rated.

3. Provide the following features:
   a. Provision to padlock removable units in a partially withdrawn TEST position, with the bus stabs disengaged.
   b. Provision to padlock unit disconnect handles in the OFF position with up to three padlocks.
   c. Mechanical interlock with bypass to prevent opening unit door with disconnect in the ON position, or moving disconnect to the ON position while the unit door is open.
   d. Mechanical split-type terminal blocks for disconnecting external control wiring.
   e. Auxiliary contact on unit disconnect to isolate control power when fed from an external source.
   f. Disconnect operating handles and control devices mounted on the removable units.
   g. All compartments shall have laminated wiring diagrams fastened to the inside of each compartment door. Compartments containing motor starters shall have laminated wiring diagrams and heater tables fastened to the inside of the compartment door. Compartments containing panelboards shall

have circuit directories consisting of two ply laminated plastic, with black face and white core fastened to the inside of the compartment door.

D. Bus Systems

1. Main horizontal bus: Tin plated copper, bolted joints, accessible from the front of the structure, fully rated throughout the lineup.

2. Vertical section bus: Tin plated copper, full height, totally insulated and isolated by glass polyester barriers with shutters to cover stab openings when units are withdrawn. Provide fishtape barriers to isolate bottom wireways from lower ends of vertical bus.

3. Vertical buses used for a tie circuit breaker or tie feeder lugs shall be rated for a continuous capacity equivalent to the main horizontal bus rating.

4. Horizontal ground bus: Provide a 1/4-inch by 2-inch (minimum) tin plated copper uninsulated ground bus in each section equipped with lugs for termination of feeder and branch circuit ground conductors. Connect to ground bus in adjacent sections with splice plates.

5. The buses shall be sized for a maximum current density of 1200 Amps per square inch.

E. Wiring

1. Wiring: Stranded copper, minimum size No. 14 AWG, with 600 Volt, 90 degree C, flame retardant, Type MTW thermoplastic insulation, NEMA Class II-S, Type B. Line side power wiring shall be sized for the full rating or frame size of the connected device.

2. Identification: All wiring shall be numbered with type written heat shrinkable type wire markers at each termination point, color coding per NEMA Standards and the NEC. Foreign voltage control wiring shall be yellow.

F. Signage

1. Each motor control center shall be furnished with a sign marked "DANGER - 480 VOLTS - KEEP OUT". Letters shall not be less than 1-in high, 1/4-in stroke. Signs shall be laminated plastic, engraved white letters with a red background.

2. Compartments with voltages from sources outside of the compartment shall have a sign mounted inside the compartment door marked "CAUTION - THIS UNIT CONTAINS A VOLTAGE FROM AN EXTERNAL SOURCE". Letters shall be black on a high visibility yellow background.

3. Provide a 2-in by 6-in nominal engraved master nameplate, of two ply laminated plastic, black face, 3/8-in high by 1/8-in stroke white letters, screw fastened to the top wireway of each lineup with stainless steel screws. Include MCC designation and service ratings.

4. Provide 1-in by 3-in nominal engraved unit nameplates of two ply laminated plastic, black face, 3/8-in high by 1/16-in stroke white letters, screw fastened to each door with stainless steel screws. Equipment names shall be as shown on the drawings.

2.03 COMPONENTS

A. General

1. The Drawings indicate the approximate horsepower and intended control scheme of the motor driven equipment. Provide the NEMA size starter, circuit breaker trip ratings, control power transformers and thermal overload heater element ratings matched to the motors and control equipment actually supplied, in compliance with the NEC and the manufacturers heater selection tables. All variations necessary to accommodate the motors and controls as actually furnished shall be made without extra cost to the Owner.

2. Provide automatic source transfer controls as specified herein and as shown on the contract Drawings.

3. Motor control center shall be coordinated with the diesel engine driven generator set controls as specified in Section 26 32 13 to make a complete and operational system.

B. Circuit Breakers

1. Circuit breakers (400 Amps and larger): 600 Volt, molded case circuit breakers with integral fully adjustable solid-state trip device. Trip device shall be temperature insensitive and have the following characteristics and functions:
   a. Independently adjustable long-time pick-up and delay.
   b. Independently adjustable short time pick-up and delay with i2t in and out switch.
   c. Adjustable instantaneous.
   d. Independently adjustable ground fault pick-up and delay.
   e. Trip mode targets for over load, short circuit and ground fault.
   f. Long time pick-up light.

2. Circuit breakers (Less than 400 Amps): Thermal-magnetic trip type, 600 Volt, 2 or 3 Pole as required, labeled in accordance with UL 489. Provide integral current limiting fuses as required to meet the specified equipment short circuit rating. Provide independently adjustable magnetic trips on 225A frame breakers and larger.

3. Provide a full function portable solid-state circuit breaker test set by the same Manufacturer as the circuit breakers.

C. Combination Starter Units

1. Combination starters shall include a motor circuit protector (MCP) in series with a motor controller and an overload protective device. The MCP shall have an adjustable magnetic trip range up to 1000 percent of rated continuous current and a trip test feature. MCP's shall be labeled in accordance with UL489.

2. Motor starters: 3 Pole, 600 Volt, electrically operated, of the types shown on the Drawings. Provide NEMA sizes as required for the horsepower shown on the Drawings. Minimum size shall be NEMA Size 1. Fractional size starters are not acceptable. IEC rated starters shall not be acceptable. Starters shall have 120 Volt encapsulated operating coils; individual control power transformers with primary and secondary fuses and silver cadmium oxide renewable line contacts.

3. Multi-speed and reversing starters shall include two motor rated contactors mechanically and electrically interlocked so that only one device may be energized at any time.

4. Reduced voltage starters: Solid state, six SCR, full wave type with adjustable current limit and voltage ramp to control starting torque, automatic load sensing circuit to minimize energy consumption, line and load side surge protection and noise suppression and controlled deceleration adjustment to reduce the effects of surges caused by centrifugal pump loads. Provide heat sinks and ventilation to remove heat from the structure. Each starter shall include a motor horsepower rated isolation contactor to positively disconnect the line voltage when the SCR control is off.

5. Wye-delta starters shall be closed circuit transition for use with 6 or 12 lead motors.

6. Contactors: Electrically held, 120 VAC coil operator, suitable for tungsten, ballast, or resistive non-motor loads, with over current protection, control transformer and contact ratings and poles as shown on the Drawings.

7. Motor overload protection: Standard, 3 Pole, ambient compensated, thermal bi-metallic Class 20 for standard motors or quick trip melting alloy type Class 10 for submersible pump motors, with push-to-test feature. Electronic overload relays will be acceptable. Overload relays shall be manually reset from outside the enclosure by means of an insulated pushbutton. Provide auxiliary alarm contacts where shown on the Drawings.

8. Auxiliary contacts: Form C, NEMA A600 rating, as required by the control schemes on the Drawings. Provide 1-normally open and 1-normally closed spare contacts on each starter. Additional auxiliary contacts shall be furnished as shown on the Drawings or as required by the control schematic and this Section.

9. Control power transformers: Two winding type, 120 VAC secondary, fused on primary and secondary, secondary grounded. Provide extra capacity as required or where shown on the Drawings.

D. Instrumentation and Metering

1. Instrumentation transformers: Indoor, 600 Volt, butyl-rubber molded, metering class designed in accordance with ANSI and NEMA standards. Window type current transformers, with burden capacity as low as 50 VA, may be used where such capacity is sufficient. Current transformer accuracy ratings shall be at least equal to NEMA standard requirements for the particular application.

2. Instrument transducers: Inputs matched to the corresponding metering circuit, 4-20 mADC output, 0.5 percent accuracy, as manufactured by Rochester Instrument Systems or equal.

3. Elapsed time hour meters: Five digit, non-reset type, with 120 Volt synchronous motor.

4. Indicating meters: 4-in square, 250 degree scale, 1 percent accuracy switchboard type. Meter types as shown on the Drawings.

5. Instrument control switches: 600 Volt switchboard type, rated 20 Amps continuous, with black molded phenolic escutcheon plates, white characters, General Electric, Type SB-1 or equal.

6. Watt-hour meters: Three element, polyphase, drawout type with built-in testing facilities, 15-minute demand attachment, potential indicator lamps, General Electric Type DS, or Cutler Hammer/Westinghouse Type D4B.

E. Relays and Timers

1. Control relays and timers: Heavy duty machine tool type, with 10 Amps, 600 Volt convertible contacts, General Electric Co., CR120 Series; Cutler Hammer/Westinghouse, Type M-600; Square D, Type X or equal. Provide solid-state timing or latching attachments as required by the control schemes shown on the Drawings.

2. Panel mounted timers: Provide as noted on the drawings, flush mounted, plug-in type, Eagle Signal, Bulletin 125 Cycle-Flex or equal, with ranges as shown on the Drawings.

F. Protective Relays

1. 3 Phase voltage relays: Solid state, with the following features:
   a. Undervoltage protection, 10 to 20 percent, adjustable.
   b. Phase Unbalance, 5 to 10 percent, adjustable.
   c. Phase loss/reversal protection.
   d. Restart timer, 0 to 5 minutes, adjustable.
   e. LED trip indicators.
   f. Automatic or manual reset.
   g. Isolated NO and NC output contacts for alarm and trip.

2. Single phase current sensing relays: Solid state, with the following features:
   a. Independently adjustable trip setting and differential.
   b. Adjustable trip time delay.
   c. Restart timer.
   d. LED trip indicator.
   e. Automatic reset.
   f. Isolated NEMA B600 output contact
   g. 5 Amp window type current transformer for input.

G. Pilot Devices

1. Control operators: Heavy duty, full size, oiltight, with NEMA A600 contact rating. Types and quantities as shown on the Drawings.

2. Indicator lights: Full size, oiltight, low voltage, LED type, with push-to-test feature. Colors and quantities as shown on the Drawings.

H. Miscellaneous Integrated Equipment

1. Bus connected surge protection: 600 Volt, 3 Phase lightning protection shall be Advanced Protection Technologies, XTE/5000 HP Series, or equal.

2. General purpose transformers: Open, dry-type, with primary and secondary overcurrent protection in accordance with the NEC, size and voltage ratings as shown on the Drawings. Refer to Section 26 19 00 for additional requirements.

3. Lighting and Distribution Panelboards: Factory wired to transformer, bolt-on branch circuit breakers, size and voltage rating as shown on the Drawings. Refer to Section 26 24 16 for additional requirements.

I. Digital Metering

1. Type: UL listed, CUL, CSA and CE certified microprocessor based, solid state, door mounted digital line meter device with accuracy per ANSI C12.16.

2. Surge withstand rating: meet ANSI standard C37.90.1 for surge withstand.

3. Monitored parameters: display values for each metered parameter and automatically range between units, kilo units and mega units for all displayed values.

4. Inputs: Provide external current transformers with rating as required. Fused internal self-contained potential transformers for voltages up to 600 volts. Control power shall be supplied internally from the motor control center.

5. Operator interface: faceplate shall be membrane type, rated NEMA 12, with a durable backlit display to allow simultaneous viewing of multiple parameters. The meter shall be completely programmable using the display keypad or via network communications. All set points and recorded minimum and maximums shall be stored in non-volatile memory.

6. Operating temperature range: 0 to 70 degrees C, and 0 to 95 percent relative humidity non-condensing.

2.04 SURFACE PREPARATION AND SHOP COATINGS

A. All non-current carrying metal parts of the control center assembly shall be cleaned of all weld spatter and other foreign material and given a heat cured, phosphatized chemical pre-treatment to inhibit rust.

B. Unpainted non-current carrying parts shall receive a protective zinc plating to prevent corrosion.

C. Indoor equipment shall be finish painted with one coat of manufacturers standard electrocoated, heat cured enamel. Color shall be ANSI-49 or 61 light grey.

D. Outdoor equipment shall be finish painted with two coats of polyurethane or epoxy enamel, 2 to 3 mil thickness. Exterior color shall be light grey.

2.05 SHOP TESTING

A. Perform manufacturers standard production testing and inspection in accordance with NEMA and ANSI standards. If requested by the Engineer, the manufacturer shall submit certified copies of the test results and reports.

PART 3 EXECUTION

3.01 INSTALLATION

A. Motor control center floor sills shall be bolted directly to the finished floor or equipment pad. Structure shall be leveled and plumb. Anchor bolts shall be ½-inch (minimum). Provide hardware and shims for installation.

B. Field installed interior wiring shall be neatly grouped by circuit and bound by plastic tie wraps. Circuit groups shall be supported so that circuit terminations are not stressed.

C. In general, all conduit entering or leaving a motor control center shall be stubbed up into the bottom horizontal wireway directly below the vertical section in which the conductors are to be terminated or shall enter the motor control center from the top. Conduits shall not enter the motor control center from the side unless approved in writing by the Engineer.

D. Housekeeping pads shall be included for the motor control centers as detailed on the Drawings with the exception of motor control centers which are to be installed adjacent to an existing unit. Housekeeping pads for these (if used) should match the existing installation.

E. Install the equipment in accordance with the manufacturer’s instructions.

F. Remove temporary lifting angles, lugs and shipping braces. Touch-up damaged paint finishes.

G. Make wiring interconnections between shipping splits.

H. Install bus splice plates and torque connections.

I. No operator devices shall be located over 6 ft. 6 in. above the operating floor. Circuit breaker operating handles located more than 6 ft. 6 in. above the operating floor shall have operating arm extensions.

J. Where outdoor enclosures are provided, seal all seams, cracks, or openings.

3.02 FIELD TESTING

A. Make the following minimum tests and checks before the manufacturer's representative is called in for testing and adjustment.

1. Megger incoming line terminals and buses, phase-to-phase and phase-to-ground after disconnecting devices sensitive to megger voltage.

2. Remove current transformer shunts after completing secondary circuit. Check polarity and continuity of metering and relaying circuits.

3. Check mechanical interlocks for proper operation.

4. Test ground connections for continuity and resistance.

5. Adjust unit compartment doors.

6. Check control circuit interlocking and continuity with starters in the TEST position. Provide external source of control power for this test.

7. Adjust motor circuit protectors and voltage trip devices to their correct settings.

8. Install overload heaters for actual motor nameplate currents.

B. In the event of an equipment fault, notify the Owner immediately. After the cause of the fault has been identified and corrected, a joint inspection of the equipment shall be conducted by the Contractor, Owner and the equipment manufacturer’s factory service technician. Repair or replace the equipment as directed by the Engineer prior to placing the equipment back into service.

3.03 ADJUSTMENT

A. The motor control center manufacturer shall provide the services of a factory trained service technician for start-up and training of the Owner's personnel. The first trip shall be coordinated with the equipment start-up. The second trip shall include any necessary follow-up or punch list work and shall also include instructions to the Owner or to his/her designated personnel. The manufacturer's service technician shall demonstrate and test all operational features of the installed equipment to the satisfaction of the Owner. Submit a certified copy of the field inspection to the Engineer. No equipment shall be energized without the written approval of the Engineer.

B. The motor control center manufacturer's factory service technician shall make the following inspection, tests and adjustments:

1. Inspect the installation for compliance with the manufacturers recommended installation practices and report all deviations to the Engineer.

3.04 CLEANING

A. Remove all rubbish and debris from inside and around the control center. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint-free rags. Do not use compressed air.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Provide labor, equipment, supervision and materials for the installation, testing and start-up of the variable frequency drive (VFD) systems as specified and as shown on the drawings.

B. The VFD equipment specified in this Section shall be furnished by the Contractor. All VFDs shall be products of the same manufacturer. The VFD supplier shall obtain motor information from the driven equipment supplier(s) and shall ensure compatibility between the VFD and the driven equipment.

C. The VFD equipment specified in this section shall be furnished by the supplier of the driven equipment who shall ensure compatibility between the VFD and the driven equipment.

D. Provide a factory trained technician to start-up each VFD. The technician shall be present through the duration of the field acceptance testing of the driven equipment. Start-up service shall include overtime charges, travel and living expenses and replacement parts.

E. Provide eight hours of on-site training instructions on VFD operation for the Owner's personnel. The training shall be conducted by personnel employed by the VFD manufacturer, unless prior approval of alternate instructors has been granted by the Engineer.

1.02 RELATED WORK

A. Electrical work is included in Division 26.

B. Instrumentation and controls, other than those specified herein, are specified under their respective Sections of Division 13.

C. Concrete for equipment pad is included in Division 03.

D. Standby generator is specified in Section 35 20 10.

E. Squirrel cage motors are specified in Section 26 05 40.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23 shop drawings and product data as follows:

1. Equipment outline drawings showing elevation, plan and interior views, front panel arrangement, dimensions, weight, shipping splits, conduit entrances and

anchor bolt pattern. Indicate all options, special features, ratings and deviations from the specifications.

2. Power and control schematics including external connections. Show wire and terminal numbers and color coding.

3. Product literature on VFD and all accessories, filters, reactors, control devices, components, etc. Clearly indicate which components or options are being provided.

4. Harmonic analysis report.

5. Drive performance specifications.

6. True (not displacement) power factor and efficiency curves.

7. Instruction and replacement parts books.

8. Certified shop test reports.

9. As-built final drawings.

10. Field test and inspection reports.

11. The VFD supplier shall submit written verification that the pulse voltage rate of rise will not produce voltage spikes at the motor terminals and that the motor terminal voltage will remain within the motor manufacturer's published data.

12. The VFD supplier shall submit written confirmation that the motor characteristics (i.e. torque type, FLA, etc.) have been coordinated with the supplier of the driven equipment and that the VFDs being supplied are matched properly for the driven load.

1.04 REFERENCE STANDARDS

A. IEEE Standard 519 (latest revision) - "IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems."

B. National Electrical Code (NFPA 70) latest edition.

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Variable frequency drives shall utilize a field proven design. The VFD manufacturer shall demonstrate at least 3 years of continuous field operating experience with equipment of similar size and design. The entire VFD system described herein shall be factory assembled and tested to assure a properly coordinated system.

B. A factory authorized service and parts organization shall be located within 100 miles of the project location. Provide the name and address of the factory authorized service and parts organization nearest to the project location at the time of the bid.

C. Equipment components and devices shall be UL labeled to the extent possible wherever UL standards exist for such equipment.

1.06 SYSTEM DESCRIPTION

A. Refer to the driven equipment specifications for description of system operation.

B. Refer to the Instrument Loop Diagrams in Division 13 and the control schematic diagrams on the Electrical Drawings for control system operation.

1.07 DELIVERY, STORAGE AND HANDLING

A. Package the equipment for maximum protection during delivery and storage.

B. Store the equipment indoors in a clean, dry, heated storage facility until ready for installation. Do not install the equipment in its final location until the facilities are permanently weather tight. Furnish, install and wire temporary electric space heaters in the equipment until the permanent heating equipment is operational. Protect the equipment at all times from exposure to moisture, chemicals, hydrogen sulfide and chlorine gas.

C. If required in the driven equipment specifications, the VFD manufacturer shall ship equipment to the driven equipment manufacturer's testing facility for use during the factory acceptance test.

1.08 PROJECT/SITE REQUIREMENTS

A. All VFDs shall be Clean Power 18-pulse PWM VFDs with an input phase-shifting transformer as an integral part of the drive or use Active Front End (AFE) technology meeting the harmonic distortion limits indicated in IEEE 519 (latest edition).

B. If the specified harmonic distortion limits cannot be obtained by the addition of line reactors, or if required to meet the specified input true power factor, the drive manufacturer shall provide shunt type harmonic filters for each drive. Filters shall be a second order high pass design utilizing line reactors, capacitors and damping and bleeder resistors. Provide an input line contactor with overcurrent and short circuit protection. Line contactor shall be interlocked with VFD operation and shall include blown fuse and filter overtemperature shutdown interlocks, with contacts for remote alarm. The compensation kVAR shall be matched to the kVAR demand such that the

true power factor does not exceed .99 lagging and shall not be less than .95 lagging. The capacitors shall not affect steady state operation of the VFD while operating from either utility or generator power. The switch-in of the filter shall not create power source transient disturbances which cause shutdown of other VFD equipment already on-line. Capacitor voltage rating shall be 600 Volts for operation on a nominal 480 Volt system. Filter cabinets shall be force ventilated and shall be similar in construction to VFD cabinets.

C. Output dV/dT Filter

1. Provide output dV/dT motor protection filters where shown on the Drawings.

D. Sine Wave Output Filter:

1. Provide a sine wave type motor protection filter where shown on the Drawings.

1.09 MAINTENANCE

A. Provide the following spare parts for each size drive in the quantities specified:

1. One of each type of microprocessor and gate driver printed circuit board.

2. Two power diodes.

3. One pair power transistors.

4. One diagnostic portable test set (when this feature is not microprocessor based).

5. 1 can of aerosol touch-up paint.

6. 50 percent replacement fuses, all types and sizes.

7. 4 replacement lamps for pilot lights.

B. Spare parts shall be boxed or packaged for long term storage. Identify each item with manufacturer's name, description and part number on the exterior of the package.

1.10 QUALIFICATION

A. It is the intent of this Section that the VFDs, isolation transformers, control panels and harmonic filters be supplied by one system supplier. The system supplier shall perform all work necessary in order to select, furnish, coordinate, supervise installation, test and place into operation all components of the system.

B. The VFDs supplier shall submit a statement verifying that they will furnish a system for this project which will meet the specified requirements for harmonics. This statement shall verify that the equipment supplied will not adversely affect the operation and stability of the speed control and voltage regulator systems of the standby engine generator set(s) when operating in the worst case mode specified. The statement shall also define any operational conditions under which the VFD, or

any combination of VFD loads, would not meet the harmonic limitations specified herein.

C. Only pre-qualified manufacturers will be considered for this project. Pre-qualified manufacturers are listed in Paragraph 2.02 below.

1.11 OPERATING INSTRUCTION

A. After approval, during and after construction, operating manuals covering instruction and maintenance on each type of equipment shall be furnished in accordance with Section 01 78 23.

B. The instructions shall be bound and shall provide at least the following as a minimum:

1. A comprehensive index.

2. A complete "as-built" set of approved shop drawings.

3. A complete list of the equipment supplied, including serial numbers, ranges and pertinent data.

4. Full specifications on each item.

5. Updated system schematic drawings "as built", illustrating all components and electrical connections of the systems supplied under this Section.

6. Detailed service, maintenance and operation instructions for each item supplied.

7. A table listing of the "as left" drive set up parameters, timing relay settings and alarm and trip set points.

8. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.

9. The operating instructions shall also incorporate a functional description of the entire system, with references to the systems schematic drawings and instructions.

10. Complete parts list with stock numbers, including spare parts.

1.12 WARRANTY

A. Provide a one year minimum warranty on all parts and labor upon start-up and customer acceptance of the equipment.

PART 2 PRODUCTS

2.01 GENERAL

A. The Contractor shall furnish and supervise installation of variable frequency drives as described in this specification and as detailed on the applicable Drawings.

B. The Contractor shall be responsible for the erection, installation, and start-up of the equipment covered by this specification.

C. The variable frequency drive shall comply with the latest applicable standards of ANSI, NEMA, IEEE, and the National Electrical Code.

D. Variable frequency drives shall operate as specified on existing or new standby generators or normal power sources.

E. Variable frequency drives shall utilize a phase shift transformer and 18 pulse (or greater) cancellation technique, or Active Front End (AFE) technology meeting the harmonic distortion limits required by IEEE 519 (latest edition).

F. Service Conditions

1.	Input power: Phase, 60 Hz.	460-480 VAC, plus 10 percent, minus 10 percent, 3
2.	Input frequency:	57 to 63 Hz.
3.	Ambient temperature:	up to 40 degrees C.
4.	Elevation:	Up to 3300 feet above mean sea level.
5.	Relative humidity:	Up to 90 percent non-condensing

G. VFD Ratings

1. The rated input power shall be 480 Volts, 3 Phase, 60 Hz.

2. VFD input shall be rated for 65 kA short circuit.

3. The rated output power shall be 480 Volts, 3 phase, 0 to 60 Hz.

4. Voltage regulation: Plus or minus 1 percent of rated value, no load to full load.

5. Output frequency drift: No more than plus or minus 0.5 percent from set point.

6. The power unit rating basis shall be 100% rated current continuous.

H. VFD Performance

1. The VFD shall be capable of 110% overcurrent for 1 minute, every 10 minutes for variable torque loads (centrifugal fans, pumps, etc.). The VFD shall be

capable of 150% overcurrent for 1 minute, every 10 minutes for constant torque loads (extruders, mixers, reciprocating compressors and pumps, conveyors, etc.).

2. The minimum VFD system efficiency shall be 96% at 100% speed and 100% torque and exceed 90% at 50% speed and load. Variable frequency drive efficiency shall be defined as drive output power at the motor output terminals divided by the input power at the line side of the main circuit breaker.

3. The variable frequency drives shall maintain the line side displacement power factor no less than 0.95 regardless of speed and load.

4. Motor Compatibility:
   a. The VFD shall be capable of operating a motor with variable torque type loads with a minimum speed range of 0-60 Hz.
   b. The VFD shall be capable of providing breakaway torque for the pump.
   c. VFD system shall provide an output waveform that will allow utilization of standard motors, without need of any special insulation or derating. Motor life expectancy should not be compromised in any way by operation with the VFD system. The system must comply with all elements of the Output Harmonics section of this specification. The VFD must provide motor overload protection in any operating condition.
   d. VFD output waveform shall be suitable for operating a standard squirrel cage induction motor without derating or requiring additional service factor.
   e. VFD shall inherently protect motor from high voltage dv/dt stress, independent of cable length to motor. The VFD system shall be designed to produce no standing waves or overvoltage conditions based on a maximum cable length of 1,000 feet.

5. Provide an output filter integral to the VFD if required to meet this requirement.
   a. The drive shall be capable of riding through a power outage of up to 5 cycle duration, without causing the drive to shutdown.
   b. When the power is restored after a complete power outage, the VFD shall be capable of catching the motor while it is still spinning and restoring it to proper operating speed. The variable frequency drives shall be able to determine the motor speed in any direction and resume operation without tripping. If the motor is spinning in the reverse direction, the variable frequency drives shall start into the motor in the reverse direction, bring the motor to a controlled stop, and then accelerate the motor in the preset method of starting.
   c. The VFD shall be capable of producing a variable AC voltage/frequency output to provide continuous operation over the normal system 30-100% speed range. The VFD must be capable of sustained operation at 1/10 speed to facilitate checkout and maintenance of the driven equipment. As a commissioning and troubleshooting feature, the VFD power circuit shall be capable of operating without a motor connected to the VFD output.
   d. Auto-Restart Capability. The VFD system must be capable of automatically restarting in the event of a momentary loss of power, or a clearing of a drive trip. The VFD system shall provide the user with the

choice of automatically restarting or not. The user shall be able to selectively apply this feature to some but not all conditions as appropriate for the specific application.

e. Motor Sound Level. All VFDs must be selected for operation at carrier frequencies at or above 8 kHz without de-rating to provide quiet motor operation. Audible motor noise, while operating under VFD control, shall be limited to 3 dB(A) above the amount of noise generated across the line measured at one meter from the motor. Should the motor generate more audible noise than specified, the VFD manufacturer shall, at no charge, provide sound shielding for the motor such that the installation meets the above performance specification.

2.02 CONSTRUCTION

A. General

1. The general arrangement of the equipment is shown on the Drawings. Variable frequency drives shall be one of the following products:
   a. GE
   b. Danfoss
   c. Fuji Electric

B. The variable frequency drives (VFD) shall be rated at 480 VAC input with features and options as specified.

C. The variable frequency drives shall be rated for the HP, full load current and rpm of the motor. The variable frequency drives shall be designed to provide microprocessor-based continuous speed adjustment of three-phase motors. The variable frequency output voltage shall provide constant volts-per-Hertz excitation for the motor up to 60 Hertz. The variable frequency drives shall be optimized for an adjustable or selectable carrier frequency to reduce motor noise. The carrier frequency shall be field adjustable and adjusted by the manufacturer's field engineer during start up.

D. The VFDs shall utilize a digital pulse width modulated (PWM) design to convert the fixed AC input to a variable voltage, variable frequency AC output. Construction shall be modular, component mounting or keyed ribbon cable connections wherever possible to minimize downtime during repair.

E. The VFD operate satisfactorily when connected to a bus supplying other solid state power conversion equipment which may be causing up to 10 percent total harmonic voltage distortion and commutation notches up to 36,500 Volt-microseconds, or when other VFDs are operating from the same bus. The drive shall include transient voltage suppression to allow reliable operation on a typical commercial power distribution system.

F. The output shall be generated by power transistors which shall be controlled by identical, optically isolated base driver circuits. The VFD shall not induce excessive power losses in the motor. The worst case RMS motor line current measured at rated speed, torque and voltage shall not exceed 1.05 times the rated RMS motor current

for pure sine-wave operation. The VFD shall have an output voltage regulator to maintain correct output Volt/Hertz despite incoming voltage variations. The VFD shall have a continuous output current rating equal to or greater than the motor full load nameplate current.

G. The variable frequency drives shall be current regulated. Variable frequency drives permitting instantaneous overcurrent trips other than an output short circuit are not acceptable.

H. Variable frequency drive enclosures shall be NEMA Type 1 freestanding floor-mounted, force ventilated (with replaceable air filters) construction requiring front access only. Variable frequency drives requiring rear access for any maintenance are not acceptable. Drives shall include an integrated air-conditioning unit powered from internal circuitry and sized to adequately cool the drive while operating at an ambient temperature up to 40 degrees C. Variable frequency drives using liquid-cooled assemblies in conjunction with associated pumps, piping, and separate remote mounted exchangers are not acceptable. The inverters and converters shall have complete unobstructed front accessibility with easily removable assemblies. The complete enclosure shall maintain a constant height, width and depth. The height for all floor-mounted enclosures shall be 94" high maximum. The enclosures shall include the integral isolation/phase shift transformer (as required) and shall not be more than:

I. All variable frequency drive programmable parameters shall be adjustable from a digital operator keypad located on the front door of the variable frequency drive. Parameters shall include:

1. Programmable maximum and minimum frequency.

2. Programmable acceleration and deceleration times.

3. Selectable carrier frequencies, V/Hz, and critical frequency avoidance lockout.

4. Adjustable electronic overload and torque limits.

5. Multiple attempt restart following utility outage or fault condition.

6. Jog, thread, and preset speeds.

7. Keypad lockout and factory default overrides.

8. Adjustable slip compensation (+/- 5%).

J. The variable frequency drives shall be additionally equipped with a digital operator station mounted on the enclosure front door. Control operator devices and indication lights shall include:

1. Local digital speed control.

2. Hand-Off-Remote control selector switch.

3. LED status lights for each HOR position.

4. Momentary start/stop push buttons utilized with the HOR in “Hand”.

5. Local-Remote speed control selector switch.

6. LED status lights for each Local-Remote position.

7. LED status lights for run, fault, alarm, up-to-speed, power on, and drive ready status.

8. Additional controls as required by as shown on the drawings. Pump Failure will require pump fail timer (as required). Provide for terminations of remote mounted operator control devices and field devices.

K. The variable frequency drives shall have the following system interfaces:

1. Inputs:
   a. Two (2) isolated process control speed reference interfaces to receive and isolate 4-20 mAdc signals.
   b. Dedicated terminal blocks for interface with remote operator and field devices.
   c. 120 Vac control to allow variable frequency drives to interface with remote contacts and with two or three-wire control.
   d. Additional inputs as shown on the drawings.

2. Outputs:
   a. Two (2) analog output signals 4-20 mAdc for speed feedback.
   b. Run relay with an isolated set of form C contacts.
   c. Dry contact output (N.O.) to indicate protective function trip.
   d. Dry contact output (N.O.) to indicate common alarm.
   e. Additional outputs as shown on the drawings.

L. System Communication:

1. Control functions to and from the VFD from the SCADA system shall be hardwired using discrete and analog wiring where shown on the drawings. Analog 4-20 mA signals shall be provided for input speed control and output speed reference. These shall be optically isolated 4-20 mA DC signals that can be sent to a remote location.

2. Communication to the site PLC shall be Modbus TCP. Refer to Instrumentation drawings for required signals. All necessary cables, connectors, software, hardware, etc. shall be provided as required to interface with the site PLC.

M. Monitoring and Displays:

1. The variable frequency drives shall have a 21-character vacuum fluorescent display indicating monitored functions as described in the following paragraph.

2. The following parameters shall be monitored:

a. Input current (3 phases)
b. Input voltage (3 phases)
c. Output current (3 phases)
d. Output voltage (3 phases)
e. Output frequency
f. Kilowatts
g. Drive temperature
h. Time
i. Date
j. Motor rpm
k. Eight (8) most recent trips/faults

N. Protection Functions:

1. The variable frequency drives shall have the following protective features (with indication for a. through i.):
   a. Speed compensated electronic motor overload current.
   b. Undervoltage.
   c. Overfrequency.
   d. Overtemperature.
   e. Ground Fault.
   f. DC bus protection.
   g. Inrush current limit (adjustable 50 to 150%).
   h. Input and output phase loss.
   i. Emergency stop pushbutton (Red mushroom head and maintained).
   j. Line reactors and current limiting fuses shall be provided on the input side of the VFDs to protect against fault currents up to 200,000 A sym.
   k. Phase insensitive to input power.
   l. Surge protection from input AC line transients at line side of main circuit breaker.
   m. Electrical isolation between the power, control and logic circuits.
   n. Drive to be capable of withstanding output terminal line short or open circuits without component failure.

O. Additional Features shall be provided as follows:

1. The variable frequency drives shall be equipped with a flange mounted molded case input circuit breaker (65,000 AIC minimum). The breaker shall be interlocked with the enclosure doors to prevent access to the variable frequency drive unless the breaker is in the open position and to prevent moving the breaker to the ON position while the unit door is open. The circuit breaker shall have provisions for padlocking in the open position. Provide mechanical interlocks on doors of auxiliary sections of multi-bay or multi-cubical cabinets. Handle height shall not exceed NEC requirements when VFD is located on 4-inch high housekeeping pad.

2. Fused space heaters with thermostat to minimize condensation potential upon drive shutdown shall be powered internally from control transformer.

3. The variable frequency drives shall be variable torque design. Provide constant torque design where required by Division 43.

4. Variable frequency drives shall be capable of unidirectional operation.

5. Variable frequency drives shall have 115 VAC control power for operator devices.

6. Control relays shall be machine tool type, heavy duty type, industrial grade, 600 volt, 10 amp rating, Square D, Class 8501, Type X, Allen Bradley 700 series or equal.

7. A tin-plated copper ground bus.

8. Separate door-mounted non-resettable elapsed time meter (0-99999.9 hour) in addition to those specified through the door display.

9. All bus and exposed copper shall be tin-plated.

10. All floor mounted enclosures shall have complete 18" (minimum) clear space in bottom of the cubical for line, motor and field cable terminations. All wall mounted enclosures shall have complete 12" (minimum) clear space in bottom of the enclosure for line, motor and field cable terminations.

11. A switchable fluorescent light within each floor mounted section of the enclosure.

12. All circuit boards shall be conformal coated to help protect them from hydrogen sulfide gases.

P. Identification:

1. All wiring shall be numbered at each end with typed sleeve type labels at each termination. Labels shall correspond to the wiring diagrams. Wiring less than 6 inches may be numbered at only one end.

2. Provide warning signs on terminals that are energized with the power disconnect OFF.

3. Provide 2-inch by 5-inch, nominal, engraved three-layer laminated plastic master nameplates on each VFD fastened with stainless steel screws or rivets. Nameplates shall be black letters with white background core, 3/8-inch high lettering and shall indicate equipment designation as shown on the Drawings.

4. Provide legend plates or 1-inch by 3-inch engraved nameplates with 1/4-inch lettering for identification of pilot devices and meters.

5. Provide permanent warning signs as follows:
   a. "DANGER - HIGH VOLTAGE - KEEP OUT" on all enclosure doors.
   b. "WARNING - HAZARD OF ELECTRIC SHOCK - DISCONNECT POWER BEFORE OPENING OR WORKING ON THIS UNIT".

Q. The isolation/phase shift transformers shall be provided as follows:

1. Transformers shall be dry type, self-ventilated, with insulation for 100 degrees C average temperature rise above 30 degrees C ambient at full continuous operation and shall be suitable for site ambient and altitude. Each shall be equipped with 120 volt single phase space heater(s) for moisture control.

2. Transformer windings shall be copper and exposed copper and bussing shall be tin plated.

3. Impedance shall be selected by the drive system designer.

4. Transformer shall be designed for Inverter duty service with three phase, eighteen-pulse or greater static power converter connected to the secondary windings. The increased eddy and stray losses due to harmonic currents shall be minimized and shall be included in the specified temperature rise.

5. A high temperature alarm and indication shall be provided.

6. Standards: The transformer shall meet the general requirements of ANSI C57.12.00 plus the applicable requirements of ANSI C57.18 (since it is for rectifier service). Tests shall be per ANSI C57.12.90. Additional dry type transformer construction requirements:
   a. Noise Level: The maximum sound level shall not be excessive and shall conform to NEMA Standard TR27-5.09.
   b. Nameplates: Nameplates, warnings, connection diagrams, etc., shall be in accordance with ANSI C57.12.00.
   c. Factory Tests: The routine tests listed in ANSI C57.12.00 shall be conducted on all transformers.
   d. Outline Drawings: To include weight, center of gravity, losses at rated load, DC resistance at 25 degrees C. and nameplate data.

7. Transformer shall be integral to VFD enclosure.

2.03 SURFACE PREPARATION AND SHOP COATINGS

A. All non-current carrying metal parts of the equipment cabinet shall be cleaned of all weld spatter and other foreign material and given a heat cured, phosphatized chemical pre-treatment to inhibit rust.

B. Indoor equipment shall be finish painted with one coat of manufacturers standard electrocoated, heat cured enamel.

C. Unpainted non-current carrying parts shall receive a protective zinc plating to prevent corrosion.

D. All printed circuit boards shall be coated with a protective conformal epoxy.

E. All power bus shall be tin-plated copper.

F. All device contacts shall be gold plated.

PART 3 EXECUTION

3.01 INSTALLATION

A. The equipment shall be leveled and anchored directly to the concrete equipment pad or finished floor. Provide hardware and metal shims for installation. Grout and caulk all voids beneath the equipment base. Anchor bolts shall be 1/2-in galvanized steel.

B. Install the equipment in accordance with the manufacturer's instructions.

C. Remove temporary lifting angles, lugs and shipping braces. Touch-up damaged paint finishes.

D. Make wiring interconnections between shipping splits.

3.02 FIELD TESTING

A. Make the following minimum test and checks before the manufacturer's representative is called in for testing and adjustment:

1. Verify that all connections are completed in accordance with shop drawings.

2. Verify supply voltage and phase sequence are correct.

3. Check mechanical interlocks for proper operation.

4. Test ground connections for continuity and resistance.

5. Adjust unit compartment doors.

6. Check control circuit interlocking and continuity.

B. The manufacturers' service technician shall perform start-up and adjustment of the drive(s).

C. In the event of an equipment fault, notify the Owner immediately. After the cause of the fault has been identified and corrected, a joint inspection of the equipment shall be conducted by the Contractor, the Owner and the equipment manufacturers factory service technician. Repair or replace the equipment as directed by the Owner.

D. Field verify the predicted results of the harmonics analysis during the seven-day pump acceptance test. Provide labor and test equipment for the field harmonics analysis. Test equipment shall be capable of displaying voltage and current waveforms and shall calculate the total harmonic distortion (TDH) of these waveforms. The equipment shall also be capable of harmonic spectrum analysis of the voltage and current waveforms from the fundamental frequency to the 50th order harmonic. Provide a hard copy of the test results from no load to full load at 10 Hz increments for each of the different combinations of drives and power sources as specified.

E. If the drives do not meet the specified performance levels, the filters shall be reconfigured or additional filter devices shall be added as required at no additional cost to the Owner. The tests shall then be run again until the specified performance is obtained.

F. The operation of the motors and driven equipment shall be inspected as a part of this test procedure to ensure that no problems with this equipment are created due to the drives. Any problems such as overheating, excessive current, excessive motor noise, vibration, etc., attributable to the drives shall be corrected under this Section at no additional cost to the Owner. Voltage surges at motor terminals shall be within acceptable limits of the motor manufacturer.

G. If, in the opinion of the Engineer, a driven motor produces an excessive amount of objectionable noise or pure tone (noise dominated by one particular frequency), the VFD manufacturer shall conduct sound tests to determine the frequency range of the objectionable noise and shall make corrections to the drives such that the noise is reduced to the level as specified in Paragraph 2.01 above.

H. The manufacturer shall field test all the hardwired discrete and analog connections and any software communication (Ethernet, Profibus, ControlNet, Modibus etc.) that are connect to remote control equipment when the drive is placed in remote. The manufacturer shall at a minimum verify with the proper testing equipment that the following can be achieved:

1. The drive can be started and stopped remotely.

2. The drive can have its speed changed remotely.

3. The remote equipment can read the VFD discrete status information.

4. The remote equipment can read the VFD speed feedback information.

3.03 SHOP TEST

A. Provide in accordance with Section 01 45 27.

B. Perform shop test on each unit prior to shipping. Test will consist of simulating the expected load to be driven, by operating the load through the speed ranges specified for the driven equipment over a minimum or 2 hours.

C. Provide a factory control and alarm test on each drive unit by simulating each control signal and each alarm function to verify proper and correct drive unit action.

D. Each VFD shall be given complete factory test including simulating operating of all control and shut down functions. All printed circuit boards shall be thermal cycle tested from room temp to 60 degrees C for 48 hours. Certified test reports shall be provided after the tests have been completed.

E. Provide above stated tests in addition to any standard factory tests performed.

F. The harmonic filter / 18 pulse phase-shifting transformer shall be tested for proper operation with the VFD before leaving the VFD factory. Testing shall include full power operation at rated voltage and current and an overload check. The test waveform shall be provided by an actual non-linear load to ensure that the filter and protection monitor function properly under real operating conditions.

3.04 ADJUSTMENT

A. Make all VFD internal adjustments and all adjustments necessary for manual and automatic operation of the entire system of driven equipment.

B. The VFD units' internal protection parameters listed below shall be set as follows:

1. Loss of speed control (reference) signal: Run at preset speed. (determined at startup)

2. Loss of drive panel control signal: Run at preset speed. (determined at startup)

3. Automatic Reset
   a. Number of fault reset trials: 3
   b. Time within which resets allowed: 30 sec.
   c. Delay time before reset-retry: 5 sec.
   d. Auto-reset on motor over-current: Yes
   e. Auto-reset on DC bus over-voltage: Yes
   f. Auto-reset on DC bus under-voltage: Yes
   g. AI Signal < minimum (loss of speed signal): Yes

4. On restoration of power after a power failure, the drive shall automatically reset to be controlled by a remote start/stop dry contact and a 4-20 mA signal from the plant SCADA system or via network communication system.

3.05 CLEANING

A. Remove all rubbish and debris from inside and around the equipment. Remove dirt, dust, or concrete spatter from the interior and exterior of the equipment using brushes, vacuum cleaner, or clean, lint-free rags. Do not use compressed air.

B. Replace all cabinet ventilation filters upon commencement of the Contract warranty period.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, and equipment and install, place in operation, and field test one diesel engine driven generator unit installed in a soundproof/weatherproof enclosure, including appurtenances with sub-base fuel tank, as specified herein and as shown on the Drawings.

B. The unit shall have a standby power rating (site rated) of not less than 1563 kVA, 1250 kW, at 80 percent lagging power factor with 480 Volt, three phase, 60 Hertz output. The alternator shall be four wire, wye connected, neutral grounded, complete with excitation system and controls. Mount the unit on a 4000-gallon steel sub-base and include all essential appurtenances whether specifically mentioned in this specification or not.

C. Arrange the unit for automatic starting and stopping and load transfer upon failure of the normal source of power. Parallel operation with the Power Company shall not be allowed under any circumstance. Transfer to and from plant load will be open transition transfer.

D. All equipment and controls specified in this Section shall be new and be considered part of the generator package. The generator manufacturer or his/her licensee shall be responsible for furnishing the package in its entirety as specified herein. External wiring connections to the generator set shall be furnished and installed under other Sections of Division 26. The generator package shall be complete in all respects and shall include all equipment and controls necessary for a fully operational standby power supply.

E. Furnish equipment under this Section including; but not limited to the following:

1. Diesel engine with attached alternator.

2. Unit mounted radiator with engine driven fan, for cooling of the engine jacket water, lubricating oil cooler, and aftercooler, including engine mounted and engine driven circulating pump(s).

3. Entire exhaust system including silencer mounted inside the enclosure, flexible connection, exhaust pipe, pipe supports, and insulation.

4. Skid-mounted factory piping, wiring and valves.

5. Flexible connectors and/or expansion joints.

6. Combination engine/alternator control panel wired, tested and shock mounted at the alternator end of the unit.

7. Engine-mounted electric starter with starting batteries and battery charger.

8. Generator main circuit breaker with LSIG adjustable trip.

9. Generator structural base and anchorage to concrete foundation.

10. Sound attenuated weatherproof enclosure for outdoor installation of the generator unit.

11. 4000-gallon double wall sub-base diesel fuel tank.

12. Aluminum stairs, platforms and handrails.

F. Provide the services of a manufacturer's representative for delivery, installation, setup, startup testing, and training of the Owner’s personnel.

1.02 RELATED WORK

A. The concrete foundation is included in Division 03.

B. Switchgear is included under Section 26 23 00.

C. Field electric wiring and connections are included under Section 26 05 10.

1.03 SUBMITTALS

A. Submit to the Engineer, in accordance with Section 01 33 23, complete sets of shop drawings and product data, including the following:

1. Shop drawings, catalog cuts, brochures, and other materials required to completely describe the systems and equipment being furnished.

2. Complete assembly drawings with identification, description and dimensions for each separately installed sub-assembly or piece of equipment and associated piping connection schematics.

3. Foundation drawings, indicating size and location of anchor bolts as well as minimum edge distance requirements. Drawings shall be signed and sealed by a Professional Engineer registered in the state of Tennessee.

4. Performance specifications of all items of equipment.

5. Control panel layout drawings showing interior and exterior views, dimensions, paint finish specifications, and component bill of materials.

6. Complete internal electrical, instrumentation, and control wiring diagrams including connections to external systems and equipment.

7. Complete identification of all field wiring connections to external systems and equipment, including numbered terminal strip identification.

8. Complete details of the engine exhaust system including pipe and insulation materials; pipe layout; and the make, model, size, the attenuation curve, and operating back pressure for the silencing equipment as offered to accomplish the specified silencing for this installation.

9. Complete details of the proposed battery charger and starting batteries, including cold cranking amps and Ampere hour rating.

10. Detailed information on the proposed jacket water treatment.

11. Detailed description of the weather protected enclosure, including dimensions, materials of construction, methods of construction and standards, description of all accessories and components, and color selection charts of available colors.

12. Detailed description of the proposed sub-base fuel tank including dimensions, capacity, materials, code rating, locations of fittings and accessories, and complete details of the fuel tank monitoring system.

13. Alternator rating data sheet showing the alternator output rating, efficiency, and temperature rise.

14. Detailed load analysis, utilizing the loads as specified herein, to demonstrate that the proposed unit will start and carry the specified loads.

15. Complete summary of engine efficiency and emissions data including exhaust temperature, flow rate, brake specific fuel consumption, and emissions rates of nitrous oxides, carbon monoxide, and particulates stated in grams/bhp-hr., when operating at rated standby load.

16. Statement of certification of engine emissions in conformance with the applicable EPA Emissions Tier Designation in effect at the time of startup of the equipment on the site.

17. Certification that the torsional mass-elastic analysis specified herein has been performed.

18. Certification of prototype testing of the unit.

19. Four copies of the manufacturer's certified shop test record of the complete engine driven generator unit. The final test record shall show the generator set performance as specified in Paragraphs 1.01.B and 1.06.A, and in accordance with Paragraph 2.11.

20. Draft copies of the warranties for the generator, enclosure, and fuel tank base as specified in Paragraph 1.10.

21. Detailed description of and reasons for any deviations from the specification as written.

B. Use the following format for submitting data for approval:

1. Engine Data:
    a. Manufacturer
    b. Model
    c. Number and arrangement of cylinders
    d. RPM

e. Displacement (in^3)
f. Bore x stroke (in)
g. Maximum power at rated RPM
h. Aspiration
i. Brake Mean Effective Pressure (BMEP) at rated kW (including any parasitic loads and generator efficiency) (psi)
j. Piston speed (fpm)
k. Make and model of governor
l. Make and model of overspeed shutdown device
m. Maximum allowable engine exhaust back pressure (inches H_2O)
n. Engine cold cranking Amps
o. Fuel consumption at 25%, 50%, 75%, and 100% of standby rating (gal/hr.).

2. Alternator Data:
   a. Manufacturer
   b. Model
   c. Rated kVA
   d. Rated kW
   e. Voltage
   f. Rated Amperes
   g. Power factor
   h. Temperature rise above 40 degrees C ambient
      1) Stator by thermometer (degrees C)
      2) Field by resistance (degrees C)
   i. Class of insulation
   j. Alternator efficiency including excitation losses and at 80 percent power factor
      1) Full load (percent)
   k. Subtransient reactance (xd") (per unit) or (Ohms)

3. Guaranteed fuel consumption rate (at alternator terminals at 138,000 BTU/gallon)
   a. Full load (gal/hr.)
   b. Three-quarters load (gal/hr.)
   c. Half load (gal/hr)

4. Generator unit and accessories
   a. Weight of skid-mounted generator set (lbs.)
   b. Weight of complete assembled enclosure including the housing, generator, fuel tank, and silencer (lbs.)
   c. Overall length of generator set (ft.)
   d. Overall length of enclosure base (ft.)
   e. Overall width of generator set (ft.)
   f. Overall width of enclosure base (ft.)
   g. Overall height of generator set (ft.)
   h. Overall height of enclosure (ft.)
   i. Exhaust pipe size (inches)

5. Exhaust gas emission data at standby rating:
   a. Temperature (degrees F)
   b. Flow (ACFM)

c. Carbon Monoxide (CO) (grams/BHP-hr)
d. Nitrogen Oxides (NOx) (grams/BHP-hr)
e. Particulates (grams/BHP-hr)
f. Design EPA Tier Designation

6. Heat rejected to enclosure:
   a. Engine: (BTU/min)
   b. Alternator: (BTU/min)

7. Heat rejected to jacket water including lubricating oil and aftercooler (BTU/min)

8. Height from bottom of skid required for removing piston with connecting rod; (also for removing cylinder liner) (ft)

9. Radiator fan cooling air volume (CFM)

10. Radiator fan static pressure rise (inches H2O)

11. Radiator fan horsepower (hp)

12. Combustion air volume (CFM)

13. Nominal Ampere hour and cold cranking Ampere rating of the engine starting batteries

1.04 REFERENCE STANDARDS

A. Design, manufacture, and assembly of elements of the equipment herein specified shall be in accordance with but not limited to published standards of the following, as applicable:

1. American Gear Manufacturers Association (AGMA)

2. American Institute of Steel Construction (AISC)

3. American Iron and Steel Institute (AISI)

4. American National Standards Institute (ANSI)

5. American Petroleum Institute (API)

6. American Society of Mechanical Engineers (ASME)

7. American Society for Testing Materials (ASTM)

8. American Welding Society (AWS)

9. American Bearing Manufacturers Association (ABMA)

10. British Standards Institution (BS)

11. Canadian Standards Association (CSA)
12. Deutsches Institut Fuer Normung (DIN) (German Institute for Standards)
13. Factory Mutual Engineering and Research Corp. (FM)
14. Institute of Electrical and Electronics Engineers (IEEE)
15. Instrument Society of America (ISA)
16. International Standards Organization (ISO)
17. National Electrical Code (NEC)
18. National Electrical Manufacturers Association (NEMA)
19. National Fire Protection Association (NFPA)
20. Occupational Safety and Health Administration (OSHA)
21. Society of Automotive Engineers (SAE)
22. The Society for Protective Coatings (SSPC)
23. Underwriters Laboratories, Inc. (UL)
24. International Building Code

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. The engine driven generator set shall be the standard product, as modified by these specifications, of a single manufacturer regularly engaged in the production of this type of equipment and having satisfactory experience in supplying units as herein specified. Build the unit from components that have proven compatibility, reliability and are coordinated and prototype tested to operate as a unit. Design, build, deliver, and field test the unit in accordance with the best practices and methods. The manufacturer shall maintain a permanent organization and supply of spare parts within 100 miles of the project site.

B. Design and build the unit in accordance with NFPA 110, Standard for Emergency and Standby Power Systems, Level 2, Type 60; NFPA 37, Standard for Installation and Use of Stationary Combustion Engines and Gas Turbines; and NEC 701, Legally Required Standby Systems, except as modified by these Specifications.

C. Certify engine exhaust emissions in compliance with the applicable EPA Tier Designation Emissions Standards under the provisions of 40 CFR 89, when tested per ISO 8178-D2 Emissions Cycle at specified ekW/bHP rating at the time of onsite installation/commissioning.

D. Should equipment that differs from the equipment described in this Section be offered and determined to be equal to that specified, such equipment shall be acceptable only on the basis that any revisions in the design and/or construction of the structure, piping, appurtenant equipment, electrical work, etc., required to accommodate such a substitution, shall be made at no additional cost to the Owner and be as approved by the Engineer. Modifications required to accommodate product substitutions shall not extend the contract time.

E. Design and build the generator unit for standby service at all points within the specified range of operation, without overheating or excessive vibration or strain. The generator shall require only that degree of maintenance generally accepted as applicable to the specific type of equipment. Design and build all parts for interchangeability so that replacement parts may be installed without additional fitting or machining.

F. Components of mechanical and electrical equipment shall be the products of manufacturers who can produce evidence of their ability to promptly furnish interchangeable replacement parts as may be needed at any time within the expected life of the equipment.

G. The manufacturer shall have testing facilities adequate for performing the shop tests and inspections specified herein. Submit a description of the manufacturer's testing facilities. The descriptive matter shall contain illustrative photographs, drawings and such other matter as may be requested.

H. Services of Manufacturer's Representative:

1. Provide services of factory trained service technicians, specifically trained on the type of equipment specified. Submit qualifications of service technicians for approval. Man-day requirements listed are exclusive of travel time and do not relieve the Contractor of the obligation to provide sufficient service to place equipment in satisfactory operation.

2. Installation: to assist in location of anchor bolts; setting, leveling and alignment; coordination of electrical and signal connections: one person-day.

3. Startup, testing and calibration (vendor furnished equipment only): one person-day.

4. Operation and maintenance instruction: one person-day.

1.06 UNIT PERFORMANCE

A. The facility load consists of a total running load of up to 1563 kVA, 1250 kW.

1. Provide an oversized alternator or enhanced voltage regulator as required to account for the harmonics from the non-linear loads and motor starting loads. Design the generator set and all of its components to provide stable operation under all operating conditions that the plant load may impose.

B. Under steady load conditions, from zero load to full-rated load, voltage regulation shall be within plus or minus one half percent, and frequency regulation shall be within plus or

minus 0.25 percent (0.15 Hz). Upon application or removal of full- rated load (resistive) in one step, the transient voltage dip or overshoot shall not exceed 20 percent of rated voltage and recovery to steady state operation shall be within 10 seconds.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Ship equipment, material and spare parts complete except where partial disassembly is required by transportation regulations or for protection of components.

B. Pack spare parts in containers bearing labels clearly designating contents and pieces of equipment for which intended.

C. All mechanical and electrical equipment shall be coated, wrapped and otherwise protected from snow, rain, drippings of any sort, dust, dirt, mud, flood and condensed water vapor during shipment and while installed in place during construction. The protective coverings shall remain in place until the work areas are substantially free of all construction dust and debris. Full details of proposed protective measures shall be submitted for approval to the Engineer prior to shipment. Alternator space heater shall be energized at all times during storage.

D. Pack and crate all equipment for shipment and provide treatment for long periods of storage before use in a temperate climate.

1.08 PROJECT/SITE REQUIREMENTS

A. House the complete generator unit for outdoor operation and include all items and equipment required for unattended automatic operation, including a sub base fuel storage tank. Arrange the unit for positive and successful quick starting at a minus 10 degrees F ambient temperature.

B. Factory assemble the complete generator unit with enclosure, sub base fuel storage tank and all accessories as specified herein, ready for installation on a concrete foundation with available connections for electric service. The unit shall not require field assembly.

C. Install the generator unit within a sound attenuated, weatherproof enclosure for outdoor mounting above a sub-base fuel storage tank. The enclosure shall have adequate provision for ventilation to limit the maximum summertime temperature within the enclosure to the maximum allowable operating temperature of the equipment, considering full load engine/alternator heat rejection and 104 degrees F outdoor ambient. All equipment furnished under this Section and intended for installation within the generator enclosure shall be designed for operation in an ambient temperature of 104 degrees F plus the temperature rise that will occur within the enclosure either during generator operation, or when the generator is on standby. The altitude at the project site will not be in excess of 1000 feet above sea level.

D. The heat sink for rejection of heat from the engine jacket, aftercooler, and lube oil cooler shall be a unit mounted radiator utilizing an engine mounted and engine driven fan to discharge air through the radiator and through a louver to outdoors. Design the radiator and engine fan to dissipate all required heat loads with the generator running at full rated

output and with 104 degree F ambient outdoor air. No other source of cooling is available or will be permitted.

E. Provide electric resistance heaters for the engine jacket, starting batteries, and alternator to maintain warmth within the equipment as an aid to starting, to minimize warm-up time, and reduce condensation within the equipment.

F. Design all structure, supports, and anchors for the generator unit for all gravity loads, dynamic loads, wind and and seismic forces.

1.09 MAINTENANCE

A. In accordance with Section 01 78 23, furnish to the Engineer four complete sets of operating and maintenance instructions covering all equipment furnished under this Section. The instructions shall be prepared specifically for this installation and shall include all required cuts, drawings, equipment lists, descriptions, etc., that are required to instruct operating and maintenance personnel unfamiliar with such equipment. Include parts lists and parts prices current to the date of submittal, and information relevant to parts supply and ordering. Furnish this information in time for review and approval prior to startup and site testing of the unit.

1.10 WARRANTY

A. Furnish a five-year comprehensive warranty from the equipment supplier(s), written to the Owner, for the generator and enclosure. The warranties shall extend from the date of acceptance of the equipment and shall include all parts, labor, and transportation for correcting/replacing any manufacturing defects in components of the equipment as furnished.

1. Base the warranty for the generator upon standby use for up to 300 hours per year of operation.

2. The warranty for the enclosure shall be for manufacturing defects.

B. Submit draft statements of warranty to the Engineer as part of the submittals package for the generator and enclosure.

PART 2 PRODUCTS

2.01 GENERAL

A. The engine driven generator set shall be a factory assembled unit, specifically designed and equipped for operation on No.2 diesel fuel oil and shall be as manufactured by Cummins, Caterpillar, Kohler, or Generac. The engine and alternator shall be directly connected with a semi-flexible steel coupling, shall be free from injurious torsional or other vibration and shall be mounted on a heavy steel sub-base. Units offered at ratings in excess of their published ratings are not acceptable and will not be approved.

B. The unit shall operate at a rotative speed of not more than 1800 rpm. The engine and alternator shall be directly connected and shall operate at the same rotative speed. The

use of gearing or other speed adjustment between the engine and the alternator, such that the engine and alternator operate at different rotative speeds will not be allowed.

C. The generator set shall be pre-piped and pre-wired. Provide separate pre-wired terminal boxes on the generator skid for A.C. and D.C. wiring. All wiring terminations for connection to field wiring shall be within terminal boxes with numbered terminal strips.

D. The generator set shall be rigid, neat in appearance and shall allow easy access to all parts for maintenance purposes. Enclose all parts to prevent the throwing or dripping of oil.

E. The complete generator unit shall be free from harmful torsional or other vibration throughout the entire operating load range. The generator manufacturer shall make, or have made, the mass-elastic system analysis of the complete engine-alternator unit. Submit a certification statement that the analysis has been performed, and no harmful vibration will occur during normal operation at any loading condition.

2.02 ENGINE

A. The diesel engine shall operate on ultra-low sulfur No. 2 diesel fuel (ASTM D975). A diesel engine requiring a premium fuel will not be considered. The engine shall be four stroke cycle, turbo-charged with separate circuit aftercooler, full compression ignition. The engine shall develop its full power output rating including alternator output, alternator efficiency, radiator fan power, and other miscellaneous parasitic loads at a brake mean effective pressure (BMEP) not to exceed 340 psi. The piston speed shall not exceed 2025 FPM.

B. The rating of the engine shall not exceed the manufacturer’s published standby rating. The gross engine horsepower required to produce the standby rating shall not exceed the manufacturer’s published continuous duty rating by more than 130 percent. Continuous duty rating shall be as defined in BS649 or DIN 6270 but in no case shall it exceed the manufacturer’s published continuous duty rating. The gross engine horsepower required for the generator set standby rating described above shall include all parasitic demands such as alternator inefficiencies, fan, fuel pumps, water pumps, and all accessories necessary to the unit’s proper operation while operating at rated load.

C. The engine shall incorporate individual electronically controlled unit injectors for each cylinder, which combine the electronic actuator, pump assembly, and nozzle into a single unit, to provide precise metering and timing of fuel delivery into each cylinder.

D. Design the engine and electronic injection control system to limit the exhaust emissions of the engine. Engine exhaust emissions shall be certified in compliance with the applicable EPA Tier Designation emissions standards per ISO 8178-D2 Emissions Cycle at specified ekW/bHP rating without further exhaust emissions control measures external to the engine.

E. The engine shall have removable wet-type cylinder liners of close grained alloy steel, heat treated for proper hardness as required for maximum cylinder life. The engine block shall be a one piece stress relieved gray iron casting.

2.03 EQUIPMENT

A. Governor:

1. Control of engine speed shall be through electronic control of the individual unit injectors in response to engine speed, load, and engine operating parameters. Locate the electronic governor in the generator control panel, powered by 24 Volts DC from the engine starting batteries. House the governor in an environmentally sealed module that obtains engine operating information from sensors mounted on the engine. The control shall be adjustable and programmable through service software. The control shall provide for isochronous regulation from no load to full rated load within 0.25 percent of rated frequency. The control shall provide control to the unit injectors for fuel injection timing and limiting, idle/rated speed setting, programmable speed acceleration ramp rate, and adjustable cool down duration.

2. Furnish also a separate overspeed shutdown device that shall, in case of predetermined overspeed or the operation of various protective devices as later specified, instantly stop the engine without the fuel injection system losing its prime.

B. Supporting Structure:

1. Mount the diesel engine, radiator, and alternator on a rigid, welded, fabricated steel base, sized to maintain the correct alignment of all system components. The base shall extend under the entire length of the engine, alternator, and radiator, and shall fully support each outboard end of the engine-alternator assembly. Fabricate the base of steel I-beam or box section, braced and reinforced as required to maintain alignment between the engine and the alternator. Mount the engine-alternator assembly on the base utilizing rubber pad type vibration isolators and felt washers. Mount the engine radiator and battery support separately on the base, independent of the engine-alternator assembly. The complete generator unit shall be free from harmful torsional or other vibration.

2. Shop prime and finish paint all exposed surfaces of the structural steel members of the fabricated base frame in accordance with the manufacturer’s standard practice.

3. Design the engine-alternator mountings and supports and anchor bolts to support the equipment gravity loads, dynamic loads, wind and seismic forces and shall conform to applicable requirements of the International Building Code. Anchor bolts to be furnished by Contractor.

2.04 SYSTEMS

A. Fuel System:

1. Subbase-Mounted, Double-Wall, Fuel-Oil Tank: Factory installed and piped, UL 2085 listed above ground vaulted double-wall in-base rectangular fuel-oil tank. Features include the following:
   a. Tank level indicator.
   b. Fuel-Tank Capacity: 4000 gallons Minimum

c. Leak detection in interstitial space.
d. Vandal-resistant fill cap.
e. Containment Provisions: Comply with requirements of authorities having jurisdiction.

2. All fuel piping within the enclosure shall be black steel, ASTM A53, and of a size recommended by the engine manufacturer.

3. All parts of the fuel system shall be installed in full compliance with OSHA Standard 1910.106 and shall meet the approval of and be installed in accordance with all applicable State and Federal codes, laws and regulations.

B. Electric (Battery) Starting System:

1. Provide one engine-mounted, solenoid shift electric starter, capable of withstanding four consecutive continuous cranking periods of 15 seconds' duration each separated by 15-second rest periods before shutting down completely and sounding the overcrank alarm.

2. The starting battery(ies) shall be low maintenance, permanently sealed, long life, lead acid type, especially designed for diesel engine cranking service. The batteries shall be of a capacity as recommended by the battery manufacturer for cranking the engine being furnished, for the necessary break-away current, cold cranking Amperes, Ampere hour capacity, and the spinning current for four consecutive starts of 15 seconds of cranking on each start, or for 60 seconds of continuous cranking without being recharged, with a battery temperature of 45 degrees F and with the SAE 30 oil in the engine maintained at 60 degrees F. The batteries shall be manufactured by Delco; Exide; or equal.

3. Furnish a floor-mounted containment type, insulated fiberglass battery box with insulated battery covers specifically designed for battery service. Design the battery box, supports, and anchors for gravity loads and seismic forces in accordance with the applicable requirements of the International Building Code. Furnish and install the required battery cables with insulated terminals and connectors for connecting the batteries to the electric starter. Furnish all connectors and hardware, cables, grease, and battery lifting device. All battery post connectors shall be insulated.

4. Furnish a completely automatic battery charger for charging the engine starting battery. The charger shall be UL 1236 listed, fully automatic, electronically controlled, solid state, temperature compensating, float/equalize-type, designed for maximum battery service life with minimum battery maintenance. Charger shall be for 120 Volt, single phase, 60 Hertz alternating current input, with a D.C. output capacity of not less than 10 Amperes. Voltage regulation shall be within one percent with plus or minus ten percent fluctuations of the input voltage and shall be current limited at 120 percent of rated output. Accessories shall include a direct current voltmeter and ammeter (panel type, two percent accuracy), float and equalize controls and indicating light, fused A.C. and D.C. circuits, and A.C. power indicating light. Furnish alarms including A.C. power failure, high D.C. voltage, and low D.C. voltage. Alarm conditions shall have individual indicator lights on the face of the charger panel and shall operate a relay for common alarm to the generator

control panel. The unit shall have automatic voltage sensing determined by the state of the battery and reducing to milliamp current on fully charged battery. The charger shall be as supplied by LaMarche, Nife, Sens, or equal, and for the correct voltage for the battery. Arrange the charger for wall mounting inside the enclosure. The battery charger shall be arranged for hard wire connection for power supply. The battery charger shall provide control power to the generator control panel when the generator is not running with correct voltage and current output to provide proper battery charge rate for maximum battery life and control panel power requirements.

5. Provide an engine driven automatic battery charging alternator with transistorized voltage regulator for power supply to the control panel and engine auxiliaries and to charge the starting batteries when the engine is running.

C. Air Intake System:

1. Provide dry type combustion air intake filter(s) on the engine to protect working parts of the engine from dirt and grit. Filter(s) shall be heavy duty, two-stage with replaceable type filter elements and service indicators.

D. D. Lubrication System:

1. Provide a full pressure lubricating oil system arranged to lubricate and cool the pistons and to distribute oil to all moving parts of the engine including the turbocharger bearings. The lubrication system shall include full flow filters of the replaceable element type easily accessible for removal and replacement. Provide a spring loaded bypass valve on the filters as an insurance against stopping of lubricating oil circulation in the event the filters become clogged. Provide a shell and tube type oil cooler and a thermostat controlled automatic temperature regulator. Provide an engine driven positive displacement type lubricating oil circulating pump of capacity to circulate the amount of oil required by the engine and turbocharger lubrication and cooling. Provide a sump type crankcase arrangement of sufficient capacity to suit the requirements of the engine. Provide a drain valve inside the enclosure and pipe the drain to the outside of the enclosure for easy access when draining the engine oil.

2. Locate the oil filters on the engine to provide easy access for removal, to minimize spillage of oil during filter changes, and to provide for easy clean-up of spilled oil.

3. Provide a coalescing type closed crankcase ventilation filtration system with crankcase emission control filter and crankcase pressure regulator to control crankcase emissions. Collect filtered contaminants in a reservoir or drain back to the crankcase. Pipe the filtered crankcase exhaust gases to the induction air inlet.

4. All drains and vents shall be ASTM A53 Schedule 40 black steel pipe and threaded fittings. Provide flexible connectors at all connections of off-skid piping to the engine.

E. Radiator Cooling System:

1. The engine shall be radiator cooled utilizing a unit mounted radiator and engine driven fan. The fan and radiator shall be adequate for cooling the unit at full rated load with an outdoor ambient temperature of 104 degrees F, and with the temperature rise inside the enclosure corresponding to the heat given off by the alternator and equipment hot surfaces. A pressurized radiator cap, if used, shall be rated for not more than 6 psi on the cooling system. The radiator shall incorporate flanges for attachment to the exhaust damper. The engine shall utilize two cooling circuits, one for the jacket water and oil cooler, and the second for the aftercooler, which shall connect to separate core segments of the unit mounted radiator. Alternatively, an air-to-air heat exchanger may be located in front of the engine driven fan to serve the aftercooler. The separate cooling circuits shall allow the aftercooler circuit to be cooled sufficiently for control of engine emissions. Provide a low coolant level switch in the radiator top tank for the jacket water circuit, wired to the low coolant alarm on the generator control panel.

2. A blower or pusher type fan mechanically driven by the engine shall cool the radiator. The fan shall provide a static pressure rise of not less than 0.5 inch of water in addition to the losses through the radiator, to move the required air flow through the intake louver and damper, discharge plenum and louver to provide the cooling required by the unit. Provide guards for fan and belts in accordance with OSHA regulations and UL 2200.

3. Furnish an engine driven centrifugal jacket water pump and an auxiliary aftercooler water pump (if required), equipped with mechanical seals and capable of circulating the required amounts of coolant through the engine jacket, oil cooler, aftercooler and radiator circuits and circuit piping. The pump(s) shall be direct driven by the engine, or the auxiliary water pump may be belt driven from the engine crank shaft extension. Provide for belt tensioning and alignment, and guards in accordance with OSHA. Provide automatic temperature regulating valves for the coolant circuits to maintain a pre-set temperature without restricting the rates of flow through the engine.

4. Coolant shall be for use in ambient temperatures that may range from minus 10 to 104 degrees F, and shall be a pre-mixed 50 percent ethylene glycol antifreeze solution in accordance with ASTM D-6210, especially formulated for extended life. The coolant shall contain additives as recommended by the engine manufacturer for the prevention of both scale formation and corrosion in the engine water jackets and cooling system components that are in contact with the engine coolant. Coolant with additives shall be as manufactured by the NALCO Chemical Company; Dow Chemical; Aqua Laboratory, or equal. Submit detailed information on the proposed jacket water treatment to the Engineer.

5. Provide thermostatically controlled heater for the engine jacket water system to maintain not less than 90 degrees F in the engine jacket water to assure quick start and load transfer with an ambient temperature of minus 10 degrees F. The heater shall include valves on the coolant inlet and outlet connections, or other means to isolate the heater for servicing of the heating elements, without the need to drain the engine cooling system. Design the heater for a 208 Volt, single-phase

power supply. Heater shall have a total rating of not less than 1500 Watts at 208 Volts.

6. Provide a valved drain on the cooling system, piped to the exterior of the enclosure for easy access to drain the cooling system. Drain shall be with Schedule 40 black steel pipe and threaded fittings. Provide flexible connectors at the connection of off-skid piping to the engine.

F. Exhaust System:

1. The exhaust silencer shall be as manufactured by Maxim; Donaldson; Nelson, or equal, of aluminized steel construction, and mounted and piped inside the enclosure. The silencer shall be of at least critical grade. There shall be no puretone. The engine supplier shall size the silencer to operate within the maximum allowable backpressure of the engine, when installed in the exhaust piping system as furnished.

2. Furnish a stainless steel bellows type expansion joint as recommended by the engine manufacturer to connect the exhaust silencer to the engine. The flexible connection shall adapt to the engine exhaust outlet connection and provide a flanged connection to the silencer. The connector shall be of Type 321 stainless steel and designed for an operating temperature of 1200 degrees F.

3. Interior exhaust pipe shall be ASTM A106, Schedule 40 black steel with flanged and welded fittings. Exhaust pipe shall be of the size recommended by the engine manufacturer. All exhaust line elbows shall be long radius. Paint the exhaust pipe with high temperature paint for corrosion resistance.

4. The roof penetration through the enclosure shall be with an insulated Type 321 stainless steel or aluminum roof jack designed to accommodate the specified exhaust pipe and allow a minimum 1-inch air gap between the exhaust pipe and the roof thimble. There shall be no heat conduction path between the exhaust pipe and the roof. The roof thimble shall project above the finished roof and shall include Type 321 stainless steel or aluminum exterior rain hood and flashing. Roof jack shall be as manufactured by GT Exhaust Systems or equal. The open space between the exhaust pipe and the roof jack shall allow for ventilation and shall include screening or mesh to prevent the entrance of insects.

5. The exhaust pipe extension above the rain hood shall be of Type 321 stainless steel. Terminate the exhaust pipe vertically with a Type 321 stainless steel counterbalanced rain cap with bronze bushings equal to Rain Fighter Systems Inc.; GT Exhaust Systems, or equal.

6. Furnish and install all required steel support framing and hanger bands for supporting the silencer and exhaust pipe from the roof of the enclosure.

2.05 ENGINE INSTRUMENTATION AND CONTROLS

A. The generator set shall include a combination engine-alternator monitoring/control panel, shock mounted at the alternator end of the unit, oriented to be easily viewed through the

open enclosure doors. The control panel shall be all electronic type, with digital displays visible in any lighting condition. House the control panel in a NEMA-1 enclosure designed for unit mounting. Provide all interconnecting wiring between the engine-alternator set and the control panel. Construction of the panel shall conform to UL 508 for control panels. Direct communication with the control panel shall be with an environmentally sealed membrane keypad. If the control panel adjustment and diagnostics are accomplished through the use of an interconnection to a PC, furnish with the generator all software, instructions, and interconnecting cables required for PC communication with the control panel.

1. The panel shall include, but not be limited to, the following indications displayed on a two-line alpha-numeric digital display:
   a. Lubricating oil pressure
   b. Jacket water temperature
   c. Engine speed (rpm)
   d. A.C. Volts, 0.5 percent accuracy
   e. A.C. Amperes, 0.5 percent accuracy
   f. Frequency, 0.5 percent accuracy
   g. Output power (kW and kVA) (total and per phase)
   h. Power factor
   i. Elapsed time meter calibrated in hours and tenths of hours
   j. DC Volts
   k. Diagnostics for servicing
   l. Emergency shutdown condition indication lamps for each shutdown condition with logic to maintain lockout condition and fault light until reset

2. Operators on the panel shall include:
   a. RUN-STOP-AUTO pushbuttons
   b. Control panel menu navigation pushbuttons
   c. Emergency stop mushroom type pushbutton
   d. Phase selector switch
   e. Voltage control
   f. Lamp test pushbutton
   g. Alarm reset pushbutton

3. The panel shall also include:
   a. Alternator voltage regulator
   b. Governor/engine control module

B. The control panel shall include a complete automatic engine start control that operates on closing contact and stop control that operates on opening contact.

1. The engine control module shall provide for cyclic cranking for a total of at least four 15-second cranking periods separated by 15-second rest periods. If the engine fails to start after the last cranking cycle, the cranking limiter shall terminate further cranking and activate the overcrank alarm.

2. The control panel shall include a three-position selector switch with the following selections: RUN-STOP-AUTO. In RUN, the engine shall start and run with load transfer controlled from a remote location; in STOP, the engine shall stop and shall not start; in AUTO, the engine shall start, run and stop from remote signals and

with load transfer controlled by the automatic transfer PLC located in the switchgear provided under Division 26 when the unit attains rated voltage and frequency.

3. The generator controls shall include an automatic cool-down timer, to allow the engine to continue to operate after load transfer back to the normal power supply, to cool down prior to automatic shutdown. The timer shall be adjustable from 0 to 10 minutes and shall be engaged when the selector switch is in the AUTO position.

4. Should any of the protective sensors on the generator activate, the engine control shall immediately shut down the engine.

C. The control panel shall include an emergency stop pushbutton. Arrange the controls to accept operation of a remote contact to provide for emergency stop. Emergency stop shall over-ride all other controls to immediately shut off the fuel supply and stop the engine.

D. Provide automatic shutdowns with fault indication for the following conditions:

1. High coolant temperature

2. Low lubricating oil pressure

3. Engine overspeed

4. Overcrank

5. Fail to crank

6. Over/Under voltage

7. Over/Under Frequency

8. Emergency stop

9. Low coolant level

E. Provide automatic pre-alarms for the following conditions with fault indication for each:

1. Low coolant temperature

2. Low oil pressure (pre-warn)

3. High coolant temperature (pre-warn)

4. Switch not in AUTO position

5. High/low battery voltage

6. Battery charger fault

7. Generator circuit breaker tripped

F. The control panel shall include an audible alarm horn to signal any of the alarm shutdown or pre-alarm conditions. Alarms shall not reset and the alarm horn shall not shut off until manually acknowledged, and fault lights shall not reset until the fault is resolved. Provide lamp test pushbutton and alarm acknowledge pushbutton.

G. The control panel shall accept remote dry contact closure for battery charger common alarm, generator circuit breaker tripped, and fuel tank alarm, and shall display each corresponding alarm condition as an individual labeled alarm on the alarm panel.

H. The control panel shall include one normally open and one normally closed electrical relay contact, rated 120 Volts, 10 Amps, for operation of a remote alarm on activation of any one or more of the pre-alarm conditions listed above, and shall include one normally open and one normally closed electrical relay contact, rated 120 Volts, 10 Amps, for operation of a remote alarm on activation of any one or more of the shutdown conditions listed above.

I. The control panel shall include three normally open and three normally closed electrical relay contacts, rated 120 Volts, 10 Amps, A.C., for operation of combustion air and ventilation air dampers within the generator enclosure upon activation of the starting sequence of the engine, and to provide a generator run signal to the automatic transfer PLC in the main switchgear and to the instrumentation system.

J. The controls shall incorporate a means to positively disable and lock out the generator from starting during maintenance. This provision shall take the form of a battery disconnect switch, a disconnect switch on the battery cable to the starter, and stop switch on the control panel, or a switch on the starter solenoid power supply, any one of which equipped with provision for placing a lock-out/tag-out.

K. The generator control panel shall accept the following field wiring connections. Provide numbered terminal strip connections for each:

1. Remote start-stop dry contact closure input from the automatic transfer PLC in the switchgear provided under Division 26 – battery voltage pair.

2. Battery charger failure dry contact closure input from the battery charger common alarm contact – battery voltage pair.

3. Generator circuit breaker tripped, dry contact closure input from the generator circuit breaker – battery voltage pair.

4. Engine run – three dry contact open/close outputs for remote connection – three 120 Volt pairs.

5. Generator shutdown alarm – dry contact open/close output for remote connection – 120 Volt pair.

6. Generator trouble alarm – dry contact open/close output for remote connection – 120 Volt pair.

7. Remote generator trouble/shutdown alarm – battery voltage output to remote audible alarm unit.

8. Remote emergency stop.

9. Shutdown Alarms (Red)
   a. Overcrank
   b. High engine temperature
   c. Low oil pressure
   d. Overspeed
   e. Emergency Stop
   f. Low coolant level
   g. Not-in-Auto

10. Pre-Alarms (Yellow)
   a. High coolant temperature (pre-warn)
   b. Low oil pressure (pre-warn)
   c. Low coolant temperature
   d. Low battery voltage
   e. High battery voltage

11. Status
   a. System ready
   b. Generator running
   c. Generator supplying load
   d. Communications Status

2.06 ALTERNATOR AND EXCITATION SYSTEM

A. The alternator shall be of the open drip-proof bracket type, especially designed for connection to the engine and shall be for the voltage, frequency, and power output as specified in Paragraphs 1.01 and 1.06, designed to start and operate the loads specified in Paragraph 1.06. The alternator shall be brushless with a rotating permanent magnet generator type excitation system with Class H insulation and temperature rise not to exceed 105 degrees C. The alternator shall have Amortiser windings.

B. The alternator shall be by Cummins; Newage; Kato; Marathon Electric Company, or equal. It shall have a forged or cast alloy steel flanged shaft for direct connection through a flywheel type coupling to the engine, or shall have an adapter and disc coupling, and shall be of the single bearing type with anti-friction bearing.

C. Brace the alternator windings to withstand any possible short circuit stresses. The windings shall withstand overheating or stresses caused by harmonics generated by the variable frequency drives. The unit shall be "Radio Interference Proof" (RIP) and the "Telephone Influence Factor" (TIF) shall be within the limits of Section 9, ANSI C50.12.

D. The voltage regulator shall be three-phase solid state digital (Volts/Hz) with RFI filters and associated controls. The voltage regulator shall provide regulation within 0.5 percent no load to full load, with temperature drift of not more than 0.5 percent. The regulator shall provide true three-phase sensing and shall maintain precise control of the alternator

output with up to 20 percent harmonic distortion in the output voltage. A voltage control shall provide a minimum of plus or minus 5 percent voltage adjustment from rated voltage. Include the voltage control in the control panel for easy manual voltage adjustment while the unit is running.

E. The alternator stator core shall be 2/3 pitch, built of low carbon steel laminations, precision punched, de-burred and individually insulated. Stator coils shall be inserted in insulated core slots. Wound core shall be vacuum impregnated with fungus resistant thermosetting synthetic varnish and baked for maximum moisture resistance, high dielectric strength and high bonding qualities. Armature lamination followers and frame ribs shall be welded integral with frame. Enclosure shall be drip-proof guarded and shall include rodent screens.

F. Alternator rotor poles shall be built up of individually insulated steel punchings. Poles shall be wound and bonded with high strength varnish, then baked. Cage connections shall be brazed for strong construction and permanent electrical characteristics. Each pole shall be securely bolted to the rotor shaft.

G. Provide a directional blower to draw cooling air from the exciter end, over the rotor poles and through louvered openings in the drive end.

H. The alternator shall have a permanently lubricated anti-friction bearing. The designed bearing life, based on the B-10 curve of the American Bearing Manufacturers Association, shall be not less than 40,000 hours.

I. Provide an automatic thermostatically controlled space heater rated 120 Volt, single-phase power supply to maintain not less than 90 degrees F (32 degrees C) temperature within the alternator enclosure with an outdoor ambient temperature of minus 10 degrees F to prevent the accumulation of condensation within the alternator enclosure under outdoor ambient temperature and humidity conditions. Provide a separate manual switch to disconnect the heater when not required. Terminate the heater connection wiring in a junction box. Wiring and conduit by generator supplier.

J. At any balanced load between 75 and 100 percent rated output, the difference in line-to-neutral voltage among the three phases shall not exceed one percent of the average line-to-neutral voltage. Under an unbalanced load, consisting of 25 percent load at 1.0 power factor placed between any phase and neutral and zero load on each of the other two phases, the maximum simultaneous difference in voltage between the three line-to-neutral phases shall not exceed three percent of rated line to neutral voltage.

2.07 GENERATOR CIRCUIT BREAKER

A. Furnish one molded case, three-pole, LSIG adjustable electronic trip circuit breaker for three-phase overloads and/or short-circuit protection for the generator. Current ratings shall be as required to protect the generator unit from overload or short circuit and shall be as shown on the Electrical Drawings. The circuit breaker shall operate both manually for normal switching functions and automatically during overload and short-circuit conditions. Circuit breaker shall be UL listed and rated per NEC requirements to carry the full ampere load of the generator and shall be rated at 100%. The circuit breaker

shall include contacts wired to the generator control panel to provide alarm if the breaker is in the “Tripped” or “Off” position.

B. The circuit breaker shall meet standards established by Underwriters Laboratories.

C. Mount the circuit breaker in a NEMA 1 housing attached to the alternator terminal box and located for easy access.

2.08 SOUNDPROOF/WEATHERPROOF HOUSING

A. Enclose the skid-mounted generator unit, engine starting batteries, battery charger, generator control panel, lighting panel, and exhaust silencer in a weather proof skin-tight type enclosure designed to meet the conditions set forth below. The enclosure shall comply with the National Electrical Code (NEC) and the National Fire Protection Association (NFPA) for clearance around electrical equipment as specified. The enclosure shall conform to the following design criteria:

1. Wind, snow and seismic requirements outlined on drawing S-1 as required by the International Building Code.

2. Roof load equal to 20 lbs per ft^2.

B. The enclosure shall have an interior width as required to provide minimum clearances on the sides and end of the generator set. The enclosure shall provide for continuous, unobstructed access on the two sides of the unit. The dimensions of the enclosure shall be such as to provide space for and NEC clearances of the generator set, the generator circuit breaker, and the generator control panel.

C. Provide at least two enclosed and gasketed 120 Volt LED light fixtures suitable for wet environment, operated by separate three-way switches located at main access doors to illuminate enclosure interior.

D. Provide one duplex 120 Volt grounded, ground fault protected convenience outlet adjacent to load center.

E. The enclosure shall be of lift-off design, consisting of a roof, walls, and louvers of aluminum panels, either frameless, one-piece semi-monocoque, or frame supported construction and intake/exhaust hoods/plenums designed to reduce source noise sufficiently that the entire installation shall conform to the noise limitations specified herein. All framing members shall be 6063-T6 aluminum, or welded steel. Skin material shall be minimum thickness of 0.040-inch aluminum. Walls may be pre-painted aluminum sheet with mill finish roof, or walls and roof shall be of frameless aluminum painted after assembly. A minimum of six colors shall be available for enclosure exterior. Exposed fasteners for skin panels shall be hand riveted to the framing members on 3-inch centers maximum. Pop rivets and bolts shall not be acceptable exposed fasteners to attach the exterior skin to the framing. Non-exposed fasteners shall be stainless steel self-tapping screws or welded. Camber the roof to aid in rain runoff.

F. Insulation in the walls and roof shall be semi-rigid, thermo-acoustic, thickness as required to meet the noise criteria specified. Lining shall be perforated, mill-finish aluminum. All joints and cut-outs of the aluminum lining shall have trim strips or other

provision to avoid sharp edges. Self-adhesive foam and loose or bat-type insulating materials shall not be acceptable.

G. The floor and underframe shall consist of two wide flange “I” beam or channel longitudinal skids, with fabricated steel crossmembers on 16-inch centers. Overlay cross members with 1/8-inch-thick steel plate firmly welded to the crossmembers to provide a solid floor. A 3/4-inch pressure treated wood subfloor may be used between the crossmembers and the steel deck for isolation of the engine/generator and base assembly. Provide steel tapping plates coordinated with the generator set manufacturer, for anchoring the equipment within the enclosure. Provide floor openings for electric conduit stub-up where required for best conduit wiring access to the equipment within the enclosure. The floor shall incorporate a diked perimeter to form a containment area for spilled fluids such as coolant, fuel, or lubricating oil. The diked volume shall be at least 150 percent of the greatest fluid volume contained within the engine. The dike shall have steel edges welded and/or caulked to the floor. The conduit stub-up and any other floor penetrations shall be diked. The diked area may form the containment within itself, or it may slope and drain to a storage volume. All portions of the diked area shall be accessible for cleaning without removing covers or floor plates.

H. Provide four-point lifting lugs at or near the corners of the enclosure base, with capacity for rigging the entire assembly. Quality assurance procedures of the manufacturer shall include regular testing of the lifting lugs. Design the enclosure base and attachment to the concrete support pad to support the enclosure gravity loads, dynamic loads, wind and seismic forces. Provide two electrical grounding lugs mounted on the base for connection of the grounding system furnished under Division 26.

I. Provide access doors on each side of the enclosure of sufficient quantity and opening to provide full access to each side of the generator set for maintenance and NEC required access and clearances to the generator circuit breaker. Doors shall consist of a steel frame with skin material matching the enclosure. Doors shall be fully gasketed to form a weathertight perimeter seal. Hinges shall be forged aluminum or stainless steel with stainless steel pins. Handle shall be stainless steel and padlockable. Doors shall have a full 180-degree swing to rotate out of the way during access to the enclosure. Provide a stainless steel hold-open latch on each door.

J. Provide access platforms and stairs to the access doors on each side of the generator enclosure to allow servicing access to all generator components. Access stairs and platforms shall be in compliance with OSHA requirements and meet the requirements of Division 5.

K. Air handling during operation of the generator set shall be as follows: Air shall enter the enclosure through a sound louver. Provide a motor operated damper on the intake louver, wired through the generator control panel to open upon engine startup. Radiator discharge shall be through a gravity operated damper and louver. The system shall not exceed 0.5-inch w.g. total external static pressure to ensure adequate airflow for cooling and combustion. Both the intake and discharge louvers shall be of formed and extruded aluminum and shall be screened with stainless steel screen. Motor-operated and gravity dampers shall be of formed and extruded aluminum. Damper motor operators shall be arranged for a 120 Volt, 60 Hz, single-phase power supply, spring to open, power to close. Wire the damper control through the generator run contact. Terminate the power

supply wiring in a junction box for field connection of power supply as part of the work of Division 26. Utilize the alternator space heater circuit.

L. The enclosure shall include all necessary hardware to internally mount the specified exhaust silencer and maintain the weatherproof integrity of the system.

M. All openings in the enclosure shall be screened, baffled, or otherwise closed to prevent the entrance of insects and rodents.

N. The housing shall have signs on all four sides of the enclosure reading "Danger-High Voltage."

O. The exterior of the enclosure shall receive the manufacturer's standard exterior paint of color as selected by the Engineer from the manufacturer's standard color chart. Furnish one quart of touch-up paint.

P. It is the intent of this specification to provide complete compliance with all applicable codes, laws and regulations.

Q. The enclosure, the stairs and the platforms shall be certified by a Professional Engineer (P. E.) licensed in the state of Tennessee, to be designed and constructed to meet the Structural design criterial listed on Sheet S-1.

R. The enclosure and all appurtenances as specified herein shall be as manufactured by Pritchard Brown Division of Enviro-Industries, Inc. Baltimore, MD; Acoustic Sheet Metal, Norfolk, VA; DTS Inc., Sioux Falls, SD; or approved equal.

2.09 GENERATOR ACCESS PLATFORM

A. Provide pre-fabricated access stairs and platforms for access to generator enclosure entrance doors and fuel fill connection.

1. Stairs and platforms of aluminum construction.

2. Comply with OSHA Standard for “Fixed industrial Stairs”, 29 CFR 1910.24

3. Include grating, plates, beams, columns, posts, bracing, struts, hangers, stairs, handrails, guardrails, toeboards, connections, brackets base plates, anchorage to foundation and all other appurtenances required for a complete code-compliant platform system for equipment access.

4. Designed to safely carry uniform load of 100 pounds per square foot and non-concurrent moving concentrated load of 1,000 pounds.

5. See drawing S-RO-19 for additional minimum requirements.

B. Shop assembled components welded or bolted. Field assembled components bolted only. Field welding not permitted.

1. Welding to comply with ANSI/AWS D1.2 Gas Metal Arc Welding.

2. Welding performed by experienced qualified welders

3. Grating clamps, nuts, bolts, washers, and other fastening devices of Type 316 stainless steel.

C. Stair stringers, platforms, legs, and bracing to be 6061-T6, 6063-T6, or 6005-TS aluminum alloy conforming to ASTM B429.

D. Stair treads and platform walkway surfaces to be aluminum grating, 6063-T6 aluminum alloy with slip resistant mill finish.

1. Stair treads minimum width 36 inches.

2. All grating anchored to supports using saddle clips, anchor blocks, or other means.

E. Guardrails and handrails of minimum 2.5-inch OD X 0.25-inch thick 6063-T5 aluminum tubing.

1. Guardrails and handrails designed to withstand uniform load of 50 pounds per linear foot and a non-concurrent concentrated load of 200 pounds applied in any direction at any point on top rail.

F. Platforms not less than 48 inches width and to provide clearance for door swing.

1. Platform length to clear door swing to point of latching of door holder.

2. Platform height set for not more than 7-inch step-over to enclosure interior and not less than 2-inch clearance between door bottom and platform.

G. Anchor stair and platform legs to concrete foundation with anchorage complying with Section 050519 utilizing minimum two bolts per leg.

2.10 ABOVE GROUND VAULTED SUB-BASE FUEL TANK

A. The 4000 gallon generator sub-base tank shall be listed and labeled as UL Special Purpose, Protected Secondary Containment Generator Base Tank. The tank shall be designed using UL 2085 standards. The tank is intended for stationary installation and in accordance with NFPA 37, NFPA 110, and Uniform Fire Code. The tank shall be labeled vehicle and projectile resistant, as manufactured by Phoenix Products, Jacksonville, FL, or equal.

B. The sub base manufacturer shall provide certification by a Professional Engineer (P. E.), licensed in the state of Tennessee issued detailed sub base tank floatation uplift calculations and specific recommendations for foundation anchoring means to confirm that the sub base tank is designed and constructed and able to be installed so as to such that the sub base tank shall not be able to floatation uplift during site flooding conditions. In addition, the sub base tank shall meet the remaining Structural

design criterial listed on Sheet S-1.

C. The primary and secondary tanks shall be fabricated from minimum ¼-in steel.

D. The tank shall be designed, tested and labeled per UL requirements to support an engine-generator set weight and lift lugs shall be approved by UL with a 4 to 1 safety factor.

E. The primary fuel tank and secondary tank shall be tested at 3-PSI air pressure as outlined in UL 142.

F. The annular space between the inner and outer walls shall be filled with a minimum of six inches of lightweight concrete to provide a minimum two hour fire wall rating per the Uniform Building Code.

G. The tank shall have a 30-year warranty that includes the concrete vaulting material as well as the primary and secondary tank.

H. The tank shall include the earthquake/tornado tie down restraint points and drillings for grounding attachments.

I. The outer tank shall be abrasive blasted per SSPC-SP10 (white metal blast), then painted with one coat of a high build polyester glass flake to a minimum of 12-15 mils (DFT) thickness, and a finish coat of aliphatic polyurethane with a minimum of 3-5 mils (DFT).

J. The tank shall be provided with UL 2085 listed and labeled 12-gage 316 stainless steel overfill containment box, welded and permanently affixed to the top of the tank and shall include a pull handle overfill drain to allow fuel to return to the tank.

K. All tank outlets shall be 316 schedule 40 stainless steel threaded pipe.

L. The proper fire regulating authority shall review all tank applications (installations).

M. The tank shall be clearly labeled with the label indicating the type of product, the volume capacity, the top loading capacity, and the manufacturer.

N. The rear of the fuel tank shall be equipped with an attached compartment, which acts as an electrical stub-up area. The rear panel of this compartment shall be detachable to allow the contractor adequate access to connect the electrical conduits.

O. A through-tank inner stub-up area, shall be available per engine-generator set design requirements.

P. Emergency venting systems shall be provided by the tank manufacturer per UL 2085 requirements.

Q. All sub base tank fuel level floats shall be stainless steel construction. The tank shall include all openings required for the level gauge system and the leak monitor system.

R. The tank shall include double wall interstitial leak sensing capable of detecting the precense of any liquid in the annulus of the vaulted sub base storage tank and tie into the fuel level/leak monitoring system.

2.11 SURFACE PREPARATION AND SHOP PAINTING

A. The generator set and associated equipment shall be shop primed and finished coated in accordance with the manufacturer's standard practice prior to shipment.

2.12 SHOP TEST

A. Perform shop tests on the complete generator unit and its generator control panel prior to shipment. Submit four copies of the complete certified test record to the Engineer within 30 days after the completed test.

B. These tests shall be sufficient to assure that the unit will operate successfully and meet all specified operational requirements. The manufacturer shall furnish all necessary instruments, filters, fuel, electric power, load banks, and matching transformers for the test.

C. Test each of the automatic alarm and shutdown devices and include certification of the test in the shop test record. Test and record the respective values at which the automatic shutdown devices actually alarmed and/or stopped the engine.

D. The shop test shall consist of, but not be limited to, operation on a reactive load bank at 0.8 power factor at full rated standby load. Test and record voltage and frequency regulation and voltage and current balance to show full compliance with this specification. Perform tests to demonstrate transient response from zero load to full load, zero load to half load and half load to full load. During the shop test, take and record readings every thirty minutes for each of the following:

1. Time

2. Ambient temperature

3. Load:
   a. Volts for each phase
   b. Amps for each phase
   c. Kilowatts
   d. Power factor
   e. Frequency

4. Engine jacket water temperature

5. Lubricating oil pressure

6. Gallons of fuel consumed per hour

E. The alternator shall be shop tested in accordance with IEEE Standard 115. Submit certified test results in accordance with Paragraph 1.03. Testing shall include the following:

1. Cold resistance of all windings.

2. Insulation resistance of all windings.

3. Polarity of field coil.

4. High potential on all windings.

5. Open circuit saturation.

F. After completion of all testing, the following is required:

1. Seal the load limit using a seal press that embosses the manufacturer's initials on the lead seal.

2. Drain all entrapped water and apply proper protection to prevent the entry of water during shipment or a long period in storage while waiting for installation.

3. Treat the engine for protection during an extended storage at the job site while waiting for completion of installation.

PART 3 EXECUTION

3.01 INSTALLATION

A. Provide the services of a qualified factory representative to check the installation of the generator unit to ensure a proper installation, perform check-out and startup services, conduct the field test specified herein, and instruct the Owner's personnel in the operation and maintenance of the equipment.

B. Mount the generator enclosure skid / sub base tank on a flat concrete foundation and level to provide equal bearing for all supports as work of this Section. Utilize grout or other approved means to level the mounting pad to provide equal bearing for all supports as work of this Section. Anchors shall comply with the manufacturer’s seismic requirements for this site. Connect the generator unit to field wiring under Division 26.

C. Installation shall include furnishing all required coolants, lubricants, all in accordance with the manufacturer’s recommendations. Diesel fuel shall be ultra-low sulfur content in accordance with Federal and State regulations for stationary standby diesel engines of the horsepower rating of the unit provided.

3.02 EQUIPMENT STARTUP

A. After installation and manufacturer's representative check of the installed equipment, operate the unit to demonstrate its ability to operate continuously without vibration, jamming, leakage, or overheating and to perform specified functions.

B. Comply with the manufacturer's operating and maintenance instructions during startup and operation.

C. Promptly correct improper installation or operation of the equipment.

D. Cooperate with the supplier of the equipment at the time of startup and in making of all final adjustments necessary to place the equipment in satisfactory working order. Startup shall not commence without the presence of the manufacturer's representative.

3.03 FIELD TEST

A. Upon completion of the installation and as soon as conditions permit, the Contractor and the service representative for the manufacturer of the generator unit shall test the generator unit and associated electrical circuits and controls in the presence of the Engineer to assure that the system functions as specified. Before conducting the onsite field tests, submit a copy of the proposed test data log sheet for the Engineer’s approval.

1. Prior to scheduling the test, notify the Engineer in writing that all requirements and provisions of the Contract Documents have been fulfilled, that all apparatus shall be clean, properly adjusted and ready for operation and that the Operation and Maintenance Manuals specified in Paragraph 1.09, have been submitted.

2. The manufacturers' representatives shall make such changes in wiring or connections and such adjustments, repairs or replacements necessary to make the circuit, device or control system function as specified and otherwise comply with the Contract Documents.

B. The test shall consist of four hours of continuous operation of the unit using a portable resistive load bank. Adjust the load bank load to provide one half hour each at 25 percent, 50 percent, and 75 percent of full load followed by the remaining operating time at rated standby load. Furnish the portable load bank, all connecting cables, metering equipment, and other equipment or devices required to perform the onsite testing. During the test, take the same readings as outlined under Paragraph 2.11 and record results at 30-minute intervals. Testing shall include verification of proper voltage regulation, transient voltage dip and recovery time, and voltage and current balance.

C. As part of the field test, test each of the automatic alarm and shutdown devices and record the respective values at which the devices will alarm and/or stop the engine. Perform any adjustments required in the devices to make the operating values correspond to those recommended by the engine manufacturer and as recorded during the shop test.

D. After the load bank test has been completed, connect the generator to the station load, and perform additional testing utilizing the main circuit breaker to simulate a utility power failure, to demonstrate the generator unit’s ability to meet the automatic starting, load transfer, and motor starting requirements as specified under Paragraph 1.06, utilizing facility load as available. Operate the facility on generator power for at least 30 minutes then restore utility power via the switchgear, to cause the transfer switching to reset and shut down the generator. Record generator operating parameters as specified above.

E. If the generator unit fails to fulfill the performance requirements of this Specification, take corrective action and retest the system to assure full compliance. Include all expenses associated with the field tests, including any corrective action, and retesting as part of the scope of work of this Section.

3.04 TRAINING

A. The equipment manufacturer shall furnish the services of a competent and experienced factory representative who has complete knowledge of proper operation and maintenance for a minimum of two 8-hour working days total to instruct representatives of the Owner and the Engineer in the proper operation and maintenance of the equipment.

B. Training shall be provided at the site and timed to accommodate all working shifts, including some late evenings, and early mornings. The instruction period shall be scheduled at least 10 working days in advance with the Owner and shall take place prior to startup and acceptance of the equipment by the Owner. Training shall minimally include system operations, preventive maintenance, and troubleshooting.

C. Submit, in accordance with Section 01 33 23, at least 30 working days prior to the start of training, a training syllabus that includes the above requirements, proposed dates and times for training, and instructor resume. Training may not commence until the first draft of the O&M manual has been submitted for review.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Provide a complete lightning protection system for all new building and structures at the Chattanooga Dupont Pump Station Basin. The system shall be UL labeled and shall be designed and installed in compliance with provisions of UL 96, UL 96A, and NFPA 780.

B. Employ the services of a licensed lightning protection systems engineering company to design and install the lightning protection system and prepare detailed installation drawings and material specifications. The Drawings and this Section shall be submitted for review in accordance with Section 01 33 23.

C. The lightning protection system shall be checked by a UL field inspector upon completion of the installation. Assume full responsibility for the correctness of the installation and shall make any and all corrections and additions deemed necessary by the UL inspector. Pay for all costs of the UL inspection and any subsequent reinspections as required.

D. The lightning protection system for the building shall consist of an aluminum ground wire with air terminals which shall be grounded to the building structural steel or ground grid at regular intervals. The Contractor has the option of submitting alternate methods of lightning protection for consideration in his/her proposal, provided they offer an equal or greater degree of protection than those specified.

E. Lightning protection system wiring shall be concealed under the building roof.

F. The grounding systems for the building shall be provided under Section 33 79 00.

1.02 REFERENCE STANDARDS

A. Underwriters Laboratories (UL)

1. UL 96 – UL Standard for Lightning Protection Components.

2. UL 96A – UL Standard for Safety Installation Requirements for Lightning Protection System.

B. National Fire Protection Association (NFPA)

1. NFPA 780 – Standard for the Installation of Lightning Protection Systems

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

PART 2 PRODUCTS

2.01 MATERIALS

A. All materials shall be new and shall comply in weight, size and composition with the requirements of UL and NFPA.

B. Grounding materials and methods shall be equal to those specified under Section 33 79 00.

C. The following is a brief description of the various items of material:

1. Air terminals shall be 5/8-in by 18-in minimum solid aluminum and shall extend at least 18-in above the object to be protected. All air terminal bases shall be cast bronze with stainless steel bolt pressure cable connectors. The air terminals should be spaced so as not to exceed 20-ft apart around the outside perimeter of the roof or the ridge and not over 50-ft apart through the center of flat roof areas. All air terminal bases for flat roof areas shall be of the adhesive type.

2. Conductors shall consist of UL listed 37 strands of 13 gauge aluminum wire weighing 200 lbs per 1000-ft and installed in accordance with the UL Code. Conductors on the flat roof areas may be run exposed. Ground connections shall be made to the main down conductor at a maximum of 60-ft-0-in on centers.

3. Fasteners
   a. Conductor fasteners shall be an approved type of non-corrosive metal, have ample strength to support conductors and shall be spaced not to exceed 3-ft-0-in centers. Masonry type cable fasteners spaced every 3-ft-0-in on masonry. Adhesive type cable fasteners spaced every 3-ft-0-in on flat roofs.

4. Cable Connectors
   a. All cable connectors shall be cast bronze with screw-pressure type stainless steel bolts and nuts.

PART 3 EXECUTION

3.01 INSTALLATION

A. All materials shall be installed by experienced workmen that specialize in this type of work. The lightning protection system shall be installed per approved shop drawings and UL and NFPA recommended practices.

B. The lightning protection system engineering company shall provide job site assistance and supervision of the installation as required, and shall be present during the UL inspection.

C. The structural steel columns on the outside perimeter of the building may be utilized as the main down conductor from roof to ground for the lightning protection system. No other parts of the structural steel structure will be accepted to substitute for lightning

conductors. The steel columns around the outside perimeter of the building shall be grounded at every other column and in no case shall average over 60-ft apart. Where the steel columns are used, a connection to the top of each steel column shall be made through the roof and connected to the roof conductor. A thru the roof connector shall be installed where a conductor penetrates the roof, by the lightning protection contractor. The thru the roof connector will be 1/2-in stainless steel threaded rod equipped with the necessary lead or neoprene washers and stainless nuts for a watertight seal. Also, copper pitch pans shall be furnished under this Section and installed by the roofing contractor.

D. All concealed conductors shall be installed in Schedule 80 PVC conduit.

E. Lightning protection system roof wiring shall be concealed under the roof of the building. Lightning protection system down conductors and conduit shall be concealed from the exterior side of the walls, so that it is not visible from the exterior of the building.

F. All metal bodies within 6-ft of the conductor shall be bonded to the system with approved fittings and conductor. Connections between dissimilar metals shall be made with approved bimetallic connections.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install all surge protective devices (SPDs), formerly referred to as transient voltage surge suppressors (TVSSs), for power systems as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A. Refer to Division 13 for SPDs for instruments, telecommunication systems, antenna systems, or computer systems.

1.03 SUBMITTALS

A. Submit to the Engineer, in accordance with Section 01 33 23, the following:

1. Detailed catalog information with sufficient detail to determine compliance with the specifications including the electrical and physical characteristics.
   a. Minimum electrical ratings shall include operating voltage, voltage protection rating (VPR), frequency and phasing.
   b. Minimum performance ratings for type 1 and type 2 SPDs shall include nominal discharge current (In) rating, maximum continuous operating voltage (MCOV), and short circuit current rating (SCCR).
   c. UL 1449, Third Edition (minimum) listing compliance certification.

2. Warranty statement.

1.04 REFERENCE STANDARDS

A. The materials and installation shall comply with the codes and standards of the following organizations:

1. American National Standards Institute (ANSI)

2. Institute of Electrical and Electronic Engineers (IEEE)

3. National Electrical Manufacturers Association (NEMA)

4. National Fire Protection Association (NFPA)

5. Underwriters Laboratories (UL)

B. Specific codes and standards that apply include the following:

1. ANSI/IEEE C62.41 – Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits

2. ANSI/IEEE C62.45 – Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits

3. NFPA 70 – National Electrical Code, Article 285

4. NFPA 780 – Standard for the Installation of Lightning Protection Systems

5. UL 1283 – Electromagnetic Interference Filters

6. UL 1449 – Surge Protective Devices

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 WARRANTY

A. All SPD panel units shall be guaranteed by the installing contractor and surge suppression manufacturer to be free of defects in materials and workmanship for a period of not less than 10 years from the date of substantial completion of the system to which the suppressor is installed.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance, the following manufacturers are acceptable:

1. Advanced Protection Technologies (Emerson)

2. Current Technology

3. DITEK

4. Eaton / Cutler-Hammer

5. Joslyn (Total Protection Solutions)

6. LEA International

7. Square D / Schneider Electric

8. Surge Suppression Inc.

2.02 PRODUCTS

A. The SPD supplied shall be selected to match the voltage, phasing, and frequency of the power system.

B. The SCCR rating of the SPD shall have at least the same rating of the electrical equipment being protected.

C. The SPD enclosure shall be rated NEMA 4X for outdoor, wet, damp, chemical, or corrosive areas.

D. The SPD shall protect against surges produced by a 1.2 / 50 µs and 8 / 20 µs combination waveform generator.

E. SPDs at switchgear, switchboards, and motor control centers shall have a nominal discharge current (In) of at least 20 kA 8 / 20 µs per phase.

F. SPDs shall include EMI/RFI noise filtration.

G. The SPD shall be of a parallel design using fast-acting energy protection that will divert and dissipate the surge energy for 480-volt distribution panels, switchgear, switchboards, substations and motor control centers.

H. The SPD shall provide LED indicator lights to provide continuous positive operational status of each individual MOV in each mode in each protected phase. Indicator lights shall be visible without the need to open any compartments.

I. The SPD shall provide all modes of protection based on the system voltage.

J. The voltage protection ratings (VPRs) shall not exceed the following:

System Voltage	Line-Neutral	Line-Ground	N-Ground	Line-Line
120 (2W+G)	700	700	700	n/a
240 (2W+G)	1200	1200	1200	n/a
120/240 (3W+G)	700	700	700	1200
120/208Y (4W+G)	700	700	700	1200
277/480Y (4W+G)	1200	1200	1200	2000
240Δ (3W+G)	n/a	1200	n/a	1200

K. SPD shall have a one nanosecond or less response time for any individual component, and shall be self-restoring and fully automatic.

L. Minimum surge current ratings per mode shall be as follows:

1. Service entrance equipment, switchgear, and switchboards (480V): 150 kA

2. Distribution panels and Motor control centers (480V): 150 kA

3. Branch panels and control panels (480V): 100 kA

4. Branch panels (120/208/240 – single or three phase): 50 kA

PART 3 EXECUTION

3.01 INSTALLATION

A. Install surge protective devices as shown on the Drawings and in accordance with manufacturer's instructions.

B. SPDs shall be installed with lead conductors as short as possible (not to exceed 24-inches), gently twisted together, and routed to avoid sharp bends or kinks.

C. SPDs may be mounted internally in motor control centers, switchgear or switchboards provided they are in an individual compartment.

D. SPDs may be mounted internally in variable frequency drives and control panels.

E. SPDs may be mounted internally at panelboards.

F. SPD's shall be externally mounted at transformer panel assemblies.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install complete lighting systems including panelboards, transformers, lighting fixtures, receptacles, switches, contactors, and all necessary accessories and appurtenances required as hereinafter specified and shown on the Drawings.

B. Definitions

1. CCT: Correlated Color Temperature.

2. CRI: Color Rendering Index.

3. Fixture: See "Luminaire." Used interchangeably with luminaire.

4. IES or IESNA: Illuminating Engineering Society of North America.

5. LED: Light Emitting Diode.

6. Lumen: Measured visible light output of lamp and luminaire, or both. One lux equals one lumen per square meter. One foot-candle equals one lumen per square foot.

7. Luminaire: Complete lighting unit, consist of all integral components including lamp, reflector, and housing. Used interchangeably with fixture.

1.02 RELATED WORK

A. All concrete and reinforcing steel required for exterior lighting pole bases shall be as specified under Division 03, but the responsibility of furnishing and installing the material shall be that of Division 26.

B. Device circuit identification is included in Section 26 00 00.

C. Conduit is included in Section 26 05 33.

D. Wire is included in Section 26 05 10.

E. Transformers are included in Section 26 19 00.

F. Time switches, photo-electric controls and contactors are included in Section 26 19 00.

G. Panelboards are included in Section 26 24 16.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23. Submittals shall include those set forth in Section 26 00 00, Paragraph 1.03.

B. Luminaire submittals shall be organized in sequential order based on the luminaire schedule designation. Material cut sheets for each luminaire shall include the following as applicable.

1. Complete physical data to confirm compliance with fixture schedule. Include description, features, accessories, finishes, and dimensions of luminaires.

2. Complete electrical and lighting data. Include voltage, design life, lumen output, CCT, CRI, photometric data, and energy efficiency data.

3. Where submitted exterior light fixtures are different than the listed manufacturer and model in the “Lighting Fixture Schedule” submit the following:
   a. Scaled drawing(s) showing calculated photometric foot-candle levels of the project site along with locations of luminaires. Drawing shall indicate the property boundary and calculate the foot-candle level twenty (20) feet beyond the property boundary. The calculations must include contributions from building mounted along with pole mounted luminaires.
   b. Calculations must be based on “one (1) foot-candle minimum maintained” with no more than 0.5 foot-candles at the property line with a maximum of 0.01 foot-candles ten (10) feet beyond the property line and a “light loss factor” (LLF) of 0.95. Luminaire photometry shall be designed using the IESNA LM-79-08 absolute photometric principles for LED lighting.
   c. The exact quantities, locations, and IESNA photometric distribution types of pole mounted luminaries, may differ from the original basis of design layout, but the required foot-candle levels must be maintained. Should the luminaire manufacturer require additional luminaires to achieve the stated foot-candle levels and/or require additional branch circuit wiring, supports, poles, etc., in conjunction with these additional luminaires, shall not cause additional expense to the Owner.

4. Maintenance information

C. Outdoor pole submittal data shall include information sufficient to confirm compliance with the Contract Documents, including but not limited to mounting details, materials of construction, and wind speed data.

1.04 REFERENCE STANDARDS

A. All lighting fixtures shall be in accordance with the National Fire Protection Association (NFPA) NFPA 70 "National Electrical Code" (NEC) and shall be constructed in accordance with the latest edition of the Underwriters Laboratories (UL) "Standards for Safety, Electric Lighting Fixtures."

B. All lighting equipment shall comply with UL 8750 Light Emitting Diode (LED) Equipment for Use in Lighting Products; and UL 844 Standard for Electric Lighting Fixtures for Use in Hazardous (Classified) Locations.

1.05 QUALITY ASSURANCE

A. The Contractor shall provide luminaires from a manufacturer engaged in the production of luminaires that are equal in material, design and workmanship to the luminaires listed on the Drawings. The manufacturer's luminaire shall have been in satisfactory commercial or industrial use for a minimum of three (3) years. The manufacturer's luminaire shall have been available on the commercial market during the three (3) year period. All luminaires shall be tested as an integral unit.

B. The luminaires shall be listed by Underwriters Laboratories, Inc. (UL) or by a Nationally Recognized Testing Laboratory (NRTL) and be listed and labeled for the installation location (i.e., dry, wet, damp, hazardous area) as noted on the Contract Documents.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Luminaires shall be stored in a dry location in their original packaging, until ready for installation.

1.07 MAINTENANCE

A. The Contractor shall furnish to the Owner at the completion of the project, a minimum of 20% (minimum of 4) spare LED driver assemblies. LED drivers shall be turned over to the Owner representative in the manufacturer's protective packaging. LED drivers without this protective packaging will not be accepted.

B. The Contractor shall furnish to the Owner at the completion of the project, a minimum of 20% (minimum of 4) spare LED light engine assemblies. LED light engines shall be turned over to the Owner representative in the manufacturer's protective packaging. LED light engines without this protective packaging will not be accepted.

C. The Contractor shall supply a complete list of replaceable parts for each luminaire supplied. List shall include complete manufacturer's part numbers for ordering; current price; minimum order quantities; delivery time, manufacturer shall also provide contact information. Installation and repair manuals, etc. for each unit.

1.08 WARRANTY

A. The Contractor shall deliver the work described herein in a first class operating condition in every respect. The Contractor shall also warrant that the material and workmanship shall be entirely free from defects. Any materials, equipment, or workmanship in which defects may develop before or during the warranty period shall be repaired or replaced at Contractor's expense. The Contractor shall further warrant that all material, equipment, and workmanship used in the installation, but not specifically mentioned in the contract documents, is the best of their respective kinds and that the construction of the luminaires and physical installation was performed in accordance with the best accepted standard practices in all details.

B. All luminaires shall have a minimum five (5) year factory warranty for defective or non-starting power supply units (driver), and LED source assemblies, which includes, but not

limited to: LED package, LED arrays, LED modules, LED die, encapsulate, and phosphor.

C. All photocells used in exterior applications shall have a minimum ten (10) year factory warranty.

PART 2 PRODUCTS

2.01 LIGHTING FIXTURES (LUMINAIRES)

A. Lighting fixture types shall be furnished as required by the "Lighting Fixture Schedule" on the Drawings. The catalog numbers are given as a guide to the design and quality of fixture desired. Equivalent designs and equal quality fixtures of other manufacturers will be acceptable upon approval by the Engineer.

B. Light Emitting Diode (LED) luminaires shall meet the following requirements.

1. Each luminaire shall be complete with prewired integral drivers and optical (LED) assemblies.

2. Luminaires that require remote mounting of any components needed for its operation, such as drivers, or light engine electronics are not permitted. All components needed to make the luminaire operational shall be integral to the fixture housing with exception of security applications.

3. Individual LEDs shall be connected such that a catastrophic loss or the failure of one LED will not result in the loss of the entire luminaire or the distribution type.

4. LED fixtures shall be modular and allow for separate replacement of LED lighting modules, drivers and surge suppressors. User serviceable LED lighting modules and drivers shall be replacement from the room side.

5. Dimmable LED luminaires shall have either a 0-10 volt, 3-wire dimming driver, or a two-step (50%-100%) line voltage, two switch controlled dimming driver, as shown on the Drawings.

6. Thermal management shall be passive by design and shall consist of heat sinks with no fans, pumps, or liquids.

7. Luminaire has been tested as an integral unit to Illuminating Engineering Society (IES) LM-79 (Electrical and Photometric Measurements of Solid State Lighting Products) and LM-80 (Measuring Lumen Maintenance of LED Light Sources).

8. The rated life and lumen depreciation of the luminaire shall be a minimum of 50,000 hours with a 70% depreciation in lumen output.

9. The color rendition index (CRI) shall be a minimum of 80 and the CCT a minimum of 3500°K, or as noted on the fixture schedule.

10. The luminaire shall have a power factor of 90% or greater at all standard operating voltages and full luminaire output.

11. The total harmonic distortion shall not exceed 20 percent at any standard input voltage.

12. Luminaire shall include surge protection.

C. LED Power Supply Unit (Drivers)

1. LED drivers shall accept the voltage as indicated on the fixture schedule.

2. Driver(s) shall be UL8750 class 2 listed for their intended purpose.

3. Individual driver(s) shall be equipped with surge protection (6kV minimum for building mounted units and 10kV minimum for pole mounted units) in accordance with IEEE/ANSI C62.4.1 and shall be rated for a category “C” environment.

4. Driver(s) shall have a minimum efficiency of 85%.

5. Driver(s) shall reliably start at minimum ambient temperatures from -40 deg. C to 40 deg. C with THD of <=20%.

6. Dimmable drivers shall deliver full-range dimming without LED strobing or flicker across their full dimming range.

D. Metal Parts:

1. Free of burrs and sharp corners and edges.

2. Sheet metal components shall be steel unless otherwise indicated.

3. Form and support to prevent warping and sagging.

E. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit re-lamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during re-lamping and when secured in operating position.

F. Diffusers and Globes:

1. Clear, UV-stabilized acrylic or polycarbonate.

2. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

3. Glass: Annealed crystal glass unless otherwise indicated.

4. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

G. Housings:

1. Extruded-aluminum housing and heat sink.

2. Clear anodized finish.

2.02 POLES AND STANDARDS

A. Poles for luminaires shall be as indicated on the Drawings and rated for the wind speed.

B. Poles greater than twenty (20) feet in length shall be complete with vibration dampers installed.

2.03 PHOTO ELECTRIC CONTROLS

A. Photo electric control with time delay for outdoor lighting shall be completely self-contained and not affected by moisture, vibration or temperature changes.

B. ON/OFF adjustments are to be made by movement of a light level selector without the use of tools in a range from 2 to 50 foot candles.

C. Photo electric control device shall be SPST, and have 2000 watt tungsten capacity and be Tork Catalog Number 2101 (120V); 2104 (208-277V) or approved equal by Intermatic Inc., Carlon, or approved equal.

PART 3 EXECUTION

3.01 FIXTURE INSTALLATION

A. Each fixture shall be a completely finished unit with all components, mounting and/or hanging devices necessary, for the proper installation of the particular fixture in its designated location and shall be completely wired ready for connection to the branch circuit wires at the outlet.

B. The Contractor shall furnish and install luminaires complete with proper reflectors, diffusers, louvers, glassware, concrete bases, gaskets, shims, wiring, control, conduit, hardware, controls, and other appropriate devices and parts for a complete lighting installation. Adjustable luminaires shall be aimed as directed by the Engineer.

C. Flexible fixture hangers shall be used for all pendant mounted fixtures. Fixtures 2-ft long and larger shall be supported with a minimum of two fixture hangers. Pendants and rods longer than 4-ft long shall have additional bracing to limit swinging.

D. Where the Drawings state a particular mounting height, it shall imply that the bottom of the fixture shall be mounted at the stated mounting height above the finished floor, unless specifically noted otherwise.

3.02 POLE INSTALLATION

A. Coordinate foundation anchor bolts of pole to ensure correct orientation of luminaire, pole hinges, or receptacles.

B. Exterior lighting poles shall be mounted plumb.

C. After installation is complete, plug with suitable semi-permanent material any alignment or installation aid or other unused holes or cavities in the poles to prevent tampering or insect or rodent intrusion. Match pole color.

3.03 CLEANING

A. Plastic dust cover bags to be provided with new parabolic reflector lighting fixtures shall be removed after all construction activity that may cause dust formation on reflector surfaces has been completed.

B. All fixtures shall be left in a clean condition, free of dirt and defects, before acceptance by the Engineer.

3.04 ACCEPTANCE TESTING

A. Schedule testing with the Engineer a minimum of two weeks in advance once the entire lighting system is complete, clean, and fully functional.

B. Demonstrate the functionality of all emergency lighting by interrupting the normal power circuit.

C. Demonstrate the lighting control system in all modes.

D. Adjust the aim of luminaires as required. This may be required to be performed other than first shift working hours to allow for night-time conditions.

E. Replace all damaged, defective, or burned out components at no additional cost to the Owner.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install all software, equipment, wiring, and related equipment/devices/ components required for an operational video surveillance system at the Pump Station as indicated in the Drawings and specified herein.

B. The work shall include, but not be limited to the following:

1. Furnish all labor and materials to design the overall system structure, nomenclature, programming, and interface the video surveillance System to achieve the functionality as described on the Contract Drawings and specified herein.

2. Furnish all video surveillance software and equipment including but not limited to video Camera, Pan-Tilt-Zoom (PTZ), dome, Remote box, power supply, digital video recorder (DVR), PTZ controller software, Mounting Rack, UPS for the System, Joystick Controller/Keyboard, mounting structure and hardware. Provide conduit, power and signal cabling, etc. from the camera to the video server unit as shown in the Drawings.

3. Furnish all wiring, cable and conduit type necessary to complete the installation of the video surveillance system and associated equipment. All cable, wiring and conduit shall be provided and installed under Division 26

4. Furnish all labor and programming and configuration necessary to provide installation and complete functionality of the video surveillance equipment via the camera management/control software located on the Owner laptop computer.

5. Final connection of all necessary wiring and cable.

6. The video surveillance System Supplier (VSSS) is responsible for verification of camera connections prior to start-up of the system.

7. Documentation for system operation.

8. Complete software and hardware training for two City personnel.

C. The work in this section is subject to all the requirements in the General and Special Conditions of the specifications. Coordinate all the work in this section with all the trades covered elsewhere in these specifications and the Owner to provide the complete and operable system required herein. All such coordination shall be completed prior to the initiation of any field construction.

D. Equipment shall be as specified on the drawings and described herein. Substitutions must be approved by the Engineer.

E. The system supplier/installer shall be a fully certified and authorized installation/ service provider of all such equipment. Such certification shall be formally illustrated in a submittal at the beginning of the project that includes formal indications of such certifications from the involved equipment manufacturers (Pelco, Altronix, International Fiber Systems, Cisco, etc.). Achieving such certification after the project is awarded is unsatisfactory.

1.02 RELATED WORK

A. Electrical Raceway Systems, wires and cables are included in Section 26 05 33.

B. Electric Wires and Cables are included in Section 26 05 10.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, the following:

1. Copies of licenses and video surveillance certifications. (Reference section 1.05)

2. Proposed Products List:

Shop Drawings:

a. Shop drawings shall include a system architecture drawing showing the system controller, camera and point-to-point connection diagrams showing cable types and device terminal numbers; layout drawings for the control consoles, including front, side and plan views with all components identified; mounting bracket detail drawings.

Product Data:

a. Product data shall include a complete bill of materials showing the manufacturer's name and catalog number for each item specified and manufacturer's descriptive literature and catalog cuts.

3. Manufacturer Instructions.

4. Test reports.

5. O&M manuals.

6. Training materials (5 sets for classroom instruction).

7. List of spare parts to be provided.

B. Submit video surveillance system O&M manual in accordance with Division 01 requirements. Manual shall include, but not be limited to:

1. All items listed in paragraph 1.03-A.

2. Manuals for software.

3. Documentation of final system software and hardware settings. Setting documentation shall include, but not be limited to:
   a. Dip switch settings.
   b. Camera settings – hardware and software.
   c. Video server settings – hardware and software.
   d. Camera monitoring/control software settings.

1.04 REFERENCE STANDARDS

A. Underwriters Laboratories (UL)

B. American National Standards Institute (ANSI)

C. American Society for Testing and Materials (ASTM)

D. National Electrical Manufacturers Association (NEMA)

E. Electronic Industries Association (EIA)

F. National Electrical Code (NEC)

G. FCC Compliance - Equipment supplied shall comply with FCC Emission Standards.

H. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. The video surveillance system components shall be listed under the appropriate category by UL and shall bear the UL label where obtainable.

B. The equipment furnished under this Section shall be provided by a VSSS which has been providing this type of equipment for the past 5 years. The VSSS shall have installed a minimum of five comprehensive computer-controlled video surveillance systems including integral subsystems described in related sections of the specifications. These systems shall be of similar size, complexity, and general operation as the system described in the specifications.

C. Hold a legally required Contractor licenses necessary to accomplish the installation and operation of the described video surveillance System as well as all subordinate subsystems at the facility indicated. Submit copies of licenses with the first submittal.

D. Provide constant supervision of the work from beginning to completion through an authorized and competent representative and further plan to employ the same workers and supervisors (within reason) throughout the duration of the project.

E. Provide a service organization which is capable of providing a factory-trained service technician within 24 hours of a request for on-site service.

1.06 SYSTEM DESCRIPTION

A. General:

1. The system shall consist of set of cameras, installed at the site designed to monitor the area as shown in the drawings. The cameras are connected to DVR installed in a rack. Perform a “line of sight” investigation for each camera to verify the arrangement and make recommendations on adjusted camera placement (if required) to allow the system that effectively monitor the area. The VSSS is responsible for field placement of all video surveillance equipment upon approval by the Owner. The cameras are to be mounted to maximize the coverage. The VSSS is responsible for slight changes in position of cameras (plus or minus ten feet) to achieve desired system of operation after initial installation.

2. The video surveillance camera at the site shall be inter-connected to the video recorder mounted in the video surveillance System Control Cabinet using CAT 6 cabling. Verify the proper location of equipment prior to cutting or installation of cable.

B. Programming:

1. The camera shall be assigned a tag number and programmed for a primary view or panning sequence.

2. The camera and DVR shall be programmed for maximum resolution and speed (frames per second).

3. A software license and the required programming shall be provided to allow access and control of the camera over the network system by the Owner’s Laptop computer.

1.07 DELIVERY, STORAGE AND HANDLING

A. With the exception of mounting hardware, no equipment shall be delivered to the site or installed in its final location until the interior facilities are permanently weathertight, dust-free, heated and substantially complete.

1.08 MAINTENANCE, SERVICE AND TESTING

A. During the Warranty Period provide the following maintenance, service and testing.

1. Include at least one scheduled visit by the manufacturer's authorized factory trained service engineer who is familiar with the type of equipment provided for this project. The visit shall occur no sooner than half-way through the warranty period and shall be independent of visits initiated by warranty claims. The visit shall include routine adjustment, calibration, cleaning and testing of system equipment and verification of correct operation.

PART 2 PRODUCTS

2.01 GENERAL

A. All equipment and materials used shall be standard components that are regularly manufactured and utilized in the manufacturer's systems.

B. All integrated equipment shall be manufactured by the same manufacturer or proven compatible for use as an integrated unit.

C. All systems and components shall be thoroughly tested and proven in actual use.

D. All systems and components shall be provided with a toll free, 24-hour technical assistance program from the manufacturer. The program shall allow for immediate technical assistance for either the dealer/installer or end user at no charge for as long as the equipment is installed.

E. All systems and components shall be provided with a one-day turnaround repair express or replacement and 24-hour parts replacement. The repair and parts express shall be guaranteed by the manufacturer on warranty and non-warranty items.

2.02 NETWORK HD PTZ CAMERAS

A. Type:

1. Fully integrated tamper-resistant dome enclosure with camera, lens, PTZ drive and thermostatically controlled heater.

2. Day/Night, high resolution, Digital PTZ camera.

B. Functionality:

1. Application: Indoor and outdoor application

2. Type: Dome/Bullet depending on manufacturer recommendation

3. Imager: 1 / 2.8" Exmor CMOS

4. Resolution: 1920 X 1080

5. Focus: Autofocus, motorized

6. Video Compression: H.264 MJPEG

7. Network Protocols: TCP, UDP, HTTP, FTP, NTP, DNS, DHCP, UPnP, RTP, RTSP, ICMP, IGMPv3, QoS, SNMP v2c/v3, DDNS.

8. Daytime Sensitivity: 0.20 lux (33 ms, F1.6) color

9. Nighttime Sensitivity: 0.004 lux (33 ms, F1.6) black & white

10. Focal Length: 4.7-94 mm
11. Zoom: 20X Optical, 12X Digital
12. Angle of Horizontal View: 55.4° to 2.9° mm zoom
13. Focus: Automatic with manual override
14. Day/Night Functionality: Automatic
15. Environmental: Thermostat controlled heater

C. Physical:

1. Housing: Aluminum for outdoor pendant mounting with smoked dome
2. Input Power: High PoE (from injector)
3. Electrical / Ethernet Ports: 100BaseTX with RJ-45 connector
4. Mounting: 1.5-inch conduit pendant mount
5. Pan Movement: 360° continuous pan rotation
6. Operating Temperature: -49 to 122 degrees F (-45 to 50 deg C)

D. Options/Accessories:

1. Environmental Pendant option.
2. Pendant arm for Dome Mounting.
3. Provide all necessary power supplies, cabling, surge protection devices, electrical grounding, mounting brackets and hardware.

E. Manufacturers:

1. Pelco Spectra Enhanced Series IP Outdoor Dome system
2. Approved equal.

2.03 POWER OVER ETHERNET INJECTOR

A. Type:

1. Provides High PoE power for the outdoor Spectra Enhanced PTZ camera.

B. Functionality:

1. Input Voltage: 100 to 240 V ac ± 10%

2. AC Input Current: 2A (RMS) maximum for 90 V ac

3. Total Output Power: 75 W

4. Short Circuit Protection: Outputs equipped with short circuit protection and overload protection as per 802.3af specifications except maximum average current is 1.34 A; the output can be shorted permanently without damage.

5. Output Connection: 4-pair powering for full power; 2-pair powering for IEEE802.3at mode.

C. Physical:

1. Operating Temperature: –4 to 104 deg F (–20 to 40 deg C)

D. Manufacturers:

1. Pelco POE75U-1UP series adapter for Spectra Enhanced PTZ

2. Approved equal.

2.04 NETWORK VIDEO RECORDER

A. Type:

1. Standalone Device to meet the demands of HD video recording and playback operations

2. Capable of recording at least 24 streams / 24 IP addresses.

B. Functionality:

1. Operating System: Windows 7 Platform

2. Video Compression: Support H.264 and MJPEG or MPEG4

3. Throughput: Supports at least 24 IP video cameras or 200 Mbps for recording of IP video streams as well as playback and export through a client software

4. Internal Storage: at least 12 TB

5. External Storage: Support for 24 TB External Storage through USB / SCSI interface

6. Network Protocols: TCP, UDP, HTTP, SMTP, FTP, Telnet, NTP, DNS, DHCP, UPnP, RTP, RTSP, ICMP, IGMPv3, QoS, SNMPv1/v2c/v3, DDNS.

7. Security: Password protected at user level and IP address filtering

C. Physical:

1. Housing: Aluminum IP30, din-rail mounting

2. Processor: Latest Intel Processor with 8 GB RAM

3. Input Power: 110 VAC

4. Video Inputs: Two Gigabit network port

5. Operator Interface: 2 DVI-D ports to provide convenient connection for high resolution digital monitors

6. Operating Temperature: 32 to 140 degrees F

7. Relative Humidity: 5 to 95% non-condensing

8. Approvals: UL-508

D. Options/Accessories:

1. Surveillance software for viewing and PTZ control interface of the PTZ cameras connected to video encoder unit and monitored by a networked computer. Software shall be compatible with the operating system installed on the Owner's Laptop computer

2. Provide all necessary power supplies, cabling, surge protection devices, electrical grounding, mounting brackets and hardware.

E. Manufacturers:

1. Pelco Digital Sentry NVR

2. Approved equal.

2.05 RACK MOUNTABLE MANAGED GIGABIT ETHERNET SWITCH

A. General:

1. Provide a modular, rack-mountable, managed Ethernet switch for connection to the video surveillance network as shown in the Drawings and specified herein.

2. Switch manufacturer shall be the same as other products of video System managed Ethernet switch specified herein so that all Ethernet switches furnished for network topology are from the same manufacturer.

B. Physical Features:

1. Modular 19" rack-mountable enclosure.

2. Modular construction such that additional copper and fiber ports can be added and removed.

3. Minimum fiber uplinks: 4 x 100/1000 SFP ports.

4. Minimum fiber Ports: Two Gigabit Ethernet ports shall be hot pluggable into the SFP uplink. Ports shall be duplex LC and operate at a wavelength of 850 nm over multi-mode cable.

5. Minimum copper ports: 8 x 10/100/1000 T(X) RJ45 ports.

6. Operating temperature: 0 to 130 °F.

7. Power: 120 V ac redundant power supplies.

8. Enclosure: Metal case.

C. Network Features:

1. Fault tolerant for use in a star topology if shown on Drawings. The switch shall be able to route the data pockets to the appropriate group of cameras in the video system.

2. Layer 3 switching.

3. Full duplex on all port.

4. Auto negotiation and manual configurable speed and duplex.

5. Wire speed switching fabric.

6. IEEE 802.1w Rapid Spanning Tree Protocol.

7. IGMP snooping.

8. IGMP filtering.

9. Configuration password protected.

10. Configuration backup capability required.

11. SNMP V3.

12. Lock port function for blocking unauthorized access based on MAC address.

D. Additional Features:

1. The switch shall come equipped with a dry contact rated for 120 VAC 5A that shall be used for common trouble alarm. The alarm shall be programmable. If the contact cannot use 120 VAC 5A, provide the necessary 24 VDC power from the PLC panel and provide interposing relays in the PLC panel.

E. Manufacturers:

1. Cisco.

2. Moxa.

3. Hirschmann.

4. Or equal.

2.05 INDUSTRIAL MANAGED ETHERNET SWITCH

A. General:

1. Provide industrial managed Ethernet switch for connection to each group of cameras in the video surveillance network shown in the Drawings and specified herein.

2. Switch manufacturer shall be the same as rack-mountable managed Ethernet switch specified herein so that all Ethernet switches furnished for network topology are from the same manufacturer.

B. Physical Features:

1. Minimum fiber uplinks: 2 x 100/1000 SFP ports.

2. Minimum fiber Ports: Two Gigabit Ethernet ports shall be hot pluggable into the SFP uplink. Ports shall be duplex LCE and operate at a wavelength of 850 nm over multimode cable.

3. Minimum copper ports: 16 x 10/100 TX RJ45 ports.

4. Operating temperature: 0 to 130 °F.

5. Power: 24 VDC redundant power supply inputs.

6. Enclosure: Metal case, DIN-rail mountable.

7. Rating: UL Class 1, Division 2 Groups A, B, C, and D.

C. Additional Features:

1. The switch shall come equipped with a dry contact rated for 120 VAC 5A that shall be used for common trouble alarm. The alarm shall be programmable. If the contact cannot use 120 VAC 5A, provide the necessary 24 VDC power from the PLC panel and provide interposing relays in the PLC panel.

D. Manufacturers:

1. Stratix.

2. Moxa.

3. Hirschmann.

4. N-Tron.

5. Or equal.

2.06 INDUSTRIAL UNMANAGED ETHERNET SWITCH

A. General:

1. Provide an unmanaged Ethernet switch for connection to the control network backbone as shown in the Drawings and specified herein.

B. Physical Features:

1. Minimum copper ports: 4 – 10/100 TX RJ45 ports.

2. Operating temperature: 0 to 130 °F.

3. Power: 24 VDC.

4. Enclosure: Metal case, DIN-rail mountable.

5. Rating: UL Class 1, Division 2 Groups A, B, C, and D.

C. Network Features:

1. Auto sensing duplex and speed.

2. LED link/activity status indication.

D. Additional Features:

1. The switch shall come equipped with a dry contact rated for 120 V ac 5A that shall be used for common trouble alarm. The alarm shall be programmable. If the contact cannot use 120 VAC 5A, provide the necessary 24 V dc power from the PLC panel and provide interposing relays in the PLC panel.

E. Acceptable Manufacturers:

1. Phoenix Contact.

2. N-Tron.

3. Moxa.

4. Or equal.

2.07 RACK MOUNTED UNINTERRUPTIBLE POWER SUPPLY

A. The UPS shall be a continuous-duty, on-line, solid state, dual conversion, single-phase uninterruptible power system. The UPS shall provide power conditioning and power backup for Ethernet Switch, Network Video Recorder and other critical electronic loads.

B. The UPS system shall consist of the following major components:

1. Rectifier and battery charger.

2. Inverter.

3. Sealed maintenance-free VRLA batteries and battery disconnect switch capable of providing backup for 60 minutes.

4. Automatic static bypass switch.

5. Optional maintenance bypass switch.

6. Rack mounted Integral control and monitoring panel.

C. Performance Requirements:

1. Ratings:
   a. Output power: refer to table contained below.
   b. Battery runtime: 60 minutes at full load.

D. Manufacturer:

1. Eaton Powerware 9130/9135/9140 Series

2. Approved Equal.

2.08 19” RACK

A. General:

1. The 19-inch equipment rack shall be enclosed on all four sides with door access in the front and rear and removable panels on each side. Furnish and install any and all appurtenances required for a fully functional equipment rack.

2. One Rack shall be provided. The slot locations shown on the drawings are for the purpose of identifying items needed and are not exact slot locations. A layout drawing of the racks shall be provided in the submittal phase with final coordination at the time of installation.

B. Features/Performance:

1. The network rack shall be furnished with the following appurtenances:
   a. Roof fans and tray

b. Combination lock handles
c. Door switch
d. Mounting rail brush strip(s)
e. Cable ring set(s) as required
f. Cable management rings (s) as required
g. Horizontal cable organizer as required

2. Coordinate the location of all devices in the rack with the Owner/ Engineer at the time of installation.

C. Manufacturer(s):

1. Racks Unlimited Inc.

2. Approved Equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Provide all labor, materials and equipment necessary to furnish and install the video surveillance system as indicated and as specified.

B. All video surveillance equipment and the cameras shall be installed in accordance with the manufacturer's instructions unless otherwise directed by the Engineer.

C. Provide all necessary setup and startup services for the video surveillance system.

D. Provide all necessary system programming and configuration required for full system functionality.

E. Test the video surveillance system for complete functionality. Develop a testing plan to demonstrate that each component is operating optimally.

F. Installation shall be in accordance with the NEC.

3.02 TESTING AND CERTIFICATION

A. The video surveillance System shall be tested in accordance with the following:

1. Conduct a complete inspection and test of all installed equipment.

2. Provide staff to test all devices and all operational features of the system for witness by the Owner’s representative. The Owner’s representative must witness all testing prior to acceptance.

3. The testing and certification shall take place as follows:
a. System shall be tested in conjunction with manufacturer’s representative.
b. All deficiencies noted in the above test shall be corrected.

c. Test results shall be submitted to the consultant or Owner's representative.
d. System test witnessed by Owner's representative and correction of any deficiencies noted.

4. A letter of certification shall be provided to indicate that the tests have been performed and all devices are operational.

3.03 TRAINING

A. All training shall be provided per the requirements of Divisions 01 and 40. Training shall include a minimum of 2, one-hour classes to cover both operator and administrator instruction as specified herein. Two classes are required to ensure personnel from all shifts receive the same training.

B. Basic operator instruction shall cover the following:

1. System Login

2. Manual Camera Selection and Control

3. Automatic Camera Controls

C. Administrator instruction shall cover the following:

1. System Configuration:
   a. Camera picture adjustments.
   b. Camera position labeling.
   c. Camera pre-set position programming.

2. System Diagnostics:
   a. Alarm device first level diagnostic procedure.
   b. Camera selections and control diagnostics.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Work described under this section pertains to excavations, dewatering, excavation support systems, pipe jacking, and/or other construction activities that may cause ground deformation and vibrations.

B. Furnish all material, equipment, labor and services required for the complete installation, maintenance, protection, and monitoring of geotechnical instrumentations and reporting of collected data for all instrumentation as specified in this Section, and as necessary to monitor construction performance and impacts on adjacent facilities.

C. Furnishing, installing, monitoring and report observation wells to monitor groundwater levels as specified in this Section.

D. Conduct pre-construction surveys as specified herein.

E. Coordinate and obtain all permissions required, both public and private, to install geotechnical instrumentation.

F. Install instruments with the Engineer present to observe their installation.

G. Establish response actions to be taken if the maximum allowable instrument readings are exceeded so that existing structures and utilities are protected from damage. Implement response actions if maximum allowable instrument readings are exceeded.

H. Dispose of all instruments at the end of the project.

1.02 RELATED WORK

A. Earthwork is included in Section 31 23 00.

B. Dewatering and Drainage are included in Section 31 23 19.

C. Trenching, Backfilling and Compaction is included in Section 31 23 33.

D. Excavation Support and Protection is included in Section 31 75 01.

E. Jacking Under Railroads is included in Section 33 05 25.

1.03 PURPOSE OF THE GEOTECHNICAL INSTRUMENTATION PROGRAM

A. The purpose of the geotechnical instrumentation is to monitor:

1. Performance of the Contractor’s excavation support system.

2. Performance of the Contractor's trenchless excavation systems.

3. Groundwater levels inside and outside the limits of the excavation.

4. Vertical deformation of ground surface adjacent to the work.

5. Vertical and horizontal deformation of existing utilities and structures adjacent to the work.

1.04 RESPONSIBILITIES OF CONTRACTOR

A. Prior to commencing any demolition, support of excavation installation, excavation, trenchless crossing, micropile installation and dewatering work, furnish components of instrumentation that are to be installed during construction.

B. Install instruments and establish initial baseline readings.

C. Protect from damage and maintain instruments installed by the Contractor.

D. Repair or replace damaged instruments furnished by the Contractor.

E. Collect, reduce, process, plot and report settlement and deformation monitoring data obtained by survey, groundwater levels, and submit to the Engineer.

F. Coordinate with the Engineer to verify consistency of collected data.

G. Implement remedial measures based on interpretations of monitoring data program.

1.05 SUBMITTALS

A. Submit in accordance with Section 01 33 23.

B. Submit for review by the Engineer the following information at least four weeks prior to instrument installation:

1. Installation Plan and Schedule: Full details of the proposed plan and schedule for installing and monitoring instruments, including proposed locations, types, installation methods, and monitoring schedule of the instruments.

2. The names, qualifications, and experience of the personnel or subcontractor(s) who will install the instruments, perform optical level survey and vibration monitoring, read the instruments, and report data to the Engineer demonstrating compliance with Paragraph 1.08.

3. Layout of monitoring points, observation wells, seismographs and reference points and description of monitoring provisions, including full details of the proposed instruments, proposed plan and schedule for installing the instruments, and schedule for monitoring and data reporting.

4. Description of methods for installing and protecting all instrumentation including but not limited to seismographs, observation wells, crack gages, monitoring points, and reference points.

5. Copies of all instrument calibrations and certifications specified.

6. Groundwater observation well construction details including casing type, filter gradation, screen interval, grout mix, drilling methods, and depth of wells.

7. For all instrumentation installed in borings provide a detailed procedure for installation, including post installation acceptance test, together with a sample installation record sheet. The installation procedures shall include:
   a. The method to be used for cleaning the inside of casing or augers.
   b. Drill casing or auger type and size.
   c. Depth increments for backfilling boreholes with sand and bentonite.
   d. Method for overcoming buoyancy of instrumentation components during grouting.
   e. Method of sealing joints in pipe casing to prevent ingress of grout.
   f. Installations Records: Within five days of installing each instrument, submit to the Engineer, the as built instrument location as specified, and its corresponding installation record sheet. Include in the installation record sheet, but do not limit the information to, the installed location of each instrument with instrument identification numbers, established elevations, initial elevations, initial coordinates, boring log, installation and/or monitoring date and time. Furnish details of installed instruments showing all dimensions and materials used, and as built drawings of each instrument.

8. Field Calibration: Within 5 working days of performing a field calibration, submit results of the calibration to the Engineer.

9. Reports and Records: Provide reports of monitoring data to the Engineer. Include the following minimum information:
   a. Pre-construction survey.
   b. As-installed location plan, installation records and baseline values for all instrumentation.
   c. Monitoring data for all instruments with plots against threshold values.
   d. Weekly records of crack monitors, including photographs with readings.
   e. Event reports and summary from vibration monitoring.
   f. Discussion and associated action related to any result exceeding the threshold values set herein.

10. Certificates: For each seismograph instrument to be furnished submit a certificate issued by the instrument's manufacturer stating that the manufacturer has inspected and tested each instrument before it leaves the factory to confirm that the instrument is working correctly and has no defects or missing parts.

11. Submit three copies of the pre-construction condition surveys as specified herein.

C. Submit proposed remedial measures to the Engineer of action to be taken in the event that the instrument Threshold Values are reached.

1.06 REFERENCED STANDARDS

A. ASTM International

1. ASTM A53 / A 53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

2. ASTM D1785 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.07 DEFINITIONS

A. Surface Monitoring Points (SMPs): Inscribed marking or approved surveyor's nail installed to measure vertical (elevation) movement.

B. Excavation Support Monitoring Points (ESMPs): Inscribed marking or fixed makers placed on excavation support systems to measure horizontal movement of the excavation support system.

C. Groundwater Observation Wells: Screened or slotted pipe with solid riser pipe installed in a drilled hole with the annulus around the pipe backfilled with sand. Near surface groundwater levels are measured in the well.

D. Seismographs: Electronic recording device with vibration transducer capable of monitoring and recording ground vibrations induced by construction activity.

1.08 QUALITY ASSURANCE

A. The Contractor shall be responsible for all aspects pertaining to the installation, maintenance and monitoring of the geotechnical instrumentation specified herein.

B. Personnel Qualifications for Instrument Installation.

1. Employ qualified technicians with comparable experience in the installation of geotechnical instrumentation similar to that specified herein.

2. Employ a qualified Geotechnical Instrumentation Engineer who is a professional engineer, with at least 5 years of experience in the installation of instrumentation specified herein, to supervise and direct technicians and be responsible for instrument installation. This person is to be present at the installation site(s) to direct and supervise the installations, oversee the reading of the instrumentation and supervise the interpretations of geotechnical instrumentation data.

C. Installation of instrumentation shall, at all times, be performed in the presence of the Engineer.

D. Provide each instrument specified herein from an approved manufacturer currently engaged in manufacturing geotechnical instrumentation hardware of the specified types.

E. Surveyor Qualifications: The professional Land Surveyors shall be licensed in the State of Tennessee and with at least 3 years of experience in surveying of similar instruments. The professional Land Surveyors shall establish the Surface Monitoring Points and Excavation Support Monitoring Points and take baseline readings.

F. Perform optical level surveys, instrument readings, and report data. Personnel responsible for this work shall be qualified by a minimum of 3 years of experience with similar work.

G. Factory Calibration: A factory calibration shall be conducted on all seismographs prior to shipment. Certification shall be provided to indicate that the test equipment used for this purpose is calibrated and maintained in accordance with the test equipment manufacturer's calibration requirements and that, where applicable, calibrations are traceable to the U.S. National Institute of Standards and Technology.

H. Vibration monitoring shall be conducted by persons trained in the use of a seismograph and records shall be analyzed and results reported by persons familiar with analyzing and reporting the frequency content of a seismograph record.

I. Persons responsible for pre-construction surveys shall be professional engineers, licensed in the State of Tennessee, and shall have had a minimum of 5 years of professional experience in structural evaluation and conditions surveys.

1.09 TOLERANCES

A. Survey measurements for initial location of each of the instrumentation elements shall consist of determining the elevation and horizontal position with respect to benchmark(s) approved by the Engineer.

B. Monitoring Points (SMPs and ESMPs)

1. Elevations of all instrumentation shall be determined to an accuracy of plus/minus 0.01 foot.

2. The horizontal position of surface monitoring points shall be determined to an accuracy of plus/minus 0.1 foot.

3. The horizontal position of excavation support monitoring points shall be determined to an accuracy of plus/minus 0.01 foot.

C. Should actual field conditions prohibit installation at the location and elevations specified in this Section, obtain prior acceptance from the Engineer for new instrument location and elevation.

1.10 DESIGN AND PROJECT REQUIREMENTS

A. Project Requirements

1. Install Geotechnical Instrumentation as required herein and as necessary to monitor ground conditions, ground response, and facilities to achieve specified project requirements, and prevent damage to facilities potentially affected.

2. Install the instrumentation in accordance with the approved Instrumentation Schedule.

3. The Engineer's monitoring of the installed instruments does not relieve the Contractor of the obligation to complete the project within the requirements specified herein and the Contractor shall take additional measurements as may be necessary.

B. Pre-Construction Survey

1. Prior to start of demolition, excavation work, trenchless excavation work, installation of excavation support, installation of micropiles and dewatering work, engage the services of an independent professional engineer, licensed in the State of Tennessee, to conduct a pre-construction survey of existing structures and conditions within 50 feet of the anticipated excavation work, trenchless crossings, micropile installation, installation of excavation support and dewatering work.
   a. Coordinate activities, issue notices, obtain clearances and provide photographic and secretarial assistance necessary to accomplish the survey.
   b. Give notice in writing, to the property owner and any representative of local authorities required to be present at such survey. Notify in writing the dates on which surveys are planned so that representatives are present during the examination. Provide copies of notices to the Owner and Engineer.

2. Record observations of the existing conditions for residences, buildings and other structures, which are affected.
   a. Provide the survey consisting of a description of interior and exterior conditions. Locate cracks, damage or other defects existing and include information to make it possible to determine the effect, if any, of the construction operations on the defect. Where significant cracks or damage exists, or for defects too complicated to describe in words, photographs shall be taken and made part of the record.
   b. The records of each property examined must be signed by the representatives present and, if practicable, by the property owner, whether or not they are present at the examinations.

3. Record of the pre-construction survey shall consist of written documentation, video and photographs of the conditions identified. At the completion of the survey, submit copies of the documentation to the Owner.

4. Upon completion of all excavation work, installation of excavation support, installation of micropiles and dewatering work, complete a similar examination of properties and structures where complaints of damage have been received or damage claims have been filed. Give notice to interested parties so that they may be present during the final examinations. Records of the final examination shall be signed and distributed as the original pre-construction survey.

5. Retain records in the Contractor's file for at least 3 years after completion of the Contract. In the event of damage claims, a report shall be prepared by the Contractor on the particular structures as requested by the Engineer from those notes and photographs and submitted to the Owner. Repair damage attributed to the Contractor’s activity promptly and completely to the property owner’s satisfaction to restore the conditions of the property to that existing prior to work.

C. Secure all required permits prior to the installation or removal of observation wells.

D. Provide and facilitate safe access to the instruments at all times. The Engineer may perform additional monitoring in a manner that will minimize unnecessary work delays. Allow and facilitate instrument monitoring as required by the Engineer. No claim for lost production time due to this activity will be allowed.

E. Maintain all instrumentation. Replace all damaged instruments within 24 hours. Report all damaged or non functional instrumentation to the Engineer within 24 hours.

F. Availability of Data

1. Interpretations developed by the Engineer will be available to Contractor. Contractor may observe readings at any time or take their own supplementary readings.

2. Monitoring data is the property of the Owner and is not to be disclosed or published to third parties without the owner’s written permission.

3. Contractor is expected to make their own interpretations for their own purposes at no additional cost to the Owner.

PART 2 PRODUCTS

2.01 MATERIALS

A. General: All instruments and materials, including readout units, remain the property of the Contractor following completion of the Contract.

B. Furnish all installation tools, materials, and miscellaneous instrumentation components.

C. Surface protection for all instruments provided shall be flush with the surface in paved or other ground surface areas, at the time that the work is completed.

D. The minimum quantity of instruments to be furnished is as follows:

Instrument	Minimum No. of Units	Approximate Installed Depth
Observation Wells	1	10 feet below bottom of tunnel invert or excavation at trenchless crossing location
Observation Wells	2	10 feet below bottom of excavation at Pump Station and Diversion Structure Excavation
Seismographs	1	N/A
Surface Monitoring Points	7	N/A
Excavation Support Monitoring Points	As needed	N/A

E. Locations and number of instruments shall be determined by the Contractor and approved by the Engineer.

2.02 GROUNDWATER OBSERVATION WELLS

A. Observation wells will be used to monitor the groundwater levels outside the excavation.

B. Pipe shall consist of 1-inch minimum inside diameter Schedule 40 PVC pipe.

C. Maximum screen size shall be 0.020-in unless otherwise approved by the Engineer.

2.03 MONITORING POINTS

A. Establish system of control points and monitor in accordance with the requirements herein.

1. Surface Monitoring Points (SMPs)
   a. SMPs shall be used to monitor vertical deformation at or near the ground surface. Clearly identify all points with permanent, easily readable letters and numbers as approved by the Engineer.
   b. Provide SMPs in paved areas consisting of a 2-inch-long masonry nail, manufactured from hardened zinc–plated steel. Drive the masonry nail into an asphalt covered surface. Identify each nail individually with an identification tag or surface marking.
   c. Provide SMPs in non-paved areas consisting of a 3-ft-long, 3/4-inch diameter steel rod. Drive the rod into the ground or set in concrete in the ground such that no more than 3 inches of the rod is exposed above the ground surface. Round the top of the rod and punch-marked it at its center. Identify each rod with a surface marking.
   d. Provide SMPs on utility manholes consisting of an observable cross mark or welded bead on the top horizontal surface of utility manhole rims.

Clean the surface within 3 inches of the point and mark it to permit easy identification of the exact point. Clearly identify the point shall using fluorescent spray paint adjacent to the point.

2. Excavation Support Monitoring Points (ESMPs)
   a. ESMPs shall be fixed markers on the vertical elements of the excavation support system and shall be used to monitor horizontal deformation of excavation support system designed by the Contractor. Clearly identified all points with permanent easily readable letters and numbers as approved by the Engineer. Surface within 3 inches of each point shall be cleaned and clearly identified using fluorescent spray paint adjacent to the point.

B. Non-Shrink Cement Grout shall be suitable for intended application.

2.04 SEISMOGRAPHS

A. Provide portable seismographs for monitoring the velocities of ground vibrations resulting from construction activities as specified herein. Provide for full-time use on the project during vibration causing construction activities. Provide two (minimum) seismographs which have been calibrated within the previous six months to a standard that is traceable to the National Institute of Standards and Technology. Required characteristics of seismographs are listed below:

1. Measure the three mutually perpendicular components of particle velocity in directions vertical, radial, and perpendicular to the vibration source.

2. Measure and display the maximum peak particle velocity continuously during vibration-generating activities.

3. Have a low frequency omnidirectional transducer for measuring air blast overpressure with a flat frequency response within the limits of 2 Hz to 250 Hz with a tolerance equal to or better than plus or minus 10 percent.

4. Seismic range: 0.01 to 4 inches per second with an accuracy of plus or minus 5 percent of the measured peak particle velocity or better at frequencies between 10 Hertz and 100 Hertz, and with a resolution of 0.01 inches per second or less.

5. Acoustic range: 110 to 140 dB (referenced to 20 micro-Pascals) with an accuracy and resolution of plus or minus 1 dB.

6. Frequency response (plus or minus 3 dB points): 2 to 200 Hertz.

7. Two power sources: internal rechargeable battery and charger and 115 volts AC. Battery must be capable of supplying power to monitor vibrations continuously for up to 24 hours.

8. Self-triggering wave form capture mode that provides the following information: plot of wave forms, peak particle velocities, peak overpressure, frequencies of peaks.

9. Continuous monitoring mode must be capable of recording single-component peak particle velocities, and frequency of peaks with an interval of 1 minute or less.

2.05 CRACK MONITORS

A. Provide crack gages for monitoring the width of existing cracks and joints as manufactured by Geokon, Inc., Lebanon, NH Model 4420, or equal.

B. Crack gages shall have threaded anchors with ball joints which can be grouted to each side of the crack in any orientation and a transducer with a range of at least 1 inch and an accuracy of less than 0.1 percent and a nonlinearity of no more than 0.5 percent. The gage shall be capable of operating in temperatures ranging from minus 20 degrees to 80 degrees (Celsius).

C. Provide a solid steel cover over each gage which does not touch or otherwise interfere with the operation of the gage.

PART 3 EXECUTION

3.01 PREPARATION

A. Prior to commencing any demolition, installation of excavation support, excavation for both open trench and trenchless crossings, micropile installation and dewatering work, furnish components of instrumentation that are to be installed during construction and conduct pre-construction surveys.

B. Install instruments.

C. Protect from damage and maintain instruments installed by the Contractor.

D. Repair or replace damaged instruments furnished by the Contractor.

E. Collect, reduce, process, plot and report monitoring data obtained by survey, seismograph data, groundwater levels, and submit to the Engineer.

F. Coordinate with the Engineer to verify consistency of collected data.

G. Implement remedial measures based on interpretations of monitoring data program.

3.02 GENERAL REQUIREMENTS

A. Perform a pre-construction survey prior to any dewatering, excavation, trenchless crossings, demolition, installation of micropiles or installation of excavation support.

B. Install instruments at locations selected by the Contractor and approved by the Engineer in accordance with the approved installation procedures. The Engineer may modify instrument locations depending on field conditions and monitoring objectives. Install all instrumentation in accordance with the approved installation schedule.

Instruments shall be installed and baseline data, acceptable to the Engineer, shall be obtained before construction starts.

C. Provide the Engineer with access to instrument locations and assistance required in obtaining monitoring data.

D. Existing Conditions: Locate conduits and underground utilities in all areas where wells are to be drilled and installed. Conduct utility clearance and contact utility companies prior to any drilling. Instrument locations shall be modified, as approved by the Engineer, to avoid interference with the existing conduits and utilities. Repair damage to existing utilities resulting from instrument installations at no additional cost to the Owner.

E. All instruments shall be clearly marked, labeled, and protected to avoid being obstructed or otherwise damaged by construction operations or the general public. Immediately following installation, the location of the top of all instruments shall be surveyed to provide horizontal and vertical coordinates. Resurveying shall be done as required by the Engineer if there is a question regarding the instrumentation location.

F. A unique instrument identification number shall be assigned to each instrument and each point. The instrument identification number shall be clearly marked on each instrument in a non-destructible manner.

G. Drilling from the Ground Surface: Obtain necessary permits for each such instrument and conform to the permit requirements during drilling and installation.

H. Initial Reading: Immediately following instrument installation, the Contractor, in the presence of the Engineer, shall take two sets of initial readings to provide baseline readings and to demonstrate the adequacy of the completed installation.

I. Factory Calibration: A factory calibration shall be conducted on all instruments at the manufacturer's facility prior to shipment. Each factory calibration shall include a calibration curve with data points clearly indicated, and a tabulation of the data. Each instrument shall be marked with a unique identification number.

J. The instrumentation and monitoring specified here is considered the minimum required. The Contractor shall obtain additional data from the instrumentation and /or furnish, install, and monitor additional instrumentation as necessary to adequately monitor construction performance and safety aspects of the work.

3.03 MONITORING POINTS

A. Monitoring Points shall include but not be limited to SMPs and ESMPs. Monitor these control points using surveying methods.

B. Install SMPs as described below near excavations, trenchless crossing locations, pier installation locations, demolition and open trench locations. Additional SMPs may be required by the Engineer.

C. SMPs shall also be installed in the pavement or ground surface, within 5 feet, along each side of trench excavations that is within 50 feet of structures. The SMPs shall be

installed at spacing not more than 50 feet. Locations may be modified to meet site constraints with the approval of the Engineer.

D. SMPs shall also be installed on the rim of manhole covers of utilities located within 30 ft of open excavations.

E. Along trenchless crossing alignments, SMPs shall be installed at intervals of not more than 25 feet over the proposed trenchless crossing locations in rows of three; one directly above the alignment and the other two located 10 feet apart on each side oriented perpendicular to the pipe alignment. Locations may be modified to meet site constraints with the approval of the Engineer.

F. ESMPs shall be installed on excavation support systems other than trench box along support walls at a spacing of not more than 25 feet at launch and exit shafts for trenchless crossing.

G. Install and obtain SMP monitoring point readings prior to demolition, installing excavation support, beginning excavation or operation of groundwater control system or start of pile installation at the site. Install ESMPs prior to excavation within the exaction support system. The Contractor shall obtain two sets of measurements for each monitoring point to establish the baseline data within three days of installation. These measurements shall be made at least 24 hours apart but not more than 48 hours apart. Monitoring points with initial surveyed elevations (or offsets as appropriate) differing by more than 0.1 inch shall be checked for secure installation and resurveyed.

H. The reading schedule of all SMPs surveyed shall be daily during excavation, dewatering, filling and backfilling, pier installation, trenchless excavation and excavation support installation by all methods within 50 feet of the work and then at least twice a week until all excavation, dewatering and backfill is completed.

I. The reading schedule of ESMPs shall be at least daily during associated excavation and twice a week until backfill is completed.

3.04 VIBRATION MONITORING

A. Seismograph readings shall be taken during pile installation, support of excavation installation and other ground vibrations including excavation support installation or other activities causing ground vibrations within 50 feet of existing structures and railroad to document that peak particle velocities do not exceed the limit criteria as described below.

B. Seismographs shall be installed by the Contractor near existing structures or railroad when vibratory or impact hammers are used for the installation of shoring within 50 feet of existing structures, and as directed by the Engineer.

3.05 GROUNDWATER OBSERVATION WELLS

A. The screened interval of each well shall be set to monitor groundwater levels.

B. Using approved drilling methods, drill 4-in minimum diameter holes for observation wells of the size and depth required, and case with temporary casing. Bentonite drilling mud shall not be used in drilling holes for the observation wells.

C. Flush all cased holes with clean water through an approved bit. Flush until the discharge water is free of soil particles.

D. Construct observation well with 10 feet of slotted PVC well screen, filter sand, bentonite seal, couplings, a pipe cap, and a locking cover.

1. Place two feet of filter sand in the bottom of the drilled hole; then place the well screen and surround it with filter sand, as the temporary casing is carefully withdrawn.

2. Insert solid PVC casing and cap and fill the annular space with bentonite pellets then non-shrink cement grout.

3. Protect the observation wells at ground surface by providing a roadway box or outer protective casing with lockable top and padlock. Design the surface protection to prevent damage by vandalism or construction operations and to prevent surface water from infiltrating.
   a. Provide two keys for each padlock to the Engineer for access to each well.
   b. Observation wells shall be developed so as to provide a reliable indication of groundwater levels. Wells shall be re-developed if well clogging is observed, in the event of apparent erroneous readings, or as directed by the Engineer.
   c. Submit observation well installation logs, top of casing elevation, and well locations to the Engineer within 24 hours of completion of well installation.

E. Observation Well Maintenance

1. The Contractor shall maintain each observation well until adjacent structures and pipelines are completed and backfilled. Clean out or replace any observation well which ceases to be operable before adjacent work is completed.

2. It is the Contractor's obligation to maintain observation wells and repair or replace them at no additional cost to the Owner, whether or not the observation wells are damaged by the Contractor's operations or by third parties.

F. Monitoring and Reporting of Observation Well Data

1. The Contractor shall begin daily monitoring of groundwater levels in work areas prior to initial operation of drainage and dewatering system. Daily monitoring in areas where groundwater control is in operation shall continue until the time that adjacent structures and pipelines are completed and backfilled and until the time that groundwater control systems are turned off.

2. The Contractor is responsible for processing and reporting observation well data to the Engineer on a daily basis. Data is to be provided to the Engineer on

a form, which should include the following information: observation well number, depth to groundwater, top of casing elevation, groundwater level elevation and date and time of reading.

G. Following construction, abandon new observation wells as directed by the Engineer. Abandon observation wells by removing all material within the original borehole, including the casing, filter, and grout seal in accordance with all applicable permits. Using approved tremie methods completely fill the hole and all voids with non-shrink cement grout prior to removal of the drill casing such that formation materials do not move into the hole prior to grouting. Restore the ground surface to its original condition. Abandon wells within paved areas by removing the vaults and well caps to the pavement subgrade. Remove wells with as discussed above and repair or patch pavement with the same surface type.

3.06 INSTRUMENT PROTECTION, MAINTENANCE AND REPAIR

A. Protect the instruments from damage. The Contractor shall immediately replace, within 72 hours of damage, any instrument that becomes damaged or is destroyed for whatever reason at no additional cost to the Owner. If necessary, the Contractor will suspend work in the areas being monitored by the damaged instrument and take remedial action.

B. Maintain the instruments by draining water and flushing debris from under protective covers and keeping covers locked and sealed at all times.

3.07 MONITORING

A. The Contractor shall collect, tabulate, plot and interpret the survey monitoring data and provide the Engineer with the tabulated and plotted data. Report the status of excavation, bracing, groundwater levels, micropile installation operation, stationing of the tunnel face and backfilling at the time of data collection with each report.

B. Monitoring frequency may be modified as directed and approved by the Engineer.

C. Provide data from readings of all monitoring points to the Engineer within 24 hours of reading. Communicate verbally with the Engineer immediately after visual observations or data collection if excessive movements or other anomalies are indicated.

D. For seismograph data, a summary report with event summary of peak particle velocity and frequency shall be provided. A strip chart indicates the time and magnitude of maximum single-component peak particle velocity measured during each 5-minute interval of the monitoring period shall be submitted. A summary of vibration producing activities for that week shall be listed along with any specific events which caused anomalous readings.

E. The Contractor shall make visual observations of ground conditions and building conditions in the vicinity of the site and communicate immediately with the Engineer if signs of ground or structure movements are observed.

F. The Engineer may take independent instrumentation measurements. Cooperate with the Engineer during instrumentation monitoring by providing access to the instrumentation locations in a timely manner and by providing and maintaining safe means of access to all instrumentation locations for data collection. Data acquired by the Engineer will be made available to the Contractor in a timely manner.

G. The Contractor may make his/her own interpretations of monitoring data for his/her own purposes. Data or interpretations shall not be published of disclosed to other parties without advance written permission of the Owner.

H. If the Contractor collects data from an instrument that has been installed to replace a damaged instrument, the formal initial reading for the damaged instrument shall be used as an initial reading for the replacement instrument so that data are plotted continuously, without an offset at the time of damage. The time of damage and replacement shall be noted on the plot.

3.08 INTERPRETATION AND RESPONSE VALUES

A. The Contractor shall make its own interpretations of the data resulting from monitoring programs.

B. Threshold and Limiting Values for instruments:

Instrument	Threshold Value	Limiting Value
Seismographs	1.0 in/sec over 40 Hz 0.75 in/sec at 30- 40 Hz 0.5 in/sec at 20-30 Hz 0.25 in/sec under 20 Hz	2.0 in/sec over 40 Hz 1.5 in/sec at 30- 40 Hz 1.0 in/sec at 20-30 Hz 0.5 in/sec under 20 Hz
Surface Monitoring Points	0.5 inch	1.0 inch
Excavation Support Monitoring Points	3/16 inch	3/8 inch
Observation Wells	2 ft below bottom of excavation or trenchless crossing	at bottom of excavation or trenchless crossing

C. These values are subject to adjustment by the Engineer as indicated by prevailing conditions and/or circumstances.

D. If a Threshold Value is reached:

1. Engineer and Contractor shall meet to discuss remedial measures.

2. Contractor shall increase the instrument monitoring frequency as directed by the Engineer.

3. Contractor shall install and monitor additional instruments as directed.

4. Contractor shall implement the remedial measures in the event the Threshold Value is reached, so the Limiting Value is not reached.

E. Contractor to take all necessary steps so that the Limiting Value is not exceeded. Contractor may be directed to suspend activities in the affected area with the exception of those actions necessary to avoid exceeding the Limiting Value.

3.09 DISPOSITION OF INSTRUMENTS

A. Monitoring Points and Crack Gages: All monitoring points and crack gages shall be removed during the cleanup and restoration work, unless directed otherwise by the Engineer.

B. Observation Wells: When required by the Engineer, abandon and remove protective housings and caps in accordance with the required permits. All surfaces affected by installation of instruments shall be restored to their original condition prior to completion of work.

1. Leave in place any casings located within the plan limits of structures or pipelines or within the zone below 1H:1V planes extending downward and out from the edges of foundation elements or from the downward vertical footprint of the pipe, or where removal would otherwise result in ground movements causing adverse settlement to adjacent ground surface, utilities or existing structures.

2. Where casings are pulled, holes shall be filled with sand. Where left in place, casings should be filled with non-shrink cement grout and cut off a minimum of 3-ft below finished ground level or 1-ft below foundation level so as not to interfere with finished structures or pipelines.

3. Following backfilling, remove precast boxes or vaults and reconstruct pavement in paved areas. Restore surface to the conditions existing prior to installation of the instruments.

C. Seismographs: Units shall be returned to the Contractor following completion of the demolition, pier installation, installation of excavation support and excavation.

END OF SECTION

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. Provide all labor, materials, equipment, and incidentals required to perform clearing and grubbing as shown and specified in the Contract Documents.

2. The Work includes cutting, removing, and disposal from the Site trees, stumps, brush, roots, shrubs, vegetation, logs, rubbish, and other objectionable material.

3. Pay all costs associated with transporting and disposing of debris resulting from clearing.

4. Limits of Clearing and Grubbing Work: Clear and grub all areas within the Work areas unless otherwise shown or indicated in the Contract Documents.

B. Related Sections:

1. Section 01 13 00, Control of Work.

2. Section 01 57 13, Erosion and Sedimentation Control.

3. Section 02 41 00, Demolition.

1.02 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with Laws and Regulations for environmental requirements, disposal of debris, burning debris on Site, and use of herbicides.

2. Coordinate clearing work with Utility Companies.

1.03 SUBMITTALS

A. Action Submittals: Submit the following

1. Shop Drawings:
   a. Plan for removing trees and other large vegetation not explicitly shown or indicated for removal in the Contract Documents.
   b. Plan showing proposed limits of clearing and grubbing, if different from clearing and grubbing limits shown or indicated in the Contract Documents.

1.04 WARRANTY

A. Warrant that Work performed under this Section will not permanently damage trees, shrubs, turf, and plants designated to remain, or other adjacent work, facilities, or property. If damage resulting from CONTRACTOR's operations becomes evident during the correction period, replace damaged items and property at no additional cost to OWNER.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PREPARATION

A. Protection:

1. Throughout the Project, protect existing site improvements, including streets, drives, and Underground Facilities to remain (if any), and adjacent property and structures. Repair damage caused by CONTRACTOR to original condition or replace in kind, to satisfaction of ENGINEER, at no additional cost to OWNER.

2. Protect trees, shrubs, vegetation, and grassed areas to remain by providing temporary fencing, barricades, wrapping, or other methods shown, specified, or accepted by ENGINEER. Correct at CONTRACTOR's expense damage caused by CONTRACTOR outside the limits of clearing Work.

3. Do not remove trees without approval of ENGINEER, unless shown or indicated for removal.

4. Do not locate construction equipment, stored materials, or stockpiles within drip line of trees and vegetation to remain.

B. Site Preparation:

1. Obtain, pay costs associated with, and comply with applicable permits required for clearing and grubbing Work.

2. Delineation of Clearing and Grubbing Limits:
   a. Locate and clearly flag trees and vegetation to remain, and other materials to remain in the clearing and grubbing limits. Locate and clearly flag salvable vegetation to be relocated.
   b. Provide flagging to delineate limits of areas to be cleared or grubbed. Review at Site with ENGINEER before commencing removal of trees, vegetation, and other materials to be removed.
   c. Replace flagging that is lost, removed, or destroyed, until clearing and grubbing Work is complete and ENGINEER allows removal of flagging.

3. Erosion and Sediment Controls:
   a. Provide applicable erosion and sediment controls before commencing clearing and grubbing Work.

b. Comply with erosion and sediment control requirements of Section 01 57 13, Erosion and Sedimentation Control.
c. Continue providing erosion and sediment controls as clearing and grubbing Work progresses to previously uncleared, ungrubbed areas of the Site.

3.02 CLEARING AND GRUBBING

A. Clearing and grubbing shall be performed along the project at the locations designated on the drawings or directed by the Engineer.

B. Conduct his operations in a manner to prevent limb, bark, or root injuries to trees, shrubs, or other types of vegetation that are to remain growing and also to prevent damage to adjacent property.

C. Exercise extreme caution in order not to clear and grub areas outside of the limits of disturbance.

D. Remove and dispose of all trees, shrubs, stumps, roots, brush, tree laps, logs, rubbish, undergrowth, and debris within limits of clearing and grubbing shown or indicated in the Contract Documents, or as required by the project, unless otherwise shown or indicated.

E. Any areas of growth or individual trees which are to be preserved due to their desirability for landscape or erosion control purposes will be designated on the drawings or by the ENGINEER.

F. Where designated on the drawings individual trees shall be limbed-up, cut into six foot lengths, and stacked outside of the construction right-of-way, as directed by the Engineer, for removal by the property owner.

G. Any surface rocks or boulders larger than 6-in in diameter shall be removed from the site.

H. Maintenance of cleared and grubbed areas include:

1. Clean-up of overgrown areas.

2. Continuous weeding, brush cutting, and pruning for all areas within the contract site that has been cleared and/or grubbed. This shall take place from the Notice to Proceed until the final approval of the contract. This work is to be accomplished regardless of the phase of work in progress or any delays caused by weather, utilities, or property acquisitions.

3. CONTRACTOR is to provide for bush-hogging or weed-eating certain areas within the public access or easements that have become overgrown as directed by the ENGINEER. This includes any staging areas being used by the CONTRACTOR for the duration of the contract.

I. Trees and shrubs to remain shall be protected, and trimmed where required.

1. Trees and shrubs to remain that have been damaged or require trimming shall be treated and repaired under the direction of a qualified arborist, or other professional with qualifications acceptable to ENGINEER. Trees and shrubs intended to remain, that are damaged beyond repair or that are removed, shall be replaced by CONTRACTOR at no additional cost to OWNER.

J. Salvable Vegetation:

1. Trees, shrubs, and other vegetation requiring removal to facilitate the Work, and that will be transplanted elsewhere at the Site, shall be carefully balled and burlapped or placed in temporary pots, and stored at the Site in an acceptable area. Work involving removing and relocating trees, shrubs, and other vegetation shall be under the direction of qualified arborist acceptable to ENGINEER, or other professional acceptable to ENGINEER, hired by CONTRACTOR.

K. Disposal of Cleared and Grubbed Materials:

1. Dispose at appropriate off-site location trees, stumps, rubbish, debris, and other cleared and grubbed material. Do not use cleared or grubbed material as fill, backfill, or in embankments.

2. Dispose of cleared and grubbed material in accordance with Laws and Regulations.

3. Do not burn clearing debris at the Site, unless approved by OWNER and authorities having jurisdiction. If burning is permitted, comply with requirements of authorities having jurisdiction and Laws and Regulations. If burning is permitted at the Site, also comply with OWNER's requirements. The authority to burn does not relieve CONTRACTOR of any damages which may result from contract operations.

4. Disposal of debris on private property shall be prohibited without authorized consent.

L. Removal of site improvements, such as existing utilities (ex. Manholes), shall comply with Section 02 41 00, Demolition.

M. Roadways, streams, and access to existing operations shall be kept clear of debris.

N. CONTRACTOR shall be responsible for compliance with all Federal, State, and Local regulations.

3.03 TOPSOIL REMOVAL

A. Existing topsoil to be removed is defined as friable, clay loam, surface soil present in depth of at least four inches. Topsoil shall be free of subsoil, clay lumps, stones, and other objects over two-inch diameter and other objectionable material.

B. Stripping:

1. Strip topsoil to depths encountered, in manner that prevents intermingling of topsoil with underlying subsoil or other objectionable material. Remove heavy growths of grass and vegetation from areas before stripping.

2. Do not strip topsoil from within drip line of each tree to remain as part of the completed Project.

C. Stockpile topsoil in storage stockpiles in areas shown, or where otherwise accepted by ENGINEER. Construct storage piles so that surface water drains freely. Stabilize large topsoil piles with a cover crop and mulch, and provide silt fencing around perimeter of pile to prevent topsoil erosion and sedimentation; silt fencing shall be in accordance with Section 01 57 13, Erosion and Sedimentation Control. Cover smaller topsoil stockpiles, when used, with reinforced fabric to prevent windblown dust. Topsoil in excess of the quantity required for the finished Project shall remain property of OWNER.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. All excavation, trenching and related sheeting, bracing, etc., shall comply with the requirements of OSHA excavation safety standards (29 CFR Part 1926.650 Subpart P) and all associated State requirements. Where conflict between OSHA and State regulations exists, the more stringent requirements shall apply.

B. Furnish all labor, materials, equipment and incidentals required and perform all earthwork, which includes clearing and stripping, procurement of fill material (on-site and imported), excavating, placing, and compacting fill and backfill, structural excavating and backfilling, transportation and storage of excess earthwork materials; disposal of unsuitable, waste and surplus materials, restoration of excavation and trench surfaces, and all subsidiary work necessary to complete the grading of the developed areas to conform with the lines, grades, and slopes as shown on the Drawings and as specified herein.

C. The work shall include, but not necessarily be limited to; excavation and backfill for structures, foundations, manholes, pipes, paving; embankments; grading; and all related work such as sheeting, bracing and dewatering.

D. Provide the services of a licensed professional engineer registered in the State of Tennessee, to prepare temporary excavation support system, and dewatering system designs and submittals in accordance with Sections 31 75 01 and 31 23 19, respectively.

E. Furnish and install temporary excavation support systems, including sheeting, shoring and bracing, to ensure the safety of personnel and protect adjacent structures, piping, etc., in accordance with Federal, State and local laws, regulations and requirements. Temporary excavation support systems shall be in accordance with Section 31 75 01.

F. Furnish and install temporary dewatering and surface water control systems and operate to dewater and maintain excavations in a dry condition. Control drainage into excavations and remove seepage water and rainwater. Dewatering and surface water control shall be in accordance with Section 31 23 19.

G. Examine the site and review the available geotechnical data prior to submitting their proposal, taking into consideration all conditions that may affect his work. The Owner and Design Engineer do not assume responsibility for variations of subsurface conditions at locations other than places shown and at the time the investigations were made.

H. No extra work shall be initiated without notification to the Engineer and Owner in writing and the written approval of the Owner in response.

I. Wherever the requirement for compaction is referenced to herein, it shall mean minimum percentage of maximum density as determined by ASTM D698.

J. Protect existing structures and utilities to remain.

1.02 RELATED WORK

A. Erosion and Sedimentation Control is included in Section 01 57 13.

B. Geotechnical Instrumentation is included in Section 31 09 00.

C. Clearing and Grubbing is included in Section 31 11 00.

D. Dewatering and Drainage is included in Section 31 23 19.

E. Trenching, Backfilling and Compaction is included in Section 31 23 33.

F. Excavation Support and Protection is included in Section 31 75 01.

G. Landscaping is included in Section 32 90 10.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, the proposed methods of construction, including earthwork operations, excavation limits, slopes, fill material moisture conditioning and handling, compaction equipment, backfilling and filling and compaction for the various portions of the work, and material sources for the various portions of the work. Contractor shall remain responsible for adequacy and safety of construction means, methods, and techniques.

B. Submit laboratory test results for all fill materials (maximum density, gradation, Atterberg limits, sand equivalent, etc., as applicable) at least 72 hours prior to importing or placing any fill.

C. Submit for the Engineer's review and approval, the qualifications of the entity proposed to conduct geotechnical observation, testing and documentation. The submittal shall include qualifications of the firm and the resumes of the soil technician(s) assigned to the project and the licensed geotechnical engineer in charge. The firm's qualifications shall meet ASTM D3740. The soil technician shall have minimum three (3) years demonstrated experience in earthwork and grading operations and satisfy the certification requirements of agency having local jurisdiction. The Engineer reserves the right to request substitution of soil technician(s) assigned to field work. Assigned soil technician(s) shall not be substituted without the prior approval of the Engineer.

D. Submit copies of field daily reports by the soil technician at the end of each work day while earthwork and grading operations are underway.

E. Upon completion of earthwork and grading operations, submit a plan showing the density test numbers and locations, a table of all density test results and depths, and a certification of compliance by the geotechnical engineer in charge.

1.04 REFERENCE STANDARDS

A. ASTM International:

1. ASTM C33 – Standard Specification for Concrete Aggregates.

2. ASTM D698 – Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft3 (600 kN-m/m3)).

3. ASTM D2216 – Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.

4. ASTM D3740 - Standard Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction.

5. ASTM D4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soil.

6. ASTM D6913 - Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis.

7. ASTM D6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

B. United States Department of Labor – Occupational Safety and Health Administration (OSHA):

1. OSHA 29 CFR Part 1926 Subpart P.

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 DEFINITIONS

A. Percent Compaction: Required in-place dry density of the material, expressed as a percentage of the maximum dry density of the same material, as determined in the laboratory by ASTM Test Method D698.

B. Optimum Moisture Content: Moisture content (percent by dry weight) corresponding to the maximum dry density of the same material as determined by ASTM Test Method D698.

C. In-the-Dry: An excavation subgrade, where the groundwater level has been lowered to at least 2 feet below the lowest level of the excavation, stable with no ponded water, mud, or muck and shall be able to support construction equipment without rutting or disturbance and shall be suitable for the placement and compaction of fill material, pipe or concrete foundations.

D. Structures: Buildings, manholes and below grade vaults, pipelines and utilities, pavements, and slabs-on-grade both above and below ground.

E. Unsuitable Soil: Includes existing fill materials, organic soils, weak native soils, or clays with a plasticity index of greater than 15.

F. Objectionable Material: Includes topsoil, organic matter, contaminated soil, construction debris, perishable materials, snow, ice, frozen earth, and rocks or lumps of cemented soils over 6 inches in maximum dimension.

G. Overexcavation: Removal of Unsuitable Soil or Objectionable Material at or below the normal grade of the excavation or subgrade as indicated on the Drawings.

H. Subgrade: Required surface of subsoil, borrow fill or compacted fill. This surface is immediately beneath site improvements, especially dimensioned fill, paving, or other surfacing material.

I. Finished Grade: Required final grade elevation indicated on the Drawings. Spot elevations shall be precedent over proposed contours.

J. Coverage: Pass of compaction equipment over the complete surface area of exposed lift or subgrade to receive compaction.

1.06 STATUTORY REQUIREMENTS

A. All excavation, trenching, sheeting, bracing, etc. shall comply with the requirements of OSHA excavation safety standards (29 CFR Part 1926 Subpart P). Where conflict between OSHA, State and local regulations exists, the most stringent requirements shall apply.

B. Three working days prior to starting any excavation, the Contractor shall notify the regional notification centers for underground utilities and underground utility owners who are not members of the notification centers.

1.07 PROTECTION

A. All existing facilities which include but are not limited to structures, utilities, tanks, pavements, sidewalks, curbing, driveway aprons, fencing, landscaping and other improvements in the vicinity of the Contractor's operations shall be adequately protected. If necessary, curbing, driveway aprons and fencing shall be removed and restored or replaced after backfilling. All existing facilities damaged by the construction shall be replaced with material fully equal to that existing prior to construction to the satisfaction of the Owner.

B. Design, furnish, install, monitor and maintain excavation support as required and as specified in Section 31 75 01.

C. Furnish, install, monitor and maintain geotechnical instrumentation as required and as specified in Section 31 09 00.

D. Furnish, install, monitor and maintain dewatering and drainage systems as required and as specified in Section 31 23 19.

E. Excavations within the zone of influence of any existing structures or utility will require the use of excavation support system as specified in Section 31 75 01. The zone of influence is defined as a line extending at least 2 feet beyond of edge of the foundation, then outward and downward at a slope of 1 horizontal to 1 vertical. No excavation below the foundation of existing structures is allowed.

F. Excavations below the level of the base of any adjacent foundation or retaining wall shall not be permitted unless the design of the excavation and bracing includes an analysis of the stability of the structure supported by the foundation and as necessary, incorporates required bracing / underpinning of the foundation.

1.08 QUALITY ASSURANCE

A. At all structures, prior to the placement of bedding material, concrete work mats, structural fill or structural concrete, coordinate with Contractor's Quality Control Laboratory (QCL) to verify the suitability of the existing subgrade soil.

B. Prior to and during the placement of backfill and fill coordinate with Contractor's QCL to perform in-place soil density tests to verify that the backfill/fill material has been placed and compacted in accordance with the compaction requirements specified elsewhere. At least 48 hours-notice shall be provided prior to placement of backfill and fill.

C. Subgrades shall not be covered with fill nor fill placed without the observation, testing, and approval by Contractor's QCL. Earthwork activities performed without properly scheduled inspection are subject to removal and replacement or additional testing as directed by the Engineer at no expense to the Owner.

D. Materials will be tested and observed as described in the following paragraphs. Cooperate by allowing free access to the work for selection of test materials and observations.

1. Materials to be used in the work shall be tested by a certified independent laboratory, engaged by the Contractor and acceptable to the Engineer, to demonstrate conformance with the requirements of these Specifications. Such testing will be paid for by the Contractor. Deliver test reports and material certifications to the Engineer before using any material in the work.

2. If field test results are not in conformance with the requirements of these Specifications, all costs involved in correcting deficiencies in compacted materials to the satisfaction of the Engineer and costs of re-testing after correction of deficiencies shall be borne by the Contractor.

3. Earthwork activities performed without properly scheduled inspection are subject to removal and replacement or additional testing as directed by the Engineer at no expense to the Owner.

4. Testing methods shall comply with the latest applicable ASTM or equivalent AASHTO Standards specified.

5. During the placement of bedding, backfill and fill, the Contractor shall perform in-place soil density testing to confirm that fill material has been compacted in accordance with the requirements of this Section. The Engineer may designate areas to be tested. Contractor shall notify Engineer at least 72 hours in advance of scheduled compaction testing. In place soil density tests on backfill/fill material shall be as required by City, State, or Federal Codes, the project geotechnical report, but in no instance, shall be less than those listed below:
   a. Structures and Embankments. At least one density and moisture content test for each 2,500 square feet of surface area for each lift of fill at embankment, structure and manhole locations
   b. Trench Excavations. At least one nuclear density and moisture content test shall be conducted at a maximum of 50-ft intervals for each lift of fill placed or as directed by the Engineer. Refer to Section 31 23 33 Trenching, Backfilling and Compaction.
   c. The Engineer may designate additional areas to be tested.

6. Materials which have been previously tested may be subjected to further testing from time to time and may be rejected if it is determined that they do not conform to the requirements of these Specifications. Rejected materials shall be removed from the work immediately when so directed by the Engineer, notwithstanding the results of previous testing.

E. The Engineer or Owner may conduct additional soil testing. Cooperate fully in obtaining the information desired and allowing free access to the work.

1.09 CONSTRUCTION CONTROL

A. The Contractor is responsible for all construction layout and reference staking necessary for the proper control and satisfactory completion of all structures, cutting, filling, grading, drainage, fencing, embankment improvements, curbing, and all other appurtenances required for the completion of the construction work and acceptance of the Contract as specified and as shown on the Drawings.

B. All construction layout and staking shall be performed by a professional land surveyor or professional engineer registered in State of Tennessee, experienced and skilled in construction layout and staking of the type required under this Contract, and acceptable to the Engineer and Owner.

PART 2 PRODUCTS

2.01 MATERIALS

A. Common Fill - Common fill shall be approved, on-site excavated material or imported fill material that is composed of durable soil free of debris, organic matter, or other deleterious materials. Common fill shall not contain stones larger than 6 inches in largest diameter, a maximum of 75 percent passing the No. 200 sieve, and a maximum dry density of at least 90 pounds per cubic foot (pcf) as determined by ASTM D 698. Common fill shall not contain granite blocks, broken concrete, masonry rubble, or other similar materials and shall have physical properties such that it can be readily spread and compacted during filling.

B. Select Common Fill – Select common fill shall be as specified above for common fill except that the material shall contain no stones larger than 2 inches in largest diameter.

C. Structural Fill – Structural fill shall consist of mineral soil free of organic material, loam, debris, frozen soil or other deleterious material which may be compressible, or which cannot be properly compacted. Structural fill should consist of materials with the following gradation:

Sieve Size	Percent Finer by Weight
3-in	100
No. 4	20 to 90
No. 40	5 to 75
No. 200	0 to 50

Structural fill should have a maximum liquid limit of 50 percent, maximum plasticity index of 15 percent, and a maximum dry density of at least 95 pcf as determined by ASTM D698.

D. Crushed Stone – Crushed stone shall conform to No. 57 stone of the Tennessee Department of Transportation (TDOT) Standard Specifications for Roads and Bridges, latest edition and all addenda and supplements thereto.

E. Screened Gravel – Screened gravel shall be used for pipe bedding as detailed and at other locations indicated on the Drawings. Screened gravel shall conform to No. 7 stone of the TDOT Standard Specifications for Roads and Bridges, latest edition and all addenda and supplements thereto.

F. Sand – Sand shall conform to ASTM C33 for fine aggregate.

G. Geotextile:

1. Geotextile shall be used as necessary or where indicated on the Drawings and shall conform to the following requirements:
   a. Minimum grab strength of 120 lbs per ASTM D4632.
   b. Apparent opening size to be equal to or greater than the U.S. Standard Sieve No. 100 (0.210 mm) per ASTM D4751.
   c. Percent open area not to exceed about 25 percent. The percent open area is defined as the ratio of the sum of 20 or more individual open areas (times 100) to the sum of the corresponding 20 or more individual total areas.
   d. Coefficient of permeability shall not be less than 0.2 cm/sec.
   e. Geotextile shall be Mirafi, Type 160N; Propex Type Geotex 1001; GSE Type NW6; or equal.

2.02 CONFORMANCE TESTINGS

A. Periodic conformance testing shall be conducted by the Contractor's Quality Control Laboratory (QCL) on common, select common, and structural fill materials prior to

their use on the project. The following tests shall be conducted on the common, select common, and structural fill at the indicated frequencies:

Test	Method	Frequency
Grain Size or change in material	ASTM D 6913	Every 4,000 cy
Atterberg Limits or change in material	ASTM D 4318	Every 4,000 cy
Moisture/Density or change in material	ASTM D 698	Every 4,000 cy
Natural Moisture or change in material	ASTM D 2216	Every 4,000 cy

The grain size conformance tests and frequencies listed above also apply to crushed stone, screened gravel, and sand and the testing shall conform to ASTM C136.

Results of the tests shall be submitted to the Engineer within 24 hours of test completion and prior to material use on the project. The Engineer reserves the right to reject material based on the results of these conformance tests and/or independent quality assurance testing conducted by the Engineer or the Owner. Rejected materials shall be removed from the site at no cost to the Owner.

PART 3 EXECUTION

3.01 PREPARATION

A. Test Pits:

1. Perform exploratory excavation work (test pits) for the purpose of verifying the location of underground utilities and structures and to check for unknown utilities and structures, prior to commencing excavation work.

2. Test pits shall be backfilled and compacted as soon as the desired information has been obtained. Backfilled surfaces shall be stabilized in accordance with approved erosion and sedimentation control plans.

B. Geotechnical instrumentation shall be installed in accordance with Section 31 09 00 prior to commencing excavation work.

3.02 DEWATERING AND DRAINAGE

A. Dewatering and drainage systems shall be in accordance with Section 31 23 19.

3.03 SUPPORT OF EXCAVATION

A. Support of excavation shall be in accordance with Section 31 75 01.

3.04 EXCAVATION

A. Excavation shall include material of every description and of whatever substance encountered. Pavement shall be cut with a saw, wheel or pneumatic chisel along straight lines before excavating.

B. In general, the on-site soils can be excavated using standard earthmoving equipment. Excavation in dense soil or rock may require special equipment. In no case shall the earth be ploughed, scraped, or dug with machinery so near to the finished subgrade as to result in excavation of, or disturbance of material below grade.

C. Excavations shall be made to the grade indicated on the Drawings and in widths sufficient for laying the pipe, construction of the structures, bracing and for dewatering and drainage facilities. Excavations for structures shall be suitably wide for construction of the structures, including excavation supports, dewatering and drainage systems and working clearances.

D. Excavation shall be performed in the dry and shall be accomplished by methods which preserve the natural undisturbed condition of the subgrade soils.

E. If the bottom of any excavation is taken out below the limits shown on the Drawings, specified, or directed by the Engineer, it shall be refilled at no additional cost to the Owner with structural fill, screened gravel, or lean concrete or other material satisfactory to the Engineer.

F. When excavation has reached prescribed depths, the Engineer shall be notified and will observe the conditions. If materials and conditions are not satisfactory to the Engineer, the Engineer will issue instructions as to the procedures. The Engineer will be the sole judge as to whether the work has been accomplished satisfactorily.

G. Subgrade soils that have become soft, loose, "quick", or otherwise unsatisfactory as a result of inadequate excavation, dewatering or other construction methods, in the opinion of the Engineer, shall be removed and replaced with structural fill, screened gravel, or lean concrete as acceptable to the Engineer at the Contractor's expense.

H. Exposed subgrades in large open areas, for foundations shall be proof rolled with at least two overlapping coverages of a vibratory drum roller with a minimum of a 10-ton static drum weight. Proofrolling in confined areas may be accomplished with hand operated vibratory equipment approved by the Engineer. Proofrolling shall be conducted in the presence of the Engineer. The Engineer shall waive this requirement if, in his/her opinion, the subgrade will be rendered unsuitable by such proofrolling.

I. Perform overexcavation at the request of the Engineer to remove Unsuitable Soil, Objectionable Material, or other materials as determined by the Engineer to such depth and width as the Engineer may direct and shall be replaced with suitable material as directed by the Engineer.

J. Excavation for all pipes, structures and footings shall be carried out with the excavating equipment operating from the subgrade for the structure. The excavation shall be carried out "in the dry" and in a manner which will preserve the undisturbed state of the subgrade soils.

K. When excavations have reached the required subgrade, including any allowances for working mats or base materials, prior to the placement of working mats or base materials, notify the soils testing laboratory to verify the suitability of the existing subgrade soils for the anticipated foundation and structural loadings. If the existing subgrade soils are determined to be unsuitable, direction will be provided by the Engineer regarding removal and replacement with suitable materials. If Contractor believes that such direction would increase Contractor's cost and would thereby entitle Contractor to a change in Contract cost, Contractor shall notify the Engineer in accordance with the applicable article(s) in the General Conditions pertaining to changes in the work.

L. Overexcavation beyond the limits and depths required by the Contract Documents shall be replaced at no additional cost to the Owner by lean concrete, structural fill or other approved material subject to the prior approval of the Engineer.

3.05 SUBGRADE PREPARATION

A. Maintain the excavated subgrade "in-the-dry".

B. Prior to placement of fill, remove all objectionable material which shall include but not be limited to pavement, topsoil, organic matter, contaminated soil, construction debris, perishable materials, snow, ice, frozen earth, and rocks or lumps of cemented soils over 6 inches in maximum dimension.

C. For subgrades consisting of granular soils, proofroll the final subgrade using at least four coverages of a vibrator plate compactor.

D. Soft subgrades or unusable material shall be removed and replaced with compacted structural fill.

E. During wet or freezing weather, the Contractor shall take measures to protect foundation excavations once they have been approved by the Engineer. These measures shall include, but are not limited to, placing insulation blankets, placing a layer of screened gravel, crushed stone, or lean concrete on the exposed subgrade, or covering the exposed subgrade with a plastic tent. If additional overexcavation is required because the subgrade was not protected against wet or freezing weather, the cost of such additional work shall be borne by the Contractor.

F. Notify the Engineer to observe the subgrade following subgrade preparation and prior to fill placement. If the existing subgrade soils are determined to be unsuitable, direction will be provided by the Engineer regarding removal and replacement with suitable materials.

3.06 FILLING PLACEMENT AND COMPACTION PROCEDURES

A. Fill and backfill materials shall be placed in lifts to suit the specified compaction requirements to the lines and grades required, making allowances for settlement and placement of cover materials (i.e., topsoil, sod, etc.). Soft spots or uncompacted areas shall be corrected.

B. Fill and backfill shall not be placed and compacted when the materials are too wet to properly compact (i.e., the in-place moisture content of the soil at that time is no more than two percentage points above the optimum moisture content of that soil as determined by the laboratory test of the moisture-density relation appropriate to the specified level of compaction).

C. Structural Fill and Embankment Fill (Select Common Fill) shall be constructed to the lines and grades required, making allowances for settlement and placement of cover materials (i.e. topsoil, sod, etc.). Soft spots or uncompacted areas shall be corrected.

D. Fill materials shall not be placed on frozen surfaces, or surfaces covered by snow or ice. Fill material shall be free of snow, ice and frozen earth.

E. All structure water-tightness tests and dampproofing/waterproofing shall be completed prior to placing fill or backfill around structures.

F. If the subgrade slopes more than 10%, the subgrade shall be stepped to produce a stable, horizontal surface for the placement of fill materials. The existing subgrade slope shall then be scarified to a depth of at least 6-inches.

G. Fill slopes should be compacted by slope rolling and trimming or should be overfilled and trimmed back to plan grade to expose a firm, smooth surface free of loose material.

H. Fill lifts shall not contain stones with a dimension larger than 1/2 the specified loose measure lift thickness.

I. Compaction in open areas may be accomplished by any of the following methods: compaction equipment, fully loaded ten-wheel trucks or front-end loaders, tractor dozers weighing at least 30,000 lbs or heavy vibratory rollers. Compaction in confined areas (including areas within a 45-degree angle extending upward and outward from the base of a wall) and in areas where the use of large equipment is impractical, shall be accomplished by hand operated vibratory equipment or mechanical tampers. Lift thickness shall not exceed 6 in (measured before compaction) when hand operated equipment is used.

J. On-Site Fill Material shall be moisture conditioned prior to placement unless the Contractor demonstrates to Engineer in-place moisture conditioning methods that can achieve the required moisture content.

K. Compaction of each specified lift of fill materials shall be conducted by a minimum of four (4) complete coverages with acceptable compaction equipment to a specified density which is expressed as a percentage of the maximum dry density as determined by ASTM D698, unless specified otherwise.

L. Fill required beneath foundations or slabs on grade (except sidewalks) shall be structural fill. Place and compact structural fill in even lifts having a maximum thickness (measured before compaction) of 8-in.

M. Fill and backfill material placed immediately adjacent to and within 10-ft of all structures shall be structural fill. All structure water-tightness tests and dampproofing / waterproofing shall be completed prior to placing fill or backfill around structures. Place and compact structural fill in even lifts having a maximum thickness (measured before compaction) of 8-in uniformly around the structure.

N. Common fill may be used in areas beyond those designated for structural fill unless shown or specified otherwise. Common fill shall be placed in even lifts having a maximum thickness (measured before compaction) of 12-in.

O. Select common fill may be used in areas designated for embankment fill unless shown or specified otherwise. Select common fill shall be placed in even lifts having a maximum thickness (measured before compaction) of 8-in.

3.07 IMPERVIOUS FILL

A. Impervious fill shall be placed in controlled, even lifts having a maximum thickness (measured before compaction) of 6-in. Compaction shall be sufficient to attain a permeability of less than 1 x 10-7 cm/sec.

B. Moisture content of impervious fill to be compacted shall be maintained at or near its optimum moisture content (minus 2 to plus 2 percent).

3.08 COMPACTION REQUIREMENTS

A. Perform in place testing of compacted fill lifts to measure in-place density and water content (ASTM D6938).

B. Beneath foundations and slabs on grade (except sidewalks): Compact the top 12-in of existing subgrade (and each layer of fill if applicable) to a minimum of 98 percent maximum dry density (ASTM D698) at or near its optimum moisture content (minus 2 to plus 2 percent).

C. 10-ft around structures: Compact each layer of fill or backfill to a minimum of 98 percent maximum dry density (ASTM D698) at or near its optimum moisture content (minus 2 to plus 2 percent).

D. Embankments (except under roadways), lawn or unimproved areas: Compact each layer of fill or backfill to a minimum of 95 percent maximum dry density (ASTM D698) at or near its optimum moisture content (minus 2 to plus 2 percent).

E. Sidewalks: Compact each layer of fill to a minimum of 98 percent standard proctor (ASTM D698) at or near its optimum moisture content (minus 2 to plus 2 percent).

F. Roads, paved areas and roadway embankments: Compact each layer of fill or backfill to a minimum of 98 percent maximum dry density (ASTM D698) at or near its optimum moisture content (minus 2 to plus 2 percent).

G. Crushed stone shall be placed in layers having a maximum thickness of 6 inches and compacted by rolling and tamping to 98% of the maximum dry density as determined by AASHTO T180 at or minus 2% of the optimum moisture content.

3.09 DISPOSAL OF UNSUITABLE, WASTE AND/OR SURPLUS EXCAVATED MATERIAL

A. Unsuitable Soil, Objectionable Material, and waste and surplus excavated material shall be removed and disposed of offsite. Materials may be temporarily stockpiled in an area within the limits of construction that does not disrupt construction activities, create any nuisances or safety hazards, or otherwise restrict access to the work site.

3.10 GRADING

A. Grading shall be performed to the lines and grades shown on the Drawings. All objectionable material encountered within the limits indicated shall be removed and disposed of. Subgrades shall be completely and continuously drained and dewatered throughout the grading process. Install temporary drains, drainage ditches, etc., to intercept or divert surface water which may affect the execution or condition of grading work.

B. If at the time of grading it is not possible to place any material in its proper section of the Work, it shall be stockpiled in approved areas for later use. No extra payment will be made for the stockpiling or double handling of excavated material.

C. In cut areas, all loose or protruding rocks in slopes shall be removed to line or finished grade of the slope. All cut and fill slopes shall be uniformly dressed to the slope, cross-section and alignment shown on the Drawings unless otherwise directed by the Engineer.

END OF SECTION

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PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. Provide all labor, materials, equipment, and incidentals as shown, specified, and required to perform rock removal required for the Work, including disposing of excavated rock material.

2. Obtain permits required by authorities having jurisdiction for rock removal Work, including transporting, storing, and using blasting materials.

3. Perform rock removal Work in compliance with Laws and Regulations applicable permits, and requirements of authorities having jurisdiction.

B. Coordination:

1. Review procedures under this and other Sections and coordinate the Work that must be performed with or before rock removal.

2. Rock removal by blasting will not be permitted unless the contractor can demonstrate that no other means (pneumatic hammering, drilling, wedging, etc.) of rock removal are reasonably possible.

C. Related Sections:

1. Section 01 13 00, Control of Work.

2. Section 31 23 00, Earthwork.

3. Section 31 23 33, Trenching and Backfilling.

1.02 REFERENCES

A. Standards referenced in this Section are:

1. United States Bureau of Mines (USBM), Report of Investigations (RI) 8507.

1.03 TERMINOLOGY

A. The following words or terms are not defined but, when used in this Section, have the following meaning:

1. "Rock removal" is removal of igneous, metamorphic, or sedimentary rock or stone; boulders over two cubic yards in volume in open areas and boulders over one cubic yard in volume in trenches; and mass concrete; that cannot be removed using rippers or other mechanical methods and therefore requires

drilling and blasting or use of large excavator-mounted pneumatic breakers. The following material will not be measured nor allowed for payment as rock removal:

a. Soft, weathered or disintegrated rock that can be removed by normal excavating equipment, including bulldozers with rippers and large trackhoes with rock teeth or rock buckets.
b. Loose or previously blasted rock.
c. Broken stone in rock fills.
d. Rock or stone that falls into the excavation from outside limits of excavation shown or indicated in the Contract Documents.
e. Boulders that can be removed without drilling, blasting, or pneumatic breakers.
f. Pavements, sidewalks, and gutters of concrete, asphalt, or masonry.

2. "Trenches" means excavations having vertical sides whose depth exceeds its width, made for Underground Facilities and drainage beds.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Professional Engineer:
   a. CONTRACTOR or blasting Subcontractor shall retain a registered professional engineer legally qualified to practice in Tennessee. Professional engineer shall have at least five years of experience conducting preblast surveys, structural evaluations, and structural condition assessments.
   b. Responsibilities include:
      1) Preparing or supervising preparation of preblast survey.
      2) Preparing written requests for clarifications or interpretations of the Contract Documents for submittal to ENGINEER by CONTRACTOR.
      3) Signing and sealing preblast survey report.
      4) Performing condition assessments of structures damaged by blasting.

1.05 SUBMITTALS

A. Informational Submittals: Submit the following:

1. Test and Evaluation Reports:
   a. Blasting Plan, prepared by the blasting professional responsible for design and execution of the work. Plan shall consider existing and new structures and the potential impacts (vibration, etc.) on these structures. Plan shall also include seismograph locations.
   b. Rock surface survey information, in accordance with Article 3.1 of this Section.
   c. Preblast survey report, in accordance with Paragraph 3.2.D of this Section.
   d. Blasting records, when requested by ENGINEER, in accordance with Paragraph 3.3.F of this Section.

e. Vibration and overpressure monitoring results, in accordance with Paragraph 3.4.A.3 of this Section.

1.06 MEASUREMENT AND PAYMENT

A. Measurement:

1. Limits of rock removal shall be as follows:
   a. Structures: Limit for all structures shall be bounded by the following:
      1) Bottom of footing, drainage course material, or compacted backfill.
      2) Pre-construction rock surface.
      3) Vertical planes located 12 inches outside footing.
   b. Trenches: Limit for trenches shall be bounded by the following:
      1) Width of trenches shall not exceed the nominal diameter of the pipe plus 2 feet. Sides of trench shall be considered vertical.
      2) Depth of trench shall be 6 inches below the barrel of the pipe unless indicated otherwise on the Drawings.
      3) Length shall be equal to installed length of the Underground Facility, measured horizontally.

2. Trench shall be excavated 9 inches outside the exterior walls of manholes and structures.

3. The quantity of rock excavation to be paid for will be the number of cubic yards of rock measured in a rectangular prism along the vertical centerline of the trench.

4. No payment will be made for additional quantity outside the limits described in this Section.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 EXAMINATION

A. Top-of-Rock Survey:

1. Prior to blasting and rock removal, survey and measure the elevation of the top of rock to determine the in-place quantity of rock to be excavated.

2. Uncover rock to be excavated in sections or areas acceptable to ENGINEER for surveying.

3. Conform to Section 01 13 00, Control of Work.

4. Submit to ENGINEER field notes, site plan showing rock elevations measured, cross-sections of rock surface when necessary or required by ENGINEER, and detailed estimation of quantity of rock to be excavated.

3.02 PREBLAST SURVEY

A. General:

1. Preblast survey shall be performed or supervised by CONTRACTOR's or Subcontractor's professional engineer qualified in accordance with Article 1.4 of this Section.

2. Complete preblast survey before starting blasting and rock removal.

3. Preblast Survey Limits:
   a. Preblast survey shall document the preblast condition, defects, and other physical factors that could reasonably be affected by blasting, of all existing residences; commercial, industrial, and institutional buildings; water supply wells; Underground Facilities and above-ground utilities; and other structures within the greater of the following distances from the limits of rock removal Work to be performed by blasting: 500 feet, or limit required in Laws and Regulations.
   b. Preblast survey shall include structures such as dams, ponds and reservoirs, cisterns, structures of historical significance, and structures with unusually costly or vulnerable contents.
   c. Preblast survey shall document the species and sensitivity of livestock and other animals that could be affected by blasting.

4. If, during the Work, CONTRACTOR is requested by a property owner or tenant to view alleged damage to property, give written notice to OWNER prior to visiting to the property.

B. Preparation for Preblast Survey:

1. Contact all owners and tenants, or their legal representative, of properties within limits of preblast survey to obtain permission to conduct preblast survey of the associated property. If property owner and tenant (if any) does not grant permission to conduct preblast survey, contact property owner and tenant (if any) a second time by registered mail (return receipt requested). Second request for permission to conduct preblast survey shall include description of preblast survey to be performed and purpose of preblast survey. At least 72 hours prior to starting blasting, provide to authority having jurisdiction, in writing, names and addresses of property owners and tenants (if any) who refuse access for preblast survey.

2. Notify property owners and tenants at least 48 hours prior to conducting preblast survey.

3. Not less than 48 hours before conducting blasting, submit preblast survey report as specified in Paragraph 3.2.D of this Section.

C. Method:

1. Buildings, Structures, Underground Facilities, and Above-ground Utilities:

a. Include in preblast survey detailed examination of interior and exterior of structures, Underground Facilities, and above-ground utilities located within specified limits of preblast survey.
b. Underground Facilities: With owner of Underground Facility, document condition of access points such as chambers, manholes, and vaults.
c. Obtain color photographs, video, and prepare sketches and written descriptions to document the condition of areas within specified limits of preblast survey. Photographs and video shall conform to Section 01 32 33, Photographic Documentation.
d. Document evident structural faults or deficiencies and recent repairs.

2. Wells: Include in preblast an assessment of water supply wells located within specified limits of preblast survey, including:
   a. Information on well's date of construction, depth, method of construction, yield, water quality, and other existing available data. Obtain information from owner of well and installer (if known).
   b. Perform short-duration pump test on each well utilizing existing pump serving the associated well. Activate pump, measure volume of water and drawdown in the well for period of one-hour or less until approximate steady state conditions are achieved. Use data obtained from these measurements to estimate approximate yield of each well.

D. Survey Report:

1. General: Prepare written report summarizing results of preblast survey.
   a. Not less than 72 hours before blasting, submit two copies of completed preblast survey report to each authority having jurisdiction for their reference, if required. Submit one copy of preblast survey to OWNER, two copies to ENGINEER, and retain one copy at the Site.
   b. CONTRACTOR's or Subcontractor's professional engineer shall sign and seal final preblast survey report.

2. Contents: Preblast survey report shall contain the following:
   a. Location and description of each property within or partially within the specified preblast survey limits.
   b. Descriptions of conditions of buildings, structures, Underground Facilities, above-ground utilities, wells, and other elements included in the preblast survey.
   c. Summary of visual observations and inspections.
   d. Color photographs, sketches, and video as appropriate.
   e. All data, results, and yield estimates developed from water supply well assessments.

3. Photographic Documentation: Provide video to present supplemental information, as required. Photographic documentation shall conform to Section 01 32 33, Photographic Documentation. Include in photographs and video (where appropriate) a scale to indicate dimensions. In addition to information required in Section 01 32 33, Photographic Documentation, label photographs with name of the professional engineer responsible for preblast survey, name of property owner, and sufficient information to determine the location of the

image. Include in preblast survey report one print of each photograph and include discs with video and electronic copies of photographs.

4. CONTRACTOR's or Subcontractor's professional engineer shall report all findings that, in professional engineer's opinion, indicate that building, structure, Underground Facility, above-ground utility, or well will be adversely affected by the rock removal and blasting Work.

3.03 BLASTING AND ROCK REMOVAL

A. Perform blasting in accordance with Laws and Regulations relative to blasting, storage and use of explosives, and rock removal.

1. All explosives must be in accordance with the local Building Code.

B. Perform rock removal adjacent to Underground Facilities and above-ground utilities and life-safety facilities with utmost care, after properly notifying and coordinating with utility owners, life-safety facility owners, and authorities having jurisdiction.

C. Perform blasting to avoid endangering persons or property, and damaging or weakening adjacent foundations, structures, sheeting, bracing, and other facilities. Cover or otherwise suitably confine blasting to prevent flyrock.

D. Be fully responsible for injury and damage caused by blasting, and shall repair or replace all injury and damage immediately, as accepted by ENGINEER at no additional cost to OWNER.

E. Limit Criteria for Blasting Vibration, Particle Velocity, and Airblast Overpressure:

1. Amount of vibration, frequency and overpressure generated by blasting shall not exceed limits in Laws or Regulations, and limits established by authorities having jurisdiction.

2. Maximum peak particle velocity (PPV) shall not exceed limits indicated in Figure B-1, Appendix B, of the USBM RI 8507 or as required based upon the results of the preblast survey, whichever is more stringent.

3. Peak airblast overpressure measured at location of nearest occupied, above-ground structure (considering wind direction) shall not exceed 0.014 psi.

F. Keep records of all blasts. Blasting records shall be kept in an orderly manner and available for inspection or submitted to the ENGINEER when requested. The following information shall be included:

1. Date and time of shot.

2. Foreman's name.

3. Name of person conducting blasting operation.

4. Location, depth, number, and diameter of drill holes.

5. Depth of overburden.

6. Type and amount of explosive used in each hole.

7. Type of caps used.

8. Weather conditions.

9. Other pertinent data.

G. Removal by Methods Other than Blasting:

1. Where conditions of hazard exist, or clearances with existing facilities, piping, or structures are very small, where criteria herein cannot be met, or where the potential for damage to persons or property is strong, perform rock removal by means other than blasting. These methods include special techniques such as drilling, expansion chemical agents and wedging.

H. Removal and Disposal of Rock:

1. Remove blasted or broken rock from excavations with suitable equipment in accordance with Section 31 23 33, Trenching and Backfilling.

2. Do not use excavated rock as backfill unless it is processed to meet the requirements of specified fill and backfill materials. Dispose of excavated rock off the Site at CONTRACTOR's expense in compliance with Laws and Regulations.

3.04 SITE QUALITY CONTROL

A. Blast Monitoring:

1. Perform blast monitoring in accordance with Laws and Regulations.

2. Monitor blasting to allow evaluation of compliance with the limitations specified in the Contract Documents. At minimum, monitor each blast as follows:
   a. Blast Monitoring Zone: Monitor vibrations at exterior walls of a minimum of two structures closest to each blast.
   b. If no structures are located within specified blast monitoring zone, monitor vibrations at three equally spaced radial points located at perimeter of specified blast monitoring zone.
   c. Monitor overpressures for all structures within specified blast monitoring zone.

3. Submit vibration and overpressure monitoring results to ENGINEER within 24 hours of blasting. CONTRACTOR's monitoring does not relieve CONTRACTOR of responsibility for controlling vibration and overpressure during blasting.

B. Post-Blast Well Monitoring:

1. Submit post blasting well monitoring reports to include pump tests and water quality as described in above section 3.2.C.2 items b and c.

3.05 UNAUTHORIZED ROCK REMOVAL

A. Rock removal outside the limits shown or indicated in the Contract Documents or that is not approved by ENGINEER, including removal, disposal, and backfill, will be at CONTRACTOR's expense.

B. Fill unauthorized excavation below pipe or foundation with compacted select backfill as directed by ENGINEER in writing, at no additional cost to OWNER. Backfill other unauthorized excavation as specified in Section 31 23 33, Trenching and Backfilling.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Design, furnish, install, operate, monitor, maintain and remove a temporary dewatering system as required to lower and control water levels at least 2-ft below pipe trench bottoms and excavation subgrades, and 2-ft below entry and exit pits and at tunnel invert elevation for trenchless crossing to permit construction to proceed in-the-dry. Deviations to requirements specified within this document must be approved by the Engineer.

B. Design, furnish, install, operate, monitor, maintain and remove temporary surface water control measures adequate to drain and remove surface water entering excavations.

C. Retain the services of a professional engineer registered in the State of Tennessee to prepare dewatering and drainage system designs and submittals described herein.

D. Work shall include the design, equipment, materials, installation, protection, and monitoring of geotechnical instrumentation required to monitor the performance of the dewatering and drainage system as required herein.

E. Collect and properly dispose of all discharge water from the dewatering and drainage systems in accordance with the provisions of Section 01110. Under no circumstances shall water from dewatering systems be discharged into the existing or new sanitary sewer systems unless written permission of the utility or property owner is obtained.

F. Obtain and pay for all permits required for dewatering and drainage systems.

G. Repair damage caused by dewatering and drainage system operations.

H. Remove temporary dewatering and drainage systems when no longer needed. Restore all disturbed areas.

1.02 RELATED WORK

A. Submittals are included in Section 01 33 23.

B. Geotechnical Instrumentation is included in Section 31 09 00.

C. Earthwork is included in Section 31 23 00.

D. Trenching, Backfilling and Compaction is included in Section 31 23 33.

E. Excavation Support and Protection is included in Section 31 75 01.

F. Jacking under Railroads is included in Section 33 05 25.

1.03 SUBMITTALS

A. Dewatering and drainage system designs shall be prepared by a licensed professional engineer retained by the Contractor, registered in the State of Tennessee. The Contractor shall submit an original and three copies of the licensed professional engineer's certification on the PE form specified in Section 01 33 23. The Contractor shall also submit qualifications as required herein.

B. At least 2 weeks prior to the start of construction in areas of anticipated dewatering, the Contractor shall submit a dewatering and drainage system design plan. The plan shall include a description of the proposed dewatering system and include the proposed installation methods to be used for dewatering and drainage system elements and for observation wells. The plan shall include equipment, drilling methods, holes sizes, filter sand placement techniques, sealing materials, development techniques, the number and location of dewatering points and observations wells, etc. Include the dewatering system design calculations in the plan.

C. The plan shall identify the anticipated area influenced by the dewatering system and address impacts (i.e., settlement) to adjacent existing and proposed structures, and provide recommended permissible drawdown at proposed observation well locations. The report shall also include detailed plans for pre-construction surveys of existing structures at the site and settlement monitoring, as well as provisions to address settlement of existing structures resulting from dewatering activities as specified in Section 33 05 25.

D. Coordinate dewatering and drainage submittals with the Earthwork, Jacking Under Railroads and Excavation Support and Protection submittals. The submittal shall show the areas and depths of excavation to be dewatered.

E. Do not proceed with any excavation or dewatering activities until the dewatering submittals has been approved by the Engineer.

1.04 QUALITY ASSURANCE

A. Regulations: Perform all work in accordance with current applicable regulations and codes of all Federal, State and local agencies.

B. The Contractor shall have at least 5 years of experience with work compatible to the Work shown and specified, employing labor and supervisory personnel who are similarly experienced in this type of Work.

C. The Contractor's design engineer shall be registered in the State of Tennessee and have a minimum of 5 years of professional experience in the design and construction of dewatering and drainage systems and shall have completed not less than 5 successful dewatering and drainage projects of equal type, size, and complexity to that require for the work and acceptable to the Engineer and Owner.

1.05 DESIGN REQUIREMENTS

A. The Contractor is responsible for the proper design and implementation of methods for controlling surface water and groundwater.

B. The primary purpose of the groundwater control system is to preserve the natural undisturbed condition of the subgrade soils in the areas of the proposed excavations. Prior to excavation, the Contractor shall lower the groundwater to at least 2-ft below the lowest excavation subgrade elevation, and 2-ft below entry and exit pits and at tunnel invert elevation for the trenchless crossing. Additional groundwater lowering may be necessary beyond these requirements, depending on construction methods and equipment used and the prevailing groundwater and soil conditions. The Contractor is responsible for lowering the groundwater as necessary to complete construction in accordance with the plans and specifications at no additional cost to the Owner.

C. Design deep wells, well points and sumps, and all other groundwater control system components to prevent loss of fines from surrounding soils. Sand filters shall be used with all dewatering installations unless screens are properly sized by the Contractor's design engineer to prevent passage of fines from surrounding soils.

D. The Contractor shall be responsible for damage to properties, buildings or structures, sewers and other utility installations, pavements and work that may result from dewatering or surface water control operations.

E. Design review and field monitoring activities by the Owner or by the Engineer shall not relieve the Contractor of his/her responsibilities for the work.

F. The Contractor shall perform pre-construction surveys of facilities as specified in Section 31 09 00.

G. As necessary, provide backup power generation and groundwater control system components and devise emergency procedures for maintaining continuous, uninterrupted surface water and groundwater control operations.

H. The Contractor shall be responsible for meeting all permit conditions.

1.06 DEFINITIONS

A. Where the phrase "in-the-dry" is used in this Section, it shall be defined as an excavation subgrade, where the groundwater level is lowered to at least 2-ft below the lowest excavation subgrade elevation, and 2-ft below entry and exit pits and at tunnel invert elevation for the trenchless crossing, is stable with no ponded water, mud, or muck, and is able to support construction equipment without rutting or disturbance and is suitable for the placement and compaction of fill material, pipe or concrete foundations.

PART 2 PRODUCTS

2.01 MATERIALS

A. Pipe for observation wells is specified in Section 31 09 00.

B. Piping, pumping equipment and all other materials required to provide control of surface water and groundwater in excavations shall be suitable for the intended purpose.

C. Standby pumping systems and a source of standby power shall be maintained at all sites.

PART 3 EXECUTION

3.01 GENERAL

A. Control surface water and groundwater such that work within the jacking casing pipe, and all excavation to final grade are made in-the-dry, the natural undisturbed condition of the subgrade soils is maintained and softening and/or instability or disturbance due to the presence or seepage of water does not occur. All construction and backfilling shall proceed in-the-dry and flotation of completed portions of work shall be prohibited.

B. Methods of groundwater control may include but are not limited to perimeter trenches and sump pumping, perimeter groundwater cutoff, well points, ejectors, deep wells and combinations thereof.

C. Where groundwater levels are above the proposed bottom of excavation level, a pumped dewatering system will be required for pre-drainage of the soils prior to excavation, and for maintaining the lowered groundwater level until construction has been completed to such an extent that the structure, pipeline or fill will not be floated or otherwise damaged.

D. It is expected that the type of system, spacing of dewatering units and other details of the work will have to be varied depending on soil/water conditions at a particular location.

E. All work included in this Section shall be done in a manner which will protect adjacent structures and utilities and shall not cause loss of ground or disturbance to the pipe bearing soils or to soils which support overlying or adjacent structures.

F. Install, monitor and report data from observation wells. Evaluate the collected data relative to groundwater control system performance and modify systems as necessary to dewater the site in accordance with the Contract requirements.

G. Locate groundwater control system components where they will not interfere with construction activities adjacent to the work area or interfere with the installation and monitoring of geotechnical instrumentation. Excavations for sumps or drainage ditches shall not be made within or below 1H:1V slopes extending downward and out

from the edges of existing or proposed foundation elements or from the downward vertical footprint of the pipe without the approval of the Engineer.

H. As necessary, provide backup power generation and groundwater control system components and devise emergency procedures for maintaining continuous, uninterrupted surface water control and groundwater control operations.

3.02 SURFACE WATER CONTROL

A. Construct surface water control measures, including dikes, ditches, sumps and other methods to prevent, as necessary, flow of surface water into excavations and to allow construction to proceed without delay.

3.03 EXCAVATION DEWATERING

A. At all times during construction, provide and maintain proper equipment and facilities to promptly remove and properly dispose of all water entering excavations. Excavations and all work within the jacking casing pipe shall be maintained in-the-dry. Groundwater levels shall be kept at least 2-ft below the lowest excavation level.

B. Excavation dewatering shall maintain the subgrade in a natural undisturbed condition and until the fill, structure or pipes to be built thereon have been completed to such extent that they will not be floated or otherwise damaged by allowing water levels to return to natural elevations.

C. Pipe, masonry, and concrete shall not be placed in water or be submerged within 24 hours after being installed. Pipe, masonry or concrete which becomes submerged shall be removed and the excavation dewatered and restored to proper conditions prior to reinstalling the pipe, masonry or concrete. Water shall not flow over new masonry or concrete within four days after placement. Excavations for foundations and structures shall be maintained in-the-dry for a minimum of 4 days after concrete placement.

D. In no event shall water rise to cause unbalanced pressure on structures. Structures shall not be subjected to uplift water pressures until the concrete or mortar has set at least 24 hours. Prevent flotation of the pipe by promptly placing backfill.

E. Dewatering shall at all times be conducted in such a manner as to preserve the natural undisturbed condition of the subgrade soils at the proposed bottom of excavation.

F. If the subgrade of the trench or excavation bottom becomes disturbed due to inadequate dewatering or drainage, excavate below normal grade as directed by the Engineer and refill with structural fill, screened gravel or other material as approved by the Engineer at the Contractor's expense at no additional cost to the Owner.

G. It is expected that the initial dewatering plan may have to be modified to suit the variable soil/water conditions to be encountered during construction. Dewater and excavate, at all times, in a manner which does not cause loss of ground or disturbance to the pipe bearing soil or soil which supports overlying or adjacent structures or instability of the tunnel face conditions.

H. If the method of dewatering does not properly dewater the excavation as specified, install additional groundwater observation wells as directed by the Engineer and do not place any pipe or structure until the readings obtained from the observation wells indicate that the groundwater has been lowered at least 2-ft below the lowest excavation subgrade elevation, and 2-ft below entry and exit pits and tunnel inverts.

I. Dewatering units used in the work shall be surrounded by suitable filter sand and no fines shall be removed by pumping. Pumping from the dewatering system shall be continuous until pipe or structure is adequately backfilled. Stand-by pumps shall be provided.

J. Water entering the excavation from precipitation or surface runoff shall be collected in shallow ditches around the perimeter of the excavation, drained to a sump and pumped from the excavation to maintain a bottom free from standing water.

K. All pumping equipment shall be electric motor driven or shall have an internal combustion engine with maximum noise of 85 dBA at a distance of 10 feet from the equipment. No internal combustion engines exceeding this noise limit shall be used between the hours of 5:00 p.m. and 8:00 a.m. The Contractor shall provide connections to a commercial power supply for electric motor-driven pumps or shall use generators meeting this noise limit.

L. Drainage shall be disposed of in an approved area as specified in Section 01 35 43. Existing or new sanitary sewers shall not be used to dispose of drainage.

M. Take all necessary precautions to preclude the accidental discharge of fuel, oil, etc., in order to prevent adverse effects on groundwater quality.

3.04 WELL POINT SYSTEMS

A. Where necessary, install a vacuum wellpoint system around the excavation to dewater the excavation. Each wellpoint and riser pipe shall be surrounded by a sand filter. Sand shall be of such a gradation that, after initial development of the wellpoints, the quantity and size of soil particles discharged shall be negligible. Wellpoint systems shall be capable of operating continuously under the highest possible vacuum.

B. Installation of well point systems shall be in accordance with the approved submittal in the presence of the Engineer.

3.05 DEEP WELLS

A. Where necessary, install a deep well system around the excavation to dewater the excavation. Each well shall be surrounded by a sand or gravel filter with adequate gradation such that after development, the quantity and size of soil particles discharged are negligible. Sufficient number of wells shall be installed to lower the groundwater level to allow excavation to proceed in-the-dry.

B. Installation of deep wells shall be in accordance with the approved submittal in the presence of the Engineer.

3.06 OBSERVATION WELLS

A. Install observation wells as required in accordance with Section 31 09 00 to monitor groundwater levels beneath and around the excavated area until adjacent structures are completed and backfilled.

B. Observation wells should be located, installed, protected, maintained and monitored in accordance with Section 31 09 00.

3.07 REMOVAL OF SYSTEMS

A. At the completion of the excavation and backfilling work, and when approved by the Engineer, all pipe, deep wells, wellpoints, pumps, generators, observation wells, other equipment and accessories used for the groundwater and surface water control systems shall be removed from the site. All materials and equipment shall become the property of the Contractor. All areas disturbed by the installation and removal of groundwater control systems and observation wells shall be restored to their original condition.

B. Leave in place any casings for deep wells, wellpoints or observation wells located within the plan limits of structures or pipelines or within the zone below a 1H:1V plane extending downward and out from the edges of foundation elements or from the downward vertical footprint of the pipe, or where removal would otherwise result in ground movements causing adverse settlement to adjacent ground surface, utilities or existing structures.

C. Where casings are pulled, holes shall be filled with sand. Where left in place, casings should be filled with cement grout and cut off a minimum of 3-ft below finished ground level or 1-ft below foundation level so as not to interfere with finished structures or pipelines.

D. When directed by the Engineer, observation wells should be left in place for continued monitoring. When so directed, cut casings flush with final ground level and provide protective lockable boxes with locking devices. The protective boxes shall be suitable for the traffic and for any other conditions to which the observation wells will be exposed.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and perform all trenching for pipelines and appurtenances, including drainage, filling, backfilling, disposal of surplus material and restoration of trench surfaces and easements.

B. Excavation shall extend to the width and depth shown on the Drawings or as specified herein and shall provide suitable room for installing pipe, structures and appurtenances.

C. Furnish and place all sheeting, bracing and supports and shall remove from the excavation all materials which the Engineer may deem unsuitable for backfilling. The bottom of the excavation shall be firm, dry and in all respects, acceptable. If conditions warrant, deposit gravel for pipe bedding, or gravel refill for excavation below grade, directly on the bottom of the trench immediately after excavation has reached the proper depth and before the bottom of the trench has become softened or disturbed by any cause whatever. The length of open trench shall be related closely to the rate of pipe laying. All excavation shall be made in open trenches.

D. All excavation, trenching and related sheeting, bracing, etc., shall comply with the requirements of OSHA excavation safety standards (29 CFR Part 1926 Subpart P) and State requirements. Where conflict between OSHA and State regulations exists, the more stringent requirements shall apply.

E. Wherever the requirement for 95 percent compaction is referred to herein it shall mean "at least 95 percent of maximum density as determined by ASTM D698".

F. Prior to the start of work submit the proposed method of backfilling and compaction to the Engineer for review.

1.02 RELATED WORK

A. Earthwork is included in Section 31 23 00.

B. Dewatering and Drainage is included in Section 31 23 19.

C. Excavation Support and Protection is included in Section 31 75 01.

1.03 SUBMITTALS

A. Refer to Section 31 23 00 Paragraph 1.03 for required submittals.

1.04 REFERENCED STANDARDS

A. American Association of State Highway and Transportation Officials:

1. AASHTO M 288 - Geotextiles.

B. ASTM International:

1. ASTM D698 – Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft3 (600 kN-m/m3)).

C. Occupational Safety and Health Administration (OSHA):

1. 29 CFR Part 1926 Subpart P.

D. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. At all structures, prior to the placement of bedding material or backfill, coordinate with Contractor's Quality Control Laboratory (QCL) to verify the suitability of the existing subgrade soil.

B. Prior to and during the placement of backfill and fill coordinate with Contractor's QCL to perform in-place soil density tests to verify that the backfill/fill material has been placed and compacted in accordance with the compaction requirements specified elsewhere. At least 48 hours notice shall be provided prior to placement of backfill and fill.

C. Subgrades shall not be covered with fill nor fill placed without the observation, testing, and approval by Contractor's QCL. Earthwork activities performed without properly scheduled inspection are subject to removal and replacement or additional testing as directed by the Engineer at no expense to the Owner.

D. Materials will be tested and observed as described in the following paragraphs. Cooperate by allowing free access to the work for selection of test materials and observations.

1. Materials to be used in the work shall be tested by a certified independent laboratory, engaged by the Contractor and acceptable to the Engineer, to demonstrate conformance with the requirements of these Specifications. Such testing will be paid for by the Contractor. Deliver test reports and material certifications to the Engineer before using any material in the work.

2. If field test results are not in conformance with the requirements of these Specifications, all costs involved in correcting deficiencies in compacted materials to the satisfaction of the Engineer and costs of re-testing after correction of deficiencies shall be borne by the Contractor.

3. Earthwork activities performed without properly scheduled inspection are subject to removal and replacement or additional testing as directed by the Engineer at no expense to the Owner.

4. Testing methods shall comply with the latest applicable ASTM or equivalent AASHTO Standards specified.

5. During the placement of bedding, backfill and fill, the Contractor shall perform in-place soil density testing to confirm that fill material has been compacted in accordance with the requirements of this Section. The Engineer may designate areas to be tested. Contractor shall notify Engineer at least 72 hours in advance of scheduled compaction testing. In place soil density tests on backfill/fill material shall be as required by City, State, or Federal Codes, the project geotechnical report, but in no instance, shall be less than those listed below:

    a. Trench Excavations. At least one nuclear density and moisture content test shall be conducted at a maximum of 50-ft intervals for each lift of fill placed or as directed by the Engineer.
    b. The Engineer may designate additional areas to be tested.

6. Materials which have been previously tested may be subjected to further testing from time to time and may be rejected if it is determined that they do not conform to the requirements of these Specifications. Rejected materials shall be removed from the work immediately when so directed by the Engineer, notwithstanding the results of previous testing.

E. The Engineer or Owner may conduct additional soil testing. Cooperate fully in obtaining the information desired and allowing free access to the work.

PART 2 PRODUCTS

2.01 GEOTEXTILES

A. Refer to Section 31 23 00 Earthwork for granular materials and geotextile specifications.

PART 3 EXECUTION

3.01 TRENCH EXCAVATION

A. Excavations for the installation of pipes shall be made to the depths indicated on the Drawings. The minimum trench width shall extend 24 inches beyond the outside diameter of the pipe as indicated on the Drawings and shall be sufficient for installing structures, pipes, or ducts, for bracing and supporting and for pumping and drainage facilities. The bottom of the excavations shall be firm and dry and, in all respects, acceptable to the Engineer.

B. Trench excavation shall include material of every description and of whatever substance encountered, except rock and boulders. Pavement shall be cut with a saw, wheel or pneumatic chisel along straight lines before excavating.

C. Strip and stockpile topsoil from grassed areas crossed by trenches. At the Contractor's option, topsoil may be otherwise disposed of and replaced, when required, with approved topsoil of equal quality.

D. While excavating and backfilling is in progress, traffic shall be maintained, and all utilities and other property protected as provided in the General Conditions and General Requirements.

E. Excavation and dewatering shall be accomplished by methods which preserve the undisturbed state of subgrade soils. The trench may be excavated by machinery to, or just below the designated subgrade, provided that material remaining in the bottom of the trench is no more than slightly disturbed. Subgrade soils which become soft, loose, "quick", or otherwise unsatisfactory as a result of inadequate excavation, dewatering or other construction methods shall be removed and replaced by screened gravel fill as required by the Engineer at the Contractor's expense.

F. Clay and organic silt soils are particularly susceptible to disturbance due to construction operations. When excavation is to end in such soils, use a smooth-edge bucket to excavate the last 1-ft of depth.

G. Where pipe is to be laid in screened gravel bedding, the trench may be excavated by machinery to the normal depth of the pipe provided that the material remaining in the bottom of the trench is no more than slightly disturbed.

H. Where pipe is to be laid directly on the trench bottom, final excavation at the bottom of the trench shall be performed manually, providing a flat-bottom true to grade upon undisturbed material. Bell holes shall be made as required.

3.02 DISPOSAL OF MATERIALS

A. Excavated material shall be stacked without excessive surcharge on the trench bank or obstructing free access to hydrants and gate valves. Inconvenience to traffic and abutters shall be avoided as much as possible. Excavated material shall be segregated for use in backfilling as specified below.

B. It is expressly understood that no excavated material shall be removed from the site of the work or disposed of, except as directed by the Engineer. When removal of surplus materials has been approved by the Engineer, dispose of such surplus material in approved designated areas.

C. Should conditions make it impracticable or unsafe to stack material adjacent to the trench, the material shall be hauled and stored at a location provided. When required, it shall be re-handled and used in backfilling the trench.

3.03 SUPPORT OF EXCAVATION

A. Refer to Section 31 75 01 Excavation Support and Protection.

3.04 TEST PITS

A. Excavation of test pits may be required for the purpose of locating underground utilities or structures as an aid in establishing the precise location of new work.

B. Test pits shall be backfilled as soon as the desired information has been obtained. The backfilled surface shall be maintained in a satisfactory condition for travel until resurfaced as specified.

3.05 EXCAVATION BELOW GRADE AND REFILL

A. Whatever the nature of unstable material encountered or the groundwater conditions, trench drainage shall be complete and effective.

B. If the Contractor excavates below grade through error or for the Contractor's own convenience, or through failure to properly dewater the trench, or disturbs the subgrade before dewatering is sufficiently complete, he may be directed by the Engineer to excavate below grade as set forth in the following paragraph, in which case the work of excavating below grade and furnishing and placing the refill shall be performed at his own expense.

C. If the material at the level of trench bottom consists of fine sand, sand and silt or soft earth which may work into the screened gravel notwithstanding effective drainage, the subgrade material shall be removed to the extent directed and the excavation refilled with a 6-in layer of crushed stone or screened gravel wrapped in filter fabric. Number 57 stone shall then be placed under the pipe and up to the spring line of the pipe as shown on standard trench bedding detail.

3.06 BACKFILLING

A. As soon as practicable after the pipe has been laid and jointed, backfilling shall begin and thereafter be prosecuted expeditiously. Bedding gravel, as specified for the type of pipe installed, shall be placed up to 1-ft over the pipe.

B. An impervious dam or bulkhead cutoff of clay or other impervious material shall be constructed in the trench as directed, to interrupt the unnatural flow of groundwater after construction is completed. The dam shall be effectively keyed into the trench bottom and sidewalls. Provide at least one clay or other impervious material dam in the pipe bedding between each manhole where directed or every 300-ft, whichever is less.

C. Where the pipes are laid in paved areas, the remainder of the trench up to a depth of 12-in below the bottom of the specified permanent paving shall be backfilled with common fill material in layers not to exceed 1-ft and thoroughly compacted.

D. To prevent longitudinal movement of the pipe, dumping backfill material into the trench and then spreading will not be permitted until selected material or screened gravel has been placed and compacted to a level 1-ft over the pipe.

E. Backfill shall be brought up evenly on all sides. Each layer of backfill material shall be thoroughly compacted by rolling, tamping, or vibrating with mechanical compacting equipment or hand tamping, to 95 percent compaction in non-paved areas and 98 percent compaction in paved areas. If rolling is employed, it shall be by use of a suitable roller or tractor, being careful to compact the fill throughout the full width of the trench.

F. Compaction by puddling or water jetting shall not be permitted.

G. Compaction in confined areas shall be by use of hand or pneumatic ramming with tools weighing at least 20 lbs. The material shall be spread and compacted in layers not

exceeding 6-in thick, uncompacted loose measure thickness. If necessary, sprinkling shall be employed in conjunction with rolling or ramming.

H. Backfill around structures shall be select common fill material as specified and as shown on the Drawings. All backfill shall be spread and compacted as specified, especially under and over pipes connected to the structures.

I. Bituminous paving shall not be placed in backfilling unless specifically permitted, in which case it shall be broken up as directed. Frozen material shall not be used under any circumstances.

J. All road surfaces shall be broomed and hose-cleaned immediately after backfilling. Dust control measures shall be employed at all times.

3.07 RESTORING TRENCH SURFACE

A. Where the trench occurs adjacent to paved streets, in shoulders, sidewalks, or in cross-country areas, thoroughly consolidate the backfill and shall maintain the surface as the work progresses. If settlement takes place, immediately deposit additional fill to restore the level of the ground.

B. In, and adjacent to streets, the 12-in of trench backfill below the specified initial pavement shall consist of compacted crushed stone. Should the Contractor wish to use material excavated from the trench as gravel subbase for pavement replacement, the Contractor, at his/her own expense, have samples of the material tested by an independent testing laboratory at intervals not to exceed 500-ft, in order to establish its compliance with the specifications. Only material which has been tested and approved by the Engineer shall be allowed to be incorporated into the work.

C. The surface of any driveway or any other area which is disturbed by the trench excavation and which is not a part of the paved road shall be restored to a condition at least equal to that existing before work began.

D. In sections where the pipeline passes through grassed areas, and at the Contractor's own expense, remove and replace the sod, or loam and seed the surface to the satisfaction of the Engineer.

END OF SECTION

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 SUMMARY

A. Furnish all equipment, materials and incidentals required to deliver to the site and install 9.75-inch (minimum) diameter drilled micropiles complete as shown on the Drawings and as specified herein.

B. Furnish all surveys including layout, inspection and record-keeping incident to drilled micropiles and as specified herein.

C. Furnish all labor, equipment, materials and incidentals required and install indicator micropiles at locations selected by the Contractor and approved by the Engineer, to the same dimensions and lengths shown for the production micropiles and conduct micropile load tests and proof tests as specified herein. Micropile load tests shall be conducted for micropiles in accordance with the Tennessee Building Code.

1.03 RELATED WORK

A. Concrete Reinforcement is included in Section 03 20 00.

1.04 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, shop drawings and product data showing materials of construction, installation equipment and details of installation for:

1. Design drawings selected permanent casing size, wall thickness, length, and embedment into competent bedrock (i.e., unweathered and continuous).

2. Plan showing location of all micropiles. Each micropile shall have a unique designation (micropile number) noted on the Shop Drawing. Include the proposed indicator micropile locations and installation sequence. The micropile number shall be referenced to the shop drawings for the micropile to be used at each location.

3. Complete description of the equipment, procedures and techniques for installation and grouting. Details of methods to maintain a stable hole including the lengths and diameters of permanent casing, types and properties of slurries, methods of desanding (if used) and cleaning the drill hole prior to grouting/concreting.

4. Complete description of methods, procedures and techniques for installing micropiles in karst conditions that may be encountered at the project site including use of permanent casing due to karst voids.

5. Grout mix design information in accordance with this Section.

6. Reinforcing steel details and information in accordance with Section 03 20 00, including centralizers and other temporary support of reinforcing steel during grout placement.

7. Submit details of micropile load test and proof test equipment, instrumentation and method, a sketch of the proposed load reaction system and a schedule for the test. Any proposed departures from the specified apparatus, methods, equipment or procedures shall be specifically noted on the submitted details and in the letter of transmittal. The load cell shall be calibrated by a certified testing laboratory within 30 days of the load test. Submit a certificate of the calibration record to the Engineer before commencing load tests.

8. Submit a micropile load test report prepared by the Contractor's Design Engineer that presents the results of the micropile load test, including the recommended installation criteria.

9. Results of the micropile proof tests prepared by the Contractor's Design Engineer that presents the results of the proof tests.

10. Within 3 working days after any drilled micropile has been deemed to be permanently obstructed or when an installed micropile has been observed to exceed the specified tolerances, provide to the Engineer a sketch showing the as-drilled location of all completed micropiles immediately adjacent to the obstructed micropile. Reference all as-drilled locations to established construction lines as shown on the Drawings.

B. Statement of Qualifications:

1. Submit qualifications of the drilled micropile subcontractor in accordance with Article 1.05.

2. Submit the qualifications of the Contractor's Engineer who will design the micropiles and design, monitor and evaluate micropile load and proof tests.

C. Project Record Documents:

1. Provide a record of each micropile installed and furnish signed, typewritten copies. The records shall include the micropile length installed, date and time of installation, time delays during installation, cut-off and tip elevations, time and type of grout placement, deviations from drawing location and from plumb and any other applicable data. Field logs shall be submitted to the Engineer daily, and final logs shall be submitted within 1 week of micropile installation.

2. Results of concrete grout cube tests in accordance with this Section.

3. Within 2 weeks after completion of all micropiles, provide Engineer with a drawing stamped by a surveyor licensedin the State of Tennessee, showing the designation number of all micropiles and their as-drilled locations with respect to the specified tolerances.

1.05 QUALITY ASSURANCE

A. The drilled micropile subcontractor shall have at least 5 years' experience obtained over the last 10 years in the installation of drilled micropiles of the type specified herein, including experience with similar subsurface materials, groundwater conditions, micropile sizes and special techniques required. A minimum of two projects shall have been conducted within karst formations similar to those that may be encountered at the project site.

B. The contractor's Engineer shall have at least 5 years' experience on design of micropiles.

C. Employ a surveyor licensed in the State of Tennessee who shall determine and certify the actual location of each micropile as installed and shall submit certified lists and drawings of the micropile locations with micropile designation numbers, tip and cutoff elevations as installed and deviations from plumb.

D. The Engineer will monitor the micropile installation operations. Micropiles shall be installed only in the presence of an authorized representative of the Engineer.

1.06 PROJECT/SITE REQUIREMENTS

A. The test boring logs and laboratory testing are included in the Geotechnical Report. The test boring logs indicate the soils and conditions at the test boring location only and soils and conditions can vary away from the actual test boring locations. The geotechnical data are made available to the Contractor for their information to be used at their own risk. The Contractor is responsible for all conclusions to be drawn from the test borings including the character of the materials to be encountered and the degree of difficulty to be expected in the performance of the work. The Contractor is encouraged to perform his/her own subsurface investigation.

B. It should not be assumed that materials other than those disclosed by the test borings will be encountered or that the proportions and character of the various materials will not vary from those indicated in the test boring logs.

C. No claim for extra compensation or extension of time will be considered because of any variation in site, soil, rock, or groundwater conditions from those indicated on test boring logs in the Geotechnical Report to those actually encountered.

1.07 DEFINITIONS

A. Micropile Bond Zone Length: The portion of the micropile grouted into a bedrock zone except the plunge depth and which transmits micropile load to the bonded strata.

B. Micropile Plunge Depth: The portion of the micropile casing that is embedded into the rock, which should be at least one foot.

PART 2 PRODUCTS

2.01 MATERIALS

A. GROUT FOR MICROPILES

1. Grout for micropiles shall conform to the requirements of the Tennessee Building Code and requirements of this Section.

2. Grout for micropiles shall consist of Portland cement, fine aggregate and water so proportioned to exhibit a water-cement ratio between 0.35 and 0.45. The grout shall have a minimum 28-day compressive strength of 4,000 psi and be capable of maintaining the solids in suspension and being pumped without difficulty. Slump shall be as required to accommodate placement techniques and shall not be less than 8 inches nor greater than 10 inches.

3. Provide field and laboratory testing and other quality control of grout for micropiles in accordance with this Section.

B. Portland Cement:

1. Portland cement shall conform to ASTM C150, Type I or Type II.

C. Fine Aggregate:

1. Sand shall meet the requirements of ASTM C33.

2. Fine aggregate shall consist of clean sand or of hard, dense, durable, uncoated rock particles and shall be free from extraneous amounts of silt, loam, lumps, soft or flaky particles, shale, alkali, organic matter, mica, and other deleterious substances.

3. Fine aggregate shall not have detrimental effects on grout pumpability or homogeneity.

D. Water:

1. Water shall be potable, free of oil, acid, alkali, salts, chlorides, organic matter or other deleterious substances.

E. Reinforcing Steel:

1. Steel core reinforcement shall, as a minimum, conform to the requirements of ASTM A615, Grade 60.

F. Equipment:

1. Provide drilling equipment capable of drilling at least 30 feet deeper than the tip elevations indicated on shop drawing.

2. Provide drilling equipment that is capable of drilling into bedrock through miscellaneous fill, stiff soils, boulders, cobbles and irregular bedrock which may be encountered.

3. Grouting Equipment:
   a. Capable of continuous mechanical mixing that will produce a uniform and thoroughly mixed grout free of lumps and undispersed cement at required pressures.
   b. Colloidal (high speed, high shear) mixers shall be used.
   c. Mixers, storage tanks and pumps shall have adequate size and capacity to allow continuous grouting of an individual bar within a period of less than 1/2 hour.
   d. The accuracy of batching equipment shall be sufficient to control the water-cement ratio of the grout to within +5 percent of the target value.
   e. Capable of grouting at a pressure sufficient to overcome any hydrostatic pressure that may exist with enough excess pressure to ensure complete and adequate grouting, and prevent introduction of oil, air, or other foreign substances into the grout. No loss of water from the grout due to poor seals, poor connections, or other causes will be permitted.
   f. Positive displacement grout pump shall be used.
   g. Screen to limit grout particles with 1/8-inch mesh openings.
   h. Pressure gauge to monitor grout pressures shall be attached to grout line just prior to entering hole.

PART 3 EXECUTION

3.01 GENERAL

A. Each micropile shall have a minimum micropile bond zone length per design drawings, unless approved by the Engineer.

B. Each micropile shall be installed to a minimum embedment into the competent bedrock strata (i.e., unweathered and continuous) per the reviewed shop drawing.

C. Locate all below grade utilities and pipes before starting micropile installation.

D. Measuring, mixing, transporting, and placing grout for micropiles shall conform to the requirements of this Section.

E. Reinforcing bar fabrication shall conform to the requirements of Section 03 20 00.

F. Grout cubes (2” x 2” x 2”) or cylinders (3” x 6”) will be taken by the Owner’s testing agency during placement. Grout cubes/cylinders shall comply with ASTM C109. The Contractor shall fully cooperate with the testing agency to facilitate observing and assisting in taking and storing of samples. No micropiles shall be grouted except in the presence of the Engineer.

G. Two samples shall be tested in compression at 5 or 7 days, two at 28 days, and two shall be held.

3.02 INSTALLATION

A. The micropiles shall be installed using rotary drilling equipment. Drilling methods shall employ sufficient fluid pressure to provide complete removal of the drill cuttings from the hole upon completion of drilling.

B. The Contractor shall protect all existing equipment and structures during micropile installation.

C. All micropile installation shall be performed in the presence of an authorized representative of the Engineer.

D. Drilling shall be performed in such a manner as to prevent loss of ground beyond the specified diameter. The drilling operation shall employ the use of a permanent casing at least one foot into the limestone (plunge depth).

E. Each micropile shall be drilled to the specified embedment (at least 7 feet excluding the plunge depth) in competent bedrock strata (i.e., unweathered and continuous) per the reviewed shop drawing.

F. Each micropile shall be drilled per the reviewed shop drawing.

G. Before grouting commences, the micropile bond zone length shall be blown clean to permit proper bonding between the micropile and bedrock.

H. After drilling is completed and the hole flushed and cleaned, core steel shall be placed and grout shall be placed with a tremie pipe and grout pump from the bottom of the micropile upward in one continuous operation until the micropile is filled.

I. Should voids be encountered in the bedrock during drilling of the micropile bond zone length, the Contractor shall extend the length of the micropile as directed by the Engineer. In general, the micropile bond zone length shall be extended as follows:

   1. Less than 6-inch void, micropile bond zone length remains unchanged.

   2. 6-inch void to 12-inch void, extend micropile bond zone length one foot.

   3. Greater than 12-inch void, restart count of the micropile bond zone length from the bottom of the void.

3.03 CUT-OFFS

A. The micropiles shall be cut-off at the required elevation on a clean and true horizontal plane unless otherwise shown on the Drawings. The grout shall continue to be chipped back until the resulting surface is sound, uncontaminated grout.

3.04 TOLERANCES

A. Drilled micropiles shall be installed as close as practicable to the plan locations shown on the Drawings. The maximum lateral deviation from the correct location at cut-off elevation will be 1.5 inch. The maximum deviation from design cut-off elevation will be 1inch. All micropiles shall be installed to no greater than 2 percent from vertical.

B. Maximum horizontal deviation from plan location: 3 inches.

C. If micropile location or construction tolerances are exceeded, develop plan and schedule for corrective construction, and submit deviations to the Engineer for approval.

D. Revise foundation and/or install additional micropiles to correct micropiles being installed beyond indicated tolerance limits in accordance with corrective construction plan.

3.05 PLACING REINFORCING STEEL AND GROUT

A. Do not place steel or grout until drilled hole has been approved by the Engineer.

B. Use centralizers spaced no greater than 10 feet on-center to maintain a minimum 2-1/2 inches of clearance between the reinforcement and sides of the hole. Centralizers shall be a maximum of 2 feet from the top and bottom of the micropile.

C. Provide reinforcement indicated. Secure reinforcement in place free of contact with sides of the hole. Protect reinforcement from damage.

D. Place grout through tremie pipe in a continuous pour to form a monolithic cylindrical shaft.

E. Provide temporary support of the steel reinforcement which maintains it at the correct elevation and orientation for a minimum of 24 hours after grout placement.

F. Perform field and laboratory tests as specified in this Section.

G. Allow grout to set for at least 72 hours prior to drilling and/or grouting for adjacent micropiles located within 6 micropile diameters.

3.06 INSPECTION

A. All micropiles shall be continuously inspected by the Engineer. A record shall be kept of:

1. Length of micropiles as installed.

2. Length of micropile bond zone.

3. Length of void zone(s).

4. Theoretical grout volume.

5. Actual grout volume.

6. Grout pressure during installation, if applicable.

7. Subsurface conditions encountered during drilling.

8. Date and time of installation.

9. Micropile number and location description.

B. Grout cube or cylinder sets of three shall be made at least every six micropiles grouted or a minimum of 1 per day of micropile installation, whichever is more frequent. The grout cube or cylinder sets shall be tested at 5 or 7 days, 28 days and two shall be held.

3.07 INDICATOR MICROPILES

A. One (1) indicator micropile shall be installed at non-production micropile locations proposed by the Contractor and reviewed and accepted by the Engineer. The indicator micropile testing shall be done at the foundation elevation of Pump Station or Diversion Structures. Indicator micropile shall be installed for conducting a micropile load test and to assist the Contractor in determining the required micropile lengths.

B. Indicator micropile shall be of the same type and size as the production micropiles. The indicator micropile shall be installed with the same type of equipment that is to be used for the installation of the remainder of the production micropiles.

3.08 MICROPILE LOAD TEST

A. Conduct at least one (1) micropile load test to confirm the design allowable compression capacities. The Engineer may require additional compression micropile load tests if the bearing conditions vary significantly amongst the indicator micropiles. Do not perform loading and unloading of the test micropile except in the presence of the Engineer. Do not perform the load test until grout test cubes or test cylinders indicate that the grout within the test micropile has obtained the required 28-day strength.

B. Conduct the micropile load test in accordance with the Tennessee Building Code and the provisions of ASTM D1143 or ASTM D3689. However, use three independent methods of monitoring butt displacement consisting of dial gauges; wire, mirror, and scale; and surveyor's level. Apply load to the test micropiles by means of a hydraulic jack, which reacts against a system of hold-down micropiles, or against a loaded box or test platform, which is supported by cribbing or temporary micropiles. The cribbing or micropiles support shall not be closer than 8 feet to the test micropile. Center the load box or platform on the test micropile and load with an approved material. The dead weight or other reaction above the jack shall be at least 40 percent greater than 2.5 times the design capacity of the micropile.

C. Provide the hydraulic jack with a capacity of at least 400 tons and capable of moving the micropile a minimum of 3 inches. The load testing equipment, shall include appropriate gauges to indicate the load applied with an accuracy within 2 percent of the target load and to measure associated displacements. Dial gauges shall have a precision of 0.001 inch with at least 2 inches of travel as a minimum, and more if necessary, to ensure that no adjustment of dial gauges is required during the performance of the load test.

D. The top of the test micropile shall be level and capped in such a manner as to produce a plane horizontal bearing surface. Set a steel billet on top of the micropile to distribute the test load over the entire cross-section area of the test micropile. Provisions made to the cap and billets to accommodate the test instrumentation shall not disrupt distribution of the load across the micropile butt.

E. The hydraulic jack, “ball and socket” and load cell shall be interposed between the steel billet and the center of the underside of the reaction beam. Provide a steel billet centered on the load cell to distribute the load to the girder, or reaction beam. The connections of the girder to the load box and to the hydraulic jack shall be tight when the test load is applied.

F. Measure the load at the top of the micropile with a load cell. Provide all instrumentation to be used, certified as accurate, if previously used, calibrated just prior to this work by an independent, certified testing agency.

G. Protect the entire measuring apparatus against rain, wind, direct sun, frost and any other disturbances, which may affect the reliability of the settlement observations. Provide heaters, not emitting offensive or hazardous exhausts, and enclosures to maintain the temperature around the test apparatus at a minimum of 40 degrees F and provide temporary lighting as necessary and required by the Engineer during the conducting of the test.

H. If the micropile load test fails to meet the design parameters, production micropiles shall be lengthened based on the back-calculated allowable skin friction obtained from the load test results as directed by the Engineer.

I. Personnel:

1. Provide personnel to maintain and operate all related equipment necessary to vary the load increments on the test micropile as required by the Engineer or their inspector. A representative of the Contractor shall be present on the site at all times during the micropile load test.

2. Setup, loading and unloading of the micropile being tested shall be performed by the Contractor, but only in the presence of the Engineer.

J. Micropile Load Test Report:

1. The micropile load test report, prepared by the Contractor’s Design Engineer, shall be submitted to the Engineer for review, prior to ordering or the installation of production micropiles.

2. The evaluation of the design load for a load tested micropile shall be in accordance with the Tennessee Building Code.

3. If a load test fails to meet the criteria, this shall be cause for rejecting the micropile tested.

3.09 MICROPILE PROOF TEST

A. Proof tests shall be conducted on one of the production micropiles at the Pump Station or Diversion Structure Buildings. At no time shall the test exceed 80 percent of the ultimate tensile strength of any steel or threaded connections placed in tension during testing, including reaction anchors.

B. Proof tests shall be conducted in accordance with Article 3.08 except that the micropile shall be tested to 160 percent of the allowable design load.

C. Proof tests shall be made by incrementally loading the micropile in accordance with the following schedule, to be used for both compression and tension loading:

Proof Test Loading Schedule		
AL = Alignment Load and DL = Allowable Design Load		
Increment	**Load**	**Hold Time**
1	AL	2.5 minutes
2	0.15 DL	2.5 minutes
3	0.30 DL	2.5 minutes
4	0.45 DL	2.5 minutes
5	0.60 DL	2.5 minutes
6	0.75 DL	2.5 minutes
7	0.90 DL	2.5 minutes
8	1.00 DL	2.5 minutes
9	1.15 DL	2.5 minutes
10	1.30 DL	60 minutes
11	1.45 DL	2.5 minutes
12	1.60 DL (Maximum Load)	2.5 minutes
13	1.30 DL	4 minutes
14	1.00 DL	4 minutes
15	0.75 DL	4 minutes
16	0.5 DL	4 minutes
17	0.25 DL	4 minutes
18	AL	4 minutes

D. Depending on performance, either a 10-minute or 60-minute creep test shall be performed at the 1.30 DL Test Load. Where the micropile top movement between 1 and 10 minutes exceeds 1 mm (0.04 in), the Maximum Test Load shall be maintained an additional 50 minutes. Movements shall be recorded at 1, 2, 3, 5, 6, 10, 20, 30, 50 and 60 minutes. The alignment load shall not exceed 5 percent of DL. Dial gauges shall be reset to zero after the initial AL is applied.

E. The acceptance criteria for micropile proof load tests are:

1. The Contractor's Engineer shall determine the criteria for tolerable movement during the load test at the top of the micropile.

2. At the end of the 1.30 DL creep test load increment, test piles shall have a creep rate not exceeding 0.05 inch/log cycle time (1 to 10 minutes) or 0.1 inch/log cycle

time (6 to 60 minutes). The creep rate shall be linear or decreasing throughout the creep load hold period.

3. Failure does not occur at the 1.60 DL maximum test load. Failure is defined as the load at which attempts to further increase the test load simply result in continued micropile movement.

3.10 ACCEPTANCE CRITERIA

A. Only micropiles meeting the requirements of this Section shall be accepted for payment.

B. Micropiles that are rejected because of damage, mislocation, or misalignment, or failure to meet the criteria, shall be cut off below the limits of the structure and abandoned and additional micropiles shall be installed as directed by the Engineer at no additional cost to the Owner.

3.11 CLEANUP

A. Remove from the site and dispose of all drilling wash water, cuttings, slurry and waste material resulting from micropile installation.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and place riprap and appurtenances as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A. Earthwork is included in Section 31 23 00.

PART 2 PRODUCTS

2.01 MATERIALS

A. Riprap used for channel and slope protection shall be sound, durable rock angular in shape, resistant to weathering, of suitable quality to insure permanence in the condition in which it is to be used and shall conform to Rubble-Stone Riprap material as specified in the Tennessee Department of Transportation (TDOT) Standard Specifications Part 709.02.A. Control of gradation shall be by visible inspection. Rounded stones, boulders, sandstone, or similar soft stone or relatively thin slabs will not be acceptable.

B. Riprap shall have a minimum thickness as indicated on the Drawings with individual pieces at the surface having a maximum deviation of plus or minus 2 inches.

C. Bedding and base/filter stone for riprap shall be placed and graded to depths indicated on the Drawings to obtain a continuous uninterrupted bed of the required thickness within the required limits. Gradation of stone shall be as shown on the Drawings.

D. Riprap shall be placed and graded off in a manner to ensure that the larger rock fragments are uniformly distributed and that the smaller rock fragments serve to fill the spaces between the larger rock fragments in a manner that will result in a compact mass of stone of the specified thickness. Hand placing will be required to the extent necessary to secure the results specified above.

E. Placing of riprap in layers, or by dumping into chutes or by similar methods to cause segregation will not be permitted.

PART 3 EXECUTION

3.01 WATER CONTROL

A. Prior to commencing work on riprap placement install water control measures as required to perform work in dry conditions. Water control measures shall include, but are not limited to, diversions, sumps with pumps, or other means necessary to maintain the level of groundwater below subgrade elevation and to divert surface water away from the work area. The Contractor is responsible for investigating and familiarizing himself

with respect to all site conditions that may affect the work, including surface water, level of groundwater, and time of year the work is to be done.

3.02 INSTALLATION

A. The construction methods, compaction equipment, and appurtenances for gravel shall be in accordance with Tennessee Department of Transportation (TDOT) Standard Specifications for Roads and Bridges.

B. Riprap shall be placed to the limits and grades shown on the Drawings.

C. Channel slopes, or other areas that are to be protected with riprap shall be free of topsoil, brush, trees, stumps, and other objectionable material and be graded to a smooth compacted surface. Contractor shall excavate areas to receive riprap to the subgrade for granular bedding. The subgrade for bedding materials shall be stable. If unsuitable materials are encountered, they shall be removed and replaced in accordance with Section 31 23 00 of the specifications. Unsuitable materials shall be disposed of from the site by Contractor at his expense. After an acceptable subgrade for granular bedding material is established, the bedding shall be immediately placed and leveled to the subgrade elevation. Immediately following this, the riprap shall be placed. If bedding material is disturbed for any reason, it shall be replaced and graded at Contractor's expense. In-place bedding materials shall not be contaminated with soils, debris, or vegetation before the riprap is placed. If contaminated, the bedding material shall be removed and replaced at Contractor's expense.

3.03 PLACEMENT

A. Following acceptable placement of granular bedding, riprap placement shall commence as follows:

1. Machine Placed Riprap: Riprap shall be placed on the prepared channel slope areas in a manner that will produce a reasonably well-graded mass of stone with the minimum practicable percentage of voids. Riprap shall be machine placed, unless otherwise stipulated in the Drawings or specifications.
    a. When riprap is placed on slopes, placement shall commence at the bottom of the slopes working up the slope. Place the riprap in a stepped fashion with the bottom of the uphill riprap below the top of the downhill riprap by half of the height of the riprap minimum.
    b. The entire mass of riprap shall be placed on either channel slopes so as to be in conformance with the required gradation mixtures and to lines, grades, and thickness shown on the Drawings. Riprap shall be placed to its full course thickness at one operation and in such a manner as to avoid displacing the underlying bedding material. Placing of riprap in layers, or by dumping into chutes, or by similar methods shall not be permitted.

c. All material going into riprap protection for channel or embankment slopes shall be so placed and distributed that there will be no large accumulations of either the larger or smaller sizes of stone. Some hand placement may be required to achieve this distribution.
d. It is the intent of these specifications to produce a fairly compact riprap protection in which all sizes of material are placed in their proper proportions. Unless otherwise authorized by the Engineer, the riprap protection shall be placed in conjunction with the construction of embankments with only sufficient delay in construction of the riprap protection, as may be necessary, to allow for proper construction of the portion of the embankment and channel slope that is to be protected. Contractor shall maintain the riprap protection until accepted. Any material displaced for any reason shall be replaced to the lines and grades shown on the Drawings at no additional cost to Owner. If the bedding materials are removed or disturbed, such material shall be replaced prior to replacing the displaced riprap.

2. Hand Placed Riprap: Hand placed riprap shall be performed during machine placement of riprap and shall conform to all the requirements of PART 2 above. Hand placed riprap shall also be required when the depth of riprap is less than two times the nominal stone size, or when required by the Drawings or specifications.
   a. After the riprap has been placed, hand placing or rearranging of individual stones by mechanical equipment shall be required to the extent necessary to secure a flat uniform surface and the specified depth of riprap, to the lines and grades as shown on the Drawings.

3. Rejection of Work and Materials: The Engineer shall reject placed riprap that does not conform to this Section and Contractor shall immediately remove and re-lay the riprap to conform to this Section.
   a. Riprap shall be rejected, which is either delivered to the job site or placed, that does not conform to this Section. Rejected riprap shall be removed from the project site by Contractor at his expense.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. The work specified in this Section includes requirements for excavation and support of temporary excavations, launch and exit shafts and trenches. The Contractor shall design, furnish, install, and maintain a system of supports, including all bracing and associated items, to retain excavations in a safe manner and to control ground movements. Upon completion of the required construction, the system of supports shall be completely removed, and the excavation and staging area sites restored as discussed herein.

B. The work shall include site grading; fencing and signing; construction staging areas; design and construction of excavation support systems; design and construction of thrust blocks; disposal of excavated material, surface water, and groundwater; backfilling; and site restoration. Work shall include all labor, materials, and equipment required to complete excavation support.

C. Retain the services of a professional engineer registered in the State of Tennessee to prepare excavation support and protection system designs and submittals described herein.

D. Work shall include the design, equipment, materials, installation, protection, and monitoring of geotechnical instrumentation, as defined in Section 31 09 00, required to monitor the performance of the excavation support system as required herein.

E. The Contractor shall be responsible for choosing and sizing the support of excavation systems. The size of the systems shall, however, be adequate for removal of material as indicated on the Drawings and to provide adequate space to meet the Contractor's work requirements for his/her selected methods of construction. The excavation support system shall be chosen such that it limits the amount of ground movements and protects the adjacent structures.

F. Vertical support members installed below mid-diameter of any pipe or within the zone of influence of new or existing structures shall be left in place. The zone of influence is defined as 2 feet beyond of edge of foundations, then outward and downward at a slope of 1 horizontal to 1 vertical.

G. All excavations and support systems shall conform to applicable OSHA excavation, trenching, and shoring standards which are contained in the U.S. Code of Federal Regulations 29 (C.F.R.) 1926.650-1926.653, other federal, state or local requirements. In the event of a conflict, comply with the more restrictive applicable requirements.

1.02 RELATED WORK

A. Shop Drawings, Product Data, and Samples are included in Section 01 33 23.

B. Geotechnical Instrumentation is included in Section 31 09 00.

C. Earthwork is included in Section 31 23 00.

D. Dewatering and Drainage are included in Section 31 23 19.

E. Trenching, Backfilling and Compaction is included in Section 31 23 33.

1.03 SUBMITTALS

A. Submit to the Engineer in accordance with Section 01 33 23, Shop Drawings and design calculations for the Contractor-designed excavation support system stamped by a Professional Engineer in the State of Tennessee. Submittals shall indicate the following, as a minimum:

B. Shop Drawings shall include:

1. Provide overall plan layout of the system, indicating clearances, dimensions, material properties, member sizes, locations, spacing and penetration depths of all members, locations of various types of lateral supports. Indicate existing and proposed utilities, structures or other obstruction, location and type of instrumentation and monitoring points within the area of influence of the excavation and thrust block dimensions for entry pit excavation support as required.

2. Provide wall elevations and locations of all bracing.

3. Show the overall sequence of installation and removal of bracing, indicating levels to which the work will be carried out before bracing is installed or removed.

4. Method of preloading bracing (if required) and the preload for each member, and the method of locking-off the preload. Include detailed drawings of the connections, jacking supports and method of shimming, and data for gage and jack calibration certified by an accepted testing agency.

5. Details, layout, arrangement, equipment requirements, and method of construction of the proposed excavation support system.

6. Design lateral pressures used for each system.

7. Procedures for resolving difficulties arising from misalignment of members exposed during excavation, and criteria for implementing those procedures.

C. Design calculations shall include:

1. Loads on the excavation support system for all stages of excavation, jacking operation, bracing removal, and concrete placement, including material and equipment loads on adjacent ground during construction.

2. Design of wall and all bracing members including all details for all stages of construction. Design shall account for water pressures associated with flood conditions.

3. Theoretical deflections of excavation support system and deformation of structures, pipelines, and other improvements located within the area of influence of the excavation.

4. Submit to the Engineer for review and acceptance, a plan of action to be implemented in the event any threshold value for deformation, as specified in 31 09 00, is reached. The plan of actions shall be positive measures by the Contractor to limit further movement of the wall including but not limited to trenching for struts and wales, placement of granular earth berms against the wall, installation of additional struts, or combinations thereof. The details of the mitigating measures shall include a schedule of implementation, location and/or availability of materials, structural details for all connections to the wall and support elements, and a detailed description of the method of implementation. The Contractor shall be prepared to work 24 hours per day to implement such measures. The remedial work/mitigating measures shall be at no additional cost to the Owner.

D. Submit quality control measures as required to ensure that the performance of the excavation support system is consistent with the approved shop drawings and the requirements herein.

E. Submit welder qualifications and weld procedures in accordance with AWS D1.1.

F. Submit Contractor's and Design Engineer's qualifications as described in herein

G. At least one copy of the design shall be maintained at the job site during excavation that includes a plan indicating the sizes, types, and configurations of the materials to be used in the protective system, and the identity of the registered engineer who approved the design.

H. Do not proceed with any support of excavation or protection activities until the submittal has been reviewed by the Engineer.

I. Contractor’s Design Engineer's documentation shall include:

1. On-site inspections of excavation support system as the systems are constructed.

2. Review of quality control measures and performance data.

3. Certification that the excavation support system is constructed per the applicable design following completion of each support system and following any modifications by Contractor during construction.

1.04 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. ASTM A36 - Specification for Structural Steel Standard Specifications

2. ASTM A242 - Standard Specification for High-Strength Low-Alloy Structural Steel

3. ASTM A252 - Standard Specification for Welded and Seamless Steel Pipe Piles

4. ASTM A328 - Standard Specification for Steel Sheet Piling

5. ASTM A572 - Standard Specification for High-Strength Low-Alloy Columbium Vanadium Structural Steel

6. ASTM A690 - Standard Specification for High-Strength Low-Alloy Nickel, Copper, Phosphorus Steel H-Piles and Sheet Piling with Atmospheric Corrosion Resistance for Use in Marine Environments

7. ASTM C33 - Standard Specification for Concrete Aggregates

8. ASTM C150 - Standard Specification for Portland Cement

B. American Welding Society (AWS)

1. AWS D1.1 for Public Works Construction

C. Codes

1. U.S. Occupational Safety and Health Administration (OSHA) Regulations, 29 CFR Part 1926 Subpart P - Excavations.

D. Norfolk Southern Corporation (NSC)

1. Specifications for Pipeline Occupancy of Norfolk Southern Corporation Property

E. Where reference is made to one of the above standards the revision in effect at the time of the bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Regulations: Perform all work in accordance with current applicable regulations and codes of all Federal, State and local agencies.

B. The Contractor shall have at least 5 years of experience with work compatible to the Work shown and specified, employing labor and supervisory personnel who are similarly experienced in this type of Work.

C. The Contractor's Design Engineer shall be a Professional Engineer registered in the State of Tennessee with at least 5 years professional experience in the design and construction of support of excavation systems and shall have completed not less than 5 successful excavation support projects of equal type, size, and complexity to that require for the work.

1.06 DESIGN REQUIREMENTS

A. The design of temporary excavation support systems is the responsibility of the Contractor. The design calculations and drawings shall be prepared, stamped and signed by a Professional Engineer registered in the State of Tennessee, who is experienced in designing similar excavation support systems.

B. Design temporary excavation support systems in accordance with requirements of this Section and minimum lateral earth pressures shown on the Drawings. These criteria are the minimum acceptable standards. Cooper E-80 loading shall be taken into account for all excavations within the zone of influence of the railroad as defined in the NSC specifications.

C. All underground utility lines shall be identified, located, and protected from damage or displacement. Utility companies and other responsible authorities shall be contacted to locate and mark the locations and, if they so desire, direct or assist with protecting the underground installation. When required, the Contractor shall obtain an excavation permit from the local authority having jurisdiction prior to the initiation of any excavation work.

D. Design excavation support systems in accordance with all OSHA requirements and other local and agency requirements.

E. Design the support system to minimize horizontal and vertical movements and to protect adjacent structures, railways and utilities from damage.

F. Excavations below the level of the base of any adjacent foundation or retaining wall shall not be permitted unless the design of the excavation and bracing includes an analysis of the stability of the structure supported by the foundation and as necessary, incorporates required bracing/underpinning of the foundation.

G. For support systems in which bracing is installed between opposite sides of the excavation, design the excavation support of both sides to be nearly the same as feasible.

H. Where necessary to resist point loads, pipe piles used as soldier piles shall be filled with concrete with a compressive strength not less than 3,000 psi. The strength of the concrete shall not be considered in design of the pipe pile for bending stress.

I. Design, install, operate, and maintain ground water control system to control ground water inflows, prevent piping or loss of ground, and maintain stability of the excavation. Refer to the requirements of Section 31 23 19.

J. Design, install, operate, and maintain excavation support monitoring points to monitor the performance of the excavation support system in accordance with Section 31 09 00.

K. Provide temporary fencing around all excavations. Provide pedestrian and traffic control around working areas and support systems located within or adjacent to streets, roadways, freeways, driveways, walkways, or parking lots.

L. Receipt of the Contractor's plans and methods of construction by the Engineer does not relieve the Contractor of his responsibility to provide an adequate support system achieving the specified requirements. Design review and field monitoring activities by the Owner or by the Engineer shall not relieve the Contractor of his/her responsibilities for the work.

M. Design review and field monitoring activities by the Owner or by the Engineer shall not relieve the Contractor of his/her responsibilities for the work.

PART 2 PRODUCTS

2.01 MATERIALS

A. All timber, structural steel, and steel sheet piling used for the supporting systems, whether new or used, shall be sound and free from defects that may impair their strength.

B. Soldier piles and structural steel members shall conform to ASTM A572 or ASTM A242 unless approved otherwise. All steel conforming to ASTM A 572 shall be Grade 50 or better. No members with permanent deformations are to be provided. Members shall not be spliced unless approved by the Engineer.

C. Pipe piles used as soldier piles shall conform to ASTM A252, Grade 3 (45 ksi), or better unless approved otherwise.

D. Steel sheet piling shall conform to ASTM A328 or ASTM A572 or ASTM A690, unless approved otherwise. All steel sheet piling conforming to ASTM A 572 shall be Grade 50or better.

E. Concrete shall conform to ASTM C33 and ASTM C150 unless otherwise approved.

F. All timber shall be structural grade with a minimum allowable flexural strength of 1100 psi. Timber lagging shall be at least 3 inches thick, and shall be fir, spruce, pine, or hemlock, Grade 1 or 2, rough or planed surface, square edges or tongue and groove and free of large or loose knots.

G. Wood shims for braces and wales shall not be permitted. Steel shims shall be used when required.

PART 3 EXECUTION

3.01 GENERAL

A. Commence installation of support system and excavations only after shop drawings have been reviewed and accepted by the Engineer.

B. All instrumentation required per Section 31 09 00 shall be installed and initialized prior to the start of work.

C. Methods of construction for excavations shall be such as to ensure the safety of the Work, Contractor's employees, Engineer, and Owner's employees and inspectors, the public and adjacent property and improvements, whether public or private.

D. Before beginning construction at any location of this project, adequately protect existing structures, utilities, trees, shrubs, and other existing facilities. Design excavation support systems to limit deformations that could damage facilities, including utilities and structures. The repair of or compensation for damage to existing facilities shall be at no additional cost to the Owner.

E. As a minimum, place fencing, gates, lights, and signs as necessary around the excavations and staging areas to provide for public safety.

F. Monitor performance of excavation support systems for both horizontal and vertical deflections in accordance with Section 31 09 00. If monitoring data indicates that deflections have exceeded estimated values, increase frequency of monitoring as required by the Engineer. Submit all monitoring measurements to the Engineer on the same day measurements are taken.

G. Install excavation support systems in accordance with the approved shop drawings and applicable permits.

H. Care shall be taken to prevent voids outside of the excavation support system, but if voids are formed, they shall be immediately filled with common fill material. Voids in locations that cannot be properly compacted upon backfilling shall be filled with lean concrete or well-graded cohesionless sand as approved by the Engineer at no additional cost to the Owner. Excavations shall be kept free of water at all times and a stable subgrade shall be maintained. Excavations shall be dewatered in accordance with Section 31 23 19.

I. If unstable material is encountered during excavation, all necessary measures shall be taken immediately to contain it in place and prevent ground displacement.

J. If settlement or deflections of supports indicate that support system requires modification to prevent excessive movements, redesign and resubmit revised shop drawings and calculations to the Engineer at no additional cost to the Owner.

K. If the Engineer is of the opinion that at any point sufficient or proper supports have not been provided, he may order additional supports placed at no additional cost to the Owner. Compliance with such order shall not relieve the Contractor from his responsibility for the sufficiency of such supports.

L. Conduct all work, including excavation, backfilling, shoring, temporary facilities, materials storage, and construction traffic within limits of work established for the project. All work shall be in accordance with the applicable permits and the approved shop drawings.

M. Sufficient quantity of material shall be maintained on site for protection of work and for use in case of accident or emergency.

N. All welding shall conform to the applicable provisions of ANSI/AWS D1.1.

3.02 PORTABLE TRENCH BOXES

A. Portable trench boxes or sliding trench shields may be used for the protection of workers only.

B. Trench boxes shall not be used as entry and exit pits for pipe jacking.

C. No trench box is allowed for excavations that extend within the zone of influence of existing structures, railroads and sensitive utilities. The zone of influence is defined as

a line extending from the springline of pipes or at least 2 feet beyond of edge of foundations, then outward and downward at a slope of 1 horizontal to 1 vertical.

D. When moveable trench bracing such as trench boxes, moveable sheeting, shoring or plates are used to support the sides of the trench, care shall be taken in placing and moving the boxes or supporting bracing to prevent movement of the pipe, or disturbance of the pipe bedding and the screened gravel backfill.

E. When installing rigid pipe (RC, etc.), any portion of the box extending below mid-diameter shall be raised above this point prior to moving the box ahead to install the next pipe. This is to prevent the separation of installed pipe joints due to movement of the box.

F. When installing flexible pipe (PVC, DI, FRP, etc.) trench boxes, moveable sheeting, shoring or plates shall not be allowed to extend below mid-diameter of the pipe. As trench boxes, moveable sheeting, shoring or plates are moved, screened gravel shall be placed to fill any voids created and the screened gravel and backfill shall be recompacted to provide uniform side support for the pipe.

G. Additional excavation, backfilling, and surface restoration required as the result of trench box use shall be at no additional cost to the Owner.

H. Trench boxes or shields shall be designed, constructed, and maintained to meet acceptable engineering and industry standards.

I. Shields shall be installed in a manner to restrict lateral or other hazardous movement of the shield in the event of the application of sudden lateral loads.

J. A copy of the trench box manufacturer's specifications, recommendations, and limitations shall be in written form and maintained at the job site during all excavation work.

3.03 SOLDIER PILES AND LAGGING

A. Install soldier piles with the minimum embedment depths as shown on approved shop drawings.

B. Soldier piles shall be installed using an impact hammer, a vibratory hammer, or in predrilled holes.

C. Driven piles shall be installed with driving shoes where hard driving is anticipated.

D. For soldier piles installed in predrilled holes, provide casing or other methods of support as necessary to prevent caving of holes and loss of ground.

E. Predrilled holes for soldier piles shall be backfilled with concrete from the pile tip elevation to the elevation of the bottom of the excavation. The remainder of the predrilled hole shall be backfilled with lean concrete or sand. Concrete strength shall be in accordance with the approved shop drawings.

F. The predrilled hole diameter shall be sufficient to allow for proper alignment and concrete backfilling of the pile.

G. Driven soldier piles shall be advanced without the aid of a water jet.

H. Provide timber lagging of sufficient thickness to withstand earth pressures and in accordance with the approved shop drawings.

I. Install lagging such that ground loss does not occur between adjacent or below the lowest board. As excavation proceeds, the maximum height of unlagged face of excavation shall not exceed 4 feet. The unlagged face shall not exceed 2-ft if water seeps or flows from the face of the excavation or if the face of the excavation becomes unstable.

J. As installation progresses, backfill the voids between the excavation face and the lagging. Pack with materials such as hay, burlap, or geotextile filter fabric where necessary to allow drainage of groundwater without loss of ground.

3.04 STEEL SHEET PILING

A. Install steel sheet piling with the minimum embedment depths as shown on the approved shop drawings.

B. Drive sheeting in plumb position with each sheet pile interlocked with adjoining piles for its entire length so as to form a continuous diaphragm throughout the length of each run of wall, bearing tightly against original ground. Exercise care in driving so that interlocking members can be extracted without damaging adjacent structures or utilities. The methods of driving, cutting, and splicing shall conform to the approved shop drawings.

C. Use templates or other temporary alignment facilities to maintain piling line.

D. Prior to installation, the sheet piles shall be thoroughly cleaned and inspected for defects and for proper interlock dimensions. The Contractor shall provide a tool for checking the interlock dimensions.

E. Each sheet pile shall have sufficient clearance in the interlocks to slide, under its own weight, into the interlock of the sheet pile previously placed.

F. Excavation shall not be carried in advance of steel sheet piling installation.

G. Where obstructions are anticipated, pre-excavation or pre-drilling along the sheet pile wall alignment shall be conducted at no additional cost to the Owner. Pre-excavation and pre-drilling shall not extend below the lowest excavation level or into bearing soils for existing or future structures.

H. Obstructions encountered before the specified embedment for piles shall be removed. Where obstructions cannot be removed, the sheet pile system shall be re-evaluated by the Contractor's Design Engineer for the resulted reduced embedment and additional toe stability measure implemented, as required or for realignment of the sheet pile wall. A submittal of the proposed measures shall be provided.

I. Damaged piling or piling with faulty alignment shall be withdrawn and new piling driven properly in its place. The cost of such additional work shall be considered as part of the pile driving and shall be borne by the Contractor.

3.05 INTERNAL BRACING

A. Provide internal bracing including wales and struts to carry maximum design load without distortion or buckling.

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

C. Install and maintain all bracing support members in tight contact with each other and with the surface being supported. Wood shims shall not be used.

D. Coordinate excavation work with installation of bracing. Excavation shall extend no more than 2 feet below any brace level prior to installation of the bracing.

E. Use procedures that produce uniform loading of bracing member without eccentricities or overstressing and distortion of members of system.

3.06 REMOVAL OF EXCAVATION SUPPORT

A. Do not remove internal bracing and transfer loads to the permanent structure without prior acceptance of the Engineer.

B. Removal shall begin at and progress from the bottom of the excavation. Members shall be released slowly as to note any indication of possible failure of the remaining members or possible cave-in of the sides of the excavation.

C. Backfilling shall progress together with the removal of support systems from excavations.

D. Unless otherwise indicated, remove all portions of excavation support.

E. Do not remove vertical support members that were installed within the zone of influence of new or existing structures. The zone of influence is defined as a zone extending 2 feet beyond of edge of foundations, then outward and downward at a slope of 1 horizontal to 1 vertical. Support members installed within this zone shall be cut off at 5 ft below finished grade and abandoned in place.

F. No wood shall remain as part of the abandoned portion of the work.

G. When removing the excavation support system, do not disturb or damage adjacent buildings, structures, waterproofing material, or utilities. Fill voids immediately with lean concrete or well-graded cohesionless sand, as indicated or as directed by the Engineer.

H. Remove material of the excavation support system from the site immediately.

END OF SECTION

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Furnish all labor, materials, equipment and incidentals required for asphalt paving complete as shown on the Drawings and as specified herein.

B. Section Includes:

1. Hot-mix asphalt patching.
2. Hot-mix asphalt paving.

1.02 RELATED WORK

A. Subgrade preparation and fill material is included in Section 31 23 00.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, detailed information on materials proposed and installation methods.

B. Product Data: For each type of product.

1. Include technical data and tested physical and performance properties.
2. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.

C. Qualification Data: For manufacturer and testing agency.

D. Material Certificates: For each paving material. Include statement that mixes containing recycled materials will perform equal to mixes produced from all new materials.

E. Material Test Reports: For each paving material, by a qualified testing agency.

F. Field quality-control reports.

1.04 REFERENCE STANDARDS

A. American Association of State Highway and Transportation Officials

1. AASHTO M 17-2007: Specification for Mineral Filler for Bituminous Paving Mixtures
2. AASHTO M 29-2003: Specification for Fine Aggregate for Bituminous Paving Mixtures
3. AASHTO M 140-2003: Specification for Emulsified Asphalt
4. AASHTO M 208-2001: Specification for Cationic Emulsified Asphalt

5. AASHTO M 288-2006: Geotextile Specification for Highway Applications
6. AASHTO M 320-2009: Specification for Performance Graded Asphalt Binder
7. AASHTO M 324-2008: Standard Practice for Joint and Crack Sealants, Hot-Applied, for Concrete and Asphalt Pavements
8. AASHTO T 168-2003: Specification for Sampling Bituminous Paving Mixtures
9. AASHTO T 245-1997 (Reapproved 2008): Method of Test for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus

B. Asphalt Institute

1. AI MS-2-1997 (Sixth Edition): Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types
2. AI MS-22-2001 (Second Edition): Construction of Hot Mix Asphalt Pavements

C. ASTM International

1. ASTM D 242/D 242M-09: Specification for Mineral Filler for Bituminous Paving Mixtures
2. ASTM D 692/D 692M-09: Specification for Coarse Aggregate for Bituminous Paving Mixtures
3. ASTM D 946/D 946M-09a: Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction
4. ASTM D 977-05: Specification for Emulsified Asphalt
5. ASTM D 979-01 (Reapproved 2006): Practice for Sampling Bituminous Paving Mixtures
6. ASTM D 1073-07: Specification for Fine Aggregate for Bituminous Paving Mixtures
7. ASTM D 1188-07: Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Coated Samples
8. ASTM D 2027-97 (Reapproved 2004): Specification for Cutback Asphalt (Medium-Curing Type) ASTM D 2041-03a: Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
9. ASTM D 2397-05: Specification for Cationic Emulsified Asphalt
10. ASTM D 2726-09: Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
11. ASTM D 2950-2009: Test Method for Density of Bituminous Concrete in Place by Nuclear Methods
12. ASTM D 3141/D 3141M-09: Specification for Asphalt for Undersealing Portland-Cement Concrete Pavements
13. ASTM D 3381/D 3381M-09a: Specification for Viscosity-Graded Asphalt Cement for Use in Pavement Construction

14. ASTM D 3549-03: Test Method for Thickness or Height of Compacted Bituminous Paving Mixture Specimens
15. ASTM D 3666-09a: Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
16. ASTM D 3910-07: Practices for Design, Testing, and Construction of Slurry Seal
17. ASTM D 6690-07: Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements
18. ASTM D 6927-06: Test Method for Marshall Stability and Flow of Bituminous Mixtures

D. Tennessee Department of Transportation (TDOT)

1. Standard Specifications for Road and Bridge Construction.

E. Unless noted otherwise, where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by TDOT.

B. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.

C. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of TDOT Standard Specifications for Road and Bridge Construction for asphalt paving work.

1.06 FIELD CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:

1. Prime Coat: Minimum surface temperature of 60 deg F (15.6 deg C).
2. Tack Coat: Minimum surface temperature of 60 deg F (15.6 deg C).
3. Asphalt Base Course: Minimum surface temperature of 40 deg F (4.4 deg C) and rising at time of placement.
4. Asphalt Surface Course: Minimum surface temperature of 60 deg F (15.6 deg C) at time of placement.

PART 2 PRODUCTS

2.01 AGGREGATES

A. General: Use materials and gradations that have performed satisfactorily in previous installations.

B. Coarse Aggregate: ASTM D 692/D 692M, sound; angular crushed stone, crushed gravel, or cured.

C. Fine Aggregate: ASTM D 1073, sharp-edged natural sand or sand prepared from stone, gravel, or combinations thereof.

1. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.

2.02 ASPHALT MATERIALS

A. Asphalt Binder: AASHTO M 320, PG 64-22.

B. Cutback Prime Coat: ASTM D 2027, medium-curing cutback asphalt, MC-30.

C. Tack Coat: ASTM D 977 emulsified asphalt, or ASTM D 2397 cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.

D. Water: Potable.

2.03 AUXILIARY MATERIALS

A. Recycled Materials for Hot-Mix Asphalt Mixes: Reclaimed asphalt pavement; reclaimed, unbound-aggregate base material; and recycled tires, asphalt shingles or glass from sources and gradations that have performed satisfactorily in previous installations, equal to performance of required hot-mix asphalt paving produced from all new materials.

2.04 MIXES

A. Surface Course Limit: Recycled content no more than 10 percent by weight.

B. Hot-Mix Asphalt: Dense-graded, hot-laid, hot-mix asphalt plant mixes approved by TDOT and complying with the following requirements:

1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
2. Base Course: Grade BM-2, per section 307 of TDOT specifications.
3. Surface Course: Grade E, per section 411 of TDOT specifications.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to begin paving.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph (5 km/h).
2. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons (13.6 tonnes).
3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Engineer, and replace with compacted backfill or fill as directed.

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

3.02 PATCHING

A. Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches (300 mm) into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.

B. Portland Cement Concrete Pavement: Break cracked slabs and roll as required to reseat concrete pieces firmly.

1. Pump hot undersealing asphalt under rocking slab until slab is stabilized or, if necessary, crack slab into pieces and roll to reseat pieces firmly.
2. Remove disintegrated or badly cracked pavement. Excavate rectangular or trapezoidal patches, extending into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Recompact existing unbound-aggregate base course to form new subgrade.

C. Tack Coat: Before placing patch material, apply tack coat uniformly to vertical asphalt surfaces abutting the patch. Apply at a rate of 0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m).

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

D. Placing Patch Material: Partially fill excavated pavements with hot-mix asphalt base mix and, while still hot, compact. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.

3.03 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

B. Cutback Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of 0.15 to 0.50 gal./sq. yd. (0.7 to 2.3 L/sq. m). Apply enough material to penetrate and seal, but not flood, surface. Allow prime coat to cure.

1. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
2. Protect primed substrate from damage until ready to receive paving.

C. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m).

1. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
2. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

3.04 PLACING HOT-MIX ASPHALT

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand in areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.

1. Place hot-mix asphalt surface course in single lift.
2. Spread mix at a minimum temperature of 250 deg F (121 deg C).
3. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
4. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.

B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.

1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Overlap mix placement about 1 to 1-1/2 inches from strip to strip to ensure proper compaction of mix along longitudinal joints.

2. Complete a section of asphalt base course before placing asphalt surface course.

C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

3.05 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.

1. Clean contact surfaces and apply tack coat to joints.
2. Offset longitudinal joints, in successive courses, a minimum of 6 inches.
3. Offset transverse joints, in successive courses, a minimum of 24 inches.
4. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."
5. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
6. Compact asphalt at joints to a density within 2 percent of specified course density.

3.06 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

1. Complete compaction before mix temperature cools to 185 deg F (85 deg C).

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:

1. Average Density: 96 percent of reference laboratory density according to ASTM D 6927, but not less than 94 percent or greater than 100 percent.
2. Average Density: 92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent or greater than 96 percent.

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.07 INSTALLATION TOLERANCES

A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:

1. Base Course: Plus or minus 1/2 inch.
2. Surface Course: Plus 1/4 inch, no minus.

B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot (3-m) straightedge applied transversely or longitudinally to paved areas:

1. Base Course: 1/4 inch.
2. Surface Course: 1/8 inch.
3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch.

3.08 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.

C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.

D. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D 979.

1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.

2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
   a. One core sample will be taken for every 1000 sq. yd. (836 sq. m) or less of installed pavement, with no fewer than three cores taken.
   b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.

E. Replace and compact hot-mix asphalt where core tests were taken.

F. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals necessary and install the chain link fence and gates as shown on the Drawings and as specified herein.

B. Repair and replace portions of existing chain link fence damaged during construction activities.

1.02 RELATED WORK

A. Earthwork is included in Section 31 23 00.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, shop drawings showing layout and details of construction and erection of fence and accessories required.

1.04 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM)

1. ASTM A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

2. ASTM A121 - Standard Specification for Zinc-Coated (Galvanized) Steel Barbed Wire.

3. ASTM A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

4. ASTM A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

5. ASTM A392 - Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.

6. ASTM A641 - Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire.

7. ASTM F668 - Standard Specification for Poly (Vinyl Chloride) (PVC) - Coated Steel Chain Link Fence Fabric.

8. CLFMI CLF 2445, Product Manual.

9. CLFMI, Step-by-Step Installation Guide.

B. Federal Specification

1. Federal Specification RR-F-191/1D - Fencing, Wire and Post, Metal (Chain-Link Fence Fabric).

2. Federal Specification RR-F-191/2D - Fencing, Wire and Post, Metal (Chain-Link Fence Gates).

3. Federal Specification RR-F-191/3D - Fencing, Wire and Post, Metal (Chain-Link Fence Posts, Top Rails and Braces).

4. Federal Specification RR-F-191/4D - Fencing, Wire and Post, Metal (Chain-Link Fence Accessories).

5. Federal Specification RR-F-191K/GEN - Fencing, Wire and Post Metal (and Gates, Chain-Link Fence Fabric and Accessories).

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

PART 2 PRODUCTS

2.01 MATERIALS

A. General

1. The chain link fencing and accessories shall conform to Federal Specification CLFMI CLF 2445 and its associated detail specifications noted below.

B. Fabric

1. The chain link fabric shall conform to CLFMI CLF 2445. The chain link fabric shall be Type I. The fabric shall be 9 gauge core wire, woven in a 2-in mesh and be hot dipped galvanized after weaving, and be in accordance with ASTM A392. The height of fabric shall be 72-in. Fabric shall be twisted and barbed on the top selvage and knuckled on the bottom salvage. Fabric shall be fastened to intermediate posts with No. 6 aluminum fabric wire spaced approximately 15-in apart and to top rail with 9 gauge wires spaced approximately 18-in apart. The fabric shall be securely fastened to all terminal and gate posts with 1/4-in by 3/4-in stretcher bars with No. 11 gauge pressed steel bands spaced approximately 12-in apart.

C. Posts, Rails and Braces

1. Posts, rails and braces shall conform to Federal Specification RR-F-191/3D and be fabricated of Class I (round steel sections), Grade A (hot-dipped galvanized), seamless steel pipe, in accordance with ASTM A53 (Schedule 40), and be of the following sizes:
   a. Corner and Terminal Posts: SP4 (2.875-in o.d.)
   b. Line Posts: SP3 (2.375-in o.d.)

c. Gate Posts: up to 6-ft SP4 (2.875-in o.d.)
up to 13-ft SP5 (4.000-in o.d.)
up to 18-ft SP6 (6.625-in o.d.)
up to 23-ft SP7 (8.625-in o.d.)

d. Rails and Braces: SP1 (1.66-in o.d.)

e. Spacing of posts shall not exceed 10-ft.

D. Gates

1. Gates and hardware shall conform to Federal Specification RR-F-191/2D. Gates shall be constructed of Class I, Grade A seamless steel pipe, size SP1, plus additional intermediate members when required and meeting the requirements of RR-F-191/3D. Gate frames shall be of welded construction or shall be assembled using fittings. When fittings are used as the construction method for gate frames, the frames shall be fitted with 3/8-in minimum diameter adjustable length truss rods, meeting the requirements of Federal Specification RR-F-191/4D. When frames are welded, all welding shall be done prior to galvanizing. Gate fabric shall be of the type, mesh, gauge, color and salvage as that specified above for fabric. Install fabric with stretcher bars at vertical edges and tie wires at top and bottom edges. Attach stretcher bars to gate frames at not more than 12-in on center. On gates with barbed wire, extend end members, 1-ft above the top horizontal member of the gate frame. Attach three strands of barbed wire, uniformly spaced, to end members with bands, clips or eyebolts.

2. Gate Hardware
   a. Hinges, latches, stops and keepers shall be hot-dipped galvanized in accordance with ASTM A153.
   b. Hinges shall be pressed steel or malleable iron, sized to suit gate, non-lift-off type and offset to permit 180 degree gate opening. Provide one pair of hinges for each leaf (up to 12-ft high).
   c. Single latch shall be forked type to permit operation from either side of gate. Provide padlock eye as integral part of latch.
   d. Keeper shall automatically engage the gate leaf and hold it in the open position until manually released.
   e. Stop, consisting of drop rod, shall be provided to hold the inactive leaf. Steel sleeves shall be provided to engage the drop rod. Provide locking device and padlock eyes as an integral part of latch, requiring one padlock for locking both gate leaves.

E. Accessories

1. Accessories shall conform to Federal Specification RR-F-191/4D, shall be hot-dipped galvanized in accordance with ASTM A123 or A153. In addition to wire ties and clips, brace bands, tension bands and bars, tension wire and truss rods (all of which are described herein), accessories shall include the following:
   a. Caps for all exposed ends of posts.
   b. Top rail and brace ends or other suitable means of connection.
   c. Top rail sleeves to allow for expansion and contraction of the top rail.

d. Bottom tension wire shall be 7 gauge galvanized steel wire. Fabric shall be attached to tension wire with 11 gauge galvanized steel hog rings spaced no more than 24-in on center.
e. Barbed wire, conforming to ASTM A121, shall consist of two 12-1/2 gauge twisted line wires with 14 gauge round aluminum wire barbs, having 4 points and spaced 5-in on center.
f. Barbed wire support arms shall be single arm, for three strands of barbed wire and be at an angle of 45 degrees, with the top strand of barbed wire being 12-in above and 12-in out from the fence line.

PART 3 EXECUTION

3.01 INSTALLATION

A. Set all posts to depth of 3-ft unless otherwise shown on the Drawings. After setting and plumbing posts, fill holes with 2,500 psi concrete. Crown top surface of concrete to shed water. Brace all terminal posts horizontally with sections used for top rail. The top rail shall extend through all line posts to form a continuous brace from end to end of each stretch of fence, be securely fastened at the end of each run and have joints made with expansion sleeve couplings not less than 6-in long.

B. Location of fence shall be approximately as shown on the drawings. Any deviation shall be reviewed and approved by the ENGINEER in advance of installation.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required for segmental retaining walls complete as shown on the Drawings and as specified herein.

B. This Section includes single-depth segmental retaining walls.

1.02 RELATED WORK

1. Excavation for segmental retaining walls is included in Section 31 23 00.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, detailed information on materials proposed and installation methods.

B. Product Data: For each type of product.

C. Samples: For each color and texture of concrete unit specified. Submit sections of units not less than 3 inches square.

D. Design Submittal: For segmental retaining walls.

E. Product Test Reports: For each type of segmental retaining wall unit, for tests performed by a qualified testing agency.

1. Include test data for shear strength between segmental retaining wall units according to ASTM D 6916.

2. Include test data for connection strength between segmental retaining wall units and soil reinforcement according to ASTM D 6638.

F. Source quality-control reports.

G. Field quality-control reports.

1.04 REFERENCES

A. ASTM International

1. ASTM C 136-06: Test Method for Sieve Analysis of Fine and Coarse Aggregates

2. ASTM C 1372-09: Specification for Dry-Cast Segmental Retaining Wall Units

3. ASTM D 698-07: Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort [12,400 ft-lbf/ft^3 (600 kN-m/m^3)]

4. ASTM D 2487-10: Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)ASTM D 4632-08: Test Method for Grab Breaking Load and Elongation of Geotextiles

5. ASTM D 4751-04: Test Method for Determining Apparent Opening Size of a Geotextile

6. ASTM D 5321-08: Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method

7. ASTM D 6638-07: Test Method for Determining Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks)

8. ASTM D 6706-01 (Reapproved 2007): Test Method for Measuring Geosynthetic Pullout Resistance in Soil

9. ASTM D 6916-06c: Test Method for Determining the Shear Strength Between Segmental Concrete Units (Modular Concrete Blocks)ASTM E 329-09: Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction

B. National Concrete Masonry Association

1. Design Manual for Segmental Retaining Walls. 2010.

2. Segmental Retaining Wall Installation Guide. 1996.

C. Unless noted otherwise, where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 PRE-INSTALLATION MEETINGS

A. Pre-installation Conference: Conduct conference at Project site.

1.06 QUALITY ASSURANCE

A. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects.

1. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.07 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform the following preconstruction testing:

1. Test soil reinforcement and backfill materials for pullout resistance according to ASTM D 6706.

2. Test soil reinforcement and backfill materials for coefficient of friction according to ASTM D 5321.

1.08 DELIVERY, STORAGE AND HANDLING

A. Store and handle concrete units and accessories to prevent deterioration or damage due to contaminants, breaking, chipping, or other causes.

B. Store geosynthetics in manufacturer's original packaging with labels intact. Store and handle geosynthetics to prevent deterioration or damage due to sunlight, chemicals, flames, temperatures above 160 deg F or below 32 deg F, and other conditions that might damage them. Verify identification of geosynthetics before use, and examine them for defects as material is placed.

PART 2 PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, licensed in the state of Tennessee to design segmental retaining walls.

B. Compliance Review: Qualified professional engineer responsible for segmental retaining wall design shall review and approve submittals and source and field quality-control reports for compliance of materials and construction with design.

C. Structural Performance: Engineering design shall be based on the following loads and be according to NCMA's "Design Manual for Segmental Retaining Walls:

1. Gravity loads due to soil pressures resulting from grades and sloped backfill indicated.

2. Superimposed loads (surcharge) indicated on Drawings.

3. Horizontal Peak Ground Acceleration (A) for Project: 0.26.

2.02 SEGMENTAL RETAINING WALL UNITS

A. Concrete Units: ASTM C 1372, Normal Weight, except that maximum water absorption shall not exceed 7 percent by weight and units shall not differ in height more than plus or minus 1/16 inch from specified dimension.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Redi-Rock International
   b. Allan Block Corporation.
   c. Anchor Wall Systems, Inc.
   d. CornerStone Wall Solutions Inc.
   e. GeoStone Retaining Wall Systems, Inc.
   f. Keystone Retaining Wall Systems, Inc.
   g. Nicolock.

h. Rockwood Retaining Walls, Inc.
i. Tensar Earth Technologies, Inc.
j. Versa-Lok Retaining Wall Systems.
k. Or equal.

2. Provide units that comply with requirements in ASTM C 1372 for freeze-thaw durability.

3. Provide units that interlock with courses above and below by means of integral lugs, lips, or tongues and grooves, clips, or splines.

B. Color: As selected by Engineer from manufacturer's full range.

C. Shape and Texture: Provide units of any basic shape and dimensions that produce segmental retaining walls of dimensions and profiles indicated without interfering with other elements of the Work and with machine-split textured.

D. Batter: Provide units that offset from course below to provide at 1:24 batter.

E. Cap Units: Provide cap units of same shape as other units with smooth, as-cast top surfaces without holes or lugs.

F. Special Units: Provide corner units, end units, and other shapes as needed to produce segmental retaining walls of dimensions and profiles indicated and to provide texture on exposed surfaces matching face.

2.03 INSTALLATION MATERIALS

A. Clips: Product supplied by segmental retaining wall unit manufacturer for use with units provided, made from non-degrading polymer reinforced with glass fibers.

B. Cap Adhesive: Product supplied or recommended by segmental retaining wall unit manufacturer for adhering cap units to units below.

C. Leveling Course: Lean concrete with a compressive strength of not more than 500 psi.

D. Drainage Fill: Comply with requirements in Section 31 23 00 for drainage course.

E. Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent.

1. Apparent Opening Size: No. 70 to 100 sieve, maximum; ASTM D 4751.

2. Minimum Grab Tensile Strength: 110 lb; ASTM D 4632.

3. Minimum Weight: 4 oz./sq. yd.

F. Sub-drainage Pipe and Filter Fabric: Comply with requirements in Section 33 46 00.

G. Soil Reinforcement: Product specifically manufactured for use as soil reinforcement and as follows:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Mirafi Construction Products.
   b. Tensar Earth Technologies, Inc.
   c. Versa-Lok Retaining Wall Systems.
   d. Or equal.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for excavation tolerances, condition of subgrades, and other conditions affecting performance of the Work.

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

3.02 RETAINING WALL INSTALLATION

A. General: Place units according to NCMA's "Segmental Retaining Wall Installation Guide" and segmental retaining wall unit manufacturer's written instructions.

1. Lay units in running bond.

2. Form corners and ends by using special units.

B. Do not use units with chips, cracks, or other defects that are visible at a distance of 20 feet where such defects are exposed in the completed Work.

C. Leveling Base: Place and compact base material to thickness indicated and with not less than 95 percent maximum dry unit weight according to ASTM D 698.

1. Leveling Course: At Contractor's option, unreinforced lean concrete may be substituted for upper 1 to 2 inches of base. Compact and screed concrete to a smooth, level surface.

D. First Course: Place first course of segmental retaining wall units for full length of wall. Place units in firm contact with each other, properly aligned and level.

E. Subsequent Courses: Remove excess fill and debris from tops of units in course below. Place units in firm contact, properly aligned, and directly on course below.

1. For units with lugs designed to fit into holes in adjacent units, lay units so lugs are accurately aligned with holes, and bedding surfaces are firmly seated on beds of units below.

2. For units with lips at front of units, slide units as far forward as possible for firm contact with lips of units below.

3. For units with lips at bottom rear of units, slide units as far forward as possible for firm contact of lips with units below.

4. For units with clips, install clips and align units.

F. Cap Units: Place cap units and secure with cap adhesive.

3.03 FILL PLACEMENT

A. General: Comply with requirements in Section 31 23 00 with NCMA's "Segmental Retaining Wall Installation Guide," and with segmental retaining wall unit manufacturer's written instructions.

B. Fill voids between and within units with drainage fill. Place fill as each course of units is laid.

C. Place, spread, and compact drainage fill and soil fill in uniform lifts for full width and length of embankment as wall is laid. Place and compact fills without disturbing alignment of units. Where both sides of wall are indicated to be filled, place fills on both sides at same time. Begin at wall, and place and spread fills toward embankment.

1. Use only hand-operated compaction equipment within 48 inches of wall, or one-half of height above bottom of wall, whichever is greater.

2. Compact reinforced-soil fill to not less than 95 percent maximum dry unit weight according to ASTM D 698.
   a. In areas where only hand-operated compaction equipment is allowed, compact fills to not less than 90 percent maximum dry unit weight according to ASTM D 698.

3. Compact non-reinforced-soil fill to comply with Section 31 23 33.

D. Place drainage geotextile against back of wall, and place layer of drainage fill at least 6 inches wide behind drainage geotextile to within 12 inches of finished grade. Place another layer of drainage geotextile between drainage fill and soil fill.

E. Wrap sub-drainage pipe with filter fabric and place in drainage fill, sloped not less than 0.5 percent to drain.

F. Place impervious fill over top edge of drainage fill layer.

G. Slope grade at top of wall away from wall unless otherwise indicated. Slope grade at wall base away from wall. Provide uniform slopes that prevent ponding.

1. In each compacted backfill layer, perform at least one field in-place compaction test for each 24 inches of fill depth and each 150 feet or less of segmental retaining wall length.

3.04 ADJUSTING

A. Remove and replace segmental retaining wall construction of the following descriptions:

1. Broken, chipped, stained, or otherwise damaged units. Units may be repaired if Engineer approves methods and results.

2. Segmental retaining walls that do not match approved samples.

3. Segmental retaining walls that do not comply with other requirements indicated.

B. Replace units so segmental retaining wall matches approved Samples and mockups, complies with other requirements, and shows no evidence of replacement.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and service required and complete all planting and related landscaping work indicated on the Drawings and as specified herein, including but not necessarily limited to the following:

1. Supplying of loam for all plant pits and planting beds. Be responsible for all topsoil preparation, testing, conditioning and fertilization and shall ensure the overall quality of the material. Loam stockpiled from other construction operations under this Section may be used.

2. Excavation of pits for trees.

3. Furnishing and planting trees and shrubs as shown on the Drawings.

4. Supplying accessory materials and wrapping, guying and staking of all trees.

5. Pruning of plant materials as specified and as approved by the Engineer.

6. Supplying and spreading mulch for tree pits and planting beds as specified herein.

7. Furnishing and placing washed gravel.

8. Maintenance and guarantee.

9. Final cleanup and all other work required to complete the job in accordance with the Drawings and as specified herein.

B. The planting work shall be performed by a landscape contractor who is fully experienced in projects of this scope and whose main business is landscaping. Selection of the landscape contractor shall be subject to the approval of the Engineer.

1.02 RELATED WORK

A. Site preparation is included in Section 31 11 00.

B. Loaming, Seeding, and mulching is included in Section 32 92 19.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, samples of all materials for inspection and approval.

1.04 REFERENCE STANDARDS

A. American Association of Nurseryman (AAN)

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

PART 2 PRODUCTS

2.01 LOAM

A. Loam shall be as specified in Section 32 92 19.

B. No loam shall be delivered or spread in a frozen or muddy condition.

2.02 FERTILIZER, SOIL AND PLANT CONDITIONERS

A. Fertilizer shall be commercial mixed free flowing granules or pelleted fertilizer, 10-10-10 (N-P2O5-K2O) with at least 40 percent of the nitrogen in the fertilizer to be slowly available (organic) form. Fertilizer shall be delivered to the site in original unopened containers each showing the manufacturer's guaranteed analysis conforming to applicable state fertilizer laws.

B. Peat Moss: Shall be domestic brown sphagnum peat, free of woody materials and of mineral matter such as sulfur and iron and shall have a pH value between 4 and 5. Deliver air dry.

C. Anti-desiccant: Shall be an emulsion which provides a protective film over plant surfaces to help retain moisture, but permeable enough to permit transpiration. Anti-desiccant shall be delivered in the manufacturer's containers and shall be mixed with water in proportions recommended by manufacturer.

D. Bone Meal: Shall be commercial raw bone meal, finely ground, having a minimum analysis of 4 percent nitrogen and 20 percent phosphoric acid.

E. Mulch: Shall be Shredded Pine Bark Mulch consisting of pine bark strips no longer than 2-in in any dimension, free of wood chips, stones or other undesirable matter with a pH range between 4 and 5. Color of mulch to be determined by ENGINEER.

F. Soil Sterilent: Shall be "TRIOX" by Ortho Chemical Co. or equal.

G. Water used in this work shall be furnished by the Contractor and shall be suitable for irrigation and free from ingredients harmful to plant life. Hose and other watering equipment required for the work shall be furnished by the Contractor.

2.03 ACCESSORY MATERIALS

A. Stakes: Shall be used for supporting all trees and shall be of sound wood, uniform in size, reasonably free of knots and capable of standing in the ground at least 2 years.

Stakes shall be treated with a non-toxic preservative stain with a rich dark brown color. A sample shall be provided for approval by the Engineer. Stakes shall be 2 by 4 and not less than 8-ft in length.

B. Wire: For tree staking, shall be Double No. 10 gauge galvanized soft steel wire, twisted.

C. Hose: To encase wires, shall be two-ply fiber-bearing black rubber garden hose, not less than 1/2-in inside diameter and a minimum of 8-in in length.

D. Wrapping Material: Shall be first quality, heavy waterproof crepe paper manufactured for this purpose. Strips shall be 6 to 10-in wide. Twine for tying shall be coarse sisal yarn.

2.04 PLANT MATERIALS

A. Furnish and install trees and shrubs as shown on the Drawings. Plants shall be nursery grown under climatic conditions similar to those in the locality of the project and shall conform to the variety and sizes indicated. Plants shall conform also to the indicated botanical names and standards of size, culture and quality for the highest grades and standards as adopted by the AAN in the American Standard for Nursery Stock.

B. All plants shall be freshly dug. No heeled-in plants or plants from cold storage shall be used. All plants shall be typical of their species or variety and shall have a normal habit of growth. Plants shall be sound, healthy and vigorous, well-branched and densely foliated when in leaf; shall be free of disease, insect pests, eggs or larvae and shall have healthy, well-developed root systems. All parts of the plant shall be moist and shall show active green cambium when cut.

C. The height of the trees, measured from the crown of the roots to the top of the top branch, shall not be less than the minimum size designated. The trunk of each tree shall be a single trunk growing from a single unmutilated crown of roots. No part of the trunk shall be conspicuously crooked as compared with normal trees of the same variety. The trunk shall be free from sun-scald, frost cracks, or wounds resulting from abrasions, fire, or other causes. No pruning wounds shall be present having a diameter of more than 2-in and such wounds must show vigorous bark on all edges.

2.05 INSPECTION OF PLANT MATERIALS

A. Inspection of plants before digging shall be at the option of the Engineer. Be present if requested by Engineer, for inspection of plants at nursery.

B. Plants shall be subjected to inspection and approval upon delivery for conformity to specified requirements as to quality, size and variety. Such approval shall not impair the right of inspection and rejection during the progress of the work.

C. Plants shall be accompanied by State Nursery inspection certificates.

PART 3 EXECUTION

3.01 DIGGING, HANDLING AND PROTECTION OF PLANTS

A. Plants shall be dug with firm natural balls of earth, of sufficient diameter and depth to include most of the fibrous roots and conforming to the standards of AAN. No plants will be accepted with plastic burlap or if the ball is cracked or broken except upon special approval of the Engineer.

B. Roots or balls of plants shall be adequately protected at all times from sun and from drying winds.

C. Plants which cannot be planted immediately upon delivery shall be set on the ground and be well-protected with soil, wet moss, bark mulch, or other acceptable material.

D. No plant shall be bound with wire or rope at any time so as to damage the bark or break branches.

3.02 PLANTING SEASONS

A. Planting shall only be done during the periods within the seasons which are normal for such work as determined by weather and by locally acceptable practice and which are approved by the Engineer. If planting occurs between June 15th and August 15th or during periods of drought, irrigation shall be furnished as directed by the Engineer.

3.03 PLANTING OPERATIONS

A. Planting: Shall be done by experienced workmen familiar with planting procedures under the supervision of a qualified foreman.

B. Stake out locations of and secure the Engineer's approval before excavating plant pits.

C. All plant pits shall be excavated with vertical sides.

D. Tree Pits: Shall be 2-ft greater in diameter than the root ball of the tree and sufficiently deep to allow for a 1-ft thick layer of compacted loam and peat moss beneath the ball.

E. Shrub Beds: Shall be tilled to 18-in below top of loam.

F. Plant backfill mixture: Loam for backfilling all tree pits shall have 3 lbs of fertilizer and 1 lb of bone meal per tree and 1 lb of fertilizer and 1/2 lb of bone meal per shrub, incorporated with peat moss at a ratio of 2 parts loam to 1 part peat moss.

G. Plants shall be set in center of pits plumb and straight and at such a level that after settlement, the crown of the plant ball will be at the surrounding finished grade.

1. When balled and burlapped plants are set, loam shall be compacted around bases of balls to fill all voids. All burlap, ropes or wires shall be removed from the top 1/3 of the balls. Plastic burlap shall be completely removed.

H. Loam shall be backfilled in layers of not more than 9-in and each layer watered sufficiently to settle before the next layer is put in place.

I. Loam around balls shall be thoroughly compacted and watered. Immediately after the plant pit is backfilled, a saucer or shallow basin slightly larger than pit shall be formed with a ridge of soil to facilitate and contain watering.

J. Spray all plants with anti-desiccant, including trunk, branches, foliage and buds. Follow manufacturer's instructions and recommendations for application of anti-desiccant.

K. Relocated plants shall be removed and relocated according to AAN standards and guaranteed for 1 year after installation.

3.04 WRAPPING, GUYING AND STAKING

A. Trees shall be inspected by the Engineer for injury to trunks, evidence of insect infestation and improper pruning before wrapping.

B. Wrap trunks of all trees spirally from bottom to top with material specified and tie securely. The wrapping shall overlap and entirely cover the trunk from the ground to the height of the second branches and shall be neat and snug. Overlap shall be approximately 2-in.

C. All shade trees, flowering trees and evergreen trees 5 to 6-ft in height and larger shall be staked in accordance with the tree staking detail.

3.05 PRUNING, MULCHING AND PLACEMENT OF WASHED GRAVEL

A. Each plant shall be pruned at the time of planting in accordance with AAN Standards to preserve the natural character of the plant and as directed by the Engineer.

B. Pruning shall be done with clean, sharp tools.

C. Cuts over 1-in in diameter shall be painted with an approved tree paint. Paint shall cover all exposed cambium as well as other exposed living tissue. Paint shall be waterproof, adhesive and elastic, antiseptic, free from kerosene, coal tar, creosote, or any other material injurious to the life of the tree.

D. Immediately after planting operations are completed, all tree pits shall be covered with a 3-in layer of the specified mulch and shrub and ground cover beds shall be treated with weed retardant in accordance with manufacturer's instructions and covered with 3-in layer of mulch as indicated on the Drawings.

E. Washed gravel shall be placed to a 6-in depth in all areas as shown on the Drawings. Prior to placement of gravel the areas shall be treated with a soil sterilent in accordance with manufacturer's instructions.

3.06 OBSTRUCTIONS BELOW GROUND

A. In the event that underground boulders, underground construction work, or obstructions are encountered in any pit excavation work under this Contract, alternate locations may be selected by the Engineer at no additional cost to the Owner.

3.07 WATERING

A. Plantings must be flooded with water twice within the first 24 hours of the time of planting and not less than twice per week until provisional acceptance.

B. Suitable water for planting and maintenance will be the responsibility of the Contractor. The Contractor shall furnish his/her own hose and hose connections or other watering equipment.

3.08 MAINTENANCE

A. Maintenance shall begin immediately after each plant is installed. Plants shall be watered, mulched, weeded, pruned, sprayed, fertilized, cultivated and otherwise maintained and protected until provisional acceptance. Settled plants shall be reset to proper grade and position, planting saucer restored and dead material removed. Guys shall be tightened and repaired. Defective work shall be corrected as soon as possible after it becomes apparent and as weather and season permit.

B. Upon completion of planting and prior to provisional acceptance, remove from the site excess soil and debris and repair all damage resulting from planting operations.

3.09 INSPECTION AND PROVISIONAL ACCEPTANCE

A. The Engineer will inspect all work for provisional acceptance, at the end of the 8-week maintenance period, upon the written request of the Contractor received at least 10 days before the anticipated date of inspection.

B. Furnish full and complete written instructions for maintenance of the planting to the Owner at the time of provisional acceptance.

C. After all necessary corrective work has been completed and maintenance instructions have been received by the Owner, the Engineer will certify in writing the provisional acceptance of the planting.

3.10 GUARANTEE PERIOD AND REPLACEMENTS

A. All plants, including relocated material shall be guaranteed for not less than one full year from the time of provisional acceptance.

B. At the end of this period, any plant that is missing, dead, not true to name or size as specified, or not in satisfactory growth, as determined by the Engineer, shall be replaced. In case of any question regarding the condition and satisfactory establishment of a rejected plant, the Engineer's decision is final. Furnish a guarantee for all replacement plants for at least one full growing season.

C. All replacements shall be plants of the same kind and size as specified. They shall be furnished and planted as specified herein. The cost of replacement shall be borne by the Contractor except where it can be definitely shown that loss resulted from vandalism.

3.11 FINAL INSPECTION AND FINAL ACCEPTANCE

A. At the end of the guarantee period, inspection will be made by the Engineer upon written request submitted by the landscape contractor at least 10 days before the anticipated date.

B. After all necessary corrective work has been completed, the Engineer will certify in writing the final acceptance of the planting.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment, and incidentals necessary and place loam, finish grade, seed, and maintain all seeded areas as specified herein including all areas disturbed by construction operations.

1.02 RELATED WORK

A. Section 01 57 13: Erosion and Sedimentation Control.

B. Section 31 10 00: Site Preparation.

C. Section 31 23 00: Earthwork.

D. Section 31 23 33: Trenching, Backfilling, and Compaction.

E. Section 32 90 10: Landscaping.

1.03 SUBMITTALS

A. Submit to the Engineer in accordance with Section 01 33 23 complete product data for all materials furnished under this Section, including seed mixtures and product label information.

B. Submit to the Engineer in accordance with Section 01 33 23 samples of all materials for inspection and acceptance if requested.

PART 2 PRODUCTS

2.01 MATERIALS

A. Loam shall be fertile, natural soil, typical of the locality; free from large stones, roots, sticks, peat, weeds and sod; obtained from naturally well drained areas; not excessively acid nor alkaline, nor contain toxic material harmful to plant growth. Topsoil stockpiled as specified may be used, but additional loam shall be furnished at no additional expense, if required.

B. Fertilizer shall be complete commercial fertilizer, 10-10-10 grade. It shall be delivered to the site in the original unopened containers each showing the manufacturer's guaranteed analysis. Store fertilizer so that when used it shall be dry and free flowing.

C. Lime shall be ground limestone containing not less than 85 percent calcium and magnesium carbonates.

D. Seed shall be from the same or previous year's crop; each variety of seed shall have a percentage of germination not less than 90, a percentage of purity not less than 85, and shall have not more than one percent weed content.

E. Seed shall be furnished and delivered premixed in the proportions specified in Paragraph 3.02 F. A manufacturer's certificate of compliance to the specified mixes shall be submitted by the manufacturer for each seed type. These certificates shall include the guaranteed percentages of purity, weed content and germination of the seed, and also the net weight and date of shipment. No seed may be sown until the required certificates have been submitted.

F. Seed shall be delivered in sealed containers bearing the dealer's guaranteed analysis.

G. Contractor shall be responsible for providing and paying for water used as part of this section.

PART 3 EXECUTION

3.01 APPLICATION

A. Loam shall be placed to a minimum depth of 4 inches.

B. Lime shall be applied at the rate of 1-1/2 tons per acre.

C. Fertilizer shall be applied at the rate of 800 pounds per acre.

D. The application of fertilizer and lime may be performed hydraulically in one operation with hydroseeding and mulching. If lime is applied in this manner, clean all structures and paved areas of unwanted deposits.

3.02 INSTALLATION

A. 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.

B. The subgrade of all areas to be loamed and seeded shall be raked and all rubbish, sticks, roots, and stones larger than 2 inches shall be removed. Loam shall be spread and lightly compacted to finished grade. Compacted loam shall not be less than the depth specified. No loam shall be spread in water or while frozen or muddy.

C. After the loam is placed and before it is raked to true lines and rolled, limestone shall be spread evenly over the loam surface and thoroughly incorporated with loam by heavy raking to at least one half the depth of loam.

D. Fertilizer shall be uniformly spread and disked or roto-tilled to a depth of at least 4 inches.

E. Immediately following this preparation the seed shall be uniformly applied and lightly raked into the surface. Lightly roll the surface and water with fine spray. Seed shall be applied, depending on the period of year, at the following rates:

Seeding Date	Seed	Rates
Apr 15 – Aug 15	Kentucky Tall Fescue #31	100 lbs/acre
	Bermuda (unhulled)	40 lbs/acre
	Bahia	40 lbs/acre
	Centipede	15 lbs/acre
	German Millet	35 lbs/acre
Aug 15 - Apr 15	Kentucky Tall Fescue #31	100 lbs/acre
	Bermuda (hulled)	40 lbs/acre
	Bahia	40 lbs/acre
	Centipede	15 lbs/acre
	German Millet	25 lbs/acre
	Winter Rye (grain)	30 lbs/acre

F. Temporary seed mixtures shall be in accordance with Section 31 25 00 – Sedimentation and Erosion Control and the Contract Drawings.

G. Seeding shall be done within 10 days following soil preparation. Seed shall be applied hydraulically at the rates and percentages indicated. The spraying equipment and mixture shall be so designed that when the mixture is sprayed over an area, the grass seed and mulch shall be equal in quantity to the specified rates.

3.03 MAINTENANCE AND PROVISIONAL ACCEPTANCE

A. Keep all seeded areas watered and in good condition, reseeding if and when necessary until a good, healthy, uniform growth is established over the entire area seeded. Maintain seeded areas in an approved condition including a minimum of two mowings of the lawn areas until provisional acceptance. Mowing shall be scheduled so as to maintain a minimum stand height of 4 inches. Stand height shall be allowed to reach 7-9 inches prior to mowing.

B. On slopes, protect against washouts by approved methods. Any washout which occurs shall be regraded and reseeded at no additional expense to Owner until a good sod is established.

C. The Engineer will inspect all work for provisional acceptance at the end of the eight-week grass maintenance period, upon the written request, received at least ten days before the anticipated date of inspection.

D. A satisfactory stand will be defined as follows:

1. No bare spots larger than 3 square feet.

2. No more than 10 percent of total area with bare spots larger than 1 square foot.

3. Not more than 15 percent of total area with bare spots larger than 6-in square.

E. Furnish full and complete written instructions for maintenance of the lawns to the Owner at the time of provisional acceptance.

F. The inspection by the Engineer will determine whether maintenance shall continue in any area of manner.

G. After all necessary corrective work and clean-up has been completed, and maintenance instructions have been received by the Owner, the Engineer will certify in writing the provisional acceptance of the lawn areas. Maintenance of lawns, or parts of lawns, shall cease on receipt of provisional acceptance.

3.04 GUARANTEE PERIOD AND FINAL ACCEPTANCE

A. All seeded areas shall be guaranteed for not less than one full year from the time of final completion.

B. At the end of the guarantee period, inspection will be made by the Owner upon written request submitted at least ten days before the anticipated date. Lawn areas not demonstrating satisfactory stands as outlined above, as determined by the Owner, shall be renovated, reseeded and maintained meeting all requirements as specified herein.

C. After all necessary corrective work has been completed, the Owner shall certify in writing the final acceptance of the lawns.

END OF SECTION

PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. Provide all labor, materials, equipment, and incidentals as shown, specified, and required to install and test all buried piping, fittings, and specials. The Work includes the following:
   a. All types and sizes of buried piping, except where buried piping installations are specified under other Sections.
   b. Unless otherwise shown or specified, this Section includes all buried piping Work required, beginning at the outside face of structures or structure foundations, including piping beneath structures, and extending away from structures.
   c. Work on or affecting existing buried piping.
   d. Installation of all jointing and gasket materials, specials, flexible couplings, mechanical couplings, harnessed and flanged adapters, sleeves, tie rods, cathodic protection, and other Work required for a complete, buried piping installation.
   e. Supports, restraints, and thrust blocks.
   f. Pipe encasements.
   g. Field quality control, including testing.
   h. Cleaning and disinfecting.
   i. Incorporation of valves, and special items shown or specified into piping systems in accordance with the Contract Documents and as required.

B. Coordination:

1. Review installation procedures under this and other Sections and coordinate installation of items to be installed with or before buried piping Work.

2. Coordinate with appropriate piping Sections of Division 33.

C. Related Sections:

1. Section 31 23 33 - Trenching, Backfilling and Compaction.

2. Section 31 11 00 - Clearing and Grubbing.

3. Section 31 23 00 - Earthwork

4. Section 31 23 16 - Rock Removal

5. Section 33 05 19 – Ductile Iron Pipe

6. Section 33 05 31 – Thermoplastic Pipe

7. Section 33 05 39 – Concrete Pipe

1.02 REFERENCES

A. Standards referenced in this Section are:

1. ASTM C12, Practice for Installing Vitrified Clay Pipe Lines.

2. ASTM C425, Specification for Compression Joints for Vitrified Clay Pipe and Fittings.

3. ASTM C828, Test Method for Low-Pressure Air Test of Vitrified Clay Pipe Lines.

4. ASTM C924, Practice for Testing Concrete Pipe Sewer Lines by Low-Pressure Test Method.

5. ASTM D2321, Practice for Underground Installation of Thermoplastic Pipe for Sewers and other Gravity-Flow Applications.

6. ASTM D2774, Practice for Underground Installation of Thermoplastic Pressure Piping.

7. ASTM F1417, Test Method for Installation Acceptance of Plastic Gravity Sewer Lines using Low-Pressure Air.

8. ASTM F2164, Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Hydrostatic Pressure.

9. ANSI/AWWA C105, Polyethylene Encasement for Ductile-Iron Pipe Systems.

10. ANSI/AWWA C111, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

11. ANSI/AWWA C600, Installation of Ductile-Iron Water Mains and Their Appurtenances.

12. ANSI/AWWA C603, Installation of Asbestos-Cement Pressure Pipe.

13. ANSI/AWWA C605, Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water.

14. ANSI/AWWA C651, Disinfecting Water Mains.

15. AWWA M9, Concrete Pressure Pipe.

16. AWWA M23, PVC Pipe - Design and Installation.

17. AWWA M41, Ductile-Iron Pipe and Fittings.

18. AWWA M55, PE Pipe - Design and Installation.

19. ASCE 37, Design and Construction of Sanitary and Storm Sewers.

20. American Concrete Pipe Association, Concrete Pipe Handbook.

21. NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

1.03 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with requirements and recommendations of authorities having jurisdiction over the Work.

2. Obtain required permits for Work in roads, rights of way, railroads, and other areas of the Work.

B. The bell ends of pipe shall face the direction of laying unless otherwise directed by the ENGINEER, for lines on appreciable slope, the ENGINEER may require that bell ends face upgrade.

1.04 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:
   a. Laying schedules for all piping.
   b. Details of piping, specials, joints, harnessing and thrust blocks, and connections to piping, structures, equipment, and appurtenances.

2. Product Data:
   a. Manufacturer's literature and specifications, as applicable, for products specified in this Section.

3. Testing Procedures:
   a. Submit proposed testing procedures, methods, apparatus, and sequencing. Obtain ENGINEER's approval prior to commencing testing.

B. Informational Submittals: Submit the following:

1. Certificates:
   a. Certificate signed by manufacturer of each product certifying that product conforms to applicable referenced standards.

2. Field Quality Control Submittals:
   a. Results of each specified field quality control test.

C. Closeout Submittals: Submit the following:

1. Record Documentation:
   a. Maintain accurate and up-to-date record documents showing modifications made in the field, in accordance with approved submittals, and other Contract modifications relative to buried piping Work. Submittal

shall show actual location of all piping Work and appurtenances at same scale as the Drawings.

b. Show piping with elevations referenced to Project datum and dimensions from permanent structures. For each horizontal bend in piping, include dimensions to at least three permanent structures, when possible. For straight runs of piping provide offset dimensions as required to document piping location.

c. Include profile drawings with buried piping record documents when the Contract Documents include piping profile drawings.

d. Conform to Section 01 78 39, Project Record Documents.

1.05 DELIVERY, STORAGE AND HANDLING

A. Delivery:

1. Deliver materials to the Site to ensure uninterrupted progress of the Work.

2. Upon delivery inspect pipe and appurtenances for cracking, gouging, chipping, denting, and other damage and immediately remove from Site and replace with acceptable material.

B. Storage:

1. Store materials to allow convenient access for inspection and identification. Store material off ground using pallets, platforms, or other supports. Protect packaged materials from corrosion and deterioration.

2. Pipe and fittings other than PVC and CPVC may be stored outdoors without cover. Cover PVC and CPVC pipe and fittings stored outdoors.

C. Handling:

1. Handle pipe, fittings, specials, and accessories carefully in accordance with pipe manufacturer's recommendations. Do not drop or roll material off trucks. Do not drop, roll or skid piping.

2. Avoid unnecessary handling of pipe.

3. Keep pipe interiors free from dirt and foreign matter.

4. Protect interior linings and exterior coatings of pipe and fittings from damage. Replace pipe and fittings with damaged lining regardless of cause of damage.

PART 2 PRODUCTS

2.01 MATERIALS

A. Piping materials are specified in the Buried Piping Schedule at end of this Section. Piping materials shall conform to Specifications for each type of pipe and piping appurtenances in applicable Sections of Division 33.

B. General:

1. Pipe Markings:
   a. Factory-mark each length of pipe and each fitting with designation conforming to those on approved laying schedules.
   b. Manufacturer shall cast or paint on each length of pipe and each fitting pipe material, diameter, and pressure or thickness class.

C. Exterior Coating

1. Buried piping shall be coated with an asphaltic coating approximately one mil thick, in accordance with AWWA C151, C115, C110, and C153.

D. Polyethylene Encasement:

1. Polyethylene may be supplied in tubes or sheets.

2. Polyethylene encasement materials shall be in accordance with ANSI/AWWA C105.

3. Polyethylene wrap may be Linear Low Density wrap 8 mils thick or Cross-laminated High Density wrap 4 mils thick.

2.02 BURIED PIPING IDENTIFICATION

A. Polyethylene Underground Warning Tape for Metallic Pipelines:

1. Tracer tape shall be of inert, acid- and alkali-resistant, polyethylene, four mils thick, six inches wide and a minimum of 5 mil thickness manufactured in accordance with ASTM-D-1000, suitable for direct burial. Tape shall be capable of stretching to twice its original length.

2. Message shall read, "CAUTION [insert customized name of pipe service, i.e., "POTABLE WATER", SANITARY SEWER" or other service as appropriate, as indicated in the Buried Pipe Schedule at the end of this Section] PIPE BURIED BELOW", with bold letters approximately two and a half inches high. Messages shall be printed at maximum intervals of one foot. Tape shall be purple for sanitary sewer force main. For other applications, the tape shall be custom colored in accordance with Great Lakes Upper Mississippi Rivers Board State Public Health Environmental Managers Recommended Standards for Water Works.

3. Manufacturer: Provide products of one of the following:
   a. Brady Corporation
   b. Seton Identification Products
   c. Marking Services, Inc.
   d. Or equal.

B. Detectable Underground Warning Tape for Non-Metallic Pipelines:

1. Tape shall be of inert, acid- and alkali-resistant, polyethylene, five mils thick, six inches wide, with aluminum backing, and have 15,000 psi tensile strength and 80 percent elongation capability. Tape shall be suitable for direct burial.

2. Message shall read, "CAUTION [insert customized name of pipe service, i.e., "POTABLE WATER", "SANITARY SEWER" , or other appropriate service, as indicated in the Buried Pipe Schedule at the end of this Section] PIPE BURIED BELOW" with bold letters approximately two and a half inches high. Messages shall be printed at maximum intervals of one foot. Tape shall be custom color in accordance with Great Lakes Upper Mississippi Rivers Board State Public Health Environmental Managers Recommended Standards for Water Works.

3. Manufacturer: Provide products of one of the following:
   a. Brady Corporation
   b. Seton Identification Products
   c. Marking Services, Inc.
   d. Or equal.

C. Utility Pipe Markers and Locator:

1. Provide buried pipe markers at least once every 100 feet of pipe.

2. Markers are to be 4.5-inch diameter HDPE balls with interior copper coils secured by interior foam and capable of a 5-foot detection range at a maximum 6-inch offset.

3. Manufacturers:
   a. Omnimarker by Tempo.
   b. Approved Equal.

4. Provide 48 extra water (blue) markers.

5. Provide 2 electronic marker locator wands with soft carrying cases and headphone sets for each by the same manufacturer intended for locating the specified markers.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install piping as shown, specified, and as recommended by pipe and fittings manufacturer.

2. In event of conflict between manufacturer's recommendations and the Contract Documents, request interpretation from ENGINEER before proceeding.

3. ENGINEER will observe excavations and bedding prior to laying pipe by CONTRACTOR. Notify ENGINEER in advance of excavating, bedding, pipe laying, and backfilling operations.

4. Minimum cover over buried piping shall be three feet, unless otherwise shown or approved by ENGINEER.

5. Section 31 23 33 covers Trenching and Backfilling.

6. Excavation in excess of that required or shown, and that is not authorized by ENGINEER shall be filled at CONTRACTOR's expense with granular material furnished, placed, and compacted in accordance with applicable Sections.

B. Plugs:

1. Temporarily plug installed pipe at end of each day of work or other interruption of pipe installation to prevent entry of animals, liquids, and persons into pipe, and entrance or insertion of deleterious materials into pipe.

2. Install standard plugs in bells at dead ends, tees, and crosses. Cap spigot and plain ends.

3. Fully secure and block plugs, caps, and bulkheads installed for testing to withstand specified test pressure.

4. Where plugging is required for phasing of the Work or subsequent connection of piping, install watertight, permanent type plugs, caps, or bulkhead acceptable to ENGINEER.

C. Bedding Pipe: Bed pipe as specified and in accordance with details shown on the Contract Drawings.

1. Trench excavation and backfill, and bedding materials shall conform to Section 31 23 33 Trenching and Backfilling, as applicable.

2. Where ENGINEER deems existing bedding material unsuitable, remove and replace existing bedding with approved granular material furnished, placed, and compacted in accordance with the defined trench conditions

3. Where ENGINEER deems the existing soil is suitable for bedding purposes, it shall be used.

4. Carefully and thoroughly compact pipe bedding with hand held pneumatic compactors.

5. Do not lay pipe until ENGINEER approves bedding condition.

6. Do not bring pipe into position until preceding length of pipe has been bedded and secured in its final position.

D. Laying Pipe:

1. Conform to manufacturer's instructions and requirements of standards and manuals listed below, as applicable:
   a. Ductile Iron Pipe: ANSI/AWWA C600, ANSI/AWWA C105, AWWA M41.
   b. Concrete Pipe: AWWA M9.
   c. Thermoplastic Pipe: ASTM D2321, ASTM D2774, ANSI/AWWA C605, AWWA M23, AWWA M45, AWWA, M55.

2. Install pipe accurately to line and grade shown and indicated in the Contract Documents, unless otherwise approved by ENGINEER. Remove and reinstall pipes that are not installed correctly.

3. Slope piping uniformly between elevations shown.

4. Keep groundwater level in trench at least 24 inches below bottom of pipe before laying pipe. Do not lay pipe in water. Maintain dry trench conditions until jointing and backfilling are complete. Keep clean and protect interiors of pipe, fittings, valves, and appurtenances.

5. Start laying pipe at lowest point and proceed towards higher elevations, unless otherwise approved by ENGINEER.

6. Place bell and spigot-type pipe so that bells face the direction of laying, unless otherwise approved by ENGINEER.

7. Place concrete pipe containing elliptical reinforcement with minor axis of reinforcement in vertical position.

8. Excavate around joints in bedding and lay pipe so that pipe barrel bears uniformly on trench bottom.

9. Deflections at joints shall not exceed 75 percent of amount allowed by pipe manufacturer, unless otherwise approved by ENGINEER.

10. For PVC and CPVC piping with solvent welded joints, 2.5-inch diameter and smaller, and copper tubing, snake piping in trench to compensate for thermal expansion and contraction.

11. Carefully examine pipe, fittings, valves, and specials for cracks, damage, and other defects while suspended above trench before installation. Immediately remove defective materials from the Site and replace with acceptable products.

12. Inspect interior of all pipe, fittings, valves, and specials and completely remove all dirt, gravel, sand, debris, and other foreign material from pipe interior and joint recesses before pipe and appurtenances are moved into excavation. Bell and spigot-type mating surfaces shall be thoroughly wire brushed, and wiped clean and dry immediately before pipe is laid.

13. Field cut pipe, where required, with machine specially designed for cutting the type of pipe being installed. Make cuts carefully, without damage to pipe,

coating or lining, and with smooth end at right angles to axis of pipe. Cut ends on push-on joint type pipe shall be tapered and sharp edges filed off smooth. Do not flame-cut pipe.

14. Do not place blocking under pipe, unless specifically approved by ENGINEER for special conditions.

15. Touch up protective coatings in manner satisfactory to ENGINEER prior to backfilling.

16. Notify ENGINEER in advance of backfilling operations.

17. On steep slopes, take measures acceptable to ENGINEER to prevent movement of pipe during installation.

18. Thrust Restraint: Where required, provide thrust restraint conforming to Article 3.3 of this Section.

19. Exercise care to avoid flotation when installing pipe in cast in-place concrete, and in locations with high groundwater.

E. Polyethylene Encasement:

1. Provide polyethylene encasement, where indicated, for ductile iron piping to prevent contact between pipe and surrounding bedding material and backfill.

2. Polyethylene encasement installation shall be in accordance with ANSI/AWWA C105.

F. Jointing Pipe:

1. Ductile Iron Mechanical Joint Pipe:
   a. Immediately before making joint, wipe clean the socket, plain end, and adjacent areas. Taper cut ends and file off sharp edges to provide smooth surface.
   b. Lubricate plain ends and gasket with soapy water or manufacturer's recommended pipe lubricant, in accordance with ANSI/AWWA C111, just prior to slipping gasket onto plain end of the joint assembly.
   c. Place gland on plain end with lip extension toward the plain end, followed by gasket with narrow edge of gasket toward plain end.
   d. Insert plain end of pipe into socket and press gasket firmly and evenly into gasket recess. Keep joint straight during assembly.
   e. Push gland toward socket and center gland around pipe with gland lip against gasket.
   f. Insert bolts and hand-tighten nuts.
   g. If deflection is required, make deflection after joint assembly and prior to tightening bolts. Alternately tighten bolts approximately 180 degrees apart to seat gasket evenly. Bolt torque shall be as follows:

Pipe Diameter (inches)	Bolt Diameter (inches)	Range of Torque (ft-lbs)
3	5/8	45 to 60
4 to 24	3/4	75 to 90
30 to 36	1	100 to 120
42 to 48	1.25	120 to 150

h. Bolts and nuts, except those of stainless steel, shall be coated with two coats, minimum dry film thickness of eight mils each, of high build solids epoxy or bituminous coating manufactured by Tnemec, or equal.
i. Restrained mechanical joints shall be in accordance with Section 33 05 19, Ductile Iron Pipe.

2. Ductile Iron Push-On Joint Pipe:
   a. Prior to assembling joints, thoroughly clean with wire brush the last eight inches of exterior surface of spigot and interior surface of bell, except where joints are lined or coated with a protective lining or coating.
   b. Wipe clean rubber gaskets and flex gaskets until resilient. Conform to manufacturer's instructions for procedures to ensure gasket resiliency when assembling joints in cold weather.
   c. Insert gasket into joint recess and smooth out entire circumference of gasket to remove bulges and to prevent interference with proper entry of spigot of entering pipe.
   d. Immediately prior to joint assembly, apply thin film of pipe manufacturer's recommended lubricant to surface of gasket that will come in contact with entering spigot end of pipe, or apply a thin film of lubricant to outside of spigot of entering pipe.
   e. For assembly, center spigot in pipe bell and push pipe forward until spigot just makes contact with rubber gasket. After gasket is compressed and before pipe is pushed or pulled in the rest of the way, carefully check gasket for proper position around the full circumference of joint. Final assembly shall be made by forcing spigot end of entering pipe past gasket until spigot makes contact with base of the bell. When more than a reasonable amount of force is required to assemble the joint, remove spigot end of pipe to verify proper positioning of gasket. Do not use gaskets that have been scored or otherwise damaged.
   f. Maintain an adequate supply of gaskets and joint lubricant at the Site when pipe jointing operations are in progress.
   g. If deflection is required, make deflection after joint assembly and prior to tightening bolts. Alternately tighten bolts approximately 180 degrees apart to seat gasket evenly. In no event, shall more deflection be allowed than 75% of the manufacturer's recommended maximum.

3. Thermoplastic Pipe Joints:
   a. Solvent Cement Welded Joints:
      1) Bevel pipe ends and remove all burrs before making joints. Clean pipe and fittings thoroughly. Do not attempt to make solvent cement joints if temperature is below 40 degrees F. Do not make solvent cement welded joints in wet conditions.
      2) Use solvent cement supplied or recommended by pipe manufacturer.

3) Apply joint primer and solvent cement and assemble joints in accordance with recommendations and instructions of manufacturer of joint materials and pipe manufacturer.
4) Take appropriate safety precautions when using joint primers and solvent cements. Allow air to circulate freely through pipelines to allow solvent vapors to escape. Slowly admit water when flushing or filling pipelines to prevent compression of gases within pipes.

b. Bell and Spigot Joints:
1) Bevel pipe ends, remove all burrs, and provide a reference mark at correct distance from pipe end before making joints.
2) Clean spigot end and bell thoroughly before making the joint. Insert O-ring gasket while ensuring that gasket is properly oriented. Lubricate spigot with manufacturer's recommended lubricant. Do not lubricate bell and O-ring. Insert spigot end of pipe carefully into bell until reference mark on spigot is flush with bell.

4. Mechanical Coupling Joints:
a. Prior to installing and assembling mechanical couplings, thoroughly clean joint ends with wire brush to remove foreign matter.
b. For mechanical couplings that incorporate gaskets, after cleaning apply lubricant to rubber gasket or inside of coupling housing and to joint ends. After lubrication, install gasket around joint end of previously installed piece and mate joint end of subsequent piece to installed piece. Position gasket and place coupling housing around gasket and over grooved or shouldered joint ends. Insert bolts and install nuts tightly by hand. Tighten bolts uniformly to produce an equal pressure on all parts of housing. When housing clamps meet metal to metal, joint is complete and further tightening is not required.
c. For plasticized PVC couplings, loosen the stainless steel clamping bands and remove clamps from coupling. Slide coupling over plain ends of pipes to be joined without using lubricants. Place clamps over each end of coupling at grooved section and tighten with torque wrench to torque recommended by manufacturer.

G. Backfilling:

1. Conform to applicable requirements of Section 31 23 33, Trenching and Backfilling.

2. Place backfill as Work progresses. Backfill by hand and use power tampers until pipe is covered by at least one foot of backfill.

H. Connections to Valves and Hydrants:

1. Install valves and hydrants as shown and indicated in the Contract Documents.

2. Provide suitable adapters when valves or hydrants and piping have different joint types.

3. Provide thrust restraint at all hydrants and at valves located at pipeline terminations.

I. Transitions from One Type of Pipe to Another:

1. Provide necessary adapters, specials, and connection pieces required when connecting different types and sizes of pipe or connecting pipe made by different manufacturers.

J. Closures:

1. Provide closure pieces shown or required to complete the Work.

3.02 TRACER TAPE INSTALLATION

A. Polyethylene Underground Warning Tape for Metallic Pipelines:

1. Provide polyethylene tracer tape for buried metallic piping, which includes pipe that is steel, ductile iron, cast iron, concrete, copper, and corrugated metal.

2. Provide tracer tape 12 to 18 inches above the pipe, above and parallel to buried pipe.

3. For pipelines buried eight feet or greater below finished grade, provide second line of magnetic tracer tape 12 to 18 inches below finished grade above crown of buried pipe, aligned along pipe centerline.

4. Tape shall be spread flat with message side up before backfilling.

B. Detectable Underground Warning Tape for Non-Metallic Pipelines:

1. Provide polyethylene tracer tape with aluminum backing for buried, non-metallic piping, which includes pipe that is PVC, CPVC, polyethylene, HDPE, FRP, ABS, and vitrified clay.

2. Provide magnetic tracer tape 12 to 18 inches below finished grade, above and parallel to buried pipe.

3. For pipelines buried eight feet or greater below finished grade, provide second line of magnetic tracer tape 2.5 feet above crown of buried pipe, aligned along the pipe centerline.

4. Tape shall be spread flat with message side up before backfilling.

3.03 UTILITY PIPE MARKERS AND LOCATOR

A. Markers are to be installed directly over the pipe 2 feet below grade as the trench is backfilled.

3.04 THRUST RESTRAINT

A. Thrust restraint shall be accomplished by using restrained pipe joints for all new pipe. Also, provide concrete thrust blocks where shown or indicated in the Contract Documents. Thrust restraints shall be designed for axial thrust exerted by test

pressure specified in the Buried Piping Schedule at the end of this Section and shall have dimensions as shown where indicated on the drawings.

B. Place concrete thrust blocks against undisturbed soil.

C. Restrained Pipe Joints:

1. Pipe joints shall be restrained by means suitable for the type of pipe being installed.
   a. Ductile Iron, Push-on Joints and Mechanical Joints: Restrain with proprietary restrained joint system as specified in Section 33 05 19, Ductile Iron Pipe; lugs and tie rods; or other joint restraint systems approved by ENGINEER.
   b. Thermoplastic and HDPE Joints: Where bell and spigot type or other non-restrained joints are utilized, provide tie rods across joint or other suitable joint restraint system, subject to the approval of ENGINEER.
   c. Joints for Concrete Pipe: Restrain joints utilizing clamp type restrained joint or snap ring-type restrained joint.

D. Concrete Reaction Blocks:

1. Provide concrete thrust blocks as approved for use by the Engineer, on pressure piping, at tees, plugs, bends and caps, and where shown or indicated in the Contract Documents. Construct thrust blocks of Class D concrete, conforming to 03 30 01, Concrete.

2. Install thrust blocks against undisturbed soil. Place concrete to contain the resultant thrust force so that pipe and fitting joints are accessible for repair.
   a. Provide reinforcing as is required.

3. Concrete thrust block size shall be as shown on the Drawings or as approved by ENGINEER.

4. No direct payment shall be made for concrete reaction blocking and reinforcement – cost shall be included in the lump sum base bid.

3.05 WORK AFFECTING EXISTING PIPING

A. Location of Existing Underground Facilities:

1. Locations of existing Underground Facilities shown on the Drawings should be considered approximate.

2. Determine the true location of existing Underground Facilities to which connections are to be made, crossed, and that could be disturbed, and determine location of Underground Facilities that could be disturbed during excavation and backfilling operations, or that may be affected by the Work.

B. Taking Existing Pipelines and Underground Facilities Out of Service:

1. Conform to Section 01 14 16, Coordination with Owner's Operations.

2. Do not take pipelines or Underground Facilities out of service unless specifically listed in Section 01 14 16, Coordination with Owner's Operations, or approved by ENGINEER.

3. Notify ENGINEER in writing prior to taking pipeline or Underground Facilities out of service. Shutdown notification shall be provided in advance of the shutdown in accordance with the General Conditions and Section 01 14 16, Coordination with Owner's Operations.

C. Work on Existing Pipelines or Underground Facilities:

1. Cut or tap piping or Underground Facilities as shown or required with machines specifically designed for cutting or tapping pipelines or Underground Facilities, as applicable.

2. Install temporary plugs to prevent entry of mud, dirt, water, and debris into pipe.

3. Provide necessary adapters, sleeves, fittings, pipe, and appurtenances required to complete the Work.

4. Conform to applicable requirements of Section 01 14 16, Coordination with Owner's Operations, Section 01 73 29, Cutting and Patching, and Section 01 73 24, Connections to Existing Facilities.

3.06 FIELD QUALITY CONTROL

A. General:

1. Test all piping, except as exempted in the Buried Piping Schedule in this Section.

2. When authorities having jurisdiction are to witness tests, notify ENGINEER and authorities having jurisdiction in writing at least 48 hours in advance of testing.

3. Conduct all tests in presence of ENGINEER.

4. Remove or protect pipeline-mounted devices that could be damaged by testing.

5. Provide all apparatus and services required for testing, including:
   a. Test pumps, compressors, hoses, calibrated gages, meters, test containers, valves, fittings, and temporary pumping systems required to maintain OWNER's operations.
   b. Temporary bulkheads, bracing, blocking, and thrust restraints.

6. Provide air if an air test is required, power if pumping is required, and gases if gases are required.

7. Unless otherwise specified, CONTRACTOR will provide water required for hydrostatic testing. Provide means to convey water for hydrostatic testing into piping being tested. Provide water for other types of testing required.

8. Repair observed leaks and repair pipe that fails to meet acceptance criteria. Retest after repair.

9. Unless otherwise specified, testing shall include existing piping systems that connect with new piping system. Test existing pipe to nearest valve. Piping not installed by CONTRACTOR and that fails the test shall be repaired upon authorization of OWNER. Unless otherwise included in the Work, repair of existing piping or Underground Facilities will be paid as extra Work.

B. Test Schedule:

1. Refer to the Buried Piping Schedule in this Section for type of test required and required test pressure. Perform all tests in the presence of the Engineer.

2. Unless otherwise specified, required test pressures are at lowest elevation of pipeline segment being tested.

3. For piping not listed in Buried Piping Schedule in this Section:
   a. Hydrostatically test pipe that will convey liquid at a pressure greater than five psig. Provide process air pipe test for pipe that will convey air or gas under pressure or vacuum.
   b. Use exfiltration testing, low-pressure air testing, or vacuum testing for other piping as required.
   c. Disinfect for bacteriological testing piping that conveys potable water.

4. Test Pressure:
   a. Use test pressures listed in Buried Piping Schedule in this Section.
   b. If test pressure is not listed in Buried Piping Schedule, or if test is required for piping not listed in the Buried Piping Schedule, test pressure will be determined by ENGINEER based on maximum anticipated sustained operating pressure and methods described in applicable ANSI/AWWA manual or standard that applies to the piping system.

C. Hydrostatic Testing:

1. Preparation for Testing:
   a. Prior to testing, ensure that adequate thrust protection is in place and joints are properly installed.

2. Inspection for Defects of Pipe
   a. Pipeline shall be visually inspected from each manhole by use of artificial light, reflecting sunlight, closed circuit television cameras, or other devices for visual inspection.
   b. Pipelines shall exhibit a fully circular pattern when viewed from one manhole to the following manhole.
   c. If the interior of the pipeline shows poor alignment, displaced or damaged pipe, or any other defect, the defects as designated by the ENGINEER shall be corrected by the CONTRACTOR at no additional cost to the City.

3. Pressure Testing for Water Pipe:
   a. Fill pipeline slowly to minimize air entrapment and surge pressures. Fill rate shall not exceed one foot of pipe length per second in pipe being tested.
   b. Expel air from pipe as required. Obtain approval of ENGINEER prior to tapping pipe for expelling air.
   c. Examine exposed joints and valves, and make repairs to eliminate visible leakage.
   d. After specified wetting period, add fluid as required to pressurize line to required test pressure. Maintain test pressure for a stabilization period of ten minutes before beginning test.
   e. Timed test period shall not begin until after pipe has been filled, exposed to required wetting period, air has been expelled, and pressure stabilized.
   f. Timed Test Period: After stabilization period, maintain test pressure for two hours. During timed testing period, add fluid as required to maintain pressure within five psig of required test pressure. Test pressure shall then remain steady for one hour, indicating no leakage.
   g. Pump from test container to maintain test pressure. Measure volume of fluid pumped from test container and record on test report. Record pressure at test pump at 15 minute intervals for duration of test.
   h. Allowable Leakage Rates: Leakage is defined as the quantity of fluid supplied to pipe segment being tested to maintain pressure 150 psi for a period of 2 hours. Allowable leakage rates for 1,000 linear feet of piping are:

Pipe Size (inches)	Allowable Leakage (gallons)
4	0.73
6	1.11
8	1.47

   i. Prior to beginning test confirm all hydrants are properly located, operable, plumb, and at correct elevation, all valves are properly located, operable, and at correct elevation, with valve boxes or manholes centered over wrench nuts, and top of box or manhole at correct elevation and the water line or lines are properly vented where entrapped air is a consideration.

D. Bacteriological Testing:

1. Bacteriological testing for potable water lines, finished water lines, and other piping in accordance with the Buried Piping Schedule, is specified in Article 3.7 of this Section.

3.07 CLEANING AND DISINFECTION

A. Cleaning, General: Clean pipe systems as follows:

1. Thoroughly clean all piping, including flushing with water, dry air, or inert gas as required, in manner approved by ENGINEER, prior to placing in service. Flush chlorine solution and sodium hypochlorite piping with water.

2. Piping 24-inch diameter and larger shall be inspected from inside and debris, dirt and foreign matter removed.

3. For piping that requires disinfection and has not been kept clean during storage or installation, swab each section individually before installation with five percent sodium hypochlorite solution.

B. Disinfection:

1. Disinfect all potable and finished water piping.

2. Suggested procedure for accomplishing complete and satisfactory disinfection is specified below. Other procedures may be considered for acceptance by ENGINEER.
   a. Prior to disinfection, clean piping as specified and flush thoroughly.
   b. Conform to procedures described in ANSI/AWWA C651. Use continuous or tablet feed method of disinfecting, unless alternative method is acceptable to ENGINEER.

3. Water for initial flushing, testing, and disinfection will be furnished by OWNER. Provide all temporary piping, hose, valves, appurtenances, and services required. Cost of water required for re-disinfection will be paid by CONTRACTOR to OWNER at water utility's standard rates.

4. Chlorinate water lines according to the following:
   a. All water lines or appurtenances added to or replaced shall be properly chlorinated before being placed in service.
   b. The Contractor under the supervision of the Engineer shall perform the chlorination.
   c. Any pipe subjected to contaminating materials shall be treated as directed by the engineer. Should such treatment fail to cleanse the pipe, replace the pipe at no cost to the City.
   d. Perform the chlorination of a completed line in the following manner:
      1) Taps will be made at the control valve located in the upstream end of the line and at all extremities of the line. These taps shall be located in such a manner as to allow high-test hypochlorite (HTH) solution to be introduced into all parts of the line.
      2) A water solution containing HTH (65%) available chlorine shall be introduced into the line by regulated pumping at the control-valve tap. The solution shall contain a concentration of HTH that will produce a uniform concentration of 100 ppm total chlorine immediately after the introduction of the solution into the line has been completed.
      3) The following quantities of 65% HTH compound per 1000 feet of line is required to produce a solution concentration of 100 ppm total chlorine as stated above:

Pipe Size (inches)	**65% HTH (Pounds per 1000 feet of line)**
4	0.84
6	1.88
8	3.35

e. The HTH solution shall be circulated in the line by opening the control valve and systematically manipulating hydrants and taps at the line extremities. The HTH solution must be pumped into the line at a constant rate for each discharge rate in order that a uniform concentration will be maintained in the line.
f. Water laterals shall be sterilized by the Contractor using methods acceptable to the Engineer. Contactor shall bear the same responsibility for water laterals as he bears for water mains and appurtenances, including any costs for corrective measures needed to comply with the bacteriological requirements.
g. The HTH Solution shall remain in the lines for a minimum of 24 hours. If directed by the Engineer the HTH solution shall remain in the lines longer than 24 hours. At the end of this period the free chlorine residual shall be a minimum of 10 ppm or the lines shall be re-chlorinated.
h. Exercise extreme caution at all times in order to prevent the HTH Solution from entering the existing water system.

5. Bacteriologic tests will be performed by OWNER. Certified test laboratory report will be provided to CONTRACTOR, if requested.

C. Bacteriological Sampling of Water Lines

1. The Engineer or Owner shall collect water samples for bacteriological analysis 24 hours after flushing of the lines is completed. Furnish any reasonable amount of assistance that may be required by the Engineer to secure these samples.

2. If test results are unsatisfactory, immediately re-chlorinate the lines and proceed with such measures as are necessary to secure sterile lines. All laterals shall be re-chlorinated during this process.

3. At the satisfactory completion of the bacteriological requirements, the lines shall be placed into service under the supervision of the Engineer.

3.08 SCHEDULES

A. Schedules listed below, following the “End of Section” designation, are part of this Specification section.

1. Table 33 05 05-A, Buried Piping Schedule.

END OF SECTION

TABLE 33 05 05-A, BURIED PIPING SCHEDULE

Service	Diameter (inch)	Material	Interior Lining	Exterior Coating	Pressure Class/ Thickness Class	Joint	Test	Remarks
Sanitary Sewer (SAN)	–24 – 48	DI	Protecto 401	AC, PEW	250 / 53	POJ / Flg	HYD (15)	
Force Main (FM)	30	DI	Protecto 401	AC, PEW	250 / 53	RPOJ / RMJ / Flg	HYD (150)	

A. Service Abbreviations

Service	Abbrev		Service	Abbrev.
Storm Sewer	ST			
Raw Water	RW			
Potable Water	PW			
Non-Potable Water	NPW			
Plant Effluent Water	PEW			
Influent	INF			
Effluent	EFF			
Drain	DR			

B. Material Abbreviations

Material	Abbrev		Material	Abbrev.
Ductile Iron	DI		Polyvinyl Chloride	PVC
Cast Iron	CI		Chlorinated Polyvinyl Chloride	CPVC
Carbon Steel	CS		Polyethylene	PE
Stainless Steel	SS		High Density Polyethylene	HDPE
Reinforced Concrete Pipe	RCP		Vitrified Clay	VC

C. Lining/Coating Abbreviations

Lining	Abbrev		Coating	Abbrev.
Cement Mortar Lined	CL		Asphaltic Coated	AC
Glass Lined	GL		Polyethylene Wrapped	PEW
Ceramic Epoxy	CE		Painted	P

D. Joint Abbreviations

Joint Type	Abbrev		Joint Type	Abbrev.
Bell and Spigot	BS		Butt Weld	BW
Restrained Bell and Spigot	RBS		Lap Weld	LW
Push-on Joint	POJ		Butt Fusion Weld	BFW
Restrained Push-on Joint	RPOJ		Solvent Weld	SW
Mechanical Joint	MJ		Sleeve-type Flexible Coupling	SLFC
Restrained Mech. Joint	RMJ		Split Flexible Coupling	SPFC
Soldered	Sd		Plasticized PVC Coupling	PPVC
Brazed	Bz		Grooved or Shouldered End Coupling	GSEC
Threaded	Thd		Flanged	Flg
Compression Sleeve Coupling	CSC		Compression Flange Adapter	CFA

E. Test Abbreviations

Test	Abbrev		Test	Abbrev.
Hydrostatic Test (test pressure in psig)	HYD ( )		Process Air Pipe Test (test pressure in psig)	PA ( )
Exfiltration	EX			
Low-pressure Air Sewer Test	AIR		Disinfection and Bacteriological Testing	DBT
Vacuum Test	VAC		Examination of Welds	EW
Vertical Deflection	VD		No Test Required	NR
Televised Inspection	TV			

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PART 1 GENERAL

1.01 DESCRIPTION

A. Scope:

1. Provide all labor, materials, equipment, and incidentals required to install and test ductile iron pipe and fittings for yard piping as shown on the Drawings and as specified herein.

2. Yard piping shall include all piping and fittings extending outward, upward and downward into the ground from the outside face of all buildings. Unless otherwise noted, non-buried pipe outside a building, including in utility tunnels, shall be specified in Division 33. Yard piping shall begin at the outside face of the buildings. The first joint shall be not more than 2 feet from the outside face of the building or structure unless otherwise shown on the Drawings. Yard piping shall include all piping in valve vaults, manholes, cleanouts and similar yard structures.

3. Extent of piping is shown on the Drawings. Piping schedules in Section 33 05 05, Buried Piping Installation, specify pipe service, diameter, material, lining, coating, pressure rating, joint type, and testing required.

4. All fittings including; plugs, caps, tees, and bends, unless otherwise specified, shall be provided with concrete reaction blocking, Meg-A-Lug type restraint systems or suitably restrained joints as indicated on the drawings or as directed by the ENGINEER.

B. Coordination:

1. Review installation procedures under this and other Sections and coordinate installation of items to be installed with or before ductile iron pipe Work.

C. Related Sections:

1. Section 31 23 33, Trenching and Backfilling.

2. Section 33 05 05, Buried Piping Installation.

1.02 REFERENCES

A. Standards referenced in this Section are:

1. ANSI B18.2.1, Square and Hex Bolts and Screws Inch Series.

2. ANSI B18.2.2, Square and Hex Nuts. (Inch Series).

3. ASTM A193, Alloy Steel and Stainless Steel Bolting Materials for High-Temperature Service.

4. ASTM A194, Specification for Carbon Steel and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both.

5. ASTM A536, Standard Specifications for Ductile Iron Castings.

6. ASTM A563, Specification for Carbon and Alloy Steel Nuts.

7. ASTM G62, Test Methods for Holiday Detection in Pipeline Coatings.

8. 17ANSI/AWWA C104, Cement Mortar Lining for Ductile Iron Pipe and Fittings for Water.

9. ANSI/AWWA C110, Ductile Iron and Gray Iron Fittings for Water.

10. ANSI/AWWA C111, Rubber Gasket Joints for Ductile Iron Pressure Pipe and Fittings.

11. ANSI/AWWA C116, Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile Iron and Gray Iron Fittings for Water Service.

12. ANSI/AWWA C151, Ductile Iron Pipe, Centrifugally Cast, for Water.

13. ANSI/AWWA C153, Ductile Iron Compact Fittings, 3 inch through 24 inch and 54 inch through 64 inch for Water Service. ANSI/AWWA C153, Ductile-Iron Compact Fittings for Water Service.

14. ANSI/AWWA C606, Grooved and Shouldered Type Joints.

15. MSS-SP 60, Connecting Flange Joint Between Tapping Sleeves and Tapping Valves.

16. NACE RP0188, Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.

17. NSF/ANSI 61, Drinking Water System Components - Health Effects.

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer:
   a. Manufacturer shall have a minimum of five years' successful experience producing ductile iron pipe and fittings and shall be able to show evidence of at least five installations in satisfactory operation in the United States that are similar applications to the specified service.
   b. Lining and coating products shall be manufactured by a firm with a minimum of five years' successful experience in protecting pipelines exposed to the specified service conditions, and shall be able to show evidence of at least five installations in satisfactory operation in the United States that are similar applications to the specified service.

c. When not applied by the manufacturer, lining and coating Subcontractor shall have a minimum of five years' successful experience in the application of the specified linings and coatings for similar applications for the specified service, and shall be able to show evidence of at least five installations in satisfactory operation in the United States.

B. Supply and Compatibility:

1. Ductile iron pipe manufacturer shall review and approve or prepare all Shop Drawings and other submittals for pipe, fittings, and appurtenances furnished under this Section.

2. Pipe, fittings, and appurtenances shall be suitable for the specified service and shall be integrated into overall piping system by ductile iron pipe manufacturer.

3. Ductile iron pipe manufacturer shall be responsible for all products and all factory-applied linings and coatings, whether installed at pipe manufacturer's facility or at manufacturer's Supplier's facility.

4. As an alternative to Class 250 iron fittings Contractor may supply Class 350 ductile iron compact fittings. Thickness of Class 350 fittings shall be equal to or exceed 350 psi working pressure and conform to with ANSI/AWWA C153/A21.53. Compact fittings shall conform to ASTM A536, minimum grade 70-50-05. The thickness class shall be equal or exceed 350 psi.

C. Regulatory Requirements:

1. Pipe and fittings, including linings and coatings, that will convey potable water or water that will be treated to become potable, shall be certified by an accredited organization in accordance with NSF/ANSI 61 as being suitable for contact with potable water, and shall comply with requirements of authorities having jurisdiction at Site.

1.04 SUBMITTALS

A. Action Submittals: Submit the following with Shop Drawings required under Section 33 05 05, Buried Piping Installation, and Section 33 05 07, Exposed Piping Installation:

1. Shop Drawings:
   a. Detailed drawings and data for pipe, fittings, gaskets, appurtenances, linings, and coatings.

2. Product Data:
   a. Surface preparation and application reports and procedures as required for lining and coating of pipe and fittings. Ductile iron pipe and fitting manufacturer and manufacturer and applicator of lining and coating, as specified, shall mutually determine recommended surface preparation and application methods, and provide written verification of mutually selected method in the submittals.

B. Informational Submittals: Submit the following:

1. Certificates:
   a. Submit certificate signed by manufacturer of each product that product conforms to applicable referenced standards and the Contract Documents.
   b. Submit certificate signed by applicator of the linings and coatings stating that product to be applied conforms to applicable referenced standards and that the applicator shall conform to the Contract Documents.

2. Source Quality Control Submittals:
   a. Submit results of specified shop tests for pipe, fittings, linings, and coatings.
   b. Lining and coating test coupons.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Refer to Section 33 05 05, Buried Piping Installation, and Section 33 05 07, Exposed Piping Installation.

PART 2 PRODUCTS

2.01 MATERIALS

A. General:

1. Piping systems shall be suitable for their intended use.

2. Joints shall be as specified in Section 33 05 05, Buried Piping Installation. If not specified, provide flanged joints for exposed piping and push-on joints for buried piping.

B. Ductile Iron Pipe, Joints, and Fittings:

1. Flanged Pipe: Fabricate in accordance with ANSI/AWWA C115.
   a. Pressure Rating: As specified in piping schedule in Section 33 05 05, Buried Piping Installation. If not otherwise specified, use Special Thickness Class 53 for 3-inch to 54-inch diameter pipe and Pressure Class 350 for 60-inch and 64-inch diameter pipe.

2. Non-Flanged Pipe: Conform to ANSI/AWWA C151 for material, pressure, dimensions, tolerances, tests, markings, and other requirements.
   a. Pressure Class: As specified in piping schedules in Section 33 05 05, Buried Piping Installation and Section 33 05 07, Exposed Piping Installation. If not otherwise specified, use Pressure Class:
      1) Water Pipe 3-inch to 12-inch designed in accordance with ANSI A21.50 for working pressure 350 psi, and Laying Condition 1.
      2) Water Pipe 16-inch or larger designed in accordance with ANSI A21.50 for working pressure of 250 psi, and Laying Condition 2.

b. Special Thickness Class: As specified in piping schedules in Section 33 05 05, Buried Piping Installation. If not otherwise specified use pipe design in accordance with ANSI A21.50 and ASNI A21.51.
c. Pipe Lining: As specified in piping schedules. If not otherwise specified, use cement mortar with a seal coat of bituminous material, all in accordance with ANSI A21.4.

3. Pipe Joints:
   a. Flanged Joints: Conform to ANSI/AWWA C110 and ANSI/AWWA C111 capable of meeting the pressure rating or special thickness class, and test pressure specified in piping schedule in Section 33 05 07, Exposed Piping Installation.
      1) Gaskets: Unless otherwise specified, gaskets shall be at least 1/8-inch thick, ring or full-face as required for the pipe, of synthetic rubber compound containing not less than 50 percent by volume nitrile or neoprene, and shall be free from factice, reclaimed rubber, and other deleterious substances. Gaskets shall be suitable for the service conditions specified, specifically designed for use with ductile iron pipe and fittings.
      2) Bolts: Comply with ANSI B18.2.1.
         a) Exposed: ASTM A307, Grade B.
         b) Buried or Submerged: ASTM A193, Grade B8M, Class 2, Heavy hex, Type 316 stainless steel.
      3) Nuts: Comply with ANSI B18.2.2.
         a) Exposed: ASTM A563, Grade A, Heavy hex.
         b) Buried or Submerged: ASTM A194, Grade B8M, Heavy hex, Type 316 stainless steel.
   b. Mechanical Joints: Comply with ANSI/AWWA C111 and ANSI/AWWA C151, capable of meeting pressure rating or special thickness class, and test pressure specified in piping schedules in Section 33 05 05, Buried Piping Installation, and Section 33 05 07, Exposed Piping Installation.
      1) Glands: Ductile iron.
      2) Gaskets: Plain tip.
      3) Bolts and Nuts: High strength, low alloy steel.
      4) Manufacturers: Provide products of one of the following:
      5) Clow Water Systems Company
      6) Atlantic States Cast Iron Pipe Company
      7) Canada Pipe Company, Ltd.
      8) McWane Cast Iron Pipe Company
      9) Pacific States Cast Iron Pipe Company
      10) Griffin Pipe Products Co.
      11) American Cast Iron Pipe Co.
      12) U.S. Pipe and Foundry Co.
      13) Or equal.
   c. Push On Joints: Comply with ANSI/AWWA C111 and ANSI/AWWA C151, capable of meeting pressure class or special thickness class, and test pressure specified in piping schedules in this Section, Section 33 05 05, Buried Piping Installation, and Section 33 05 07, Exposed Piping Installation.
      1) Gaskets: Vulcanized SBR, unless otherwise specified.

2) Stripes: Each plain end shall be painted with a circular stripe to provide a guide for visual check that joint is properly assembled.
3) Products and Manufacturers: Provide one of the following:
   a) Tyton or Fastite Joint by Clow Water Systems, Atlantic States Cast Iron Pipe Company, Canada Pipe Company, Ltd., McWane Cast Iron Pipe Company, Pacific States Cast Iron Pipe Company, and Griffin Pipe Products Company.
   b) Fastite Joint by American Cast Iron Pipe Company.
   c) Tyton Joint by U.S. Pipe and Foundry Company.
   d) Or equal.

d. Restrained Joints: Restraint for push-on joint pipe and mechanical joint pipe shall be positive locking “Locked-type” joints manufactured by the pipe and fitting manufacturer that utilize restraint independent of the joint gasket. Restrained joints shall be capable of being deflected after full assembly. Field cuts of restrained pipe are not allowed without approval of ENGINEER. If field cuts to accommodate bends are pre-approved by ENGINEER, restraint may be accomplished by mechanical joint bends using methods and products noted below.
   1) Products and Manufacturers: Provide restrained joints for buried piping 4" through 16" rated 350 psi and 18" through 48" rated 250 psi by one of the following:
      a) Flex-Ring, by American Cast Iron Pipe Co.
      b) TRFlex or MJ Harness-Lok, by US Pipe.
      c) Or pre-approved equal.

4. Flanged and Push-On Joint Fittings: Comply with ANSI/AWWA C110 and ANSI/AWWA C111.
   a. Material: Ductile iron.
   b. Pressure rating, gaskets, bolts, and nuts shall be as specified for flanged joints. Pressure rating of fittings shall meet, but not exceed, specified pressure rating or special thickness class of the connected pipe.

5. Mechanical Joint Fittings: Comply with ANSI/AWWA C110 and ANSI/AWWA C111 and ANSI A21.4.
   a. Material: Ductile iron.
   b. Glands: Ductile iron.
   c. Pressure rating, gaskets, bolts, and nuts shall be as specified for mechanical joints. Pressure rating of fittings shall meet, but not exceed, specified pressure rating or special thickness class of connected pipe.
   d. Restraint for mechanical joint fittings shall be wedge action retainer glands, as manufactured by: EBAA – Megalug Series 1100, or equal.

C. Interior Lining:

1. Where specified in piping schedules included with Section 33 05 05, Buried Piping Installation, pipe and fittings shall be lined with bituminous seal coated cement mortar lining in accordance with ANSI/AWWA C104.

2. When lining is not specified for piping provide cement-mortar with a seal coat of bituminous material in accordance with ANSI A21.4.

3. Where specified in the piping schedule, pipe and fittings shall be lined with a ceramic-filled amine-cured epoxy, Protecto 401 by Induron. The lining thickness shall be a minimum of 40 mils. Application shall be performed by an applicator approved by the coating manufacturer, in accordance with the manufacturer's instruction.

D. Specials:

1. Transition Pieces:
   a. Provide suitable transition pieces (adapters) for connecting to existing piping.
   b. Unless otherwise shown or indicated, expose existing piping to determine material, dimensions, and other data required for transition pieces.

2.02 MARKING FOR IDENTIFICATION

A. In addition to identification markings specified in Section 33 05 05, Buried Piping Installation, also stamp, mark, and identify push-on joint and mechanical joint pipe with:

1. Name or trademark of manufacturer.

2. Weight, class or nominal thickness, and casting period.

3. Country where cast.

4. Year the pipe was produced.

5. Letters "DI" or "Ductile" shall be cast or metal stamped

B. In addition to identification markings specified in Section 33 05 05, Buried Piping Installation, also stamp, mark, and identify flanged pipe with:

1. Flange manufacturer's mark, size, and letters "DI" cast or stamped on the flanges.

2. Fabricator's mark if other than flange manufacturer.

3. Length and weight.

C. In addition to identification markings specified in Section 33 05 05, Buried Piping Installation, also stamp, mark, and identify fittings with:

1. Manufacturer's identification.

2. Pressure rating.

3. Nominal diameters of openings.

4. Country where cast.

5. Number of degrees or fraction of the circle on bends.

6. Letters "DI" or "Ductile" cast on them.

2.03 EXTERIOR SURFACE PREPARATION AND COATINGS

A. General Coating Requirements:

1. Coating types are specified in piping schedules in Section 33 05 05, Buried Piping Installation.

B. Exposed Pipe and Fittings:

1. Surface Preparation:
   a. Initial Surface Inspection: Pipe and fitting manufacturer and coating applicator shall inspect surface to be coated and mutually determine recommended NAPF 500-03 surface preparation method.
   b. Surface Preparation: Prepare surface in accordance with recommended NAPF 500-03 method.
   c. Finished Surface Inspection: Prepared surfaces shall be inspected by coating applicator prior to application to determine acceptability of finished surface. If surface is unacceptable, repeat surface preparation and re-application as necessary.

2. After recommended surface preparation, prime coat exterior ferrous metal surfaces of pipe and fittings in the shop.

C. Buried Pipe and Fittings:

1. Asphaltic Coating: Where specified in piping schedule in Section 33 05 05, Buried Piping Installation, coat pipe and fittings with an asphaltic coating approximately one-mil thick, in accordance with ANSI/AWWA C151, ANSI/AWWA C115, ANSI/AWWA C110, and ANSI/AWWA C153, as applicable.

PART 3 EXECUTION

3.01 INSPECTION

A. Inspect piping to assure that piping is free from defects in material and workmanship. Verify compatibility of pipe, fittings, gaskets, linings, and coatings.

3.02 INSTALLATION AND FIELD QUALITY CONTROL

A. For buried piping installation and testing, refer to Section 33 05 05, Buried Piping Installation.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install precast concrete manholes, structures, frames and covers, access hatches, manhole rungs, ladders and appurtenances all as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A. Excavation and backfill is included is Section 31 23 00.

B. Cast-in-place concrete is included in Section 03 30 00.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, shop drawings showing details of construction, reinforcing, joints, pipe connection to manhole, manhole rungs, manhole platforms (if applicable), manhole frames and covers, access hatches, and ladders.

B. Submit for review, structural calculations and drawings for all precast structures.

C. Concrete design mix data and concrete test cylinder reports from an approved concrete testing laboratory certifying that the concrete used in the precast structures conforms with the strength requirements specified herein.

1.04 REFERENCE STANDARDS

A. American Society for Testing and Materials (ASTM)

1. ASTM A48 - Standard Specification for Gray Iron Castings

2. ASTM A615 - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

3. ASTM C32 - Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale).

4. ASTM C62 - Standard Specification for Building Brick (Solid Masonry Units Made from Clay or Shale).

5. ASTM C150 - Standard Specification for Portland Cement.

6. ASTM C207 - Standard Specification for Hydrated Lime for Masonry Purposes.

7. ASTM C443 - Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.

8. ASTM C478 - Standard Specification for Precast Reinforced Concrete Manhole Sections.

9. ASTM D4101 - Standard Specification for Propylene Plastic Injection and Extrusion Materials.

B. American Concrete Institute (ACI)

1. ACI 318 - Building Code Requirement for Structural Concrete.

C. American Association of State Highway and Transportation Officials (AASHTO)

D. Occupational Safety and Health Administration (OSHA)

E. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. The quality of all materials, the process of manufacture, and the finished sections shall be subject to inspection and approval by the Engineer, or other representative of the Owner. Such inspection may be made at the place of manufacture, or on the work after delivery, or at both places and the materials shall be subject to rejection at any time on account of failure to meet any of the requirements specified herein; even though samples may have been accepted as satisfactory at the place of manufacture. Material rejected after delivery to the job shall be marked for identification and shall be removed from the job at once. All materials which have been damaged after delivery will be rejected, and if already installed, shall be acceptably repaired, if permitted, or removed and replaced, entirely at the Contractor's expense.

B. At the time of inspection, the materials will be carefully examined for compliance with the ASTM standard specified below and this Section and with the approved manufacturer's drawings. All manhole sections shall be inspected for general appearance, dimension, "scratch-strength", blisters, cracks, roughness, soundness, etc. The surface shall be dense and close-textured.

C. Imperfections in manhole sections may be repaired, subject to the approval of the Engineer, after demonstration by the manufacturer that strong and permanent repairs result. Repairs shall be carefully inspected before final approval. Cement mortar used for repairs shall have a minimum compressive strength of 4,000 psi at 7 days and 5,000 psi at 28 days, when tested in 3-in by 6-in cylinders stored in the standard manner. Epoxy mortar may be utilized for repairs subject to the approval of the Engineer.

PART 2 PRODUCTS

2.01 PRECAST CONCRETE MANHOLE SECTIONS

A. Precast concrete barrel sections and transition top sections, shall conform to ASTM C478 and meet the following requirements:

1. The wall thickness shall not be less than 5-in for 48-in diameter reinforced barrel sections, 6-in for 60-in diameter reinforced barrel sections and 7-in for 72-in diameter reinforced barrel sections.

2. Top sections shall be eccentric except that barrel sections shall be used where shallow pipe cover requires a top section less than 4-ft as shown on the Drawings.

3. Barrel sections shall have tongue and groove joints.

4. All sections shall be cured by an approved method and shall not be shipped nor subjected to loading until the concrete compressive strength has attained 3,000 psi and not before 5 days after fabrication and/or repair, whichever is longer.

5. Precast concrete barrel sections with precast top slabs and precast concrete transition sections shall be designed for a minimum of H-20 loading plus the weight of the soil above at 120 pcf.

6. The date of manufacture and the name and trademark of the manufacturer shall be clearly marked on the inside of each precast section.

7. Precast concrete bases shall be constructed and installed as shown on the Drawings. The thickness of the bottom slab of the precast bases shall not be less than the manhole barrel sections or top slab whichever is greater.

8. Knock out panels shall be provided in precast manhole sections at the locations shown on the Drawings. They shall be integrally cast with the section, 2-1/2-in thick and shall be sized as shown on the Drawings. There shall be no steel reinforcing in knock out panels.

2.02 PRECAST CONCRETE STRUCTURES

A. The precast reinforced concrete structures shall be manufactured by Rotundo & Sons, Inc.; American Precast or equal. The inside dimensions, headroom requirements and minimum thickness of concrete shall be as indicated on the Drawings. The manufacturer shall notify the Engineer at least 5 working days prior to placing concrete during the manufacturing process. The Engineer may inspect the reinforcing steel placement and/or require the manufacturer to provide photographs of each section showing the location of all reinforcing steel prior to the placing of concrete. Should it be found that the placement of steel is not as detailed in the shop drawing submittals, the section in question shall be rejected and a replacement section shall be manufactured at the Contractor's expense. Failure to properly notify the Engineer prior to placing concrete shall require the precast sections to be rejected and replacement sections to be manufactured at the Contractor's expense.

B. Structural design calculations and Drawings shall be prepared and stamped by a professional engineer registered in the State of Tennessee.

C. All precast concrete shall have a minimum compressive strength of 5,000 psi at 28 days. Water shall be kept to a minimum to obtain concrete which is as dense and watertight as possible. The maximum water-to-cement ratio shall be 0.40 by weight and the minimum cement content shall be 600 lbs. of cement per cubic yard of concrete. The above ratios shall be revised for sacks of cement weighing different from 94 pounds per sack.

D. Design Criteria

1. All precast concrete members shall conform to ACI 318.

2. When the design yield strength "fy" for tension reinforcement exceeds 40,000 psi, the "z" values referred to in ACI 318 shall not exceed 95 kips/in. The flexural stress in reinforcement under service loads "fs" shall be calculated and shall not be greater than 50 percent of the specified yield strength fy.

3. The precast concrete structure's elements shall be designed to support their own weight, the weight of soil above at 120 pcf and shall be capable of withstanding a live load equal to an AASHTO HS-20 highway loading applied to the top slab.

4. The base slab and walls shall be cast together to form a monolithic base section.

5. All exterior walls shall be designed for an equivalent fluid pressure of 90 lbs. /sq. ft. The top of the pressure diagram shall be assumed to originate at finished ground level. Additional lateral pressure from approaching truck wheels shall be considered in accordance with AASHTO.

6. The structural design shall take into account discontinuities in the structure produced by openings and joints in the structure.

7. The structures shall be designed to prevent flotation without the benefit of skin friction when the ground water level is at finished ground surface. Flotation forces shall be resisted by the dead load of the structure and soil directly above the structure. Weight of equipment and piping within the structure and soil frictional forces shall not be considered as being effective in resisting flotation forces.

8. If the design of the box structure requires a concrete pad to prevent flotation, the cost of designing, furnishing and installing a reinforced concrete pad shall be included in the price for the structure. Details of the design of the concrete pad (if required) shall be submitted to the Engineer for review.

9. All walls and slabs shall be analyzed by accepted engineering principles. Openings shall be completely framed as required to carry the full design loads to support walls. All slabs and walls shall be fully reinforced on both faces and the minimum reinforcing shall be No. 5 at 12-in E.F.E.W. Additional reinforcing shall be provided around all openings.

10. The horizontal wall joints shall not be located within 18-in of the horizontal centerline of wall penetrations.

E. The structure shall be built by the manufacturer in no more than four major sections including the top slab if required.

F. Where top slabs are used or required, lifting hooks shall be provided.

G. As required, access openings and pipe penetrations shall be formed openings and located as shown on the Drawings.

H. Wall sleeves as shown on the Drawings, shall be provided to the precast concrete manufacturer for inclusion in the manufacture of the structure.

2.03 BRICK MASONRY

A. The bricks shall be good, sound, hard and uniformly burned, regular and uniform in shape and size, of compact texture and satisfactory to the Engineer. Underburned or salmon brick will not be acceptable and only whole brick shall be used unless otherwise permitted. In case bricks are rejected by the Engineer, they shall be immediately removed from the site of the work and satisfactory bricks substituted therefor.

1. Bricks for the channels and shelves shall comply with ASTM C32 for Sewer Brick, Grade SS (from clay or shale) except that the mean of five tests for absorption shall not exceed 8 percent and no individual brick exceed 11 percent.

2. Bricks for building up and leveling manhole frames shall conform to ASTM C62.

B. Mortar used in the brickwork shall be composed of 1 part Type II Portland Cement conforming to ASTM C150 to 2 parts sand to which a small amount of hydrated lime not to exceed 10 lbs. to each bag of cement shall be added.

C. The sand used shall be washed, cleaned, screened, sharp and well graded as to different sizes and with no grain larger than will pass a No. 4 sieve. It shall be free from vegetable matter, loam, organic or other materials of such nature or of such quantity as to render it unsatisfactory.

D. The hydrated lime shall also conform to ASTM C207.

2.04 MANHOLE FRAME AND COVER

A. Manhole frames and covers shall be of good quality, strong, tough, even grained cast iron smooth, free from scale, lumps, blisters, sand holes and defects of any kind which render them unfit for the service for which they are intended. Manhole covers and frame seats shall be machined to a true surface. Castings shall be thoroughly cleaned and subject to hammer inspection. Cast iron shall conform to ASTM A48, Class 30.

B. Manhole covers shall have a diamond pattern, pickholes and the words SANITRAY SEWER, WATER, ELECTRIC, etc., as appropriate, cast in 3-in letters. Manhole frame and covers shall be LeBaron Foundry; Mechanics Iron Foundry; Neenah Foundry or equal.

2.05 JOINTING PRECAST MANHOLE SECTIONS AND STRUCTURES

A. Tongue and groove joints of precast manhole and structure sections shall be sealed with either a round rubber O-ring gasket or a preformed flexible joint sealant. The O-ring shall conform to ASTM C443. The preformed flexible joint sealant shall be Kent Seal No. 2 by Hamilton-Kent; Ram-Nek by Henry Company, El Segundo, CA or equal.

B. Joints shall be designed and manufactured so that the completed joint will withstand an internal water pressure of 15 psi without leakage or displacement of the gasket or sealant.

2.07 PIPE CONNECTIONS

A. Pipe connections may be accomplished in the following ways:

1. A tapered hole filled with non-shrink waterproof grout, Hallemite; Waterplug; Embeco or equal, after the pipe is inserted is acceptable, providing the grout is placed carefully to completely fill around the pipe. If this method is used, place concrete encasement to assure a total 12-in of concrete including manhole thickness around the pipe stub.

2. The "Lock Joint Flexible Manhole Sleeve" shall be cast in the precast manhole base. The stainless steel strap shall be protected from corrosion with a bituminous coat.

3. "A-Lok" shall be a rubber like gasket cast in the precast manhole base. The rubber gasket shall be cast into a formed opening in the manhole.

4. "KOR-N-SEAL" joint shall be installed as recommended by the manufacturer. The stainless steel clamp shall be protected from corrosion with a bituminous coat.

2.08 DAMPPROOFING

A. Brushed dampproofing shall be an asphalt emulsion reinforced with fibers conforming to ASTM D1227, Type II, Class 1. The dampproofing shall be Hydrocide 700B by Sonneborn Building Products, Division of BASF; Karnak 220 Asphalt Emulsion by Karnak Corporation, Clark, NJ or equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Manhole and Structure Installation

1. Manhole and structure shall be constructed to the dimensions shown on the Drawings and as specified herein. All work shall be protected against flooding and flotation.

2. The bases of manholes shall be placed on a bed of 12-in screened gravel as shown on the Drawings. The bases shall be set at a grade to assure that a maximum of 8-in thickness of brickwork will bring the manhole frame and cover to final grade.

Cast-in-place bases shall be constructed in accordance with the requirements of Division 3 and the details shown on the Drawings.

3. Precast concrete barrel sections and structures shall be set plumb and with sections in true alignment with a 1/4-in maximum tolerance to be allowed. The joints of precast barrel sections shall be sealed with either a rubber O-ring set in a recess or the preformed flexible joint sealant used in sufficient quantity to fill 75 percent of the joint cavity. The outside and inside joint shall be filled with non-shrink mortar and finished flush with the adjoining surfaces. Allow joints to set for 24-hours before backfilling. Backfilling shall be done in a careful manner, bringing the fill up evenly on all sides. If any leaks appear in the manholes, the inside joints shall be caulked with lead wool to the satisfaction of the Engineer. Install the precast sections in a manner that will result in a watertight joint.

4. Holes in the concrete barrel sections required for handling or other purposes shall be plugged with a non-shrinking grout or non-shrinking grout in combination with concrete plugs and finished flush on the inside.

5. Where holes must be cut in the precast sections to accommodate pipes, cutting shall be done prior to setting manhole sections in place to prevent any subsequent jarring which may loosen the mortar joints.

B. Manhole Pipe Connections

1. Manhole pipe connections shall be accomplished in the ways specified herein. Pipe stubs for future extensions shall also be connected and the stub end closed by a suitable watertight plug.

C. Brickwork

1. Mortar shall be mixed only in such quantity as may be required for immediate use and shall be used before the initial set has taken place. Mortar shall not be retained for more than 1-1/2 hours and shall be constantly worked over with hoe or shovel until used. Anti-freeze mixtures will not be allowed in the mortar. No masonry shall be laid when the outside temperature is below 40 degrees F unless provisions are made to protect the mortar, bricks and finished work from frost by heating and enclosing the work with tarpaulins or other suitable material. The Engineer's decision as to the adequacy of protection against freezing shall be final.

2. Channels and shelves shall be constructed of brick and concrete as shown on the Drawings. The brick lined channels shall correspond in shape with the lower half of the pipe. The top of the shelf shall be set at the elevation of the crown of the highest pipe and shall be sloped 1-in per foot to drain toward the flow through channel. Brick surfaces exposed to sewage flow shall be constructed with the nominal 2-in by 8-in face exposed (i.e. bricks on edge).

3. Manhole covers and frames shall be set in a full mortar bed and bricks, a maximum of 8-in thick, shall be utilized to assure frame and cover are set to the existing grade. If full width paving is the permanent paving, the manhole frame and cover shall be reset to final grade prior to placement of permanent paving.

D. Dampproofing

1. Outer surfaces of precast and cast-in-place manholes [and structures] shall dampproofed at the rate of 30 to 35 sq. ft. per gallon as directed by the Engineer and in accordance with manufacturer's instructions.

3.02 LEAKAGE TESTS

A. Leakage tests shall be made and observed by the Engineer on each manhole. The test shall be the exfiltration test made as described below:

B. After the manhole has been assembled in place, all lifting holes and those exterior joints within 6-ft of the ground surface shall be filled and pointed with an approved non-shrinking mortar. The test shall be made prior to placing the shelf and invert and before filling and pointing the horizontal joints below the 6-ft depth line. If the groundwater table has been allowed to rise above the bottom of the manhole, it shall be lowered for the duration of the test. All pipes and other openings into the manhole shall be suitably plugged and the plugs braced to prevent blow out.

C. The manhole shall then be filled with water to the top of the cone section. If the excavation has not been backfilled and observation indicates no visible leakage, that is, no water visibly moving down the surface of the manhole, the manhole may be considered to be satisfactorily water-tight. If the test, as described above is unsatisfactory as determined by the Engineer, or if the manhole excavation has been backfilled, the test shall be continued. A period of time may be permitted if the Contractor so wishes, to allow for absorption. At the end of this period, the manhole shall be refilled to the top of the cone, if necessary and the measuring time of at least 8 hours begun. At the end of the test period, the manhole shall be refilled to the top of the cone, measuring the volume of water added. This amount shall be extrapolated to a 24-hour rate and the leakage determined on the basis of depth. The leakage for each manhole shall not exceed 1 gallon per vertical foot for a 24-hour period. If the manhole fails this requirement, but the leakage does not exceed 3 gallons per vertical foot per day, repairs by approved methods may be made as directed by the Engineer to bring the leakage within the allowable rate of 1 gallon per foot per day. Leakage due to a defective section or joint or exceeding the 3 gallon per vertical foot per day shall be the cause for the rejection of the manhole. It shall be the Contractor's responsibility to uncover the manhole as necessary and to disassemble, reconstruct or replace it as directed by the Engineer. The manhole shall then be retested and, if satisfactory, interior joints shall be filled and pointed.

D. No adjustment in the leakage allowance will be made for unknown causes such as leaking plugs, absorptions, etc., i.e. it will be assumed that all loss of water during the test is a result of leaks through the joints or through the concrete. Furthermore, take any steps necessary to assure the Engineer that the water table is below the bottom of the manhole throughout the test.

E. If the groundwater table is above the highest joint in the manhole, and if there is no leakage into the manhole as determined by the Engineer, such a test can be used to evaluate the water- tightness of the manhole. However, if the Engineer is not satisfied, lower the water table and carry out the test as described hereinbefore.

F. Leakage Tests for Structures

1. The Engineer will visually inspect structure(s) for possible leaks before backfilling of structures is allowed. All joints shall be sealed to the satisfaction of the Engineer.

2. The Engineer may require an exfiltration test as described for manholes on any structure for which he/she deems the test appropriate.

3.03 CLEANING

A. All new manholes shall be thoroughly cleaned of all silt, debris and foreign matter of any kind, prior to final inspection.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment, and incidentals required and install, complete and ready for operation, simplex submersible sump pump arrangements as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A. Yard piping is included in Division 31.

B. Concrete work is included in Division 03.

C. Mechanical piping, valves, pipe hangers and supports are included in the respective sections of Division 40.

D. Electrical work is included in Division 26.

1.03 SUBMITTALS

A. Copies of all materials required to establish compliance with the Specifications shall be submitted in accordance with the provision of the General Conditions and Section 01 33 23. Submittals shall include at least the following:

1. Certified shop drawings showing all important details of construction, dimensions and anchor bolt locations.

2. Descriptive literature, bulletins, and/or catalogs of the equipment.

3. Data on the characteristics and performance of each size pump. Data shall include guaranteed performance curves, based on actual shop tests of duplicate units, which show that they meet the specified requirements for head, capacity, efficiency and horsepower. Curves shall be submitted on 8-1/2-inch by 11-inch sheets.

4. The total weight of the equipment including the weight of the single largest item.

5. A complete total bill of materials for all equipment.

B. Upon receipt of submitted material, provide certified prints as specified in Section 01 33 23.

1.04 DESCRIPTION OF SYSTEMS

A. All the equipment specified herein is intended to be standard equipment for pumping water that has been collected in sump.

1.05 QUALIFICATIONS

A. The submersible sump pump shall be Model SPD50H as manufactured by Hydromatic or equal.

B. All pumps shall be the product of a single pump manufacturer.

1.06 OPERATING INSTRUCTIONS

A. Copies of an operating and maintenance manual for each size pump shall be furnished to the Engineer as provided for in Section 01 78 23. 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 operating and maintenance personnel unfamiliar with such equipment.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. The equipment covered by these Specifications is intended to be standard pumping equipment of proven ability as manufactured by reputable concerns having long experience in the production of such equipment. The equipment furnished shall be designed, constructed, and installed in accordance with the best practice and methods, and shall operate satisfactorily when installed as shown on the Drawings.

B. All parts shall be so designed and proportioned as to have liberal strength, and stiffness and to be especially adapted for the work to be done. Ample room and facilities shall be provided for inspection, repairs, and adjustment.

C. Brass or stainless steel nameplates giving the name of the manufacturer, the rated capacity, head, speed, serial number, model number, horsepower, voltage, amperes and all other pertinent data shall be attached to each pump.

D. The nameplate ratings for the motors shall not be exceeded, nor shall the design service factor be reduced when its pump is operating at any point on its characteristic curve at maximum speed.

2.02 SUBMERSIBLE SUMP PUMPS

A. General:

1. The sump pump shall be of the heavy duty, non-clog impeller submersible type. One pump shall be installed in each Wet-Weather Pump Station as shown on the Drawings.

B. Performance Requirements:

1. The pumps shall be designed and manufactured as specified for the conditions of service tabulated below.

a. Submersible sump pump:

Number - (Refer to Drawings for special arrangement)	
Discharge size	2 inches (minimum)
Capacity	50 gpm
Total dynamic head	30 feet
Solid passing size	3/4-inch
Drive horsepower (minimum)	0.50
Power Supply	460V, 3-phase, 60Hz

C. The casing shall be ASTM A48 Class 30 cast iron and have a two-inch NPT discharge.

D. Impeller shall be manufactured of ASTM A48 Class 30 cast iron and shall be of the non-clog type and be able to pass a 3/4-inch solid.

E. Motor shall be oil filled for continuous duty and be controlled by an integral diaphragm switch.

F. Shaft shall be heavy-duty stainless steel.

2.03 CONTROLS

A. Sump pump shall be automatically controlled by the liquid level in the sump. Float switches shall be provided to automatically start/stop the pump.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation shall be in strict accordance with the manufacturer's instructions and recommendations in the locations shown on the Drawings.

B. Supply all anchor bolts, temporary lift equipment, power, water, labor, and all other incidentals required for the proper installation of the pumps.

3.02 SURFACE PREPARATION AND SHOP PAINTING

A. All surfaces shall be prepared, shop primed and finish coated as part of the work under this Section.

3.03 INSPECTION AND TESTING

A. Furnish the services of a factory representative for one day who has complete knowledge of proper operation and maintenance to inspect the final installation and supervise a test run of the equipment.

B. After all pumps have been completely installed and are working under the direction of the manufacturer, conduct in the presence of the Engineer such tests as are necessary to indicate that pump efficiency and discharge conform to the specifications. Field tests shall include all pumps included under this Section. Supply all electric power, water or wastewater, labor, equipment, and incidentals required to complete the field test.

C. If the pump performance does not meet the Specifications, corrective measures shall be taken by the Contractor, or pumps shall be removed and replaced with pumps that satisfy the conditions specified. A four-hour operating period of the pumps will be required before acceptance. During this four-hour operating period, the Contractor shall supply all power necessary.

D. The components of each lubricating system shall be completely tested by the Contractor in the presence of the Engineer. All component parts which are damaged as a result of testing or which fail to meet the requirements of the specification shall be replaced, reinstalled and retested at the manufacturer's expense.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish and install a complete underground system of raceways and handholes as shown on the Drawings and as specified herein.

B. Where referred in this Section, raceways are underground conduits; ductbanks are a collection of underground raceways. Underground system is the collection of underground raceways and handholes.

C. The Contractor shall be responsible for setting handholes at the proper elevation such that the pitch of raceways will be towards handholes and away from structures, vaults and buildings.

D. Ductbanks shall be encased in steel reinforced concrete up to the building, structure, vault, and handhole unless otherwise specified or shown on the Drawings.

1. Ductbank and handhole depths vary. Coordinate with other utilities, yard piping, yard structures and field conditions to determine required depths and install raceways and handholes at that required depth at no additional cost to the Owner.

2. Ductbank routing and handhole locations shown on the Drawings are diagrammatically depicted. Coordinate with other utilities, yard piping, yard structures and field conditions to determine required paths and depths at no additional cost to the Owner.

1.02 RELATED WORK

A. Excavation and backfilling, including gravel and sand bedding, are included in Division 31.

B. Concrete and reinforcing steel are included in Division 03.

C. All trenching and surface restoration shall be as specified in Division 31, but the responsibility of furnishing and installing the material shall be that of this Section.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, shop drawings and product data, for the following:

1. Handholes

2. Plastic duct spacers

3. Handhole frames, covers and chimney rings

4. Buoyancy calculations

5. Warning tape

PART 2 PRODUCTS

2.01 MATERIALS

A. Raceways shall be polyvinyl chloride conduit encased in steel reinforced concrete, except that rigid aluminum conduit shall be used for shielded signal wiring, analog I/O and copper or non-fiber optic data highway wiring. Refer to Section 26 05 33 and detail drawings for material requirements.

B. Direct buried raceways for site lighting shall be polyvinyl chloride conduit. Refer to the detail drawings for embedment and installation requirements.

C. Cable racks, supports, pulling-in irons and hardware shall be galvanized steel as manufactured by Line Materials Co.; Underground Devices, Inc.; Chance or equal.

D. Precast handholes shall be designed as specified below for precast concrete structures. Manufacturer shall provide buoyancy calculations to the Engineer for approval.

1. Refer to the drawings for inside dimensions, headroom requirements and minimum thickness of concrete for precast reinforced concrete structures.

2. Structural design calculations shall be prepared and stamped by a professional engineer registered in the State of Tennessee.

3. Design Criteria
   a. Precast Concrete
      1) Minimum compressive strength shall be 5,000 psi at 28 days.
      2) Maximum water to concrete ratio shall be 0.40 by weight.
      3) Minimum cement content shall be 600 lbs of cement per cubic yard of concrete.
   b. Manufactured Products
      1) Conform to ACI 318.
      2) Products shall support their own weight, weight of soil above at 130 pcf and a live load equal to AASHTO H20 applied to top slab. Depth of soil will be calculated from finished grade.
      3) Cast base slab and walls together to form a monolithic base section.
      4) Structure walls shall be designed for an equivalent lateral fluid pressure of 90 pcf. Originate pressure diagram at finished ground surface. Include lateral pressure from vehicles in accordance with AASHTO.
      5) Consider discontinuities in structure produced by openings and joints. Provide additional reinforcing around openings. Frame openings to carry full design loads to support walls.
      6) Prevent flotation, with ground water level at finished ground surface, by dead weight of structure and soil load above structure. Do not

consider skin friction, soil friction, or weight of equipment or contents in structure. Factor of safety against buoyancy shall be 1.15. If a concrete slab is required to prevent flotation, design the slab and provide anchorage of the structure to the slab.

7) Design structure with a minimum number of joints.
8) Provide lifting hooks for the top slab.
9) Locate access openings, knockouts, and penetrations as indicated.

4. The date of manufacture, name and trademark of manufacturer shall be marked on the inside of each precast section.

5. Provide integrally cast knock-out panels in precast concrete handhole sections at locations indicated and with sizes indicated. Knock-out panels shall have no steel reinforcing.

6. Seal tongue and groove joints of precast handhole sections with rubber O-ring gasket. O-ring gasket shall conform to ASTM C443. In lieu of the O-ring gasket, a flexible joint sealant may be used. Sealant shall be Kent Seal No. 2; ConSeal No. 2; Ram-Nek or equal. Completed joints shall withstand 15 psi internal water pressure without leakage or displacement of gasket or sealant.

7. Dampproofing shall be Hydrocide 648 by Sonneborn Building Products; Dehydratine 4 by A.C. Horn, Inc.; RIW Marine Liquid by Toch Brothers; or equal.

E. Precast handholes shall be as manufactured by Chase Precast Corp.; Rotondo Company, Inc.; American Precast Co., equal and constructed to dimensions as shown on the Drawings.

F. Handhole frames and covers shall be cast iron, heavy duty type for Class H-20 wheel loading as manufactured by Neenah; LeBaron; Vulcan or equal. Covers shall be marked and sized as shown on the Drawings.

G. Ground rods and other grounding materials and methods shall be as specified in Section 33 79 00.

H. Bell ends and plastic duct spacers shall be as manufactured by Carlon; Underground Devices Inc. or equal.

I. Pull line for spare conduits shall be 1/8-in nylon rope.

J. Lighting Handholes (For Site Lighting Systems)

1. Lighting handholes shall be constructed of polymer concrete and reinforced with heavy weave fiberglass, green finish, open bottom and minimal dimensions of 32-in long by 19-in wide by 30-in deep.

2. Lighting handhole cover shall be heavy duty type, green finish with stainless steel penta head bolts. Covers shall be marked "Roadway Lighting". Covers shall have a service load of 15,000 pounds over a 10-in square.

3. Lighting handholes and covers shall be as manufactured by Quazite; Oldcastle; Easton Pre-Cast or equal.

K. Detectable Warning Tape

1. Each ductbank section shall be marked by means of a detectable warning tape (tracer tape) as shown on the Drawings. The detectable warning tape shall be capable of being detected or located by either conductive or inductive location techniques.

2. The detectable warning tape shall consist of 5 mil (.005-in) overall thickness; five-ply composition; ultra-high molecular weight; virgin polyethylene; acid; alkaline and corrosion resistant; with 150 pounds of tensile break strength minimum per 6-in width.

3. The top side of the tracer tape shall be color banded red for electrical and high voltage lines, and orange for signal, communication, telephone and fire alarm lines. Tracer tape shall be 4-in wide with four color bands. The tape shall be inscribed with the warning message for the utility such as "CAUTION – ELECTRICAL LINED BURIED BELOW". Tape shall be as manufactured by Mutual Industries, Inc.; Terra Tape, Div. of Reef Industries Inc. or equal.

L. Bricks for raising handhole frames to finished grade shall conform to ASTM C62. Mortar shall be composed of one part portland cement, two parts sand and hydrated lime not to exceed 10-lbs to each bag of cement.

1. Portland cement shall be ASTM C150, Type II.

2. Hydrated lime shall conform to ASTM C207.

3. Sand shall be washed, cleaned, screened, well graded with all particles passing a No. 4 sieve and conform to ASTM C33.

M. Sidewalk boxes and boxes for concrete slabs shall be cast iron intended for outdoor use primarily to provide a degree of protection against falling rain, sleet and external ice formation (NEMA 3R). Boxes shall be manufactured by O-Z/Gedney; Appleton; Killark or equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install raceways to drain away from buildings. Raceways between handholes shall drain toward the handholes. Raceway slopes shall not be less than 3-in per 100-ft.

B. Steel reinforce and concrete encase all ductbanks. See ductbank detail on the Drawings.

C. Lay raceway lines in trenches on mats of bank gravel not less than 6-in thick and graded as per Paragraph 3.02A.

D. Use plastic spacers located not more than 4-ft apart to hold raceways in place. Spacers shall provide not less than 2-in clearance between raceways and edge of concrete envelope. Power system raceways shall be separated by 7.5-in center-to-center. Non-power system raceways shall be separated by 4.5-in center-to-center.

E. The minimum cover for raceway banks shall be 24-in unless otherwise indicated on the detail drawings.

F. Make raceway entrances to buildings, structures and vaults (except handholes) with rigid aluminum conduit not less than 10-ft long.

G. Where bends in raceways are required, use long radius elbows, sweeps and offsets. Elbows and sweeps are to be rigid aluminum or PVC-coated rigid aluminum where shown on the drawings.

H. Swab all raceways clean before installing cable.

I. Plug and seal spare raceways watertight at all handholes, buildings and structures.

J. Seal the ends of raceways and make watertight at all handholes, buildings and structures.

K. Train cables in handholes and support and restrain them on racks and hooks. Furnish inserts on all handhole walls for mounting future racks as well as racks required for present installation.

L. A pull line shall be installed and left in all spare raceways.

M. Install detectable warning tape in all ductbanks as shown on the Drawings. Where trench exceeds 24-in width, provide additional detectable tape runs to mark each side of the ductbank in addition to the one in the center.

N. Handhole Installation

1. Place bases on 12-in bed screened gravel or crushed stone as shown on the drawings. Set base grade so that a minimum grade adjustment of 4-in of grade ring is required to bring the handhole frame and cover to final grade.
   a. Use [HDPE grade rings] [brick and non-shrink mortar] to adjust frame and cover to final grade.

2. Set precast sections plumb with a 1/4-in maximum out-of-plumb tolerance. Seal joints of precast sections with either a rubber O-ring set in a recess or a flexible joint sealant used in sufficient quantity to fill 75 percent of the joint cavity. Fill the outside and inside joint with non-shrink grout and finished flush with the adjoining surfaces. Caulk the inside of leaking barrel section joints with non-shrink grout. If leaks appear in the handholes the inside joints shall be cleaned out and remade in a manner that will result in a watertight joint.

3. Allow joints to set for 24 hours before backfilling. Backfilling shall be performed by bringing the fill up evenly on all sides.

4. Plug holes in concrete with non-shrink grout or non-shrink grout in combination with concrete plugs. Finish flush on the inside.

5. Cut holes in precast sections to accommodate conduits prior to setting handhole sections in place.

O. Brickwork

1. Mix mortar only in such quantity as may be required for immediate use and use before initial set takes place. Anti-freeze mixtures shall not be included in the mortar. Install masonry when the outside temperature is above 40 degrees F unless provisions are made to protect the mortar, brick and finished work from frost by heating and enclosing the work with tarpaulins other equivalent material.

2. Set handhole covers and frames in a full mortar bed. Utilize bricks or HDPE grade rings, a maximum of 8-in thick, to assure frame and cover are set to the finished grade.

3.02 CLEANING

A. All new handholes shall be thoroughly cleaned of all silt, debris and foreign matter prior to final inspection.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install a complete grounding system in strict accordance with Article 250 of the National Electrical Code (NEC), as shown on the Drawings and as specified herein.

B. All raceways, conduits, ducts and multi-conductor cables shall contain equipment grounding conductors sized in accordance with the NEC. Minimum sizes shall be No. 12 AWG.

C. A supplemental grounding conductor shall be provided from each motor control center, power panelboard, lighting panelboard, motor or process control panel, instrumentation control panel to the system ground loop. Supplemental grounding conductors shall be installed in PVC Schedule 80 conduit. Conductors shall be connected to opposite ends of the distribution equipment ground bus.

D. Provide ground resistance measurements for the grounding system.

E. Connect all hatches, metal stairs and handrails to system ground grid or system ground loop.

1.02 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, shop drawings and product data, for the following:

1. Manufacturer's name and catalog data for ground rods, exothermic welding methods, grounding clamps including installation requirements and materials.

B. Submit results of grounding and bonding resistance testing as specified herein

PART 2 PRODUCTS

2.01 MATERIALS

A. Conduit shall be as specified under Section 26 05 33.

B. Wire shall be as specified under Section 26 05 10.

C. Ground rods shall be 3/4-in by 10-ft copper clad steel and constructed in accordance with UL 467. The minimum copper thickness shall be 0.25 mm. Ground rods shall be Copperweld; Blackburn; Erico, Inc., or equal.

D. Grounding conduit hubs shall be malleable iron type, and of the correct size for the conduit, as manufactured by Thomas & Betts Co.; Catalog No. 3940 Series, similar by Burndy; O.Z. Gedney Co., or equal.

E. Water pipe ground clamps shall be cast bronze saddle type, and of the correct size for the pipe, as manufactured by Thomas & Betts Co. Cat. No. 2 (1/2-in, 3/4-in, or 1-in size), similar by Burndy; O.Z. Gedney Co., or equal and of the correct size for the pipe.

F. Buried grounding connections shall be by Cadweld process, or equal exothermic welding system.

1. Molds, cartridge materials and accessories shall be provided in kit form and selected per the manufacturer's written instructions for specific types, sizes and combinations of conductors and connected items. Molds and powder shall be furnished by the same manufacturer.

G. Ground Rod Test Wells

1. Ground rod test wells shall be complete with cast iron riser ring and traffic cover marked "GROUND ROD". Boxes and covers shall be suitable for H-20 wheel loading.

2. Test wells shall be as manufactured by Erico, T416A; Christy Co., No. G5; Lightning and Grounding System, Inc., Series I-R.

PART 3 EXECUTION

3.01 INSTALLATION

A. Run grounding electrode conductors in rigid steel conduits. Bond the protecting conduits to the grounding electrode conductors at both ends. Do not allow water pipe connections to be painted. If the connections are painted, dis-assemble them and re-make them with new fittings.

B. Install equipment grounding conductors with all feeders and branch circuits.

C. Bond all steel building columns in new structures together with ground wire in rigid conduit and connect to the distribution equipment ground bus, as shown on the Drawings.

D. Ground wire connections to structural steel columns shall be made with exothermic welds.

E. Metal conduits stubbed into a motor control center or floor mounted electrical enclosure shall be terminated with insulated grounding bushings and connected to the motor control center or electrical enclosure ground bus. Bond boxes mounted below motor control centers to the motor control center ground bus. Size the grounding wire in accordance with NEC Table 250-122, except that a minimum No. 12 AWG shall be used.

F. Liquid tight flexible metal conduit in sizes 1-1/2-in and larger shall have bonding jumpers. Bonding jumpers shall be external, run parallel (not spiraled) and fastened with plastic tie wraps.

G. Ground transformer neutrals to the nearest available grounding electrode with a conductor sized in accordance with NEC Article 250-66.

H. Drive grounding electrodes as shown on the Drawings.

I. All equipment enclosures, motor and transformer frames, conduits systems, cable armor, exposed structural steel and all other equipment and materials required by the NEC to be grounded, shall be grounded and bonded in accordance with the NEC.

J. Seal exposed connections between different metals with No-Oxide Paint Grade A, or equal.

K. Lay all underground grounding conductors slack and, where exposed to mechanical injury, protect by pipes or other substantial guards. If guards are iron pipe, or other magnetic material, electrically connect conductors to both ends of the guard. Make connections as specified herein.

L. Care shall be taken to ensure good ground continuity, in particular between the conduit system and equipment frames and enclosures. Where necessary, jumper wires shall be installed.

M. All grounding type receptacles shall be grounded to the outlet boxes with a No. 12 THW green conductor connected to the ground terminal of the receptacle and fastened to the outlet box by means of a grounding screw.

N. Molds used for welding shall be new. The number of welds made per mold shall not exceed manufacturer's recommendations

O. Ground metal poles supporting outdoor lighting fixtures to a supplemental grounding electrode (rod) in addition to the separate equipment grounding conductor run with the supply branch circuit.

P. Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with ground clamp connectors.

Q. Bond interior mental piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters and HVAC equipment. Use braided-type bonding straps.

R. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate in accordance with NEC Paragraph 250.52 using a minimum of 20-ft of bare copper conductor not smaller than No. 4 AWG. Where base of foundation is less than 20-ft in length, coil excess conductor within base of concrete foundation. Extend grounding conductor below grade and connect to building grounding grid, ground loop, or grounding electrode external to concrete.

S. Install driven ground rods in manholes and handholes close to wall and set rod depth so 4-in will extend above finished floor. Protect ground rods with double wrapping of pressure-sensitive tape or heat shrunk insulating sleeve from 2-in above to 6-in below concrete floor. Seal floor opening with waterproof, non-shrink grout. Where ground rods are installed outside of manhole or handhole, provide a No. 4/0 AWG bare, tinned copper conductor from ground rod into manhole or handhole through a waterproof sleeve in the wall.

3.02 INSPECTION AND TESTING

A. Inspect the grounding and bonding system conductors and connections for tightness and proper installation.

B. Use Biddle Direct Reading Earth Resistance Tester or equivalent test instrument to measure resistance to ground of the system. Perform testing in accordance with test instrument manufacturer's recommendations using the fall-of-potential method.

C. All test equipment shall be provided under this Section and approved by the Engineer.

D. Resistance to ground testing shall be performed during dry season. Submit test results in the form of a graph showing the number of points measured (12 minimum) and the numerical resistance to ground.

E. Testing shall be performed before energizing the distribution system.

F. A separate test shall be conducted for each building or system.

G. Test all grounded cases and metal parts associated with the electrical equipment for continuity with the ground system.

H. Submit test results to the Engineer for review.

I. Notify the Engineer immediately if the resistance to ground for any building or system is greater than five ohms.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install complete, slide gates, weir gates, operators, operating systems and appurtenances as shown on the Drawings and as specified herein.

1.02 RELATED WORK

A. Warranty is included in Section 01 78 36.

B. Concrete work is included in Division 03.

C. Surface preparation and shop priming is included in Section 09 91 10.

D. Field painting is included in Section 09 91 00.

E. Instrumentation and control work, except as specified herein, is included in Division 40. Instrumentation and controls provided in this section shall adhere to Instrumentation and Control Specifications Sections in Division 40.

F. Electrical work, except electric motor operators and controls, is included in Division 26.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, shop drawings and product data showing materials of construction and details of installation for:

1. Complete description of all materials.

2. Certified shop and installation drawings showing all details of construction, dimensions and anchor bolt locations.

3. Descriptive literature, bulletins and/or catalogs of the equipment.

4. A complete bill of materials.

5. The weight of each component.

6. Description of surface preparation and shop prime painting of gates and accessories.

B. In the event it is not possible to conform to certain details of this Section, describe completely all non-conforming aspects.

C. Operation and Maintenance Data

1. Operating and maintenance instructions for each type of equipment shall be furnished to the Engineer as provided for in Section 01 78 23.

1.04 REFERENCE STANDARDS

A. American Waterworks Association (AWWA)

1. ANSI/AWWA C561-14 Standard for Fabricated Stainless-Steel Slide Gates

B. ASTM International

C. National Electrical Manufacturers Association (NEMA)

D. Aluminum Association, Inc. (AA)

E. Factory Mutual (FM)

F. Underwriters Laboratories (UL)

G. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. The slide gates, weir gates, operators, operating stems and appurtenances specified under this Section shall be furnished by manufacturers who are fully experienced, reputable and qualified in the manufacture of the equipment furnished. The slide gates, weir gates, operators, operating stems and all related equipment shall be designed, constructed and installed in accordance with the best practices and methods.

B. A factory representative who has complete knowledge of proper operation and maintenance of the equipment provided under this section shall be provided for one eight-hour day to instruct representatives of the Owner and Engineer on the proper operation and maintenance of the equipment. This work may be conducted in conjunction with the inspection of the installation and test runs as provided under Part 3.

C. This instruction period shall be scheduled with the Owner at least ten days in advance and shall take place prior to start-up and acceptance by the Owner.

1.06 WARRANTY

A. All equipment supplied under this section shall be warranted for a period of one year by the Contractor and the Manufacturer. Warranty period shall commence on the date as outlined in Division 1 and in Division 0.

B. The equipment shall be warranted to be free from defects in workmanship, design and materials. If any part of the equipment should fail during the warranty period, it

shall be replaced in the machine(s) and the unit(s) restored to service at no expense to the Owner.

C. The Manufacturer's warranty period shall run concurrently with the Contractor's warranty period. No exception to this provision shall be allowed.

D. Refer to Section 01 78 36 for additional warranty requirements.

1.07 MAINTENANCE

A. Special tools, if required for normal operation and maintenance, shall be furnished with the equipment.

B. Manufacturer's recommended spare parts shall be provided. Spare parts shall be packaged and labeled.

C. Refer to Section 01 13 10 for additional requirements.

PART 2 PRODUCTS

2.01 STAINLESS STEEL SLIDE GATES AND WEIR GATES

A. Materials shall be as follows:

1. Frame and Slides: 316 Stainless Steel
2. Rails, Yokes, and Stems: 316 Stainless Steel
3. Fasteners and Anchor Bolts: 316 Stainless Steel
4. Stem, Bolts, and Taps: 316 Stainless Steel, ASTM A276
5. Invert Seal, and Seals: Neoprene
6. Seats: Ultra High Molecular Weight Polyethyene (UHMWPE)

B. The slide gates and weir gates shall have the characteristics and dimensions as shown on the Drawings and as specified in Table 1.

C. The stainless steel slide gates and accessories shall be fabricated Type 316 stainless steel self-contained type with the disc arranged to lower or raise to open and with the guides designed to mount on the face of, or embedded in concrete.

D. The frames shall be of flange back design, suitable for mounting flush onto a concrete wall surface.

E. The guides shall be of Type 316 stainless steel construction. The guides shall be designed for maximum rigidity, shall have a weight of not less than 3 lbs/ft and will be provided with holes for anchor bolts every 18-in for face mounted units or embedding keyways for embedded units. Guides shall extend beneath the opening a sufficient

amount to support the disc in the fully down or open position for downward opening gates.

F. An angle shall be welded to the guides across the invert of the opening on face-mounted gates and up both sides of all gates. Seals shall be made of UHMWPE and include a nitrile neoprene compression cord that ensures contact between the guide and gate. Hollow neoprene “J” bulb or “P” seals are not acceptable.

G. The operating stem shall be Type 316 stainless steel with a minimum diameter of 1-1/2-in designed to withstand at least twice the rated output of the operator. The slenderness ratio (l/r) shall be less than 200. Where weir gates are supplied having a slide width greater than two times the slide height, a dual stem and compatible operator shall be provided.

H. Where the guides extend above the operating floor, they shall be sufficiently strong so that no further reinforcing will be required. Where required, the yoke to support the operating benchstand will be formed by two angles welded at the top of the guides to provide a one-piece rigid frame. The arrangement of the yoke will be such that the disc and stem can be removed without disconnecting the yoke.

I. The disc or sliding member shall be of Type 316 and the stainless-steel plate reinforced with "U" or angle-shaped stainless steel members welded to the plate not more than 16-in apart. The disc shall not deflect more than 1/720 of the span of the gate under the design head. Reinforcing ribs shall extend into the guides so that they overlap the seating surface of the guide. The bottom seal shall be mechanically fastened to the frame. The side and top seals shall be of the self-adjusting type consisting of UHMWPE guides and nitrile neoprene compression cord seals. The shape of the seal shall produce a seating surface having a minimum width of 3/4-in and the seal shall extend into the secondary slot of the guide. The vertical face of the seal shall be in contact with the seating surface of the guide to provide a proper seal at the corners. Reinforcements, retainer and bolts shall be of the same material as the disc. The invert of embedded unit frames shall have an angle welded to the lower ends of the guides to form a seating surface for a resilient seal mounted on the disc. Angle shall be of the same material as the guides.

J. All parts of the gate shall have a minimum thickness of 1/4-in.

K. The actuator shall be a yoke mounted, electric modulating, non-geared, handwheel operator with rising Type 316 stainless steel stem, stem guide and clear plastic stem cover. Handwheel operators shall have a minimum 18-in diameter handwheel and shall operate the gate under the specified operating head with not greater than 40 lbs of force on the handwheel. Operators shall be equipped with fracture-resistant clear butyrate plastic stem covers which shall not discolor or become opaque for a minimum of 5 years after installation. The top of the stem cover shall be closed. The bottom end of the stem cover shall be mounted in a housing or adapter plate for easy field mounting. Stem covers shall be complete with indicator markings to indicate gate position. An arrow with the word "OPEN" shall be permanently attached or cast onto the operator to indicate the direction or rotation to open the gate. The direction of rotation to open shall be clockwise.

L. All necessary attaching bolts and anchor bolts shall be Type 316 stainless steel and shall be furnished by the slide gate manufacturer.

M. Stainless steel slide gates and weir gates shall be manufactured by:

1. Whipps, Inc., Athol, MA.

2. Hydrogate Corporation, Longmont, CO

3. Aquanox Water Control Gates, Magog, Canada.

4. Waterman Industries, Exeter, CA

5. WACO Products, Inc., Baltimore, MD

2.02 OPERATORS

A. Unless otherwise shown on the Drawings, slide gates and weir gates shall be operated by a gear operated handwheel or gear operated stand mounted on the yoke. The benchstand shall be fully enclosed, equipped with roller bearings above and below the operating nut and with a mechanical seal around the operating nut. The pinion shaft shall be cadmium-plated and supported on roller bearings. A mechanical seal shall be provided around the pinion shaft where it extends from the hoist enclosure.

B. A side mount or front mount operator system utilizing right angle bevel boxes, stainless steel interconnecting shafting, and flexible couplings shall be furnished by the manufacturer when the benchstand is located over 48-in above the operating floor. The transmission system design shall provide for the gate to be operated from a position 30-in above the operating floor.

C. Bevel boxes for the transmission system shall be provided with cadmium plated pinion shafts supported on roller bearings. A mechanical seal will be provided around the pinion shaft where it extends from the bevel box enclosure.

D. Floor stands shall be furnished for all other gate operators not supported on the gate yoke. Floor stands shall be cast iron or fabricated steel construction. The pedestal height shall be such that the crank shaft will be approximately 36-in above the operating floor. Wall brackets shall be used to support floor stands where shown on the Drawings and shall be furnished in cast iron or welded steel construction, designed to withstand all normal operating loads. Where shown on the Drawings, floor stands shall be offset type mounted on the floor surface and offset to align with the gate stem. The floor stand shall be mounted on a heavily ribbed reinforced cast iron bracket anchored to the concrete with Type 304 stainless steel anchors. The bracket and anchor bolts shall be sized to transfer the upward or downward thrust required to ultimately fail the stainless steel stem. The design and detail of the brackets and anchor bolts shall be provided by the gate manufacturer and shall be approved by the Engineer. The bracket, anchors, backplate and accessories shall be supplied as part of the gate assembly by the gate manufacturer.

E. Manual operators shall be furnished where shown and shall consist of a handwheel or crank operator mounted on the gate yoke or on a floor stand, as indicated in the Drawings.

1. Handwheel operators shall have a minimum 18-in diameter handwheel and shall operate the gate under the specified operating head with not greater than 40 lbs of force on the handwheel. The operator shall be fully enclosed, equipped with roller bearings above and below the operating nut and mechanical seals. Alternatively, polyethylene bearing pads may be used.

2. Crank operators shall have either single or double gear reduction depending upon the lifting capacity required. Double reduction operators shall also be 2-speed type with a square nut drive on the high speed and low speed shafts. Each type shall be provided with a threaded cast bronze lift nut to engage the operating stem. Bearings shall be provided above and below a flange on the operating nut to support both opening and closing thrusts. Operators shall be designed for a maximum crank effort of 40 lbs under the specified operating conditions. Gears, where required, shall be steel with machined cut teeth designed for smooth operation. The pinion shafts on crank-operated floorstands, either single or double ratio, shall be supported on tapered roller bearings and enclosed in a cast iron case and cover. Positive mechanical seals shall be provided on the operating nut and the pinion shafts to exclude moisture and dirt and prevent leakage of lubricant out of the hoist. Lubricating fittings shall be provided for the lubrication of all gears and bearings. The crank shall be of cast iron with a revolving brass grip. The crank shall be removable.

3. Operators shall be equipped with fracture-resistant clear butyrate plastic stem covers which shall not discolor or become opaque for a minimum of five years after installation. The top of the stem cover shall be closed. The bottom end of the stem cover shall be mounted in a housing or adapter plate for easy field mounting. Stem covers shall be complete with indicator markings to indicate gate position.

4. An arrow with the word "OPEN" shall be permanently attached or cast onto the operator to indicate the direction or rotation to open the gate. The direction of rotation to open shall be clockwise.

5. On gates as shown, provide dual operators to maintain stability of the disc. Operators shall be crank operators as specified above, joined together by a shaft such that operating a crank on one will cause both operators to move together.

F. Electric operators shall be furnished where shown on the Drawings and shall be electric operated floor or bench stand mounted and shall include the motor, operator unit gearing, limit switch gearing, limit switches, torque switches, stem nut, declutch lever and auxiliary handwheel. The motor operator shall drive the gate stem at a rate of one foot per minute.

1. The motor shall be specifically designed for gate operator service and shall be continuous duty rated (modulating service only), of a high torque, totally enclosed non-ventilated construction with the motor leads brought into the limit

switch compartment without having external piping or conduit box. The motor shall be of ample size to open or close the gate against maximum load when voltage to the motor terminals is within ten percent of the nominal voltage. It shall be pre-lubricated and all bearings shall be of the anti-friction type. Motors shall be of weatherproof construction unless otherwise shown and shall have encapsulated windings with void free slot penetration and be capable of passing water immersion test as outlined in NEMA MGI-20.48 to provide protection against moisture ingress and condensation when the motor is not running. Threaded condensate drain holes shall be suitably positioned on the lower external surface to expel any moisture that may have accumulated. Motor power requirements shall be as specified below. In addition, the motor shall conform to all applicable portions of Division 26.

2. The power gearing shall consist of carburized and hardened alloy steel worms with threads ground after heat treating. The worm gear shall be of alloy bronze, accurately cut with a hobbing machine. Where required, additional generated helical gears of heat treated steel shall be used. All power gearing shall be suitably lubricated with oil or grease and shall be suitable for mounting in any position. Ball or roller bearings shall be used throughout.

3. Limit switches and gearing shall be an integral part of the gate operator. The limit switch gearing shall be totally enclosed in its own gear case and permanently grease or oil lubricated. The limit switch mechanism shall be designed so that one set of limit switches is provided for each direction of travel and shall be provided with two normally open and two normally closed contacts per set of switches. The switches shall be adjustable to allow the switch to trip at any point on the gate's travel. The limit switches shall be geared to the drive mechanism and in step at all times whether the unit is in motor or manual operation. A mechanical gate position indicator shall be provided to indicate gate opening.

4. The gate control shall be equipped with a double torque switch. The torque switch shall be adjustable and shall be responsive to load encountered in either direction of travel. It shall operate during the complete cycle to protect the gate should excessive load be met because of obstruction in either direction of travel.

5. The operator shall have a stem nut of high tensile bronze for open-close service. Stem nuts for modulating service shall have a nylon stem nut. The nut arrangement shall be of the 2-piece type to simplify field replacement. The stem nut shall be capable of being removed from the top of the operator without the necessity of removing the operator from the floor stand or disassembling any of the gearing within the operator.

6. A handwheel shall be provided for manual operation. The handwheel shall not rotate during electric operation, but shall be responsive to manual operation at all times except when the motor is in operation. The motor shall not rotate during hand operation, nor shall a fused motor prevent hand operation. When in the hand operating position, the unit shall remain in this position until the motor is energized, at which time the operator shall automatically return to electric operations and shall remain in the electric position until hand operation is again

desired. This movement from electric to hand operation shall be accomplished by a positive declutching lever which shall disengage the motor and motor gearing mechanically, but not electrically. It shall be impossible to place the unit in hand operation when the motor is running. When in hand operation, not more than 40 lbs of force shall be required on the handwheel for operation of the gate. An arrow shall be cast on the handwheel labeled to indicate the direction of rotation to open the gate. The direction of rotation to open shall be clockwise.

7. Furnish floor stands as required for operators and as specified above. The floor stand, anchors and accessories shall be supplied as part of the gate assembly by the gate manufacturer.

8. A weatherproof locking device shall be provided on the gate operator to prevent use of the manual operator and prevent access to the locally mounted electric controls. The device shall allow remote operation.

9. Furnish fracture-resistant clear butyrate plastic stem covers complete with indicator markings to indicate gate position. Stem covers shall not discolor or become opaque for a minimum of five years after installation. The top of the stem cover shall be closed. The bottom end of the stem cover shall be mounted in a housing or adapter plate for easy field mounting.

10. Enclosures shall be FM certified or UL certified and shall be provided with space heaters to prevent condensation.

11. Each operator shall be provided with its own electrical controls housed in a NEMA 4 enclosure (unless otherwise shown) which shall be part of the operator. For outdoor installation, the controls shall be completely factory wired to the motor, limit switches and torque switch such that the only field wiring connection required, shall be for power supply and signal. All field wiring shall be to terminal strips.

12. Electrical operators arranged for open-close operation shall open and close the gate between the limit switch settings in response to a local or remote signal. The controls shall consist of a combination lockable circuit breaker and reversing starter with control power transformers. Control power shall be 110 Volt. A Raise-Stop-Lock-Lower pushbutton station shall be furnished and mounted as an integral part of the controls. A lockable Hand-Off-Remote selector switch shall also be provided to allow response to a remote Raise-Stop-Lower control. In addition to the mechanical position indicator, two indicating lights, one green and one red, shall be furnished. The lights shall be wired such that the green light shall be illuminated when the gate is fully closed, the red light shall be illuminated when the gate is fully open and both lights shall be illuminated when the gate is in any intermediate position. The power supply to the gate operator shall be 480 Volts, 3 Phase, 60 Hz.

13. Electrical operators arranged for modulating control shall provide raise and lower control in response to a 4-20 mADC remote signal, utilizing a completely solid state modulating control.
    a. The operator shall utilize a 480 VAC, 3 Phase, reversing motor controlled by a solid state reversing starter to position the gate. Overshoot of the

operator shall be controlled by pulsing the motor once the gate position approaches the desired position to decelerate the motor speed.

b. The controller shall compare the incoming 4-20 mADC signal with an internal position feedback signal generated by a mechanical potentiometer connected to the gate stem drive, and shall drive the operator to match these signals. The controller shall have an adjustable dead band to determine the difference between the reference signal and position signal at which the operator will readjust position.

c. The controller shall incorporate adjustments for span, zero, gain, and dead band. Power supply shall be 480 Volts, 3 Phase, 60 Hz. A control power transformer for 110 Volt, single phase control power shall be provided.

d. A Hand-Off-Automatic selector switch and a spring return Open-Stop-Close selector switch shall be provided as an integral part of the controls.

e. The gate shall remain in its last position on loss of power.

f. The gate shall on loss of control signal remain in its last position.

g. The operator control shall be Modutronic 30 by Limitorque or equal. If intermittent modulation or position is required, then the operator control shall be Modutronic 40 by Limitorque or equal.

14. The electric operators shall be by Limitorque Corp.; Rotork by Rotork Inc. or approved equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation of all gates and guides shall be done in a workmanlike manner. Handle, store and install the equipment specified in this Section in strict accordance with the manufacturer's drawings and recommendations. Frames and guides shall be installed in a true vertical plane and shall be installed with 90-degree corners.

B. Gates with embedded guides and inverts shall be installed in accordance with the recommendations of the manufacturer subject to the Engineer's approval.

C. The installation of all gates shall be under the supervision of a representative of the manufacturer furnishing the gates.

3.02 FIELD TESTING

A. Furnish the services of a factory representative, as provided under Part 1, who has complete knowledge of proper operation and maintenance to inspect the final installation and supervise a test of the equipment. These services may be combined with those provided under Part 1.

B. After installation, all slide gates and weir gates shall be field tested at maximum differential head to ensure that all items of equipment are in compliance with this Section, including the leakage requirements.

1. Maximum allowable leakage for slide gates and weir gates shall be 0.1 gpm/ft of perimeter under the design seating head.

C. In the event that any unit fails to meet the above requirements, the necessary changes shall be made and the unit retested. If the unit remains unable to meet the test requirements to the satisfaction of the Engineer, it shall be removed and replaced with a satisfactory unit at no additional cost to the Owner.

Table 1: Gate Schedule

Gate I.D.	**Type**	**Opening (WXH)**	**Frame/ Mounting**	**Top of Wall EL.**	**Top of Gate Opening EL.**	**Bottom of Gate Frame EL.**	**Top of Frame EL.**	**Lift Type**
WG-1020-1	Weir Gate	8’X8’	Face Mounted	661.00	653.09	637.00	663.00	Yoke w/ Electric Actuator
WG-1020-2	Weir Gate	8’X8’	Face Mounted	661.00	653.09	637.00	663.00	Yoke w/ Electric Actuator
WG-1020-3	Weir Gate	8’X7’	Face Mounted	661.00	653.09	637.00	663.00	Yoke w/ Electric Actuator
SG-1020-1	Slide Gate	48”X48”	Face Mounted	661.00	647.67	644.17	663.00	Yoke w/ Electric Actuator

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This Section specifies the basic administrative and testing requirements for piping. Specific piping materials, systems and related installation and testing requirements are specified in other Sections of Divisions 01, 23 and 40.

1.02 RELATED WORK

A. Piping materials and systems are included in other Sections of Division 40.

B. Valves are included in Section 40 05 50.

C. Pipe insulation is included in Section 23 07 00.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, general submittals for piping and piping systems are listed below. It is not intended that all submittals listed below be provided for all piping materials and systems. Refer to individual System or Piping Sections for specific submittals.

B. Shop Drawings and Product Data

1. Piping layouts in full detail.

2. Location of pipe hangers and supports.

3. Location and type of backup block or device to prevent joint separation.

4. Large scale details of wall penetrations and fabricated fittings.

5. Schedules of all pipe, fittings, special castings, couplings, expansion joints and other appurtenances.

6. Catalog cuts of joints, couplings, harnesses, expansion joints, gaskets, fasteners and other accessories.

7. Brochures and technical data on coatings and linings and proposed method for application and repair.

C. Samples

D. Design Data

E. Test Reports

1. Certified shop tests showing compliance with appropriate standard.

2. All field test reports, signed by Contractor and RPR.

F. Certificates

1. Copies of certification for all welders performing work in accordance with ANSI B31.1.

G. Manufacturer's Installation (or application) instructions.

H. Statement of Qualifications

I. Manufacturers Field Report

J. Project Record Document

K. Operation and Maintenance Data in accordance with Section 01 78 23.

L. Warranties

1.04 REFERENCE STANDARDS

A. ASTM International

1. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength

B. American National Standards Institute (ANSI)

1. ANSI B16.5 - Pipe Flanges and Flanged Fittings

2. ANSI B31.1 - Power Piping

C. American Welding Society (AWS)

1. AWS B3.0 - Specification for Welding Procedure and Performance Qualifications

D. American Water Works Association (AWWA)

1. AWWA Manual M11 - Steel Pipe - A Guide for Design and Installation

E. American Society of Mechanical Engineers (ASME)

F. Underwriters Laboratories (UL)

G. Factory Mutual (FM)

H. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. All materials shall be new and unused.

B. Install piping to meet requirements of local codes.

C. Provide manufacturer's certification that materials meet or exceed minimum requirements as specified. Reference to standards such as ASTM and ANSI shall apply to those versions in effect at the time of bid opening.

D. Coordinate dimensions and drilling of flanges with flanges for valves, pumps and other equipment to be installed in piping systems. Bolt holes in flanges to straddle vertical centerline.

E. Reject materials contaminated with gasoline, lubricating oil, liquid or gaseous fuel, aromatic compounds, paint solvent, paint thinner and acid solder.

F. Pipe-joint compound, for pipe carrying flammable or toxic gas, must bear approval of UL or FM.

G. Unless otherwise specified, pressures referred to in all Piping Sections are expressed in pounds per square in gauge above atmospheric pressure, psig and all temperature are expressed in degrees Fahrenheit (F).

1.06 DELIVERY, STORAGE, AND HANDLING

A. During loading, transportation and unloading take care to prevent damage to pipes and coating. Carefully load and unload each pipe under control at all times. Place skids or blocks under each pipe in the shop and securely wedge pipe during transportation to ensure no injury to pipe and lining.

PART 2 PRODUCTS

2.01 MATERIALS

A. Specific piping materials and appurtenances are specified in the respective Piping or System Sections.

B. General installation materials shall be as specified below.

1. Unions shall be brass or bronze unions for joining nonferrous pipe; malleable brass or bronze-seated iron or steel unions for joining ferrous pipe; PVC unions for joining PVC pipe; CPVC unions for joining CPVC pipe.

2. Flanged Joints. Bolt and nuts – Grade B, ASTM A307, hot-dip galvanized, bolt number and size same as flange standard; studs – same quality as machine bolts; gaskets shall be1/8-in thick full face red rubber; rust-resistant coatings.

3. Temporary Plugs shall be standard plugs or caps which are suitable for permanent service.

4. Wall Sleeve Seals shall be as specified in Section 01 60 09.

5. Flexible Connections shall be flanged spool type, 180-degree F maximum service, single filled arch with synthetic rubber tube and cover, steel-ring reinforced synthetic fiber carcass, with flanges drilled to 150 lb ANSI B16.5 Standard. Steel retaining rings, control rods and compression sleeves shall be provided where shown and as required for the working pressure of the system in which the joint is installed. All flexible joints shall be rated for the working pressure of the system in which they are installed.

PART 3 EXECUTION

3.01 GENERAL

A. All dirt, scale, weld splatter, water and other foreign matter shall be removed from the inside and outside of all pipe and sub-assemblies prior to installing.

B. All pipe joints and connections to equipment shall be made in such a manner as to produce a minimum of strain at the joint.

C. Install piping in a neat manner with lines straight and parallel or at right angles to walls or column lines and with risers plumb. Run piping so as to avoid passing through ductwork or directly under electric light outlets and/or interference with other lines. All work shall be accomplished using recognized methods and procedures of pipe fabrication and in accordance with the latest revision of applicable ANSI Standards, ASME Codes and Pipe Fabrication Institute Standards.

1. Use full length of pipe except where cut lengths are necessary. Do not spring or deform piping to make up joints.

2. Pipe shall be cut square, not upset, undersize or out of round. Ends shall be carefully reamed and cleaned before being installed.

3. Bending of pipe is not permitted. Use fittings for all changes in direction.

4. Do not use bushings except where specifically approved by the Engineer. Reducers shall be eccentric to provide for drainage from all liquid-bearing lines and facilitate air removal from water lines.

5. Verify the locations and elevations of any existing piping and manholes before proceeding with work on any system. Any discrepancies between the information shown on the Drawings and the actual conditions found in the field shall be reported at once to the Engineer. No claim for extra payment will be considered if the above provision has not been complied with.

6. Where lines of lower service rating tie into services or equipment of higher service rating the isolation valve between the two shall conform to the higher rating.

7. Mitering of pipe to form elbow is not permitted.

8. All piping interiors shall be thoroughly cleaned after installation and kept clean by approved temporary closures on all openings until the system is put in service. Closures should be suitable to withstand the hydrostatic test.

9. End caps on pre-cleaned pipe shall not be removed until immediately before assembly. All open ends shall be capped immediately after completion of installation.

D. Test Connections

1. Provide 1/2-in female NPT test connection equipped with 1/2-in brass plug on all pump suction and discharge lines. Test connections shall be equipped with a tie, valve, and pressure gauge.

E. Unions

1. Unions screwed or flanged shall be provided where indicated and in the following locations even if not indicated.
   a. In long runs of piping to permit convenient disassembly for alterations or repairs.
   b. In by-passes around equipment.
   c. In connections to tanks, pumps and other equipment between the shut-off valve and the equipment.
   d. In connections on both sides of traps, controls and automatic control valves.

F. Vents and Drains

1. Provide vents and drains in the following places:
   a. Water Lines - Vents at high points and drains at low points.
   b. Air Lines - Drains at low points.

3.02 UNIONS

A. Use unions to allow dismantling of pipe, valves and equipment.

3.03 WELDING

A. Welding in accordance with ANSI B31 and AWS B3.0.

B. Install welding fittings on all welded lines. Make changes in direction and intersection of lines with welding fittings. Do not miter pipes to form elbows or notching of straight runs to form tees, or any similar construction. Do not employ welder who has not

been fully qualified in above specified procedure and so certified by approved welding bureau or similar locally recognized testing authority.

3.04 FLANGED JOINTS

A. Make flanged joints with bolts; bolt studs with nut on each end; or studs with nuts where one flange is tapped. Use number and size of bolts conforming to same ANSI Standard as flanges. Before flanges pieces are assembled, remove rust resistant coating from machined surfaces, clean gaskets and smooth all burrs and other defects. Make up flanged joints tight, care being taken to prevent undue strain upon valves or other pieces of equipment.

3.05 SLEEVE COUPLINGS

A. Install tierods, pipe clamps or bridles when sleeve type couplings or fittings are used in piping system where indicated, and at changes in direction or other places as necessary, to prevent joints from pulling apart under pressure. Use bridles and tierods at least 3/4-in in diameter, except where tierods replace flange bolts of smaller size, in which case fit with nut on each side of pair of flanges. Joint harnessing shall conform, as a minimum, to the requirements for the bolts and tie bolt lugs as set forth in AWWA Manual M11.

3.06 WALL SLEEVE SEALS

A. Use expandable rubber segmented sealing device with corrosion-resistant fasteners to make watertight the annular space between pipe and sleeve. Determined the required inside diameter of each individual wall opening or sleeve to fit the pipe and seal it to assure a watertight joint as recommended by the manufacturer, before ordering, fabricating or installing. Install pipe concentrically through wall sleeve. Install and tighten seal per manufacturer's instructions.

3.07 TESTING

A. Test all pipelines for water/gas tightness as specified in the Piping or System sections. Furnish all labor, testing plugs or caps, pressure pumps, pipe connections, gauges and all other equipment required. Testing shall be performed in accordance with one or more of the testing procedures appended to this Section as specified in each Piping or System Section. All testing shall be performed in the presence of the Engineer

B. Repair faulty joints or remove defective pipe and fittings and replace as approved by the Engineer. Retest.

3.08 DISINFECTION

A. Disinfect the piping system as specified.

3.09 HYDROSTATIC TEST

A. Scope: This test shall be used to hydrostatically test piping systems for structural integrity and leaks. The test shall be performed at ambient temperature unless otherwise specified. Test pressures shall be as specified for each type of piping and shall otherwise be as directed by the Engineer.

B. Test Fluid

1. Water should be used as the test fluid whenever possible. In those systems where water cannot be used the test fluid may be either the one to be used in the system or the one agreed upon by the Engineer and the Contractor.

C. Test Equipment

1. Water - Of sufficient capacity to deliver the required test pressure.

2. Strainer - On inlet side of the pump to prevent foreign matter from entering the system.

3. Valves - Shall be provided on the suction and discharge side of the pump.

4. Heater - To allow heating of the test fluid when elevated temperatures are required for test.

5. Relief Valve - Set at a pressure to relieve at 20 to 25 percent above the required test pressure.

6. Pressure Gauge(s) - Capable of reaching 50 percent over the test pressure. These should be located at the pump discharge and any other place deemed convenient by the Contractor.

7. Pressure gauges and relief valves shall be checked for accuracy before use in test procedures.

D. Preparation for Test

1. Determine the fluid to be used for the test, and, if other than ambient temperature is required, what the test temperature will be.

2. When a fluid other than water is used for a test, the equipment used for the test shall be of a material compatible with the test fluid. Normally this would be equal to the piping material.

3. Vents shall be provided at the high points of the system and drains provided where means of venting or draining do not exist.

4. Remove or block off, all relief valves, rupture discs, alarms, control instruments, etc., that shall not be subjected to the test pressure.

5. All discs, balls, or pistons from check valves shall be removed if they interfere with filling of the system. Open all valves between inlet and outlet of the section to be tested.

6. Connect pump and provide temporary closures for all of the external openings in the system. Use caution to ensure that the closures are properly designed and strong enough to withstand the test pressure.

7. All joints, including welds, are to be left uninsulated and exposed for examination during test.

8. A joint previously tested in accordance with this Section may be covered or insulated.

9. Piping designed for vapor or gas shall be provided with additional temporary supports, if necessary, to support the weight of the test liquid.

10. Expansion joints shall be provided with temporary restraint for additional pressure under test or shall be isolated from the test.

11. Flanged joints, where blanks are inserted to isolate equipment during the test, need not be tested.

E. Test Pressure

1. The hydrostatic test pressure shall be 1-1/2 times the design pressure unless otherwise specified in the System Section. Contractor is responsible for verifying all components are designed and rated for at least the test pressure or higher before conducting pressure tests.

F. Test Procedure

1. Allow the test fluid to enter the system. Open vents to allow displacement of all entrapped air. For all pipelines exceeding 500-ft in length, the maximum rate of filling shall be limited to that which produces a maximum nominal flow velocity of one foot per second in the pipe to be tested.

2. Close vents and restrict personnel in the test area to those involved in the test.

3. Raise the pressure slowly with the pump until the predetermined test pressure is reached. Maintain pressure for duration of time specified in System Section, keeping personnel at a safe distance.

4. Reduce the pressure about 20 percent and hold it at that point while the entire system is carefully inspected for leaks, cracks, or other signs of defects.

5. If defects are found, the pressure shall be released, the system drained, the defects corrected and the test repeated.

6. After a satisfactory test has been completed, the line shall be drained.

G. Flushing

1. Lines tested with water shall be completely drained.

2. Lines shall be flushed, after test.

H. Test Records

1. Records shall be maintained of all tests performed.

2. Test records shall include:
   a. Date of Testing
   b. Identification of Piping Tested
   c. Test Fluid
   d. Test Pressure
   e. Signature(s) of Contractor and Engineer

3. If leaks are found, they shall be noted, on the record. After correction, retesting as specified for original test.

4. Records of test shall be maintained by the Contractor and copies furnished to the Engineer.

3.10 SERVICE PRESSURE TEST

A. Scope: This test shall be used to test piping systems using service pressure and the fluid for which the system is used.

1. It shall not be used to test piping systems conveying combustible or flammable liquids or systems that comply with ANSI B31 codes.

B. Test Fluid

1. The fluid for which the system is designed shall be the test fluid.

C. Test Equipment

1. A pressure gauge capable of registering 25 psi over the design pressure shall be installed down-stream from the supply shut-off valve if one is not included in the system.

D. Preparation for Test

1. Insulated lines shall have all joints left exposed until completion of the test.

E. Test Pressure

1. The test pressure shall be equal to the maximum pressure that the line will be subjected to under normal operating conditions as determined by the Engineer.

F. Test Procedure

1. Liquids
   a. See that all personnel not involved in the test vacate the area.
   b. Allow the system fluid to enter the system slowly while venting the air at the extreme far and uppermost points. For all pipelines exceeding 500-ft in length, the maximum rate of filling shall be limited to that which produces a maximum nominal flow velocity of one foot per second in the pipe to be tested.
   c. When the system is full and all air is vented, close the vents.
   d. Allow the pressure in the system to build up to the full line pressure.
   e. Inspect entire system for leaks.

2. Gas or Vapor (Including Compressed Air and Steam)
   a. See that all personnel not involved in the test vacate the area.
   b. In systems that do not have a pressure gauge near the main shut-off valve, a gauge shall be installed.
   c. Allow the system fluid to enter the system slowly until the full operating pressure is reached.
   d. Shut off main supply valve. Observe the gauge for 15 minutes. The pressure gauge shall not drop during this time.
   e. If the gauge drops, indicating the presence of leaks, the systems shall be inspected visually and, if necessary, with soap suds or commercially available leak detectors to locate the leak(s).

3. If leaks are found, the lines shall be relieved of pressure, purged if necessary, and repaired. Tests shall be repeated for repaired sections.

G. Test Records

1. Records shall be maintained of all tests performed.

2. Test records shall include:
   a. Date of Testing
   b. Identification of Piping Tested
   c. Test Fluid
   d. Test Pressure
   e. Signature(s) of Contractor and Engineer

3. If leaks are found, they shall be noted on the record. After correction, retesting is required.

4. Test records shall be maintained by the Contractor and copies furnished to the Engineer.

3.11 PNEUMATIC TEST

A. Scope: This procedure for a pneumatic test of piping systems shall be used when water, or other liquid, cannot be introduced into the line, or as a supplement to a

hydrostatic test. IT SHALL NOT BE USED TO TEST NON-METALLIC (PLASTIC) PIPE.

B. General

1. There is a hazard in using gases for test fluids because of their compressibility.

2. Gases shall never be used unless there is ample justification and always in a safe manner. See Paragraph 3.0.

C. Test Gases and Pressures

1. Compressed air shall normally be used. Other gases may be used when specified or directed by the Engineer.

2. Test pressures shall be 110 percent of the anticipated maximum operating pressure, but not exceeding 100 psig and not less than 5-psig at the highest point in the system.

D. Safety

1. All pneumatic tests shall be done under the supervision of Contractor and in the presence of the Engineer.

2. The Engineer's permission shall be secured before testing.

3. Only those people actively participating in the test shall be allowed in the test area.

4. Safety glasses and hard-hats must be worn.

5. Pneumatic testing should not be performed on plastic piping.

E. Equipment

1. Building supply air to deliver the required test pressure, if available, or Contractor shall provide a compressor capable of the required test pressure.

2. Valves shall be provided on the discharge side of the pump.

3. Relief valve to relieve at 10 to 15 percent over the test pressure.

4. Pressure Gauge(s) capable of reaching 50 percent over the test pressure. A gauge shall be located on the pump discharge and other location as required.

F. Test Procedure

1. Increase the pressure in the line gradually, in steps, to the specified pressure. Checks shall be made at 25 psig intervals until the test pressure is reached using sound, soap solution or a drop in indicated pressure.

2. When the specified pressure for the test is reached, shut off the valve in the supply line from the pump or compressor.

3. Maintain the test pressure long enough to visually inspect all joints or a minimum of 10 minutes. There shall be no drop in the test pressure in this time.

4. Leaks shall be repaired and the line retested. All leaks shall be noted on the Test Record form.

5. After satisfactory completion of the test, vent the line and allow it to return to atmospheric pressure. Connection can then be made to the supply line.

G. Test Records

1. Records shall be maintained of all tests performed.

2. Test records shall include:
   a. Date of Testing
   b. Identification of Piping Tested
   c. Test Fluid
   d. Test Pressure
   e. Signature(s) of Contractor and Engineer

3. If leaks are found, they shall be noted on the record. After correction, retesting is required.

4. Test records shall be maintained by the Contractor and copies furnished to the Engineer.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install 1/8-in to 6-in non-buried plastic piping and appurtenances as shown on the Drawings and as specified herein.

B. Refer to Section 40 05 10 for additional general piping requirements.

1.02 RELATED WORK

A. Valves and appurtenances are included in Section 40 05 52.

B. Pipe hangers and supports are included in Section 40 05 75.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, shop drawings and product data required to establish compliance with this Section. Submittals shall include the following:

1. Shop drawings including piping layouts and schedules shall be submitted to the Engineer and shall include dimensioning, fittings, locations of valves and appurtenances, joint details, methods and locations of supports and all other pertinent technical specifications for all piping to be furnished.

2. Shop drawing submittals for piping under this Section shall include all data and information required for the complete piping systems. All dimensions shall be based on the actual equipment to be furnished. Types and locations of pipe hangers and/or supports shall be shown on the piping layout for each piping submittal.

1.04 REFERENCE STANDARDS

A. ASTM International.

1. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.

2. ASTM D1785 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80 and 120.

3. ASTM D2447 - Standard Specification for Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter.

4. ASTM D2464 - Standard Specification for Threaded Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.

5. ASTM D2466 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.

6. ASTM D2467 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.

7. ASTM D2564 - Standard Specification for Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.

8. ASTM D2657 - Standard Practice for Heat Fusion Joining of Polyolefin Pipe and Fittings.

9. ASTM D2665 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste and Vent Pipe and Fittings.

10. ASTM D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly (Vinyl Chloride) (PVC) Pipe and Fittings.

11. ASTM D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.

12. ASTM D3311 - Standard Specification for Drain, Waste and Vent (DWV) Plastic Fittings Patterns.

13. ASTM D3350 - Standard Specification for Polyethylene Plastic Pipe and Fittings Materials.

14. ASTM D5260 - Standard Classification for Chemical Resistance of Poly(Vinyl Chloride) (PVC) Homopolymer and Copolymer Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds

15. ASTM F437 - Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.

16. ASTM F438 - Standard Specification for Socket - Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.

17. ASTM F439 - Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.

18. ASTM F441 - Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.

19. ASTM F493 - Standard Specification for Solvent Cements for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.

20. ASTM F593 - Standard Specification for Stainless Steel Bolts, Hex Cap Screws and Studs.

21. ASTM F594 - Standard Specification for Stainless Steel Nuts.

B. Plastic Pipe Institute (PPI)

1. PPI Handbook of Polyethylene Pipe

C. Handbook of PVC Pipe Design and Construction, Uni-Bell PVC Pipe Association

D. American National Standard Institute (ANSI)

1. ANSI B16.5 Pipe Flanges and Flanged Fittings.

E. National Sanitation Foundation (NSF)

F. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. All plastic pipe and fittings of each type shall be furnished by a single manufacturer who is experienced in the manufacture of the items to be furnished; however, it shall not be a requirement that the pipe and fittings be manufactured by the same manufacturer, provided that the pipe and fittings are compatible in both compounding and size. The pipe and fittings shall be designed, constructed and installed in accordance with the best practices and methods and shall be suitable for the intended service.

1.06 SYSTEM DESCRIPTION

A. Piping shall be installed in those locations as shown on the Drawings.

B. The equipment and materials specified herein are intended to be standard types of plastic pipe and fittings for use in transporting wastewater, water, air and chemicals.

C. Plastic piping systems shall be designed for the following conditions:

1. System: Drain Piping

2. Material: Schedule 80 PVC

3. Fluids: Wastewater

4. Pressure: Atmosphere to 15 psig

5. System: Washdown Water Supply

6. Material: Schedule 80 HDPE

7. Fluid: Water

8. Pressure: 150 psig

PART 2 PRODUCTS

2.01 MATERIALS

A. Poly (Vinyl Chloride) Pipe and Fittings - PVC

1. Pipe shall be manufactured from PVC compounds meeting ASTM D1784, Class 12454 in accordance with ASTM D1785, PVC 1120. The pipe shall have a minimum hydrostatic design stress of 2,000 psi at 73 degrees F and shall be suitable for field cutting and solvent welding. Pipe shall be of the sizes as shown on the Drawings and shall be Schedule 80 unless otherwise shown.

2. Fittings shall be the socket type for solvent welded joints conforming to ASTM D2467 or ASTM D2466 where Schedule 40 pipe is shown on the Drawings. Fittings shall be manufactured from PVC compound meeting ASTM D1784, Class 12454. Solvent cement shall be as specified in ASTM D2564.

B. Poly (Vinyl Chloride) Pipe and Fittings for Drain, Waste and Vent Service (DWV).

1. Pipe shall be manufactured from PVC compounds meeting ASTM D1784, Class 12454 in accordance with ASTM D2665. The patterns, dimensions and laying lengths of fittings including adapters shall meet the requirements of ASTM D3311. Solvent cement for joining DWV pipe and fittings shall be as specified in ASTM D2564.

C. Chlorinated Poly (Vinyl Chloride) Pipe and fittings - CPVC

1. Pipe shall be manufactured from CPVC compounds meeting ASTM D1784, Class 23447 in accordance with ASTM F441, CPVC 4120. The pipe shall have a minimum hydrostatic design stress of 2000 psi at 73 degrees F and 500 psi at 180 degrees F and shall be suitable for field cutting and solvent welding. Pipe shall be of the sizes as shown on the Drawings and shall be Schedule 80 unless otherwise shown.

2. Fittings shall be socket type for solvent weld joints conforming to ASTM F439 or ASTM F438 where Schedule 40 pipe is shown on the Drawings. Fittings shall be manufactured from CPVC compound meeting ASTM D1784 and any additional compound classification requirements for specific chemical resistance for the applications specified in Paragraph 1.06 in accordance with ASTM D5260. Solvent cement shall be as specified in ASTM F493.

D. Polyethylene Pipe and Fittings - HDPE

1. Pipe shall be manufactured from High Density Polyethylene (HDPE) base resin conforming to Grade P34 (PPI PE3406 or better) in accordance with the requirements of ASTM D2447. The pipe shall have a minimum hydrostatic design stress of 630 psi at 73 degrees F and be suitable for field cutting and heat fusion joining. Pipe shall be of the sizes shown on the Drawings and shall be Schedule 80 unless otherwise shown.

2. Fittings shall be the butt type for heat fusion joints conforming to ASTM D3261, except that Schedule 80 fittings shall meet the sustained pressure test conditions as specified for Schedule 80 pipe in Table 3 of ASTM D2447. Fittings shall be manufactured from the same HDPE base resin, conforming to Grade P34, Class C (PPI PE3406 or better), as is used to produce the pipe to which the fittings are to be joined. Both pipe and fittings shall be manufactured by the same manufacturer to assure compatibility of the piping system components.

E. Threaded joints shall be as specified under the applicable ASTM standard for the pipe and fittings being used. Thread sealer shall be thread tape which shall be standard industrial quality Teflon, Type 1.

F. Flanged Joints

1. Where flanged joints are shown on the Drawings, they shall be supplied with 1/8-in thick full-faced Viton-N gaskets or equal.

2. Flange bolt spacing, number and dimensions shall conform to the requirements of ANSI B16.5. CPVC and PVC flanges shall be suitable for solvent cementing to the pipe and shall be suitable for a minimum pressure of 150 psi.

3. Bolts, nuts and washers for flanged joints shall be for corrosive service conditions and shall be ASTM F593 and F594, Type 316 stainless steel. Anti-seize compound for stainless steel bolts and nuts shall be of a molybdenum disulfide base such as Molycoat-G or equal.

G. Fittings, specials, unions and flanges shall be of the same schedule number and manufactured of the same materials as the pipe. Whenever unions are called out on the Drawings, flanged connections may be substituted, provided that dimensional controls do not preclude use of flanges.

H. Sleeves for plastic pipe shall be as specified in Section 01 60 09.

I. Expansion joints for PVC and CPVC sizes 1/2-in to 6-in shall be telescoping type as manufactured by Plastinetics, Inc.; ASAHI/America or equal. Expansion in pipes smaller than 1/2-in shall be accommodated with expansion loops.

2.02 SURFACE PREPARATION AND SHOP COATING

A. All PVC and CPVC piping and fittings exposed to view shall have its surface prepared and be shop painted as specified in Section 09 91 10]. Surface preparation and shop priming are a part of the work of this Section. Field finish painting is included in Section 09 91 00. Assist as required in identifying pipe contents, direction of flow and all else required for proper finish painting and marking of pipe.

B. Painting will not be required on HDPE pipe, however, marking the pipe to indicate normal direction of flow and the fluid being transported in accordance with the marking schedule included in Section 09 91 00 shall be required as part of the work of this Section. Marking systems consisting of mylar/aluminum sandwich sheets held in place

by mastic or adhesive compounds which are compatible with the HDPE resin used to manufacture the pipe shall be used to identify pipe contents and direction of flow.

PART 3 EXECUTION

3.01 INSTALLATION

A. The installation of plastic pipe shall be strictly in accordance with the manufacturer's technical data and printed instructions.

B. Joints for PVC and CPVC pipe shall be solvent cemented unless flanged or threaded are otherwise shown on the Drawings or are specified as other types herein. In making solvent cemented connections, clean dirt and moisture from pipe and fittings, bevel pipe ends slightly with emery cloth to remove any shoulder or burrs created by cutting of the pipe. Solvent cement joints shall be made in accordance with ASTM D2855 except that solvent cement formulated especially for and as specified above shall be used for joining CPVC pipe and fittings. Primer shall be used whenever recommended by the pipe, fitting, or cement manufacturer and in all cases for joints on pipe systems 4-in in diameter or larger. Making solvent cement joints shall not be performed and the work shall stop when the temperature, measured in the shade, is 40 degrees F and falling.

C. Joints between PVC drain, waste and vent pipe and cast-iron soil pipe shall be made with approved mechanical compression joints designed for such use.

D. Joints for HDPE pipe shall be butt heat fusion. Butt heat fusion joints shall be made in accordance with the requirements of ASTM D2657.

E. Installation of valves and fittings shall be in accordance with manufacturer's instructions. Particular care shall be taken not to overstress threaded connections. In making solvent cement connections, the solvent cement or primer shall not be spilled on valves. Cement allowed to run from joints shall be cleaned from the pipe and fittings immediately.

F. All piping shall have a sufficient number of unions to allow convenient removal of piping and shall be as approved by the Engineer. PVC and CPVC pipe shall be installed with at least one expansion joint or loop near the center of each straight run of pipe which is 50-ft or longer with the maximum spacing between expansion joints or loops being 150-ft.

G. Where plastic pipe passes through wall sleeves, the space between the pipe and sleeve shall be sealed with a mechanical sealing element as specified in Section 01 60 09.

H. All plastic pipe to metal pipe connections shall be made using flanged connections. Metal piping shall not be threaded into plastic fittings, valves, or couplings nor shall plastic piping be threaded into metal valves, fittings or couplings. Only socket to thread adaptors shall be used for threaded plastic pipe connections to other threaded devices.

I. Concrete inserts for hangers and supports shall be furnished and installed in the concrete as it is placed. The inserts shall be set in accordance with the requirements of the piping layout and the Contractor shall verify these locations from approved piping layout drawings and the structural drawings. Pipe hangers and supports are specified in Section 40 05 75.

J. Due to its large coefficient of thermal expansion, HDPE pipe shall be installed at its maximum operating temperature to prevent sagging between the hangers or supports. Supports at each end of the straight HDPE pipe runs shall be of sufficient strength to develop anchoring forces adequate to oppose the tensile forces developed in the pipe due to thermal contraction. The exception to this requirement shall be for flanged HDPE connections, because, if the flanged connection is made up at the maximum operating temperature, the thermal contraction of the flange thickness will reduce the required tensile force in the flange bolts. Flanged HDPE connections shall, therefore be made up at the lowest expected operating temperature and then the entire piping system shall be brought up to the maximum operating temperature for final installation. (Note: Packing the flanges in ice may be necessary to achieve the proper installation temperature).

3.02 FIELD TESTING

A. All pipelines shall remain undisturbed for the minimum curing or cooling time specified for each type of pipe material but no less than 8 hours to develop full curing and complete strength at all joints. All pipe systems shall be flushed clean and then subjected to a hydrostatic pressure test for 12 hours at a test pressure and temperature specified below. Testing procedures shall be as specified below and in Section 40 05 01. Should the temperature not be attainable under hydrostatic conditions, then the test may be performed under hydro-dynamic conditions, provided that accurate measurements for loss of the test fluid can be made, or the pressure shall be proportionally increased to simulate the stresses of the higher temperature in relation to the lowest system temperature that is expected during the duration of the test. The proportionally higher test pressures shall be determined in accordance with the accepted temperature versus strength properties as published by the pipe manufacturer, PPI or other pipe material standards organization. Allowance for expansion of polyethylene pipe during the test shall be made in accordance with design and installation guidelines in PPI Handbook of Polyethylene Pipe.

B. The test pressures and temperatures for the various pipe lines shall be as follows:

1. Drain piping: 15 psi at ambient temperature

2. Water: 150 psi at ambient temperature

C. The test shall be performed by slowly filling the piping system, expelling entrapped air from all high points. The fill rate shall be controlled so that the fluid velocity within the pipe system is less than 2 fps. Upon completion of the filling process, the system shall be brought up to the specified test temperature as applicable, holding the system pressure to less than 10 percent of the test pressure. Once the system has been stabilized at the specified test temperature, the pipe should be slowly brought up to the test pressure in such a manner so as to not create shock, surge or water hammer in

the pipe system. The test duration time limit shall not begin until the full pressure specified above has been reached and the system has been stabilized to within 5 percent of the test temperature. The system pressure and temperature shall be maintained to within 1/2 percent but no more than 5 percent of the specified value for the temperature and within 5 psi of the specified value for the pressure. These tolerances shall be held for the entire duration of the test. Upon completion of the test, the pressure shall be slowly removed by opening a valve or other pressure relieving device at a location remote to the location of the pressure/temperature monitoring equipment.

D. The pressure test shall be monitored by a recording type pressure gauge for tests not requiring temperature control or a dual pen pressure/temperature recording gauge when temperature control is required. The entire test process shall be recorded, including the initial temperature stabilization and pressurization of the piping system. The record shall be continuous through the system test and shall show the final de-pressurization of the pipe system.

E. All visible leaks detected during the pressure test shall be repaired and the pressure/ temperature test rerun. A successful test shall be a test in which no visible leaks are detected and the pipe system pressure can be maintained within 1/2 percent but no more than 5 psi of the specified value.

F. Prior to testing, the pipelines shall be supported in an approved manner to prevent movement during the tests.

3.03 PAINTING

A. All CPVC and PVC pipe and fittings exposed to the direct sunlight shall be field painted to provide additional UV protection. This painting shall be required whether or not marking is required and shall be in accordance with Section 09 91 10.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required to install and test ductile iron pipe and fittings as shown on the Drawings and as specified herein.

B. Mechanical piping shall include all piping and fittings installed above grade, in utility tunnel or gallery and shall exclude pipe in vaults, manholes, cleanouts and similar yard structures.

C. Mechanical piping shall be installed as shown on the Drawings. For above grade piping, provide pipe supports, hangers and couplings as required to achieve a complete pipe system.

D. Where the word "pipe" is used, it shall refer to pipe, fittings, or appurtenances unless otherwise noted.

E. Review installation procedures under this and other Sections and coordinate installation of items to be installed with or before ductile iron pipe work.

1.02 RELATED WORK

A. Delivery, Storage and Handling is included in Section 01 66 10.

B. Painting is included in Section 09 91 10 and Section 09 91 00.

C. Thermal Insulation is included in Section 23 07 00.

D. Buried Pipe Installation is included in Section 33 05 05.

E. Valves and Appurtenances are included in Section 40 05 50.

F. Piping Specialties are included in Section 40 05 70.

G. Pipe Hangers and Supports are included in Section 40 05 75.

H. Electrical Heat Tracing is included in Section 40 41 13.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, shop drawings and product data required to establish compliance with the Section. Submittals shall include the following

1. Tabulated layout drawings showing actual pipe lengths, diameters, linings, coatings, fittings and appurtenances.

2. Prior to shipment of pipe, submit a certified affidavit of compliance from the pipe manufacturer stating that the pipe, fittings, gaskets, linings and exterior coatings for this project have been manufactured and tested in accordance AWWA and ASTM standards and requirements specified herein.

1.04 REFERENCE STANDARDS

A. ASTM International

1. ASTM A536, Standard Specifications for Ductile Iron Castings.

2. ASTM A563, Specification for Carbon and Alloy Steel Nuts.

3. ASTM G62, Test Methods for Holiday Detection in Pipeline Coatings.

4. ASTM C150 - Standard Specification for Portland Cement.

5. ASTM

B. American National Standards Institute (ANSI)

1. ANSI B1.1 - Unified Inch Screw Threads (UN and UNR Thread Form).

2. ANSI B16.1 - Cast Iron Pipe Flanges and Flanged Fittings Classes 25, 125 and 250.

3. ANSI B18.2 - Square and Hex Bolts and Screws Inch Series Including Hex Cap Screws and Lag Screws.

C. American Water Works Association (AWWA)

1. AWWA C104, Cement Mortar Lining for Ductile Iron Pipe and Fittings for Water.

2. AWWA C110 - Ductile-Iron and Gray-Iron Fittings.

3. AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

4. AWWA C115 - Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.

5. AWWA C116 - Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings.

6. AWWA C150 - Thickness Design of Ductile-Iron Pipe.

7. AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast.

8. AWWA C153 - Ductile-Iron Compact Fittings for Water Service.

9. AWWA C606 - Grooved and Shouldered Joints.

D. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Each length of ductile iron pipe supplied for the project shall be hydrostatically tested at the point of manufacture to 500 psi for a duration of 10 seconds per AWWA C151. Testing may be performed prior to machining bell and spigot. Failure of ductile iron pipe shall be defined as any rupture of the pipe wall. Certified test results shall be furnished in duplicate to the Engineer prior to time of shipment.

B. All ductile-iron pipe and fittings to be installed under this project shall be inspected and tested at the foundry as required by the standard specifications to which the material is manufactured. Furnish in duplicate to the Engineer sworn certificates of such tests and their results prior to the shipment of the pipe.

C. All pipe and fittings to be installed under this Contract may be inspected at the plant for compliance with this Section by an independent testing laboratory selected by the Owner, at the Owner's expense.

D. Inspection of the pipe and fittings will also be made by the Engineer or representative of the Owner after delivery. The pipe shall be subject to rejection at any time on account of failure to meet any of the specified requirements, even though sample pipes may have been accepted as satisfactory at the place of manufacture. Pipe rejected after delivery shall be marked for identification and shall be removed from the job.

E. All pipe and fittings shall be permanently marked with the following information:

1. Manufacturer, date.

2. Size, type, class, or wall thickness.

3. Standard produced to (AWWA, ASTM, etc).

1.06 DELIVERY, STORAGE AND HANDLING

A. See Section 01 66 10 for general requirements.

B. Care shall be taken in loading, transporting and unloading to prevent injury to the pipe or coatings. Under no circumstances shall the pipe be dropped or skidded against each other. Slings, hooks, or pipe tongs shall be padded and used in such a manner as to prevent damage to the exterior surface or internal lining of the pipe. Any damage to the pipe linings or coatings shall be repaired as directed by the Engineer.

C. Materials, if stored, shall be kept safe from damage. The interior of all piping, fittings and other appurtenances shall be kept free from dirt or foreign matter at all times.

D. Pipe ends including flange faces shall be protected from damage. All openings shall be adequately covered to prevent entrance of dirt, water and debris, and keep the pipe interior clean.

E. Pipe shall not be stacked higher than the limits recommended by its manufacturer. The bottom tier shall be kept off the ground on timbers, rails, or concrete. Stacking shall conform to manufacturer's recommendations.

F. If any defective pipe is discovered after it has been installed it shall be removed and replaced with a sound pipe in a satisfactory manner. All pipe and fittings shall be thoroughly cleaned before installing, shall be kept clean until they are used in the work and when installed shall conform to the lines, grades and dimensions required.

PART 2 PRODUCTS

2.01 GENERAL

A. Superceding any lesser pressure ratings in the Contract Documents, all valves and piping shall be rated for at least 150 psi normal working pressure and at least 200 psi max operating pressure, and this equipment (pipe, valves, etc.) shall be certified by the manufacturer as such, and that it is capable of withstanding a 200 psi pressure test for 24 hours duration.

2.02 MATERIALS

A. Pipe

1. Flanged Pipe: Fabricate in accordance with AWWA C115 and C110.
   a. Flanged and groove end pipe shall be Thickness Class 53 per AWWA C150. Pipe shall have a minimum working pressure of 250 psi.
   b. Pipe shall be supplied in standard lengths as much as possible.
   c. Pipe Lining: Protecto 401 for sanitary sewer piping.

2. Ductile iron pipe shall be as manufactured by U.S. Pipe and Foundry Company, Inc.; American Cast Iron Pipe Company; Clow Water System Company, or equal.

B. Joints

1. Flanged Joints
   a. Flanged joints shall be flat face type, unless otherwise noted, meeting requirements of AWWA C110 and capable of meeting the pressure rating or thickness class of the associated piping.
   b. Flange gasket shall be full face type per AWWA C111 to provide positive sealing for the flanged ductile iron joints. Thickness shall be 1/8-in unless otherwise indicated. The gasket material shall be synthetic rubber compound containing not less than 50 percent by volume nitrile or neoprene, and shall be free from factice, reclaimed rubber, and other deleterious substances. Gaskets shall be suitable for the service conditions specified, specifically designed for use with ductile iron pipe and fittings and for potable water pipe shall be certified by NSF61. Gaskets for air piping shall be viton.
   c. Assembly bolts shall be square headed carbon steel machine bolts with hexagon nuts per ANSI B18.2. Thread shall conform to ANSI B1.1. Bolt

length shall be such that after joints are assembled, the bolts shall protrude through the nuts, but not more than 1/2-in.

d. Grooved joints shall conform to AWWA C606 standard rigid couplings and shall be Style 31 couplings as manufactured by Victaulic, or equivalent products of STAR Pipe Products, America, Anvil International or approved equal.
e. Sleeve type couplings shall be Dresser Style 38 or 138 as manufactured by Dresser Industries, or equivalent products of Smith-Blair, Romac Industries, Ford Meter Box Co or approved equal.
f. Flanged coupling adaptors shall be Smith-Blair Type 913, or equivalent products of Klamflex Pipe Couplings (PTY) LTD, Robar Industries LTD or approved equal.

2. Push On Joints
   a. Push on joints shall comply with AWWA C110 and C151 and be capable of meeting pressure rating and test pressure of associated pipe.
   b. Gaskets shall be vulcanized SBR, unless otherwise indicated.
   c. Joints shall be Fastite Joint by American Cast Iron, Tyton Joint by U.S. Pipe, or equal.

3. Restrained Joints
   a. Restrained joints for push on and mechanical joint pipe shall be positive locking type joints manufactured by the pipe and fitting manufacturer that utilizes restraint independent of the joint gasket. Restrained joints shall be capable of being deflected after full assembly. Restrained joints shall be capable of being deflected after full assembly. Field cuts of restrained pipe are not allowed without approval of ENGINEER. If field cuts to accommodate bends are pre-approved by ENGINEER, restraint may be accomplished by mechanical joint bends using methods and products noted below.
   b. Gaskets shall be vulcanized SBR, unless otherwise indicated.
   c. Joints shall be Flex-Ring by American Cast Iron, TR-Flex by U.S. Pipe, or equal.

4. Restrained mechanical joints shall be wedge action retainer glands, as manufactured by: EBAA – Megalug Series 1100, or equal.

C. Fittings

1. Pipe fittings shall be ductile iron with a pressure rating of 250 psi. Fittings shall meet the requirements of AWWA C110 as applicable. Fittings shall have the same pressure rating, as a minimum, of the connecting pipe.

2. Flanged and push-on joint fittings shall be ductile iron with pressure rating, gaskets, bolts, and nuts as specified for flanged joints. Pressure rating of fittings shall meet, but not exceed specified pressure rating of the connected pipe.

3. Restrained joint fittings shall be ductile iron with pressure rating, gaskets, bolts, and nuts as specified for flanged joints. Pressure rating of fittings shall meet, but not exceed specified pressure rating of the connected pipe.

4. Restrained mechanical joint fittings shall be wedge action retainer glands, as manufactured by: EBAA – Megalug Series 1100, or equal.

D. Interior Lining

1. Ductile iron pipe and fittings shall have the same type of lining.

2. Ductile iron pipe and fittings for sewer service shall be lined with a ceramic-filled amine-cured epoxy, Protecto 401 by Induron. The lining thickness shall be 40-mils minimum. Application shall be performed by an applicator approved by the coating manufacturer, in accordance with manufacturer's instructions and under controlled conditions at the applicator's shop or the pipe manufacturer's plant. Applicator shall submit a certified affidavit of compliance with manufacturer's instructions and requirements specified herein.

E. Exterior Coatings

1. Unless otherwise specified, all coatings shall be shop applied with "hold-backs" provided as required at pipe and fitting ends for satisfactory installation for joint connections in the field. Provide all necessary coating materials to perform field coating applications at joints. Unless otherwise noted, field applied coating material shall be compatible with or equal to the shop applied material. Field repair of pipe with damaged coating shall receive prior approval of the Engineer. If, in the opinion of the Engineer that the coating damage is beyond repair the pipe shall be replaced at the expense of the Contractor. All flange bearing surfaces shall be uncoated.

2. Unless otherwise specified, all exposed exterior ferrous surfaces shall be painted with an applicable paint system as specified under Division 9. Surface preparation and application thereof shall be in conformance with applicable provisions of Division 9.

F. Pipe Hangers and Supports

1. Pipe hangers and supports shall be provided at suitable distance along the pipeline regardless whether they are shown or not shown on the Drawings.

2. Pipe hangers and supports shall be as specified in Section 40 05 75.

G. Thermal Insulation

1. Insulation shall be provided as indicated on the Drawings.

2. Pipe insulation shall be as specified in Section 23 07 00.

PART 3 EXECUTION

3.01 PIPE INSTALLATION

A. General

1. All piping and fittings shall be installed true to alignment and rigidly supported. Anchorage shall be provided where required. Any damage to linings shall be repaired to the satisfaction of the Engineer before the pipe is installed. Each length of pipe shall be cleaned out before installation. All of manufacturer's recommendations shall be complied with.

2. The deflection at joints shall not exceed that recommended by the pipe manufacturer. Fittings, in addition to those shown on the Drawings, shall be provided, if required, in areas where conflict exists with the existing facilities.

3. When pipe cutting is acceptable to the Engineer, the cutting shall be done by abrasive saw, leaving a smooth cut at right angles to the axis of the pipe. Any damage to the lining shall be repaired to the satisfaction of the Engineer. Field cut ends shall be sealed with approved epoxy coating in accordance with manufacturer's instructions.

4. Ductile iron and fittings shall be installed in accordance with requirements of AWWA C600 modified.

5. Buried piping shall be installed in accordance with Section 33 05 05.

B. Jointing

1. Flanged joints shall be made using gaskets, bolts, bolt studs with a nut on each end, or studs with nuts where the flange is tapped. The number and size of bolts shall conform to the same ANSI Standard as the flanges.

2. Bolts in flanged joints or mechanical joints shall be tightened alternately and evenly.

3. Sleeve type couplings and grooved joints using split ring couplings shall be installed in accordance with the procedures recommended by their respective manufacturers.

C. All pipe and appurtenances connected to equipment shall be supported in such a manner as to prevent any strain being imposed on the equipment. When manufacturers have indicated requirements that piping loads shall not be transmitted to their equipment, submit a certification stating that such requirements have been complied with.

D. Sleeves of proper size shall be installed for all pipes passing through floors or walls. Sleeves shall be installed as shown on the Drawings. Where indicated on the Drawings or required for liquid or gas-tightness, the pipe shall be sealed with a mechanical seal similar to Link-Seal as manufactured by Thunderline Corporation, or equal.

E. Sleeves and wall pipes shall have thrust collar located at the mid-depth of wall.

F. Concrete inserts for hangers and supports shall be furnished and installed as recommended by the manufacturer as shown on the Drawings or as specified herein. The inserts shall be set in accordance with the requirements of the piping layout and

their locations verified from approved piping layout drawings and the structural drawings.

3.02 TESTING

A. All piping shall be subject to acceptance tests. Provide all necessary utilities, labor and equipment for flushing and testing and dispose all waste after the test including water.

B. All ductile iron pipe and fittings shall be pressure tested using water to 200 psi for one hour and the pipeline shall show no leakage.

C. Correct any leakage and repair any damage to the pipe and pipe appurtenances or to any structures resulting from, or caused by tests. All leaks shall be repaired and lines retested.

D. See Section 40 05 00 for additional requirements.

3.03 CLEANING

A. Clean the pipe by flushing with water or other means to remove all dirt, stones, pieces of wood, or other material which may have entered during the construction period. All debris shall be removed from the pipeline. The lowest segment outlet shall be flushed last to assure debris removal.

3.04 PIPE MARKING

A. All exposed piping, exterior and interior, shall be identified by painted legend markers, directional arrow markers and number markers as required. Pipe marking colors shall contrast with pipe color for ease of visibility. Pipe marking shall match the existing markings. Letters and markers with a width of 1-1/8-in in width shall be installed on pipes under 3-in in diameter. Markers with a width of 2-1/2-in in width shall be installed on pipes 3-in in diameter and larger. Legend markers, directional arrow markers and number markers shall be placed as directed by the Engineer. Markers shall be located where pipes pass through walls or floors, at piping intersections and maximum 15-ft spacing on piping runs.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install complete and ready for operation and test all non-buried valves as shown on the Drawings and as specified herein.

B. The equipment shall include, but not be limited to, the following; however not all items specified herein may be included in this project.

1. General Requirements.
2. Valve Actuators – General/Manual
3. Valve Actuators – Electric
4. Valve Boxes
5. Gate Valves.
6. Plug Valves.
7. Check Valves.
8. Thermoplastic Valves
9. Yard Hydrants and Hose Bibbs
10. Backflow Preventers
11. Solenoid Valves.
12. Corporation Stops.
13. Air Release and Vacuum Relief Valves.
14. Hose End Valves.

1.02 RELATED WORK

A. Shop and Finish painting is included in Sections 09 91 10 and 09 91 00.

B. Pipe hangers, supports and anchorage are included in Section 40 05 75.

C. Instrumentation, not specified herein, is included in Division 40.

D. Valves on HVAC and plumbing systems are included in their respective Sections of Division 23.

E. Electrical work is included in Division 26.

F. Certain items similar to those specified in this Section may be specified to be furnished and installed with individual equipment or systems. In case of a conflict, those individual equipment or system requirements shall govern.

G. Electric valve operators of all types, rate of flow controllers (including modulating valves and operators) and other types of valves which are part of the automated instrumentation (such as some solenoid valves) if not included herein are included in Division 40. Valve operators shall, however, be mounted at factory on valves as specified herein, as part of the work of this Section.

H. Pipeline appurtenances are included in Section 40 05 70 and include the following:

1. Unions.
2. Flanged Joints.
3. Dielectric Connectors.
4. Plugs and Caps.
5. Miscellaneous Adaptors.
6. Vents and Drains.
7. Line Strainers.
8. Service Clamps.
9. Cleanouts.
10. Floor Drains.
11. Quick Connect Couplings.
12. Mechanical Sleeve Seals.
13. Flexible Connectors.
14. Expansion Joints.
15. Harnessing and Restraints.
16. Pressure Gauges.
17. Air Temperature Gauges.
18. Diaphragm Seals and Snubbers for Gauges.
19. Rotameters and Flow Indicators.
20. Pipe Cleaning Equipment.

21. Spray Nozzles.

22. Appurtenances and Miscellaneous Items.

23. Color Coding and Labeling.

24. Duplex Basket Strainer.

1.03 SUBMITTALS

A. Submit to Engineer, in accordance with Section 01 33 23, materials required to establish compliance with this Section. First submittal shall be valve schedule described in paragraph 1.09. Approval of valve schedule submittal is required prior to Contractor submitting any of equipment in this specification. Subsequent Equipment Submittals shall include at least the following:

1. Valve tag number.

2. Manufacturer and supplier.

3. Address at which equipment will be fabricated or assembled.

4. Drawings showing assembly details, materials of construction and dimensions.

5. Descriptive literature, bulletins and/or catalogs of the equipment.

6. Total weight of each item.

7. A complete bill of materials.

8. Additional submittal data, where noted with individual pieces of equipment.

9. Individual electrical control schematics and wiring diagrams for each valve operator with external interfaces, identified exactly as detailed on Electrical and Instrumentation Drawings. Standard catalogue cut sheets that show typical wiring diagrams only are not acceptable. Valve actuators shall be coordinated with electrical requirements shown on Drawings and valves as specified herein.

B. Test Reports:

1. Provide certified hydrostatic test data, per manufacturer's standard procedure or MSS-SP-61 for valves.

C. Certificates:

1. For each valve specified to be manufactured, tested and/or installed in accordance with AWWA and other standards, submit an affidavit of compliance with appropriate standards, including certified results of required tests and certification of proper installation.

D. Manufacturer's Installation and Application Data.

E. Operating and Maintenance Data.

1. Operating and maintenance instructions shall be furnished to Engineer as provided in Section 01 78 23. Instructions shall be prepared specifically for this installation and shall include required cuts, drawings, equipment lists, descriptions and other information required to instruct operating and maintenance personnel unfamiliar with such equipment.

F. Warranty

1. See Section 01 78 36.

1.04 REFERENCE STANDARDS

A. ASTM International:

1. ASTM A48 - Standard Specification for Gray Iron Castings.

2. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.

3. ASTM A240 - Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels.

4. ASTM A276 - Standard Specification for Stainless Steel Bars and Shapes.

5. ASTM A436 - Standard Specification for Austenitic Gray Iron Castings.

6. ASTM A536 - Standard Specification for Ductile Iron Castings.

7. ASTM B30 - Standard Specification for Copper-Base Alloys in Ingot Form.

8. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings.

B. American Water Works Association (AWWA):

1. AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

2. AWWA C500 - Metal-Seated Gate Valves Supply Service.

3. AWWA C504 - Rubber-Seated Butterfly Valves.

4. AWWA C507 - Ball Valves, 6-in through 48-in (150mm through 1200mm).

5. AWWA C508 - Swing-Check Valves for Waterworks Service, 2-in (50mm through 24-in (600mm) NPS.

6. AWWA C509 - Resilient-Seated Gate Valves for Water Supply Service.

7. AWWA C511 - Reduced-Pressure Principle Backflow-Prevention Assembly.

8. AWWA C540 - Power-Actuating Devices for Valves and Sluice Gates.

9. AWWA C541 - Hydraulic and Pneumatic Cylinder and Vane Type Actuators for Valves and Slide Gates.

10. AWWA C550 - Protective Epoxy Interior Coatings for Valves and Hydrants.

11. AWWA C800 - Underground Service Line Valves and Fittings.

C. American National Standards Institute (ANSI):

1. ANSI B1.20.1 - Specifications, Dimensions, Gauging for Taper and Straight Pipe Threads (except dry seals).

2. ANSI B16.1 - Cast Iron Pipe Flanges and Flanged Fittings.

3. ANSI B16.10 - Face-to-Face and End-to-End Dimensions of Valves.

D. American Iron and Steel Institute (AISI).

E. Manufacturer's Standardization Society of the Valve and Fittings Industry (MSS):

1. MSS-SP-61 - Pressure Testing of Steel Valves.

2. MSS-SP-70 - Cast Iron Gate Valves, Flanged and Threaded Ends.

3. MSS-SP-71 - Cast Iron Swing Check Valves, Flanges and Threaded Ends.

4. MSS-SP-72 - Ball Valves with Flanged or Butt-Welding Ends for General Services.

5. MSS-SP-78 - Cast Iron Plug Valves, Flanged and Threaded Ends.

6. MSS-SP-80 - Bronze Gate, Globe, Angle and Check Valves.

7. MSS-SP-82 - Valve Pressure Testing Methods.

8. MSS-SP-98 - Protective Coatings for the Interior of Valves, Hydrants and Fittings.

F. National Electrical Manufacturers Association (NEMA).

G. Underwriters Laboratories (UL).

H. Factory Mutual (FM).

I. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Valves and appurtenances shall be products of well-established firms who are fully experienced, minimum ten years, reputable and qualified in manufacture of particular equipment to be furnished.

2. Equipment shall be designed, constructed and installed in accordance with best practices and methods and shall comply with this Section as applicable.

3. Units of the same type shall be the product of one manufacturer.

4. All 480 volt motor actuators shall be product of one manufacturer. Contractor shall coordinate this requirement with vendors who supply actuated valves as part of systems specified in Division 40.

B. Certifications:

1. Manufacturers shall furnish an affidavit of compliance with Standards referred to herein as specified in paragraph 1.03.C above. Refer to Part 3 for testing required for certain items in addition to that required by referenced standards.

C. Provide services of a qualified and factory-trained service representative of manufacturer to provide operational and maintenance instruction, for a one day, eight-hour period for each type of the following equipment:

1. Valve motor operators.

2. Air release, air and vacuum valves.

3. Surge relief valves.

4. Hydraulic cylinder actuators.

D. Inspection of units may also be made by Engineer or other representative of Owner after delivery. Equipment shall be subject to rejection at any time due to failure to meet any of specified requirements, even though submittal data may have been accepted previously. Equipment rejected after delivery shall be marked for identification and shall be removed from job site at once.

1.06 SYSTEM DESCRIPTION

A. Equipment and materials specified herein are intended to be standard for use in controlling flow of water, wastewater, sludge, air, and chemicals as noted on Drawings.

B. Valves, appurtenances and miscellaneous items shall be installed as shown on Drawings and as specified, so as to form complete workable systems.

C. Unless otherwise noted, powered valve operators shall have:

1. Valves larger than 3-in: electric operators 460 Volt, 3 Phase, 60 Hz.

2. Valves 3-inch and under: electric operators, 120 Volt, 1 Phase, 60 Hz.

3. Solenoid valves: 120 volt, single phase, 60 Hz, NEMA 4 enclosure, continuous duty Class F coils and manual operator. Solenoid valves for seal water systems shall be "fail open" design; others shall be "fail closed" unless otherwise noted on Drawings or in the Instrumentation specifications.

1.07 DELIVERY, STORAGE AND HANDLING

A. Reference is made to Section 01 66 10 for additional information.

B. Packing and Shipping:

1. Care shall be taken in loading, transporting and unloading to prevent injury to the valves, appurtenances, or coatings. Equipment shall not be dropped. Valves and appurtenances shall be examined before installation and no piece shall be installed which is found to be defective. Damage to the coatings shall be repaired as acceptable to Engineer.

2. Prior to shipping, ends of valves shall be acceptably covered to prevent entry of foreign material. Covers shall remain in place until after installation and connecting piping is completed.
   a. Valves 3-in and larger shall be shipped and stored on site until time of use with wood or plywood covers on each valve end.
   b. Valves smaller than 3-in shall be shipped and stored as above except that heavy cardboard covers may be used on the openings.
   c. Rising stems and exposed stem valves shall be coated with a protective oil film which shall be maintained until the valve is installed and put into use.
   d. Corrosion in evidence at the time of acceptance by the Owner shall be removed, or the valve shall be removed and replaced.

C. Storage and Protection:

1. Special care shall be taken to prevent plastic and similar brittle items from being directly exposed to the sun, or exposed to extremes in temperature, to prevent deformation. See the individual piping sections and manufacturer's information for further requirements.

1.08 SPECIAL TOOLS AND SPARE PARTS

A. Special tools and the manufacturer's standard spare parts, if required for normal operation and maintenance, shall be supplied with the equipment in accordance with Section 01 13 10 and where noted, as specified herein. Tools shall be packaged in a steel case, clearly and indelibly marked on the exterior to indicate equipment for which tools are intended.

B. Provide one operations and maintenance manual for each type of valve and operator supplied under this specification in accordance with Section 01 78 23.

C. Included within operations and maintenance manuals, provide a list of all spare and replacement parts with individual prices and location where they are available.

1.09 VALVE DESIGNATIONS AND SCHEDULE

A. Valves shall be identified by a unique valve tag as identified in valve schedule prepared by Contractor. Specific type of valve to be used will be identified by symbol and/or call out on Drawings. Contractor shall identify each valve by its assigned tag number on shop drawings and equipment submittals.

B. Contractor shall refer to the P&IDs and mechanical plans for type of each valve called out by abbreviation or drawing symbol. Prior to first valve submittal, Contractor shall submit a detailed valve schedule listing process valves to be furnished along with Contract Drawing P&IDs edited electronically which shall include valve tag numbers prepared by Contractor identifying each valve. This valve schedule shall NOT include valves furnished under Plumbing and HVAC sections of Division 23. Valve schedule shall include: valve tag number; valve designation; valve size; end connections and operator type. Valve tag convention shall be four digits long, numbering shall be linked to the P&ID Sheet on which it is shown. Identical valves in same position in parallel processes (EX. Pump inlet/outlet isolation valves where there are three parallel pumps of same type) shall have same tag number followed by a hyphen and quantifier -1, 2, 3 etc. Where electric, hydraulic or pneumatic actuators are supplied their type shall be so noted with an E, H or P. Modulating duty actuators shall be noted with an M following the actuator type notation. An excerpt of an EXAMPLE schedule is as follows:

Valve Tag.	Designation	Size	Ends	Operator	Notes
1000-1	BFV100	8-in	Flanged	Gear/Hand wheel	Extra description as necessary
1000-2	BFV100	8-in	Flanged	Gear/Hand wheel	
1005	PV103	6-in	Flanged	EM	

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT - GENERAL

A. Reference is made to Division 1 for additional requirements, including nameplates, provisions for temporary pressure gauges, protection against electrolysis and anchor bolts.

B. Use of a manufacturer's name and/or model or catalog number is for purpose of establishing standard of quality and general configuration desired.

C. Valves and appurtenances shall be of size shown on the Drawings or as noted and as far as possible equipment of same type shall be identical and from one manufacturer.

D. Valves and appurtenances shall have name of maker, nominal size, flow directional arrows, working pressure for which they are designed and standard referenced, cast in raised letters or via riveted stainless steel nameplate upon some appropriate part of the body.

E. Unless otherwise noted, items shall have a minimum working pressure of 150 psi or be of same working pressure as pipe they connect to, whichever is higher and suitable for pressures noted where they are installed.

F. Joints, size and material - unless otherwise noted or required by Engineer:

1. Joints referred to herein shall be of same type, nominal diameter, material and with a minimum rating equal to pipe or fittings they are connected to.

2. Valves and appurtenances shall be of same nominal diameter as pipe or fittings they are connected to.

3. Valves exposed to view, or in vaults:
   a. Plastic valves in chemical service - solvent cement, or flanged ends.
   b. 3-in and smaller - threaded ends- unless noted otherwise herein or on Drawings.
   c. 4-in and larger - flanged ends.

G. Provide special adaptors as required to ensure compatibility between valves, appurtenances, and adjacent pipe.

H. Valves and actuators shall be especially designed for submerged service where water may completely submerge the valve and operator.

I. Where applicable, valves shall be especially constructed for buried service.

J. All valves shall be provided with a permanent number plate. The location of number plates and the method of fastening shall be approved by the Engineer. Numerals shall be at least 1 inch high and shall be black baked enamel on an anodized aluminum plate. Plates shall be fastened prior to shipping.

2.02 VALVE ACTUATORS – GENERAL/MANUAL

A. Geared actuators shall be suitable for all weather service, with mechanical shaft seals, shall be permanently greased, or shall have provisions for greasing. Actuators for submerged duty shall be so rated, with certification by manufacturer for submerged service.

B. Valve manufacturer shall supply, mount, and test all actuators on valves at factory. Valves and their individual actuators shall be shipped as a unit.

C. Unless otherwise noted on Drawings, valves shall be manually actuated; non-buried valves shall have an operating wheel, handle or lever mounted on operator; buried

valves and those with operating nuts shall have a non-rising stem with an AWWA 2-in nut; At least two tee handles shall be provided for operating nuts. Unless otherwise noted, operation for valves shall be CCW open.

D. Manually actuated butterfly valves 6 inches and smaller for fluid service shall have a 10 position, spring retained ratcheting handle. Handle shall be fusion bonded epoxy coated steel or cast iron, hardware, spring and ratcheting plate shall be Type 316 stainless steel. Manually actuated butterfly valves for air service 6 inches and smaller shall have a memory stop handle with infinite throttling position capability. Memory stop plate and hardware shall be Type 316 stainless steel.

E. Except as otherwise shown on Drawings or specified herein, valves 3-in diameter or larger, with valve hand wheel center line located 7-ft or more above operating floor, shall be provided with chain wheel operators complete with chain guides and hot dipped galvanized steel chain, which loop within 4-ft of operating floor. These requirements shall supersede positioning lever actuator requirements of manual butterfly valves 6 inch and smaller.

F. Actuators shall be capable of moving valve from full open to full close position and in reverse and holding valve at any position part way between full open or closed.

G. Each operating device shall have cast on it the word "OPEN" and an arrow indicating direction of operation.

H. Floor boxes for operating nuts recessed in concrete shall be standard cast iron type, cast-in-place, with fastening top.

I. Stem guides shall be of the adjustable wall bracket type, bronze bushed, with maximum spacing of 10-ft as manufactured by Clow, Rodney Hunt or equal. Extended operating nuts and/or stems shall have universal joints and pin couplings, if longer than 10-ft and a rating of at least five times the maximum operating torque. Stem adaptors shall be provided.

J. Where required by installation, or as specified, provide the following: extended stem; floor stand and handwheel; position indicator and etched or cast arrow to show direction of rotation to open the valve; resilient, moisture-resistant seal around stem penetration of slab.

K. Gear Actuators:

1. Unless otherwise noted, gear actuators shall be provided for the following: plug valves of 6-in and larger diameter, all buried valves with operating shaft mounted horizontally (butterfly, plug, etc.), ball valves larger than 3-in diameter; where specified and/or indicated on Drawings; where manual operator effort is greater than 40 lbs rim pull.

2. Actuators shall be capable of being removed from valve without dismantling the valve or removing valve from the line.

3. Gear actuators for quarter turn valves shall be of worm or helical worm gear type with output shaft perpendicular to valve shaft, having a removable hand wheel

mounted on output shaft. Where shown on Drawings or specified, a two inch cast iron operating nut shall be provided. Actuators shall conform to AWWA C504 except where more stringent requirements are provided hereinafter. Gearing shall be machine cut steel designed for smooth operation. Bearings shall be permanently lubricated, with bronze bearing bushings provided to take thrusts and mechanical shaft seals to contain lubricants. Housings shall be sealed to exclude moisture and dirt, allow reduction mechanisms to operate in lubricant and be constructed of cast iron, ASTM A 126, Grade B, or of ductile iron, ASTM A 536. Gear housing bodies for thermoplastic valves may be cast aluminum or fabricated steel to reduce weight. Gear actuators shall indicate valve position and have adjustable stops.

4. Where indicated on Drawings or specified, gear actuators for butterfly valves shall be of travelling nut type with output shaft perpendicular to valve shaft, having a removable hand wheel mounted on output shaft. Unless noted they shall conform to AWWA C504. Stem shaft shall be machine cut alloy steel, nut and cross head shall be bronze, lever shall be ductile iron. Nut Actuators for valves 24-in and smaller shall be slotted lever design, actuators for valves greater than 24 inch shall be link and lever design. Mechanism shall be lubricated with water resistant extreme pressure NLGI No. 2 grease. Bevel gear reduction box shall be mounted on the actuator when required to meet specified manual operating effort requirements Gear actuators shall have mechanical, external indication of valve position and have adjustable threaded stops secured to the stem with spring pins. Stop shall be capable of withstanding 450-fts-lb of input torque. Stop adjustment requiring shims are not acceptable.

5. Manual Input torque to produce required valve operating torque for worm and travelling nut gear operators shall not exceed 80 ft-lbs. In addition, hand wheel rim pull shall not exceed 20 lbs for valve sizes up to 12 inches, 40 lbs for valve size between 14 and 20 inches, 60 lbs for valve size 24 and greater. Minimum hand wheel size shall be 8 inches for up to 12-inch valve size, 12 inches for up to 16-inch valve size, 18 inches for up to 20-inch size.

6. Gear actuators for multi turn valves shall be of bevel or spiral bevel type with output shaft perpendicular to valve shaft, having a removable hand wheel mounted on output shaft. Gearing shall be machine cut steel designed for smooth operation. Bearings shall be permanently grease lubricated, with dual anti-friction ball bearings on output shaft and mechanical shaft seals to contain lubricants. Output flange of primary gear reducer shall be designed to meet an appropriate MSS or ISO standard to allow mounting to secondary gear reducer. Ring gear shall ride on ball bearings. Stem nut shall be bronze alloy, shouldered, and ride on needle bearings. Housing components shall be o-ring sealed to exclude moisture and dirt, constructed of cast iron, ASTM A 126, Grade B, or of ductile iron, ASTM A 536. Gear housing bodies for thermoplastic valves may be cast aluminum or fabricated steel to reduce weight. Manual operator input effort to the hand wheel shall be a maximum of 30 lbs for operating the valve from full open to full close, under any conditions. Maximum hand wheel size shall be 24-in diameter.

L. Additional valve actuator requirements are included with the individual valve types and as noted in paragraph 1.02 above.

M. Position indication and direction of opening arrows shall be embossed, stamped, engraved, etched, or raised castings. Decals or painted indications shall not be allowed.

N. Unless otherwise noted, valves larger than 3-in nominal diameter shall be provided with position indicators at the point of operation.

2.03 VALVE ACTUATORS - ELECTRIC

A. General:

1. Electric actuators for 1/4 turn valves three inches and under, which do not have submergence requirements, and which exhibit a maximum torque specified below shall be operated on 120 volt single phase power as specified below. Other actuators shall be operated on 480 volt power.

2. Actuators shall conform to AWWA Standard C540, insofar as applicable and as herein specified. Actuators shall be O-ring sealed, watertight to standard NEMA 4X/6, submersion to 6 feet for 30 minutes. Actuators installed in vaults below grade and elsewhere subject to submergence shall be watertight to standard NEMA 6P/IP68, 15 ft for 72 hours minimum. Actuators installed in hazardous locations as noted on the Electrical Drawings and/or area classification sheets of the Architectural Drawings shall be FM certified explosion proof for Class 1 Division 1 & 2, Groups C & D and also meet the standard NEMA 4X/6 rating.

3. Valve service/operation shall be as indicated on the P&IDs and as specified in the Process Control Strategies in Section 40 96 45.

4. 480 Volt powered actuators shall be Rotork IQ/IQM; Limitorque MX; EIM TEK 2000. Actuators shall be configured as required to provide for part turn or multi-turn and be coupled with gearboxes as required to obtain the speed and operating torque as required for the valve or gate it controls.

5. Modulating actuators shall contain proportional control unit and be capable of 1200 starts per hour, open-closed valve actuators shall not require a proportional control unit, and be capable of 60 starts per hour.

6. Where shown on Instrumentation Drawings, actuators shall have a digital control module, to allow valves or gates to be positioned remotely via a 2-wire non-proprietary field bus protocol. Digital control module shall be equipped with serial communication ports to allow actuation to be linked by a two wire local area network utilizing Modbus function code (report by exception) and arranged in a self-healing ring configuration, with multi-drop taps to each actuator.

B. 120 Volt Single Phase Reversing, Non-Spring Return Electric Actuators for 1/4 Turn Valves, 100 to 1000 in-lb Torque Range

1. Valve actuators shall be sized by valve supplier meeting requirements of AWWA C540. Actuators shall be mounted on valves in valve supplier’s facility, and factory tested.

2. Actuators shall operate on 120 volt, 60 hz single phase, power supply. Enclosure rating shall be NEMA 4X, constructed of cast aluminum or steel alloy, powder coated or fusion bonded epoxy finish.

3. Power train shall be self-locking planetary epicyclical gear design, consisting of hardened steel and or hardened bronze alloy gears with bronze bearings. Housing penetrations shall be sealed with mechanical seals. Housing shall be equipped with space heaters. Valve mounting system shall be ISO 5211.

4. Actuator shall be designed for open/close/jog reversing service. Proportional/ modulating service shall be provided where required in the equipment specifications or Instrumentation Drawings. Actuators shall have visual mechanical indication of position. Manual override shall be direct worm drive with minimum 5 inch diameter hand wheel. Hand wheel size shall be provided such that a maximum 40 lb rim pull is required.

5. Motors shall be designed specifically for valve actuation service, with Class F insulation, with split phase capacitor protection. Duty cycle shall not be less than 40% at 100 degrees F. for open/close duty, and 100% for modulating duty. 90 degree travel time shall vary from 10 to 20 seconds depending on actuator size. Actuators shall have SPDT contacts for remote valve position indication.

6. Actuators shall be P Series as manufactured by Promation Engineering, Brooksville, FL, or equal.

C. 480 Volt Powered Actuators for Part Turn or Multi-Turn Valve Operation:

1. Operation:
   a. Capabilities shall be provided to position valve (or gate) locally via Local/Off/Remote selector switch and Open/Stop/Close push buttons.
   b. For on/off service, when in remote, actuator shall accept one remote signal to open valve or gate and a second remote signal to close valve or gate.
   c. For modulating service, when in remote actuator shall accept a 4-20mADC position control signal, and shall position valve 0-90 degrees or gate 0-100% of travel in proportion to control signal.
   d. Unless stated otherwise in valve specifications, actuator and gearing size shall be designed to operate valve at a disc speed of one foot travel per minute of operation. For quarter turn valves, valves shall rotate from stop to stop in 30 seconds per foot of throat diameter.

2. Functional:
   a. Motor operated valve controller shall include motor, operator unit gearing, limit switch gearing, limit switches, control power transformer, position transmitter (when required), torque switches, bored and key-wayed drive sleeve for non-rising stem valves, declutch lever and auxiliary handwheel as a self-contained unit. Valve contacts shall be capable of handling the current equivalent of a NEMA 1 size starter.
   b. Reversing starters shall be integral with actuator, and shall be solid-state starters for modulating service. Electro-mechanical reversing starters shall be acceptable for open-close service and shall be mechanically and electrically interlocked.

c. Limit switches and gearing shall be an integral part of valve control. Limit switch gearing shall be made of bronze or stainless steel and shall be fully lubricated, intermittent type and totally enclosed to prevent dirt and foreign matter from entering gear train. Limit switches shall be of adjustable type capable of being adjusted to trip at any point between fully opened valve and fully closed valve. Limit and torque switches shall be provided for stopping valve in both directions. Mid-travel switches shall be provided as required. Set position shall not be lost if over travel occurs in either manual or electric modes of operation.

d. Valve position transmitter shall be a gear actuated, two-wire device, producing 4-20 mADC signal proportional to 0-90 degree valve position or to 0-100% of valve travel. Transmitter shall be provided with easily accessible zero and span adjustment potentiometers. Valve actuator shall be provided with a local digital or mechanical indicator integral with operator with a 0-100 percent scale. DC power supply shall be provided integral with operator and powered from 110 volt AC internal transformer. Positioner board shall provide repeatable accuracy to 0.25% of span. There shall be separate trim pots on positioner board for zero, span and dead band adjustment.

e. Speed of actuator shall be responsibility of system supplier with regards to hydraulic requirements and response compatibility with other components within control loop. Each valve controller shall be provided with a minimum of two limit switch functions, one for opening and one for closing. Each limit switch will have two normally open and two normally closed contacts. Gear limit switches shall be geared to driving mechanism and in step at all times whether in motor or manual operation. Provision shall be made for two extra sets of limit switches as described above, each to have two normally open and two normally closed contacts. Each valve controller shall be equipped with a double torque switch. Torque switch shall be adjustable and responsive to load encountered in either direction of travel. Limit and torque switch contacts shall be silver inlay type.

f. Each actuator shall include monitor relays to remotely indicate fault signal for indication of power failure, phase failure, thermal switch tripped, torque switch tripped between travel stops and Local-Off-Remote selector switch position.

3. Physical:

a. Operator shall be equipped with open-stop-close push-buttons, a local-off-remote selector switch and indicating lights mounted on operator. Where operator will not be situated between 2-ft-0-in and 7-ft-0-in above operator platform, and where shown on Drawings provide a separate remote valve operating station.

b. Motor shall operate on 460 volt, 60 hertz, 3 phase power and shall be sized by actuator manufacturer to provide the required output torque for service intended. Motor shall have Class F insulation, with a duty rating of at least 15 minutes at 40 degrees C ambient temperature. Motor shall be specifically designed and built by actuator manufacturer for electric actuator service. Commercially available motors shall not be acceptable. Actuator shall include a device to ensure that motor runs with correct

rotation for required direction of valve travel regardless of connection sequence of the power supply.

c. Operators utilizing multiple reduction power gearing shall consist of spur, helical, or bevel gearing and worm of hardened alloy steel, and the worm gear shall be alloy bronze. Operators utilizing single-stage reduction shall be single-stage worm gear totally enclosed in a fully lubricated gearcase, with filling and drain plugs. Non-metallic, aluminum, or cast gearing shall not be allowed. Output shaft shall incorporate thrust bearings of the ball or roller type at the base of the actuator.

d. An operating wheel shall be provided for manual and/or emergency operation, engaged when motor is declutched by a lever or similar means, the drive being restored to power automatically by starting the motor. Operating wheel drive shall be mechanically independent of motor drive, and any gearing shall be such as to permit emergency manual operation, using a 40 pound force in a reasonable time. Clockwise operation of handwheel shall give closing movement of valve unless otherwise stated.

e. Each actuator shall be supplied with a start-up kit including installation instructions, wiring diagrams, and spare cover screws and seals to provide for losses during commissioning.

f. Continuous mechanical dial indication of valve and position shall be provided. Mechanical dial position indicator shall be in step with actuator at all times in both hand wheel and motor operation. For modulating applications, mechanical dial position indicator shall include graduations of 0-100 percent scale.

4. Wiring and Terminals:

a. Internal wiring shall be of tropical grade PVC insulated stranded cable of 5 amp minimum rating for control circuits and of appropriate size for the motor 3 phase power. Each wire shall be clearly identified at each end.

b. Terminals shall be of stud type embedded in a terminal block of high tracking-resistance compound. The 3-phase power terminals shall be shrouded from control terminals by means of an insulating cover.

c. Terminal compartment shall be separated from inner electrical components of actuator by means of a watertight seal. Terminal compartment of actuator shall be provided with three threaded cable entries.

d. Each actuator shall be provided with a commissioning kit consisting of a wiring diagram and installation and operation manual. A separate wiring diagram shall be provided inside the terminal cover. No special tools, devices or parts shall be required for commissioning.

e. Actuators shall have separately sealed motor and control compartments. Operators shall have space heaters in their limit switch, motor, and control compartments.

5. Remote Control Stations:

a. Where shown on Drawings, or where specified in Equipment Specifications, valve actuators shall be furnished with control stations suitable for mounting remotely from, but, in vicinity of actuator. Remote mount control station shall include a Local - Off - Remote selector switch, Open - Stop - Close pushbuttons and Open - Close indicating lights. Control station operators shall be heavy duty devices mounted in a cast iron, cast aluminum, or stainless steel NEMA 4X enclosure suitable for wall

mounting. Wire gage and device quality shall meet or exceed the requirements of Division 26. Local - Off - Remote selector switch shall have auxiliary contacts for remote indication of switch position. Local - Off - Remote selector switch shall have provisions for padlocking in the "Off" position. Additional functionality and/or devices to those specified above are detailed on Instrumentation P&IDs and/or Electrical Control Schematic drawings. Refer to Drawings for confirmation of scope of the Remote Control Stations.

6. Performance Test:
   a. Each actuator shall be shop performance tested, and individual test certificates shall be supplied without additional charge to Owner. Test certificates shall be submitted prior to shipment of valve actuators. Test equipment shall simulate a typical valve load, and the following parameters shall be recorded:
      1) No load current.
      2) Current at maximum torque setting.
      3) Stall current.
      4) Torque at maximum torque setting.
      5) Stall torque.
      6) Test voltage and frequency.
      7) Flash test voltage.
      8) Actuator output speed.

2.04 VALVE BOXES

A. All buried valves shall be provided with extension shafts, operating nuts and valve boxes as follows:

1. Extension shafts shall be solid Type 316 stainless steel and the operating nuts shall be 2-inch square stainless or bronze. Shafts shall be designed to provide a factor of safety of not less than four. Operating nuts shall be bolted to the shafts with stainless steel bolts or adequate diameter to withstand 150 percent of the normal operating torque.

2. Top of the operating nut shall be located 2-inch below the rim of the valve box.

3. Valve boxes shall be as manufactured by Clow; or equal and shall be a heavy-pattern cast iron, three-piece, telescoping type box with dome base suitable for installation on the buried valves. Inside diameter shall be at least 4-1/2-inch. Barrel length shall be adapted to the depth of cover, with a lap of at least 6-inch when in the most extended position. Covers shall be cast iron with integrally cast direction-to-open arrow and the word “Water”, “Sewer”, or “Drain” (as applicable) cast in the top. Aluminum or plastic are not acceptable. A means of lateral support for the valve extension shafts shall be provided in the top portion of the valve box.

4. The upper section of each box shall have a bottom flange of sufficient bearing area to prevent settling. The bottom of the lower section shall enclose the stuffing box and operating nut of the valve and shall be oval.

5. A position-indicating device shall be provided for each valve. The position-indicating device shall be GPI Series Geared Position Indicator by DynaTorque, Inc., Muskegon, MI or equal, which shall mount over the shaft and visually show the position of the valve at all times. All material shall be noncorrosive, nonmagnetic, and shall require no lubrication. Unit shall be furnished and arranged for use with the valve box. The required valve box adapters and cover shall be provided.

6. An approved operating key or wrench shall be provided one per every three valves of each type furnished.

7. All fasteners shall be Type 316 stainless steel.

2.05 GATE VALVES: TAG TYPE NOTED BELOW

A. General Requirements:

1. Unless otherwise specified below, these requirements shall apply to gate valves.

2. Gate valves shall meet requirements of AWWA C500, AWWA C509 and AWWA C515 as applicable to type of valve specified.

3. Submerged valves shall be furnished with mechanical joints and Type 316 stainless steel hardware; non-rising stem design. Flanges shall be provided if so indicated on Drawings.

4. Exposed valves shall be furnished with Class 125 flanged ends; provide valves with bolted bonnet, outside screw and yoke, unless otherwise noted on Drawings. Fasteners shall be Type 304 stainless steel.

5. Buried valves shall be mechanical joint end conforming to ANSI C111.

6. Rising stem valves shall be sealed with adjustable and replaceable packing; valve design must permit packing replacement under operating system pressures with only moderate leakage.

7. Non-rising stem valves shall utilize a minimum of two O-ring stem seals.

8. Unless otherwise specified, valves shall be rated at or above for the following working water pressures:

Valve Size	Pressure (psig)
3-in to 12-in	200
14-in to 30-in	150
36-in and greater	as specified

a. Valve bodies shall be hydrostatically tested to at least twice the rated working water pressure. In addition, valves shall be seat-tested, bi-directional at rated working pressure, with seat leakage not to exceed one

fluid ounce per inch of valve diameter per hour. Provide certificates of testing.

9. Flanged valves to have face-to-face dimensions per ANSI B16.10 and flanges per ANSI B16.1.

10. Bonnet and packing gland bolts shall be Type 316 stainless steel; packing gland bolts shall have bronze nuts.

11. Provide geared operator and chain wheel, chain and chain guides for valves with handwheel centerline more than 7-ft above operating level.

12. Valves shall be marked per AWWA Standards, including name of manufacturer, valve size, and working pressure and year of manufacture.

13. Unless otherwise indicated, valves 12-in and smaller shall be capable of installation in vertical or horizontal position, and sealing in both directions at rated pressure.

B. Valve Applications:

1. Valves for Potable Water Service:
   a. Double disc design manufactured by Kennedy/ M&H/ Clow Valve.
   b. Solid wedge-resilient seated design as manufactured by Mueller Co; J & H Valve; M&H/Clow Valve; American Flow Control; American R/D Valve.

2. Valves for Water Residuals Service:
   a. Solid wedge metal seated design manufactured by M&H Valve; American R/D Valve; Stockham Valve, or Walworth.
   b. Resilient seated design manufactured by American Flow Control; Kennedy/M&H/Clow Valve; J & S Valve; US Pipe; Mueller or American R/D.

C. Valve Requirements:

1. Double Disc: Tag Type GV1.
   a. Conform to AWWA C500.
   b. Wedging surfaces shall be bronze, Monel or stainless steel.

2. Solid Wedge: Tag Type GV3.
   a. All-metal valves shall be manufactured of ASTM A 126 Cast Iron, Class B. Wedge seating surfaces and body seat rings shall be cast from B62 bronze, and shall conform to AWWA C500.
   b. Shall be coated internally and externally with an asphaltic varnish, per AWWA C500.
   c. Body shall have tongue and grooved guides for wedges.

3. Resilient Seated: Tag type GV400, GV401.
   a. Resilient seated valves shall be manufactured of ASTM A 536 ductile iron, vulcanized rubber disc per AWWA C509, manganese bronze or Type 316 stainless steel stem and trim, full port design, Type 304 or Type 316

stainless steel fasteners as required in general requirements. Valves shall conform to AWWA C509 and be UL and FM approved.

b. Shall have internal and external fusion bonded epoxy coating of valve body, including bonnet, per AWWA C550.
c. Gate shall be encapsulated with EPDM according to ASTM D 2000. It shall be bonded and vulcanized in accordance with ASTM B 429 Method B.
d. Shall have no recesses in valve body.
e. GV400: Mechanical for buried service, operating nut and valve box.
f. GV401: Flanged ends, handwheel operator.

D. Gate Valves 3 inch and Smaller: Tag Type GV5.

1. Gate valves 2.5-in diameter and smaller shall have screwed ends and shall be bronze body. Gate valves 3-in diameter shall be flanged end, iron or bronze body. Gate shall be brass, bronze, or Type 304 stainless steel solid wedge; union bonnet; silicon bronze rising-stem; equal to Jenkins Figure 47CUJ, division of Crane Valve Group; Lunkenheimer Figure 3127, Cincinnati Valve Co, Fairbanks Figure U-0252, or equal. Model numbers referenced above are for screwed ends, flanged shall be equal construction with appropriate end connections. Iron body valves shall be installed in steel or iron pipelines.

E. Tapping Valves and Sleeves: Tag Type TGV.

1. Under no circumstances shall a standard gate valve be used for a tapping valve. Tapping valves shall comply with same requirements as solid wedge, resilient seat or double disc gate valves except they shall have flanged end and port opening modified for tapping service. Tapping valves shall be provided with plugged flush port at bottom of gate guide and plugged tap for pressure/leak testing. Valves shall be capable of passing a full nominal sized cutter without damage to the valve. Tapping sleeve shall be gray cast iron or ductile iron mechanical joint type with outlet flange conforming to MSS-SP-60.

2.06 PLUG VALVES

A. Plug valves shall be of offset disc type, 1/4 turn, non-lubricated, serviceable (able to be repacked) under full line pressure and capable of sealing in both directions at rated pressure. Disc shall be completely out of flow path when open. Plug valves specified herein shall be manufactured by DeZurik; Pratt; Val-Matic; or approved equal. Manufacturers named or otherwise, shall comply completely with this Section.

1. Minimum port area shall be 80 percent when measured by percent cross-sectional area of equivalent size (nominal same diameter) pipe.

2. Plug valves shall be capable of passing "pigging" cleaning equipment (using a Girard or similar cleaning pig of full nominal pipeline diameter) in either direction and manufacturer shall so certify that this may be done without use of special equipment.

B. Valves shall be rated at minimum 175 psi WOG (Water, Oil and Gas) working pressure for sizes 4-in to 12-in inclusive and at minimum 150 psi WOG working pressure for sizes

14-in and larger and shall be capable of providing drop tight shut-off to full valve rating with pressure on either side of plug.

1. Plug valves under this Paragraph shall be performance, leakage and hydrostatically tested in accordance with AWWA C517, except as modified herein.

2. At above rated minimum working pressures, valves shall be certified by manufacturer as permitting zero leakage for a five-minute duration with full pressure applied in either direction.

3. At direction of Engineer, valve manufacturer may be requested to perform a valve seat leakage test, witnessed by Engineer to prove compliance with this Section.

C. Valve bodies shall be of cast iron, 30,000 psi tensile strength, ASTM A 126, Grade B, or of ductile iron, ASTM A 536 and of top entry, bolted bonnet design, cast with integral flanges conforming to connecting piping. Exposed bolts, nuts, and washers shall be zinc or cadmium-plated, except for submerged valves, which shall have Type 316 stainless steel hardware.

D. Valve Plug:

1. Shall be Buna N coated, cast iron ASTM A 126, Grade B, or ductile iron, ASTM A 536, Grade 65-45-12.

2. Shall be removable without removing valve from the line.

3. Shall have an integral upper and lower shaft which shall have seals on upper and lower journals to prevent entrance of solids into journals.

4. Shall be one piece for all valves.

E. Shaft bearings shall be permanently lubricated stainless steel or bronze at both upper and lower stem journals. Operator shaft shall have easily replaceable seals, which shall be externally adjustable and repackable without removing bonnet from valve, or shall have self-adjusting packing.

F. Valve seating surface shall provide full 360-degree seating by contact of a resilient seating material on plug mating with welded-in high nickel content overlay seating surface in body.

1. Seating design shall be resilient and of continuous interface type having consistent opening and closing torques and shall be non-jamming in closed position. Screw-in seats shall not be acceptable.

2. Plugs shall have a full resilient facing of neoprene or Buna-N.

G. Valves 6 inch and larger shall be actuated via gearbox and hand wheel, unless mechanized, which shall require gearbox and actuator. A suitably sized steel actuator mounting bracket shall be provided to provide an air gap between actuator and valve

stem seal. Under no circumstance shall gear box be mounted directly to top body flange such that leakage could directly enter gear box.

H. Unless otherwise required due to location or mechanized operation, each valve 4-in and smaller shall be provided with its own securely attached lever. Provide adjustable limit stops for both opening and closing and a clearly marked position indicator.

I. Plug valves shall be installed so that direction of flow through valve and shaft orientation is in accordance with manufacturer's recommendations. Unless otherwise noted, shaft shall be horizontal, with plug opening up.

J. Valve Ends and Operators

1. PV 1010: Mechanical joint for buried service, totally enclosed gear actuators with 2-inch extended operating nut, stem, and valve box.

2. PV 2010: Flanged ends, electric actuator.

2.07 CHECK VALVES

A. Iron Swing Check Valves for Metallic Lines of 4-in to 30-in Diameter: Tag Type SCV1.

1. Check valves shall be swing type and shall meet the requirements of AWWA C508. Valves shall be iron body, bronze mounted, single disc, minimum 175 psi working pressure for 4 to 12 inch, 150 psi working pressure for 14 to 30 inch, non-shock and hydrostatically tested at 300 psi. When there is no flow through line, disc shall hang lightly against its seat in practically a vertical position. When open, disc shall swing clear of waterway. Valves shall be so constructed that disc and body seat may easily be removed and replaced without removing valve from line.

2. Check valves shall have bronze seat and body rings, bronze or ductile clapper arm and bronze nuts on the bolts of bolted covers. Shaft assembly and key shall be ASTM A 582 Type 416 stainless steel. Hinge shaft shall extend from body of valve, sealed with stuffing box, packing and gland. Shaft side plug bearing, stuffing box and gland shall be bronze, packing shall be reinforced Teflon, both side plug and stuffing box shall be provided with grease fittings.

3. Valves 6 inch and larger shall be fitted with an extended hinge arm with outside lever and spring. Tension of spring shall be adjustable. Lever shall be installed to horizontal in closed position, for both horizontal and vertical pipeline installations.

4. Where check valve position switches are required as shown on Instrumentation Drawings, check valves shall be furnished complete with position switch mounting bracket and actuation lever mounted to stem shaft. Where outside lever and weights are required, stem shaft shall extend both sides of valve body and position switch assembly shall be mounted on opposite side of lever and weight assembly.

5. Where position switches are to be supplied for existing check valves with external shaft and lever, supply mounting brackets and hardware required to mount position switches to existing valves. Contractor shall use existing bolting where possible to mount brackets. If bolting is not available in required area, Contractor shall drill and tap valve body if required to mount position switches. Drill location and depth shall be reviewed with, and approved by Engineer.

6. Position switches shall be lever type, NEMA 7 enclosure, SPST, 120VAC, 6A, Square D Type 9007CR or equal. Hardware shall be Type 316 stainless steel.

7. Check valves shall be manufactured by American Flow Control; M&H/Clow/ Kennedy; Golden Anderson; Mueller; or equal.

B. Swing Check Valves 3 inch and Smaller: Tag Type SCV2.

1. Check valves 2-in and smaller for installation in copper and steel pipes shall be bronze, swing type, bronze disc, stainless steel pin, 125 lb with solder or screwed ends. Solder or thread end check valves 3-in and smaller shall be similar to Hammond 1B-940, or Jenkins Figure 996. Flanged end check valves 2 to 4-in in water service shall be Bronze fitted Hammond 1R-1124 or Jenkins Figure 587J.

C. Rubber Flapper Check Valves: Tag Type RFCV.

1. The valve body shall be full flow equal to nominal pipe diameter at all points through the valve. The seating surface shall be on a 45-degree angle to minimize disc travel. A threaded port with pipe plug shall be provided on the bottom of the valve to allow for field installation of a backflow actuator or oil cushion device without special tools or removing the valve from the line.

2. The top access port shall be full size, allowing removal of the disc without removing the valve from the line. A threaded port shall be provided on the top access port with a mechanical, disc position indicator to indicate whether the valve is open or closed. The indicator shall have continuous contact with the disc under all operating conditions to assure accurate disc position indication.

3. The disc shall be one-piece construction, precision molded with an O-ring sealing surface and reinforced with alloy steel. Non-slam closing characteristics shall be provided through a short 35-degree disc stroke and a disc accelerator to provide a cracking pressure of 0.3 psig.

4. 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 field adjustable and replaceable without removal of the valve from the line.

5. The valve body shall be ductile iron ASTM A536 Grade 65-45-12 or ASTM A126 class B gray iron.

6. The disc shall be molded Buna-N (NBR), ASTM D2000-BG.

7. The disc accelerator shall be Type 302 stainless steel.

8. The valve shall be rated for a working pressure of 150 psig.

9. The valve shall have spring assist closure.

10. A pre-wired limit switch shall be provided to indicate open/closed position to a remote location. The mechanical type limit switch shall be activated by the mechanical indicator. The switch shall be rated for NEMA 4 and shall have U.L. rated 5 amp, 125 VAC contacts. Limit switch shall be Model 802B Compact as Manufactured by Allen Bradley, or equal.

11. Rubber flapper check valves shall be Surgebuster® Swing Check Valve by Val-Matic®, or equal by GA Industries LLC.

2.08 THERMOPLASTIC VALVES: TAG TYPE NOTED BELOW

A. General:

1. Valves shall be certified as completely compatible with intended and specified service; compatibility shall apply to material of valve and internal components, including seals, gaskets, O-rings and washers; solvents and primers used in valve joint make-up shall be specifically in conformance with written instructions of valve supplier. Service chemicals and service conditions are shown in the piping sections in Division 15].

2. Except as otherwise specified, valve ends shall be socket-type designed for solvent welding. Solvent and primer shall be as specified in piping specifications, except that valves installed in systems carrying strong oxidizing, high alkalinity, and strong acid solutions shall contain NO fumed silica, and shall be Weld-On 724 for CPVC pipe as manufactured by IPS Corp., Compton, CA and Oatey Industrial Grade Low VOC Heavy Duty Gray for PVC pipe as manufactured by Oatey Corp., Cleveland OH.

3. Valve body material shall be same as piping system in which valve will be installed, unless explicitly stated otherwise on Drawings or in valve specification.
   a. PVC shall have a cell classification 12454 according to ASTM D 1784, made from unplasticized polymer, and generally suitable for service to 120 degrees F.
   b. CPVC shall have a cell classification 23447 according to ASTM D 1784, generally suitable for service to 180 degrees F.
   c. Polypropylene (PP) shall conform to material requirements of ASTM D 4101 for copolymer polypropylene.
   d. PVDF (polyvinylidene fluoride) shall be manufactured from high molecular weight polymers of vinylidene fluoride.
   e. Manufacturer of valves shall retain material source quality documentation and shall furnish it to Engineer upon request.

4. Unless otherwise specified:
   a. Valve seats shall be Teflon, or Teflon encapsulated elastomer. Alternative materials shall not be substituted without complete documentation provided to Engineer of service suitability.

b. Flange Gaskets shall be low torque, full face ANSI B16.5 with two concentric convex rings between ID and bolt hole diameter, constructed of EPDM, PTFE-bonded EPDM or PVDF-bonded EPDM as manufactured by Asahi of America or equal. Documentation shall be provided to show compatibility of bonded surface material for fluid service intended.
c. Valve external hardware shall be Type 316 stainless steel. No internal metallic components shall be exposed to service fluid.
d. No factory or field coatings shall be applied to valves.

5. Valves, except butterfly valves, shall have a non-shock service pressure rating of not less than 120 psig at 70 degrees F.

6. Valves from 1/2-in to 2-in shall have a snap-on fit handle attaching to valve stem to prevent handle from falling off. Valves from 2-1/2-in to 6-in shall have a handle mechanically attached to valve stem to prevent handle from falling off. Valves shall have limit stops at full open and full close to limit handle rotation.

7. Valves shall be given hydrostatic and pressure and leakage tests at factory. Provide certified copy of test results.

8. Valves shall be the standard, catalogued products of the following manufacturers:
a. Chemtrol.
b. Asahi/America.
c. Plast-O-Matic.
d. George-Fischer.
e. IPEX.

9. Valves specified as furnished with equipment or equipment systems shall comply with these requirements.

B. Ball Valves: Tag Type Noted Below.

1. Ball valves shall be double-union type, unless otherwise specified, full-port, adjustable seats.

2. Provide quarter-turn manual valve operator unless mechanized actuators are specified on Drawings.

3. Tag Type TBV1- General Service. Shall be PVC body, furnished with socket ends, EPDM O-rings and stem seals, PTFE seats with EPDM O-ring backup.

4. Tag Type TBV2- Sodium Hypochlorite Service. Shall be PVC body, furnished with socket ends, Viton B O-rings and stem seals, PTFE seats with Viton B O-ring backup. Sodium hypochlorite service ball valves shall have ball drilled to permit venting of pressure and gas from confined ball cavity, when valve is closed. Drilling shall vent to vented portion of piping in which valve is installed. Drilling shall be 1/8-in opening, de-burred and drilled by factory only. Directional indicator arrow labels shall be provided on valve body to indicate flow/vent.

C. Butterfly Valves: Tag Type TBFV.

1. Valves shall be of lined body design with PP disc with only the liner, seals and disc as wetted parts. Liner shall be molded and formed around body, functioning as a gasket on each side of valve. Double O-ring seals on top and bottom disc trunnions will fully isolate a Type 316 stainless steel straight-through stem. Body and disc shall be [PVC, PP, PVDF], Liner (seat) shall be [EPDM, FKM, NBR], O-rings shall be [EPDM, FKM, NBR].

2. Valves shall be wafer style, and lug style for dead-end service as applicable.

3. Each valve shall be furnished with a lever actuator on sizes through 6-in; gear operator on sizes 8-in and larger.

4. Butterfly valves shall be Type 57 as manufactured by Asahi-America, FK Series as manufactured by IPEX or equal.

D. Diaphragm valves: Tag Type TDV.

1. Valves shall have double-union ends. Acid service valves shall have flanged ends.

2. Acid service body and bonnet shall be PVDF, ASTM D3222 Cell Classification Type II.

3. Diaphragms shall be single layer EPDM or Viton as the service requires or shall be two layer, non-laminated. Acid service diaphragms shall be non-laminated, layered EPDM, PVDF gas barrier, PTFE wetted.

4. Valve shall have a full-width weir, designed for throttling, and complete bubble-tight closure.

5. Provide a handwheel valve operator, with a stainless steel stem, a cast stem sleeve and a clear plastic stem cover with a position indicator; provide an adjustable limit stop to prevent over-travel.

6. Diaphragm valves shall be Type 14 as manufactured by Asahi-America, VM Series as manufactured by IPEX or equal.

E. Gate Valves: Tag Type TGV.

1. Gate valves shall be non-rising stem, polypropylene plugs and viton seals. Where indicated on Drawings, valves shall be provided with stem extensions and handwheels, as manufactured by Asahi-America or equal.

F. Needle Valves: Tag Type TNV.

1. Needle valves shall be designed for close control of flow throttling with a multi-turn valve handle. Valves shall have FPM seal, PTFE seat. Stem shall be 20 or 24 pitch for fine throttling control. Valve shall have lugs or panel screw on bonnet for panel mounting.

2. Needle valves shall be as manufactured by Chemline Plastics Limited, George Fischer, or equal.

G. Ball Check Valves: Tag Type TBCV.

1. Ball check valves shall be double-union style with socket ends, solid and completely spherical ball, EPDM seals, PTFE seat, capable of either horizontal or vertical mounting. Ball check valves shall be SXE Series as manufactured by IPEX or equal.

H. Diaphragm Check Valves: Tag type TDCV.

1. Diaphragm check valves shall be union PVC, CPVC or PVDF body, thread or socket weld ends, EPDM or FKM diaphragms. Acid service valves shall be PVDF body with FKM diaphragm, and shall be furnished with PVDF flanges to connect to flanged piping. Valves shall be mountable in any position, and shall be Plast-O-Matic model CKM or equal.

I. Swing Check Valves: Tag Type TSCV.

1. Swing check valves shall be flanged body; seats and seals shall be EPDM, FKM or PTFE as required by fluid service; disc serviceable from top entry without removing valve, O-ring sealed top flange, ANSI flanged ends. Outside lever and weight and limit switch mounting shall be provided where shown on Drawings. Swing check valves shall be SC Series as manufactured by IPEX or equal.

J. Backpressure Regulating/Control Valves: Tag Type TBPV.

1. Backpressure control valves shall be spring-loaded diaphragm design, fully-adjustable pressure setting, set to assure continuous positive pressure at the pump discharge.

2. Furnish with reinforced Teflon diaphragms and elastomer-coated springs.

3. Body shall be of same material as pipeline in which it is installed or, CPVC if not otherwise specified. Valves shall be manufactured by Plast-O-Matic, or equal.

K. Pressure Relief Valves: Tag Type TPRV.

1. Relief valves shall be spring opposed, angle-pattern design, with adjustable relief pressure and locking nut. Pressure shall be adjustable over range up to 100 psig.

2. Valve spring shall be elastomer-coated and isolated from the process flow. Elastomer shall be compatible with fluid service. Diaphragm shall be reinforced Teflon.

3. Relief valves shall be piped as indicated, and if not indicated, relief piping shall be directed to floor or adjacent gutter or drain.

4. Pressure relief valve settings shall be set to a pressure as recommended by pump or equipment supplier and adjusted at time of equipment testing, inspection and start-up.

5. Body shall be of same material as pipeline in which it is installed or, CPVC if not otherwise specified. Valves shall be equal to Model RVD by Plast-O-Matic; Type A by Asahi-America or equal.

2.09 YARD HYDRANTS AND HOSE BIBBS

A. Yard hydrants located in the plant yard shall be post type. The hydrant shall be self-draining, non-freezing, compression type with 1.25-inch main valve opening. The system (whether or not shown on the drawings) shall consist of the post hydrant and a gate valve (with 2-inch nut and valve box) of the same size as the service pipe. The post hydrant inlet connection shall be 3-inch threaded. The hydrant outlet shall be provided with a cam and groove (male adapter fitting) and a chained dust cap (with cam levers). All cam and groove fittings including the cap shall be brass. The cam and groove fittings shall be installed at the hydrant manufacturing facility.

B. Furnish a total of two T-handles to operate the post hydrants for the project at the plant. Each yard hydrant shall be installed adjacent to a yard hydrant hose rack as detailed on the Drawings.

C. The yard hydrant hose rack shall be furnished with a chained brass or stainless steel tag indicating that the nature of the service as “NON-POTABLE, DO NOT DRINK”. The hydrant shall be painted red and in accordance with the specifications.

D. The post hydrant shall be No.2 Post Hydrant by John C. Kupferle Foundry Company of St. Louis, MO.

E. Hose Bibbs located inside and outside of buildings shall be 1 1/4 inch and shall be polished brass, as manufactured by Chicago Faucet Co. or equal, with vacuum breaker and 1 1/4-inch hose thread outlet.

2.10 BACKFLOW PREVENTERS

A. The backflow preventer shall operate on the reduced pressure principle to safeguard potable water supplies against the hazards of cross-connection. The device shall have ductile iron body (ASTM A536) or heavy-duty steel, OS&Y resilient wedge gate valves meeting AWWA C509 specifications, stainless steel spring and flanged end connections. The assembly shall be designed for the same working pressure as the pipeline to which it connects or 175 psi, whichever is greater. All components of the device shall be furnished by a single manufacturer. The device shall be by FEBCO, AMES Fire and Waterworks, Hersey, Cla-Val, or any other device approved by Charlotte-Mecklenburg Utilities which operates on the reduced pressure principle. Devices classified as double-check type units are not acceptable. All above ground components of the assembly shall be covered by a heated, insulated enclosure as described below.

B. Upon installation and prior to putting the line in service, the unit shall be tested by a registered tester and the results approved by City of Durham Water Resources.

C. All above-ground backflow prevention assemblies shall be covered by an insulated pre-fabricated enclosure. The enclosure shall provide minimum 6.5R factor insulation. Enclosure shall be provided with an internal heater to be powered by a 208-volt, 3-phase supply. Enclosure shall be prefabricated fiberglass or aluminum as manufactured by Hot Box Enclosures or equal.

2.11 SOLENOID VALVES: TAG TYPE "SV"

A. Solenoid valves shall be packless piston type direct acting for sizes less than 1-in and internal pilot operated for sizes 1-in and larger, 2-way or 3-way, valves and shall be ASCO Valve; Red Hat by Automatic Switch Co., similar by Circle Seal Controls-Atkomatic Valve Co. or equal for air and water service.

B. Valves shall be energized to open, except for valves on water seal lines to pumps which shall be energize to close.

C. Valves shall have forged brass bodies, NPT end connections of connected piping Type 304 stainless steel internal parts, and Buna-N or Ethylene Propylene valve seats. Valves shall have a minimum 150 psig safe working pressure and zero minimum operating pressure differential. Connections shall be threaded.

D. Solenoid valves size 2-inch and larger shall be full bore bronze body, Type 430 stainless steel plunger, copper coil class A encapsulated, Type 302 stainless steel spring, wash-down safe, equal to type A as manufactured by Magnatrol Valve Corp., Hawthorne, NJ or equal. Solenoid valves shall have a manual override actuated by a handle levered plunger mounted on bottom of valve body. These valves shall be mounted in a horizontal run of piping, with solenoid up in vertical position.

E. Note that solenoid valves may be shown on Electrical and/or Mechanical Drawings, or may only be specified, but if so specified or shown, shall be provided. Solenoid valves located in hazardous classified areas shall be provided with electrical enclosures which satisfy electrical classification as specified or shown on Electrical Drawings.

2.12 CORPORATION STOPS: TAG TYPE "CS"

A. Corporation Stops 3/4-in through 2-in shall be ball valve type, meeting AWWA Standard C800-01, Sec. 4.2.3 (High Pressure), withstanding working pressures up to 300 psi. Body, ball, operating stem, T-head, and service line connector shall be manufactured from red brass and conform to ASTM B 62 and/or ASTM B 584, UNS No. C83600. Ball shall be fluorocarbon coated and shall float on two EPDM seats and be watertight in both directions. Operating stem and nut shall be one piece, held in place by a mating machined flange on stem and in body. Operating stem shall have an EPDM O-ring to provide a watertight seal against the body.

B. Inlet threads shall be AWWA Taper, except where used with service clamps, where threads shall be IPS threads. Thread types and diameters shall conform to AWWA C800. Inlet threads will be integral to body. Waterway diameter shall be approximately equivalent to nominal size of stop, and shall accommodate maximum cutter size established by AWWA C800. Outlet shall be a compression connection meeting AWWA C800 Sec. 4.4.9.

C. Corporation Stops shall be FB Style Ballcorp, as manufactured by The Ford Meter Box Company, Inc., Wabash, Indiana, or equal. Where corporation stops are used with plastic pipe, a brass companion flange shall be provided on outlet of each corporation stop.

2.13 AIR RELEASE AND VACUUM RELIEF VALVES: TAG TYPE NOTED BELOW

A. Pipeline air and vacuum valves shall be supplied with shutoff gate or ball valves with operator handle or lever removed. Valves shall be properly vented and piped to drain.

B. Valve pressure rating shall be at least equal to attached pipe's rating.

C. Valves for sewage service shall have connections for draining and flushing with isolation ball valves for connection size up to 3 inch, and solid wedge gate valves for size 4 inch and larger.

D. Air Release Valves: Tag Type “ARV”.

1. Small orifice assembly air release valves shall automatically release air accumulations from pipe while under positive pressure. When valve body fills with air, float mechanism shall fall to open small orifice and exhaust air to atmosphere. When air has been exhausted, float mechanism shall be buoyed up and shall tightly close small orifice. Small orifice assembly shall be furnished with Type 304 stainless steel body and cover, and shall use Type 316 stainless steel hardware. Float mechanism shall be constructed of polypropylene or Type 316 stainless steel. Wetted components shall be polypropylene, Buna-N or Type 316 stainless steel. A resilient, Buna-N seat shall provide drop-tight closure.

2. Separate air release valves shall be Vent-O-Mat Model RBXb, equal as manufactured by APCO; Val-Matic; GA; Crispin or equal of the special type for use with non-clean water.

E. Vacuum Relief Valves: Tag Type “VRV”.

1. Large orifice assembly vacuum valves shall automatically allow air to enter pipeline when pressure falls below atmospheric pressure. Vacuum relief valves shall not be configured to release air.

2. Vacuum relief valves shall be constructed as specified in subparagraph F below, except providing vacuum relief only, as manufactured by Vent-O-Mat.

F. Air and Vacuum Relief Valves: Tag Type “AVV”

1. Valves shall be designed to automatically discharge or admit large volumes of air (gas) during filling or draining. This valve will open to relieve negative pressures valve at pump shut-off and at water column separation. Air and vacuum relief valves for general sizes 3 to 4 inches housed in a ductile iron body with epoxy powder coated cast iron or steel ends. Valve shall have an intake orifice area equal to the nominal size of the valve.

2. Valves shall be rated for 230 psi service. Materials of construction shall be as follows: body Ductile Iron ASTM a526 coated with fusion bonded epoxy; top and bottom flanges- fusion bonded epoxy steel; small orifice nozzle seat and o-rings- Buna-N; nozzle, baffle plate, tie rods, studs, nuts, washers- 304 stainless steel. End Connections shall be 125 lb flange.

3. Valves shall be Model K-020 as manufactured by A.R.I.

G. Combination Air and Vacuum Relief Valves: Tag Type “CAV”.

1. Valves shall be designed to release large amounts of air during pipeline filling, release small amounts of air accumulated during pipeline operation, and allow large volume of air during pipeline drainage or pipe break. Combination double orifice air/vacuum valve for general service in sizes 1 to 6 inches housed in a tubular stainless steel body with epoxy powder coated cast iron or steel ends secured by means of stainless steel tie rods. Valve shall have an intake orifice area equal to the nominal size of the valve.

2. Air release/vacuum valves shall be single cylindrical chamber design with a polycarbonate l float. Discharge of pressurized air shall be controlled by the seating and unseating of a small orifice nozzle on a natural rubber seal affixed into the control float. The nozzle shall have a flat seating land surrounding the orifice so that damage to the rubber seal is prevented. Venting of large quantities of air during pipeline filling shall be accomplished through the large orifice at the top of the valve. Large orifice sealing shall be affected by the flat face of the control float seating against an “O” ring housed in a dovetail groove circumferentially surrounding the orifice. Vacuum relief shall be accomplished through the large orifice when the control floats fall due to negative pressure in the pipeline. The valve design shall incorporate an over pressure safety feature that will fail without an explosive effect, such as is normally the case when highly compressed air is released suddenly. The feature shall consist of easily replaceable gaskets.

3. Valves shall be rated for 230 psi service. Materials of construction shall be as follows: body Ductile Iron ASTM a526 coated with fusion bonded epoxy; top and bottom flanges- fusion bonded epoxy steel; small orifice nozzle seat and o-rings- Buna-N; nozzle, baffle plate, tie rods, studs, nuts, washers- 304 stainless steel. End Connections shall be 125 lb flange 3 to 6 inch.

4. Valves shall be Model D-026 – with Non Slam attachment as manufactured by A.R.I.

H. Tank Pressure Vacuum Relief Valve: Tag Type “PVRV”.

1. Tank pressure and vacuum relief valves shall be weighted pallet type. Pallet shall be guided from top and bottom to minimize flutter and wear. Seat and pallet shall be manufactured from polyphenylene sulfide for anti-sticking properties, high temperature and corrosive service. Pallet and seat assemblies shall be field replaceable without special tools. Valve body and pallet weights shall be Type 316 stainless steel, gaskets shall be Viton. Flanges shall be ANSI standard.

2. Valves shall be pipe away style Model 850 as manufactured by ENARDO, Tulsa, OK or equal.

I. Discharge Throttling Attachment

1. Valve shall include a Non-Slam discharge throttling attachment that allows for free air intake, and throttles air discharge. Attachment shallow allow for a minimum 5% opening area.

2.14 HOSE END VALVES: TAG TYPE HEV

A. Hose end valves shall be globe pattern valves, similar to Fairbanks Fig. 074; Jenkins Fig. 112 or equal. Furnish cap and chain.

2.15 SURFACE PREPARATION AND SHOP COATINGS

A. Notwithstanding any of these specified requirements, coatings and lubricants in contact with potable water shall be certified as acceptable for use with that fluid.

B. If not specified herein, coatings shall comply with the requirements of Section 09 91 10 and 09 91 00. In case of a conflict, requirements of this Section govern.

C. If manufacturer's requirement is not to require finished coating on interior surfaces, then manufacturer shall so state and no interior finish coating will be required, if acceptable to Engineer.

D. Exterior surface of various parts of valves, operators, floor-stands and miscellaneous piping shall be thoroughly cleaned of all scale, dirt, grease or other foreign matter and thereafter one shop coat of an approved rust-inhibitive primer such as Inertol Primer No. 621 shall be applied in accordance with instructions of paint manufacturer or other primer compatible with finish coat provided.

E. Unless otherwise noted, interior ferrous surfaces of valves shall be given a shop finish of an asphalt varnish conforming to AWWA C509, (except mounting faces/surfaces) or epoxy conforming to AWWA C550 with a minimum thickness of 6 mils.

F. Ferrous surfaces obviously not to be painted shall be given a shop coat of grease or other suitable rust-resistant coating. Mounting surfaces shall be especially coated with a rust preventative.

G. Special care shall be taken to protect uncoated items and plastic items, especially from environmental damage.

2.16 FACTORY INSPECTION AND TESTING

A. Factory inspection, testing and correction of deficiencies shall be done in accordance with the referenced standards and as noted herein.

B. See Division 1 for additional requirements. Also, refer to Part 1, especially for required submission of test data to Engineer.

C. In addition to tests required by referenced standards, the following shall also be factory tested:

1. Pressure regulating valves shall be factory tested at specified pressures and flows.

2. Butterfly valves shall be factory tested to demonstrate drop tight closure at specified conditions.

3. All types of air and vacuum valves.

2.17 ACCESSORIES

A. Floor Stands:

1. Materials:
   a. Stand: Cast iron
   b. Stem Bushing: Sintered bronze.
   c. Position Indicator: Bronze.

2. Height to input shaft or handwheel: 36 inch

3. Base Mounting Requirements:
   a. Concrete Floor Mounting: Type 316 stainless-steel anchor bolts.
   b. Face of Basin or Offset Mounting: Heavily reinforced, adjustable wall bracket with required anchor hardware using Type 316 stainless-steel.

4. Actuator Mounting Requirements:
   a. Manual Actuator: Cast iron handwheel on top of floor stand with dual ball type thrust bearings, grease fitting on bearing bowl, hardened machined alloy bronze lift nut (for rising stem). Where manual effort is greater than 40 lb rim pull with 2 feet diameter wheel, provide geared actuator with a handwheel or crank.
      1) Handwheel casting to include the word “OPEN” and an arrow indicating the direction of operation.
   b. Gearbox or Direct Powered Actuator: Through bolt holes matched to actuator or gearbox bolting pattern.

5. Non-rising stem position indicator: Mechanical indicator connected to and driven by stem extension and cast position marks on floor stand with the word “OPEN” cast at the top of the travel, and a field mounted aluminum “CLOSED” tag supplied with drive rivets, installed based on number of valve turns.

6. Rising Stem Position Indicator: Permanent markings on transparent stem covers.

B. Stem Covers: Fracture-resistant clear butyrate plastic stem covers for rising stems. Closed top with adhesive type position indicator markings.

C. Extension Stems and Stem Guides:

1. Extension stems and couplings to actuate recessed, buried, below slab valves and gates via operating nut or floor stand mounted actuator.

2. Stem Extensions and Stem Couplings: Alloy steel, hardware of Type 316 stainless-steel unless specified otherwise in the respective slide gate specification.

3. Stem and Stem Couplings: Rated for five times the maximum input torque capacity of the actuator.

4. Adjustable, Cast Iron Wall Bracket Type Stem Guides: Include bronze bushing.

5. Spacing: 10 feet spacing or at spacing calculated by manufacturer to prevent buckling with a safety factor of 2 based on design thrust, shaft material and shaft size.

PART 3 EXECUTION

3.01 INSTALLATION - GENERAL

A. Valves and appurtenances shall be installed per manufacturer's instructions in locations shown, true to alignment and rigidly supported. Damage to above items shall be repaired to satisfaction of Engineer before they are installed.

B. Install brackets, extension rods, guides, various types of operators and appurtenances as shown on Drawings, or otherwise required. Before setting these items, check Drawings and figures which have a direct bearing on their location. Contractor shall be responsible for proper location of valves and appurtenances during construction of the work.

C. Materials shall be carefully inspected for defects in construction and materials. Debris and foreign material shall be cleaned out of openings, etc. Valve flange covers shall remain in place until connected piping is in place. Operating mechanisms shall be operated to check their proper functioning and nuts and bolts checked for tightness. Valves and other equipment which do not operate easily, or are otherwise defective, shall be repaired or replaced at no additional cost to Owner.

D. Where installation is covered by a referenced standard, installation shall be in accordance with that standard, except as herein modified, and Contractor shall certify such. Also, note additional requirements in other parts of this Section.

E. Unless otherwise noted, joints for valves and appurtenances shall be made up utilizing same procedures as specified under applicable type connecting pipe joint and valves and other items shall be installed in proper position as recommended by manufacturer. Contractor shall be responsible for verifying manufacturers' torqueing requirements for all valves.

3.02 INSTALLATION OF MANUAL OPERATIONAL DEVICES

A. Unless otherwise noted, operational devices shall be installed with units of factory, as shown on Drawings or as acceptable to Engineer to allow accessibility to operate and maintain item and to prevent interference with other piping, valves, and appurtenances.

B. For manually operated valves 3-in in diameter and smaller, valve operators and indicators shall be rotated to display toward normal operation locations.

C. Floor boxes, valve boxes, extension stems and low floor stands shall be installed vertically centered over operating nut, with couplings as required and elevation of box top shall be adjusted to conform to elevation of finished floor surface or grade at completion of Contract. Boxes and stem guides shall be adequately supported during concrete placement to maintain vertical alignment.

3.03 INSPECTION, TESTING AND CORRECTION OF DEFICIENCIES

A. See also Division 1. Take care not to over pressure valves or appurtenances during pipe testing. If unit proves to be defective, it shall be replaced or repaired to satisfaction of Engineer.

B. Functional Test: Prior to plant startup, items shall be inspected for proper alignment, quiet operation, proper connection and satisfactory performance. After installation, manual valves shall be opened and closed in presence of Engineer to show valve operates smoothly from full open to full close and without leakage. Valves equipped with electric, pneumatic or hydraulic actuators shall by cycled five times from full open to full closed in presence of Engineer without vibration, jamming, leakage, or overheating. Pressure control and pressure relief valves shall be operated in presence of Engineer to show they perform their specified function at some time prior to placing piping system in operation and as agreed during construction coordination meetings

C. Various pipe lines in which valves and appurtenances are to be installed are specified to be field tested. During these tests, any defective valve or appurtenance shall be adjusted, removed, and replaced, or otherwise made acceptable to Engineer.

D. Various regulating valves, strainers, or other appurtenances shall be tested to demonstrate their conformance with specified operational capabilities and deficiencies shall be corrected or device replaced or otherwise made acceptable to Engineer.

3.04 CLEANING

A. Items including valve interiors shall be inspected before line closure, for presence of debris. At option of Engineer, internal inspection of valve and appurtenances may be required any time that likelihood of debris is a possibility. Pipes and valves shall be cleaned prior to installation, testing disinfection and final acceptance.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install complete test, and make ready for operation all piping specialties required by the work of this Contract. Specific piping materials, systems and related installation and testing requirements shall be coordinated with the related sections in Divisions 33 and 40. The items shall include the following:

1. Unions
2. Flanged Joints
3. Dielectric Connectors
4. Plugs and Caps
5. Miscellaneous Adaptors
6. Vents and Drains
7. Service Clamps
8. Cleanouts
9. Floor Drains
10. Quick Connect Couplings
11. Mechanical Sleeve Seals
12. Flexible Connectors
    a. Sleeve Couplings
    b. Split or Grooved Couplings
    c. Pump and Equipment Flexible Connectors
    d. Flexible Connectors
13. Expansion Joints
    a. Single- and Multiple-Arch Type
    b. Bellows Style
    c. Flexible Metal Hose
14. Harnessing and Restraints

1.02 RELATED WORK

A. Piping penetration are included in Section 01 60 09.

B. Pipeline color coding and labeling is included in Section 09 91 10.

C. Piping materials and systems are included in other Sections of Division 15.

D. Specialties and apparatus furnished with equipment and systems are included in individual Sections in Division 11.

E. Valves are included in Section 40 05 50.

F. Pipe supports are included in Section 40 05 75.

G. Pipe insulation is included in Section 23 07 00.

H. Pipe heat tracing is included in Section 40 41 13.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, general submittals for piping, piping systems and pipeline appurtenances are listed below. It is not intended that all submittals listed below be provided for all piping materials and systems. Refer to individual System or Piping Sections for specific submittals.

B. Shop Drawings and Product Data

1. Piping layouts with specialties.

2. Location of pipe hangers and supports.

3. Location and type of backup block or device to prevent joint separation.

4. Large scale details of wall penetrations and fabricated fittings.

5. Schedule of all pipe, fittings, special castings, couplings, expansion joints and other appurtenances.

6. Catalog cuts of specialties, joints, couplings, harnesses, expansion joints, gaskets, fasteners and other accessories.

7. Catalog cuts of all pipeline appurtenances specified herein.

8. Brochures and technical data on coatings and linings and proposed method for application and repair.

C. Samples

D. Design Data

E. Test Reports

1. Four copies of certified shop tests showing compliance with appropriate standard.

F. Certificates

1. Copies of certification for all welders performing work in accordance with ANSI B31.1.

G. Manufacturer's Installation (or application) instructions.

H. Statement of Qualifications

I. Manufacturers Field Report

J. Project Record Document

K. Operation and Maintenance Data in accordance with Section 01 78 23.

L. Warranties

1.04 REFERENCE STANDARDS

A. ASTM International

1. ASTM A36 - Standard Specification for Carbon Structural Steel.

2. ASTM A126 - Standard Specification for Gray Iron Casting for Valves, Flanges and Pipe Fittings.

3. ASTM A183 - Standard Specification for Carbon Steel Track Bolts and Nuts.

4. ASTM A278 - Standard Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures up to 650 Degrees F.

5. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.

6. ASTM A325 - Standard Specification for Strength Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.

7. ASTM A536 - Standard Specification for Ductile Iron Castings

8. ASTM A575 - Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades.

9. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings.

10. ASTM B88 - Standard Specification for Seamless Copper Water Tube.

B. American National Standards Institute (ANSI)

1. ANSI A13.1 - Scheme for the Identification of Piping Systems.

2. ANSI B1.1 - Unified Inch Screw Threads (UN and UNR Thread Form)

3. ANSI B18.2 - Square and Hex Bolts and Screws Inch Series Including Hex Cap Screws and Lag Screws.

4. ANSI B31 - Code for Pressure Piping.

5. ANSI B31.1 - Power Piping

C. American Society of Mechanical Engineers (ASME)

1. ASME B2.1 - Specifications, Dimensions, Gauging for Taper and Straight Pipe Threads (except dry seals).

2. ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings.

3. ASME B16.5 - Pipe Flanges and Flange Fittings

D. American Welding Society (AWS)

1. AWS B3.0 - Welding Procedure and Performance Qualifications

E. American Water Works Association (AWWA)

1. AWWA C110 - Ductile-Iron and Gray-Iron Fittings, 3-in through 48-in (75mm through 1200mm), for Water and Other Liquids.

2. AWWA C111 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.

3. AWWA C219 - Bolted Sleeve-Type Couplings for Plain-End Pipe

4. AWWA C606 - Grooved and Shouldered Joints.

5. AWWA Manual M11 - Steel Pipe - A Guide for Design and Installation.

F. Plumbing and Drainage Institute (PDI)

1. WH 201 - Water Hammer Arrestors

G. Underwriters Laboratories (UL)

H. Factory Mutual (FM)

I. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. All materials shall be new and unused.

B. Install piping to meet requirements of local codes.

C. Provide manufacturer's certification that materials meet or exceed minimum requirements as specified. Reference to standards such as ASTM and ANSI shall apply to those versions in effect at the time of the bid opening.

D. Coordinate dimensions and drilling of flanges with flanges for valves, pumps and other equipment to be installed in piping systems. Bolt holes in flanges to straddle vertical centerline.

E. Reject materials contaminated with gasoline, lubricating oil, liquid or gaseous fuel, aromatic compounds, paint solvent, paint thinner and acid solder.

F. Pipe-joint compound, for pipe carrying flammable or toxic gas, must bear approval of UL or FM.

G. Unless otherwise specified, pressures referred to in all Piping Sections are expressed in pounds per square inch, gauge above atmospheric pressure, psig and all temperature are expressed in degrees Fahrenheit (F).

1.06 DELIVERY, STORAGE AND HANDLING

A. During loading, transportation and unloading, take care to prevent damage to pipes and coating. Carefully load and unload each pipe under control at all times. Place skids or blocks under each pipe in the shop and securely wedge pipe during transportation to ensure no injury to pipe and lining. Cover or cap all pipe ends while pipe is in storage, until it is made a part of the work. See Section 01 66 10 for additional requirements.

PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Specific piping materials and appurtenances are specified in the respective Piping or System Sections. The use of a manufacturer's name and/or model number is for the purpose of establishing the standard of quality and general configuration desired.

B. Equipment shall be of the size shown on the Drawings or as noted and as far as possible equipment of the same type shall be identical and from one manufacturer.

C. Equipment shall have the name of the maker, nominal size, flow directional arrows (if applicable), working pressure for which they are designed and standard referenced specifications cast in raised letters or indelibly marked upon some appropriate part of the body.

D. Unless otherwise noted, items shall have a minimum working pressure of 150 psi or be of the same working pressure as the pipe they connect to, whichever is higher and suitable for the pressures noted where they are installed.

2.02 UNIONS

A. Unions shall be brass or bronze unions for joining nonferrous pipe; malleable brass or bronze-seated iron or steel unions for joining ferrous pipe; PVC unions for joining PVC pipe; CPVC unions for joining CPVC pipe.

2.03 FLANGED JOINTS

A. Flanged Joints. Bolt and nuts, Grade B, ASTM A307, unless otherwise specified, bolt number and size same as flange standard; studs - same quality as machine bolts; 1/8-in thick rubber gaskets with cloth insertions; rust-resistant coatings.

2.04 DIELECTRIC CONNECTORS

A. Dielectric pipe fittings/insulators and unions shall be used to prevent galvanic action wherever valves or piping of dissimilar metals connect. This shall be particularly the case for copper, brass and bronze piping connecting to cast iron or steel piping systems.

B. Dielectric unions shall be used for 2-in and smaller connections. Steel union nuts shall meet ASTM A575 requirements. The steel or ductile iron connection end shall have a steel body and shall have accurately machined taper tapped pipe threads in accordance with ASME B2.1. The copper connection end shall be a copper solder joint that meets requirements of ASTM B88. Dielectric unions shall be rated for at least 250 psi at 210 degrees F.

C. Dielectric flange unions shall be used for connections 2 ½-in and larger. Cast iron flanges shall meet ASTM A126; the copper solder end shall meet ASTM B62 and the pipe thread shall meet ASME B2.1. Dielectric flange unions shall be rated for at least 175 psi at 210 degrees F.

D. Dielectric unions and flange unions shall be as manufactured by Epco Inc., Cleveland, OH or equal.

E. Flange insulating kits shall be as acceptable to the Engineer, as manufactured by PSI or equal.

F. Insulated sleeve couplings and flange adaptors shall be similar to those units as specified elsewhere.

2.05 PLUGS AND CAPS

A. Provide standard plug or cap as required for testing; plugs, caps suitable for permanent service.

B. Plug or cap or otherwise cover all piping work in progress.

2.06 MISCELLANEOUS ADAPTORS

A. Between different types of pipe and/or fittings special adapters may be required to provide proper connection. Some of these may be indicated on the Drawings or specified with individual types of pipe or equipment. However, it is the Contractor's responsibility to ensure proper connection between various types of pipe, to structures and between pipe and valves, gates, fittings and other appurtenances. Provide all adapters as required, whether specifically noted or not.

B. As required, these adapters shall be suitable for direct bury, with proper dielectric insulation and as a minimum, if metallic (not stainless steel or galvanized), with two coats of Coal Tar Epoxy.

2.07 VENTS AND DRAINS

A. ½-in vents shall be provided at the high point in each system. Vent connections may be tapped, provided the tap will accept three full threads on the bronze nipple.

B. 1 ½-in drains shall be provided to permit drainage of each system located on the invert of the blind flange; provide hose-end valve.

2.08 SERVICE CLAMPS

A. Service clamps for outlet sizes up to 2-in shall have malleable or ductile iron bodies which extend at least 160 degrees around the circumference of the pipe and shall have neoprene gaskets cemented to the saddle body. Bodies shall be tapped for IPS. Clamps shall be of the double strap design. Service clamps shall be Style 91 by Dresser Industries, Inc.; Smith Blair; Mueller or equal.

B. Service clamps for outlet sizes 4-in through 12-in where the outlet size is not greater than half the size of the main pipe shall have ductile iron bodies and a neoprene circular cross section O-ring gasket confined within the body. Outlet shall be AWWA C110 flange or AWWA C111 mechanical joint as required for the application. Straps shall be alloy steel, minimum ¼-in by 1 ½-in in cross section and fabricated with ¾-in threaded ends. Service clamps shall be Fig. A-10920 or A-30920 by American Cast Iron Pipe Company or equal.

2.09 CLEANOUTS

A. Interior flush floor cleanouts shall consist of a coated cast iron ferrule, a tapered threaded bronze cleanout plug, adjustable housing and a scoriated round cast iron tractor cover with bronze top. Interior flush floor cleanouts shall be Type No. 56056 by Josam Manufacturing Co., Michigan City, IN, similar models by Tyler, or equal.

B. Exterior cleanouts shall consist of a coated cast iron ferrule with cut-off sections, a tapered threaded bronze cleanout plug, Josam 58486 or equal, with a heavy round coated cast iron access frame with anchor flanges and a gasketed cover, Josam Type No. 58680, similar models by Tyler or equal. Exterior cleanouts shall be installed as noted on the Drawings.

C. Cleanouts shall be located where shown on the Drawings.

D. Cleanout connections to 6-in cast iron bell and spigot soil pipe and cleanout connections to 6-in ductile iron bell and spigot pipe shall be caulked.

2.10 FLOOR DRAINS

A. Floor drains shall have 8-in square, adjustable, bronze top strainers and coated cast iron bodies.

B. Floor drains shall have outlet connections for 4-in cast iron bell and spigot soil pipe except where required by other type pipe and/or indicated on the Drawings. They shall be Series No. 30004-8S by Josam, similar by Tyler or equal.

2.11 MECHANICAL SLEEVE SEALS

A. Mechanical sleeve seals shall be used to secure and seal the annular space around all new sleeved and core-drilled wall penetrations.

B. A single seal shall be provided for all sleeve and cores in walls up to 14-in thick; dual sleeves shall be provided in larger walls.

C. Galvanized steel wall sleeves and concrete core diameter shall be sized sufficiently larger to accommodate the modular elements, per the manufacturer's recommendations.

D. Bolts and hardware shall be carbon steel, zinc-plated. Pressure plates shall be corrosion-resistant acetal resin.

E. Mechanical sleeve seals shall consist of modular bolted, synthetic rubber sealing elements, Link Seal by Thunderline Corp. or equal.

2.12 FLEXIBLE CONNECTORS

A. Sleeve Couplings

1. Provide plain end type ends to be joined by sleeve couplings as stipulated in AWWA C219.
    a. Join welds on ends by couplings without pipe stops. Grind flush to permit slipping coupling in at least one direction to clear pipe joint.
    b. Outside diameter and out-of-round tolerances shall be within limits specified by coupling manufacturer.
    c. Provide lugs in accordance with ASTM A36.
    d. Provide hardened steel washers in accordance with ASTM A325.
    e. Plastic plugs shall be fitted in coupling to protect bolt holes.
    f. Nuts and bolts
        1) Provide bolts and bolt-studs in accordance with ASTM A307 and ANSI B1.1 with hexagonal or square heads, coarse thread fit, threaded full length with ends chamfered or rounded.
        2) Project ends ¼-in beyond surface of nuts.
        3) Hexagonal nuts with dimensions in accordance with ANSI B18.2 and coarse threads in accordance with ANSI B1.1.

2. Middle ring of each mechanical coupling shall have a thickness at least equal to that specified for size of pipe on which coupling is to be used and shall not be less than 10-in long for pipe 30-in and larger and not less than 7-in long for pipe under 30-in in diameter.
   a. Omit pipe stop from inner surface of middle rings of couplings whenever necessary to permit removal of valves, flowmeters and other installed equipment.
   b. Provide pipe stops in other couplings.

3. Clean and shop prime with manufacturer's standard rust inhibitive primer.

4. Furnish gaskets of a composition suitable for exposure to the fluid service.

5. Where shown on the Drawings, anchor sleeve-coupled joints with harness bolts. Weld harness lugs to steel pipe.
   a. Joint harness bolts shall be of sufficient length, with harness lugs placed so that coupling can be slipped at least in one direction to clear joint. Provide harnesses of sufficient number and strength to withstand test pressure as recommended in AWWA M-11.
   b. Each harness shall have a minimum of two 5/8-in diameter bolts.

6. Similar insulation type couplings shall be provided at the face of buildings, between different type metals or where otherwise noted.

B. Split or Grooved Couplings

1. Split couplings shall be cast in two or more parts. When secured together with ASTM A183 bolts and nuts, couplings shall engage grooved or shouldered pipe ends and encase an elastomeric gasket to create a pipe seal. Gasket material shall be as recommended by the manufacturer for the service required.

2. Split couplings shall be as manufactured by Victaulic Company of America; Gustin-Bacon, or equal. Numbers below refer to Victaulic Co. items, for reference only.

3. Unless otherwise specified with the individual type of pipe:
   a. Flexible split ring couplings shall be:
      1) grooved ends - Style 77 (for steel/stainless steel) or Style 31 (for grooved ductile iron)
      2) shouldered ends – Victaulic Style 44 or Fluid Master
      3) fixed ends – Victaulic Depend-O-Lok, F x F (fixed by fixed)
   b. Rigid split ring couplings shall be:
      1) grooved ends - rigid groove with Style 31 couplings on ductile iron 36-in and smaller diameter with sufficient wall thickness per AWWA C606, or manufacturer's recommendation, or standard groove with Style 07 Zero-Flex coupling on manufactured steel or IPS pipe.
      2) shouldered ends – Style 44 coupling on ductile iron over 36-in diameter or without sufficient wall thickness per AWWA C606 or on manufactured steel pipe or thin wall stainless steel pipe. Field welding of shoulders of ductile iron pipe is specifically prohibited.

4. Ductile iron pipe for use with split-type coupling joints shall have radius grooved ends conforming to AWWA C606. Pipe shall have grooved ends to provide either a rigid joint or flexible joint as shown on the Drawings and as specified herein. Flexible joint grooving shall permit expansion and contraction, and angular deflection. Rigid joint grooving shall allow no angular or linear movement. Minimum pipe wall thickness for grooved pipe shall be the following class:

Size	Class
4 thru 16	53
18	54
20	55
24	56

5. Grooved couplings for steel and stainless steel piping shall have roll grooving, machine-grooving, or ring collars fully welded to the pipe or fitting.

6. Rigid split couplings may be substituted for flanges as noted on the Drawings and in the individual pipe requirements.

7. Certain minimum thickness of pipe walls are required by AWWA C606 and coupling manufacturers for use of various type split couplings with certain pipes. Utilize at least those minimum wall thicknesses required (unless a greater thickness is specified or required in the individual pipe specifications) with split couplings.

8. If minimum thicknesses are not utilized with grooving, then a shouldered end treatment with couplings as noted shall be utilized.

C. Pump and Equipment Flexible Connectors

1. The flexible connectors shall be expansion/vibration joints of the single arch type of butyl rubber construction with carcass of high grade woven cotton or suitable synthetic fiber and individual solid steel ring reinforcement. Soft rubber fillers shall be integrally cured into the arches to provide a smooth flow path to prevent settling of material into the arch. Joints shall be constructed to pipeline size and to meet working pressures and corrosive conditions similar to the line where installed. Joints shall have full faced fabric reinforced butyl flanges integral with the body.

2. Split steel or ductile iron back-up rings shall be provided to ensure a good joint. Rings shall be designed for mating with ANSI Standard minimum 150 lb flanges. All joints shall be finish coated with Hypalon or equal paint.

3. Expansion/vibration joints shall be furnished with control (harness) units. Harness units shall consist of minimum two drilled plates, stretcher bolts, and rubber washers backed by metal washers. The stretcher bolts shall prevent over-elongation of the joint. Extra nuts shall be provided on the stretcher bolts on the inside of the plate to prevent overcompression. All nuts, bolts and plates shall be galvanized.

4. The manufacturer of the expansion joints shall be a member of the Rubber Expansion Joint Division of the Fluid Sealing Association. Expansion joints shall be Style 1025 filled arch by General Rubber Corp., South Hackensack, NJ or similar products of Mercer Rubber; Goodall Rubber; Garloc; Red Valve Co., Inc.; Proco Products Inc., Stockton, CA or equal.

5. In addition to other locations shown on the Drawings, expansion joints shall be utilized in all exposed piping, within 1-ft of a building expansion joint.

2.13 EXPANSION JOINTS

A. Expansion Couplings

1. Bolted split sleeve type couplings to allow for thermal expansion and contraction at the pipe joints shall consist of one piece housing, gasket assembly, bolts and nuts, and end rings to hold the coupling in the proper location.

2. Couplings shall be manufactured from ASTM A240 Type 304 or Type 316 stainless steel material for use on stainless steel pipe. Couplings for use on carbon steel or ductile iron pipe shall be manufactured from ASTM A36 material. Gaskets shall be of a composition suitable for exposure to the fluid or air service.

3. Carbon steel couplings shall be coated in accordance with liquid epoxy coating per AWWA C210 or fusion bonded epoxy coating per AWWA C213. Manufacturers standard shop primer will not be accepted as a coating system. Stainless steel couplings shall be passivated after all welding is completed.

4. End rings of the same material as the coupling housing shall be welded to the plain end of the pipe ends that form the joint per the coupling manufacturer's recommendations to hold the coupling in the proper location.

5. The expansion joints shall be designed for the axial movements shown on the Drawings along with the maximum axial force required to compress the joint. The joints shall prevent axial, lateral and rotational movement and vibration from being transmitted to the piping and equipment and shall be suitable for 50 psig operating pressure unless otherwise indicated.

6. Expansion couplings for expansion joints for plain end pipe shall be Depend-O-Lok F x E by Victaulic Depend-O-Lok, equal by Red Valve Company, or equal.

B. Single- and Multiple-Arch Type

1. The expansion joints shall be of the rubber spool type, soft rubber filled with single-, double-, or triple-arch steel reinforced expansion joint, as indicated on the Drawings, suitable for 120 degrees F service, unless otherwise indicated.

2. The rubber used shall be suited for service with wastewater and/or wastewater sludge, including three-ply abrasion resistant liner.

3. Provide galvanized retaining rings to mate with adjacent pipe flanges.

4. The expansion joints shall be designed for the axial movements with the maximum axial force required to compress the joint. The joints shall prevent axial, lateral and rotational movement and vibration from being transmitted to the piping and equipment and shall be suitable for 50 psig operating pressure unless otherwise indicated.

5. Provide guides for each expansion joint.

C. Bellows Style

1. Expansion joints shall be hydraulically formed (with dies on the outside only) and having only longitudinal seam welds. These seams shall have the same strength, physical properties and thickness as the parent metal without grinding. Expansion joints, bellow, and internal sleeves shall be made of Type 304 stainless steel with carbon steel flanges at each end. The entire inside length of the expansion joint shall be straight. Manufacturer to provide lifting lugs at each flange for ease in handling and removal sheet metal coverage for any expansion joint.

2. Expansion joints shall be designed to prevent rotational movement and vibration from being transmitted to the piping and equipment and shall be suitable for 25 psig operation pressure unless otherwise specified.

3. Expansion joints shall be suitable for continuous operating temperature range of 200 to 300 degrees F.

4. Hinged or Gimbal expansion joints shall be used at horizontal and vertical bends in strict accordance with the standards of the EJMA, Inc.

5. Drilling and facing of flanges shall match or be suitable for use with equipment or companion flanges.

6. Guides shall be furnished with all bellows style expansion joints.

7. Manufacturer shall warrant this product to be suitable for the proposed conditions and shall furnish drawings for approval giving materials of construction, including gauge of corrugated element, maximum test pressure force to compress joint, bellows spring rate, shear force and end moment due to calculated traverse only. Manufacturer shall also furnish evidence of completing cycle life testing for the maximum diameter to be installed and shall indicate such assured cycle life test results on material submitted for approval.

D. Flexible Metal Hose

1. Flexible metal hose shall be constructed of corrugated inner tubing of tin-bronze or Type 321 stainless steel and shall have an outer shield of wire-braid of either tin-bronze or Type 321 stainless steel.

2. The flexible hose connectors shall have a length not less than five times the nominal pipe diameter.

3. The connectors shall have 150 psi flanged ends in all sizes and shall be suitable for pressure up to 150 psig and temperatures to 400 degrees F.

4. Flexible hose connectors shall be manufactured by Flexonics; Metraflex or equal.

2.14 HARNESSING AND RESTRAINT

A. Where harnessed couplings or adapters are noted, they shall conform to AWWA Manual M11 except as modified by the Drawings or this Section.

B. Unless otherwise noted, size and material for tie rods, clamps, plates and hex nuts shall be as shown on the Drawings, or, if not shown on the Drawings, shall be as required in AWWA Manual M11. Manufactured restraining clamp assemblies shall be as manufactured by [Stellar Corporation, Columbus, OH, or fabricated equal.

C. Restrained joints (such as welded, locking mechanical joints) shall be of the type specified with the individual type of pipe. If not specified, restrained (locking) mechanical joint pipe shall be of the manufacturer's standard design utilizing a locking device (ring or ears) integrally cast with the pipe.

D. For up through 12-in diameter ductile iron pipe only, the following may be used as an alternative to other restraint system:

1. The optional mechanical joint restraints shall be incorporated in the design of a follower gland. The gland shall be manufactured of ductile iron conforming to ASTM A536. Dimensions of the gland shall be such that it can be used with the standardized mechanical joint bell and tee-head bolts as specified with the pipe.

2. The restraint mechanism shall consist of numerous individually activated gripping surfaces to maximize restraint capability. The gripping surfaces shall be wedges designed to spread the bearing surfaces on the pipe. Twist-off nuts, sized same as tee-head bolts, shall be used to ensure proper actuating of restraining devices. When the nut is sheared off, standard hex nut shall remain.

3. The mechanical joint restraint device for ductile iron pipe shall have a working pressure of at least 250 psi with a minimum safety factor of 2:1.

4. The mechanical joint restraint devices shall be of the type listed below or equal.

5. For Ductile Iron Pipe: EBAA Iron, Inc. Megalug 1100 series for up to 16-in only.

E. The Contractor shall be responsible for anchorage including restraint as noted elsewhere in Division 40.

2.15 COLOR CODING AND LABELING

A. General

1. Provide a complete color coding system consisting of preprinted labels and banding by Brady; Seton or equal. Field painting shall be specified in Section 09 91 00.

2. Piping system identification shall comply with the requirements of ANSI A13.1.

3. Colors listed are general. Actual colors will be selected based on a comparison to the existing plant color codes, except as otherwise indicated; samples shall be furnished for all pipe paint colors; with chips from existing piping where new service lines are connecting.

4. Banding
   a. Unless special spacing is listed in schedule, apply banding to pipe at connections to equipment, valves, branch fittings, at wall, floor, or ceiling boundaries and at intervals not greater than 36-ft.

5. Labels and Directional Arrows
   a. Apply labels with directional arrows at connections to equipment, valves, branch fittings, at least one wall, floor, or ceiling boundary within a room and at intervals not greater than 36-ft.
   b. At each label, arrows indicating direction of flow shall point away from label. If flow may be in both directions, use double headed arrows.
   c. Lettering shall bear the full pipe system name as scheduled.
   d. Lettering height shall be as follows:

Outside Pipe Diameter	Minimum Letter Height
3/4-in to 1-1/4-in	1/2-in
1-1/2-in to 2-in	3/4-in
2-1/2-in to 6-in	1-1/4-in
8-in to 10-in	2-1/2-in
Over 10-in	3-1/2-in

   e. Two labels minimum each room, crawl space or compartment, unless otherwise approved.

PART 3 EXECUTION

3.01 GENERAL

A. All dirt, scale, weld splatter, water and other foreign matter shall be removed from the inside and outside of all pipe and sub-assemblies prior to installing.

B. All pipe joints and connections to equipment shall be made in such a manner as to produce a minimum of strain at the joint.

C. Test Connections

1. Provide ½-in female NPT test connection equipped with ½-in brass plug on all pump suction and discharge lines. Where indicated on the Drawings, test connections should be equipped with bar stock valve and gauge. Provide test connections at all steam traps. The connection shall be located on the discharge side of the trap between the trap and the first valve. It shall consist of a ½-in branch connection terminated with a gate valve.

D. Installation of Expansion Joints and Flexible Connectors

1. Piping systems shall be aligned prior to installation of expansion fittings. Alignment shall be provided by fitting a rigid pipe spool in place of the expansion joint. Prior to testing of the piping system, the pipe spool shall be replaced with the specified expansion or flexible fitting.

2. In addition to the locations noted on the Drawings and in PART 2, expansion fittings and anchors shall be located and spaced as specified by the Expansion Joint Manufacturer's Association. The expansion joints/flexible connectors shall not be installed during times of temperature extreme or in a fully compressed or fully expanded condition.

E. Installation of Sleeve Couplings

1. Unless otherwise required by the manufacturer's instructions, prior to installation of sleeve couplings, the pipe ends shall be cleaned thoroughly for a distance of at least 12-in. Soapy water may be used as a gasket lubricant. A follower and gasket, in that order, shall be slipped over each pipe to a distance of about 6-in from the end, the middle ring shall be placed on the already installed pipe and shall be inserted into the middle ring flair and brought to proper position in relation to the pipe already installed. The gaskets and followers shall then be pressed evenly and firmly into the middle ring flares.

2. After the bolts have been inserted and all nuts have been made up finger-tight, diametrically opposite nuts shall be progressively and uniformly tightened all around the joint, preferably by use of a torque wrench of the appropriate size and torque for the bolts.

3. The correct torque as indicated by a torque wrench shall not exceed 75 ft-lb for 5/8-in bolts and 90 ft-lb for ¾-in bolts.

4. If a wrench other than a torque wrench is used, it should be no longer than 12-in so that when used by the average person the above torque values shall not be exceeded.

5. To prevent sleeve couplings from pulling apart under pressure, a suitable harnessing or flange clamp assembly shall be provided and installed where shown on the Drawings, directed by the Engineer or required elsewhere under Division 40 concerning anchorage.

6. Note the additional locations required for sleeve couplings in PART 2. Also note Contractor's responsibility for locating, providing and installing restraints.

F. Installation of Split Couplings

1. Prior to assembly of split couplings, grooves or shoulders of the pipe as well as other parts shall be thoroughly cleaned. The ends of the pipes and outside of the gaskets shall be moderately coated with manufacturer's recommended lubricant, petroleum jelly, cup grease, soft soap, or graphite paste and the gasket shall be slipped over one pipe end. Lubricant shall be compatible with potable water application. After the other pipe has been brought to the correct position, the gasket shall be centered properly over the pipe ends with the lips against the pipes. The housing sections then shall be placed.

2. Ensure that the joints are fully extended after the rings are in place and prior to tightening the bolts. After the bolts have been inserted, the nuts shall be tightened until the housing sections are firmly in contact, as required by the manufacturer, without excessive bolt tension or strain on the pipe.

G. Installation of Pipeline Appurtenances

1. All pipeline appurtenances shall be installed as required and in accordance with the manufacturer's recommendations, as acceptable to the Engineer.

2. Gauges, meters and similar in-line items shall be isolated from testing pressures in excess of the rated pressure of the assembly.

3. Use Teflon tape on all screwed fittings.

H. Installation of Unions

1. Use unions to allow dismantling of pipe, valves, and equipment.

I. Welding

1. Welding shall be in accordance with ANSI B31 and AWS B3.0.

2. Install welding fittings on all welded lines. Make changes in direction and intersection of lines with welding fittings. Do not miter pipes to form elbows or notch straight runs to form tees, or any similar construction. Do not employ welder who has not been fully qualified in above specified procedure and so certified by approved welding bureau or similar locally recognized testing authority.

J. Installation of Flanged Joints

1. Make flanged joints with bolts; bolt studs with nut on each end; or studs with nuts where one flange is tapped. Use number and size of bolts conforming to same ANSI Standard as flanges. Before flanges pieces are assembled, remove rust resistant coating from machined surfaces, clean gaskets and smooth all burrs and other defects. Make up flanged joints tight, care being taken to prevent undue strain upon valves or other pieces of equipment.

3.02 TESTING

A. Test all pipelines for water/gas tightness as specified in the Piping or System Sections. Furnish all labor, testing plugs or caps, pressure pumps, pipe connections, gauges and all other equipment required. Testing shall be performed in accordance with one or more of the testing procedures appended to this Section as specified in each Piping or System Section. All testing shall be performed in the presence of the Engineer.

B. Repair faulty joints or remove defective pipe and fittings and replace as approved by the Engineer. Retest.

C. See Section 40 05 00 for additional requirements.

3.03 DISINFECTION

A. After satisfactory testing, all plant water systems shall be thoroughly disinfected with a solution of not less than 50 ppm of available chlorine. The disinfecting solution shall be allowed to remain in the system for a period of three hours after which time all valves and faucets shall be opened and the system shall be flushed with clean water.

B. Water being flushed from structures or pipelines after disinfection with a chlorine residual of two mg/l or greater, shall be treated with a dechlorination solution, in a method approved by the Engineer, prior to discharge.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals and install a complete system of pipe hangers, supports, concrete inserts and anchor bolts including all metallic hanging and supporting devices for supporting non-buried piping as shown on the Drawings and as specified herein.

B. The absence of pipe supports and details on the Drawings shall not relieve the Contractor of the responsibility for providing them. Pipe supports indicated on the Drawings are shown only to convey the intent of the design for a particular location and are not intended to represent a complete system.

1.02 RELATED WORK

A. Concrete is included in Division 3.

B. Miscellaneous metal is included in Section 05 50 00.

C. Pipe and fittings are included in respective sections of Divisions 33 and 40.

D. Valves and appurtenances are included in Section 40 05 50.

E. Hangers and supports pertaining to HVAC and Plumbing systems are included in their respective Sections.

1.03 SUBMITTALS

A. Submit, in accordance with Section 01 33 23, complete sets of shop drawings of all items to be furnished under this Section. Submittals shall include complete layouts, schedules, location plans and complete total bill of materials for all pipe support systems.

B. Submittals shall include a representative catalog cut for each different type of pipe hanger or support indicating the materials of construction, important dimensions and range of pipe sizes for which that hanger is suitable. Where standard hangers and/or supports are not suitable, submit detailed drawings showing materials and details of construction for each type of special hanger and/or support. Provide detailed information on anti-seize compound.

C. Submittals shall include complete piping drawings as submitted for each piping submittal indicating type of hanger and/or support, location, magnitude of load transmitted to the structure and type of anchor, guide and other pipe supporting appurtenances including structural fasteners.

D. Types and locations of pipe hangers and/or supports shall also be shown on the piping layouts for each piping submittal as specified in the respective Division 33 and

40 pipe sections. Service conditions for each piping system, including service temperatures, and operating and test pressures, are tabulated in the piping sections.

E. Submit complete design data for pipe support systems to show conformance with this Section.

F. Support System Design

1. Engage the services of an independent registered professional engineer ordinarily engaged in the business of pipe support systems analysis, to analyze system piping and service conditions and to develop a detailed support system, specific to the piping material, pipe joints, valves and piping appurtenances proposed for use.
   a. The proposed support system engineer shall have at least five years of experience in the analysis and design of similar systems, including the use of commercial and custom pipe support and in the use of commercial pipe stress software programs. Provide a detailed resume, including references from projects within the past five years. The use of support systems engineer shall be subject to the approval of the Engineer.

2. The proposed systems engineer shall attend a conference with the Engineer, scheduled prior to any support systems design.

3. The support system design shall include:
   a. Criteria by piping system.
   b. Summary of Contractor-selected related components including joints, class, valves appurtenances, etc., and commercial supports and especially including pipe materials.
   c. Dead weight and dynamic analysis, including system thermal effects and pressure thrusts. Computer-based software system equivalent to ADLPIPE.
      1) Each system shall be presented in an isometric graphic and shall show the resolved and resultant force and moment systems, as well as all recommended hangers, supports, anchors, restraints and expansion/flexible joints.
   d. Submit a draft report to the Engineer for approval.
      1) After the work is installed, but before it is filled for start-up and testing, the support system design engineer shall inspect the work and shall certify its complete adequacy. Each system shall be inspected and certified in the same way.
      2) Submit a report, including all field modifications and including all certificates.
      3) The report shall bear the stamp of a registered professional engineer and shall be subject to the approval of the Engineer.
   e. All aspects of the analysis and design shall comply with the provisions of ANSI B31.1 and the referenced standards.
   f. Support arrangements shall be coordinated to eliminate interference with similar systems to be installed under HVAC, Plumbing and Electrical; to account for structural expansion joints and to maintain access for both personnel and for the removal of equipment. Support systems shall not

include the use of monorail or bridge crane support. Nor shall they rely on the horizontal structural struts.

g. Commercial hardware and custom supports shall comply with the requirements of this Section.

h. Expansion joints shall comply with the provisions of Section 40 05 70.

4. Prepare for and attend a post-analysis review and presentation, after the Engineer's review of the report. Revise per the comments and issue as FINAL REPORT.

1.04 REFERENCE STANDARDS

A. Manufacturer's Standardization Society of the Valve and Fittings Industry (MSS)

1. MSS SP-58 - Pipe Hangers and Supports - Materials, Design and Manufacture.

2. MSS SP-69 - Pipe Hangers and Supports - Selection and Application.

B. ASTM International

1. ASTM A36 - Standard Specification for Carbon Structural Steel.

2. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.

C. American National Standards Institute (ANSI)

1. ANSI B31.1 - Power Piping.

D. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. All hangers, supports and appurtenances shall conform to the latest applicable requirements of ANSI B31.1, except as supplemented or modified by the requirements of this Section.

B. All hangers, supports and appurtenances shall be of approved standard design where possible and shall be adequate to maintain the supported load in proper position under all operating conditions. The minimum working factor of safety for all supporting equipment, with the exception of springs, shall be five times the ultimate tensile strength of the material, assuming 10-ft of water-filled pipe being supported.

C. All pipe and appurtenances connected to equipment shall be supported in such a manner as to prevent any strain being imposed on the equipment. When manufacturers have indicated requirements that piping loads shall not be transmitted to their equipment, submit certification stating that such requirements have been complied with.

1.06 DELIVERY, STORAGE AND HANDLING

A. All supports and hangers shall be crated, delivered and uncrated so as to protect against any damage.

B. All parts shall be properly protected so that no damage or deterioration shall occur during a prolonged delay from the time of shipment until installation is completed.

C. Finished metal surfaces not galvanized, that are not of stainless steel construction, or that are not coated, shall be grease coated, to prevent rust and corrosion.

PART 2 PRODUCTS

2.01 GENERAL

A. All of the equipment specified herein is intended to support the various types of pipe and piping systems shown on the Drawings. It shall be the responsibility of the Contractor to develop final details and any details associated with special conditions not already covered to meet the system conditions (in particular system temperatures and pressures) specified in the respective Division 2 and 15 Pipe Sections.

B. All pipe and tubing shall be supported as required to prevent significant stresses in the pipe or tubing material, valves, fittings and other pipe appurtenances and to support and secure the pipe in the intended position and alignment. All supports shall be designed to adequately secure the pipe against excessive dislocation due to thermal expansion and contraction, internal flow forces and all probable external forces such as equipment, pipe and personnel contact. Any structural steel members required to brace any piping from excessive dislocation shall conform to the applicable requirements of Section 05 50 00 and shall be furnished and installed under this Section.

C. The Contractor may propose minor adjustments to the piping arrangements in order to simplify the supports, or in order to resolve minor conflicts in the work. Such an adjustment might involve minor change to a pipe centerline elevation so that a single trapeze support may be used.

D. Where flexible couplings are required at equipment, tanks, etc., the end opposite to the piece of equipment, tank, etc., shall be rigidly supported, to prevent transfer of force systems to the equipment. No fixed or restraining supports shall be installed between a flexible coupling and the piece of equipment.

E. All pipe and appurtenances connected to the equipment shall be supported in a manner to prevent any strain from being imposed on the equipment or piping system.

F. All rods, clamps, hangers, inserts, anchor bolts, brackets and components for interior pipe supports shall be furnished with galvanized finish, hot dipped or electro-galvanized coated, except where field welding is required, where cold-applied galvanizing may be used. Interior clamps on plastic pipe shall be plastic coated. Supports for copper pipe shall be copper plated or shall have a 1/16-in plastic coating. All rods, clamps, hangers, inserts, anchor bolts, brackets and components for

exterior pipe, submerged pipe and pipe within outdoor structures shall be of Type 316 stainless steel.

G. Supports shall be sufficiently close together such that the sag of the pipe is within limits that will permit drainage and avoid excessive bending stresses from concentrated loads between supports.

H. All uninsulated non-metallic piping such as PVC, CPVC, etc., shall be protected from local stress concentrations at each support point. Protection shall be provided by galvanized steel protection shields or other method as approved by the Engineer. Where pipes are bottom supported 180 degrees, arc shields shall be furnished. Where 360 degree arc support is required, such as U bolts, protection shields shall be provided for the entire pipe circumference. Protection shields shall have an 18 gauge minimum thickness, not be less than 12-inches in length and be securely fastened to pipe with stainless steel or galvanized metal straps not less than ½-in wide.

I. All insulated pipe shall be furnished with a rigid foam insulating saddle at each pipe support location as specified under respective pipe insulation. Provide protection shields as specified in at each support location.

J. Where pipe hangers and supports come in contact with copper piping provide protection from galvanic corrosion by; wrapping pipe with 1/16-in thick neoprene sheet material and galvanized protection shield; isolators similar to Elcen, Figure No. 228; or copper plated or PVC coated hangers and supports. All stainless steel piping shall be isolated from all ferrous materials, including galvanized steel by use of neoprene sheet material and protection shields, similar to above methods.

K. Pipe supports shall be provided as follows:

1. Cast iron and ductile iron, steel and stainless steel piping shall be supported at a maximum support spacing of 10-ft with a minimum of one support per pipe section at the joints.

2. Insofar as is possible, floor supports shall be given preference. Typical concrete supports are shown on the structural drawings. Base elbow and base tees shall be used where possible.

3. Support spacing for steel and stainless steel piping 2-in and smaller diameter and copper tubing shall not exceed 5-ft.

4. For all stainless steel piping, provide neoprene isolators between the pipe and support components.

5. Supports for multiple PVC plastic piping shall be continuous wherever possible. Individually supported PVC pipes shall be supported as recommended by the manufacturer except that support-spacing shall not exceed 3-ft. Multiple, suspended, horizontal plastic PVC pipe runs, where possible, shall be supported by ladder type cable trays such as the Electray Ladder by Husky-Burndy; the Globetray by the Metal Products, a Division of United States Gypsum, or equal. Ladder shall be of galvanized steel construction. Rung

spacing shall be 12-in. Tray width shall be approximately 6-in for single runs and 12-in for double runs. Ladder type cable trays shall be furnished complete with all hanger rods, rod couplings, concrete inserts, hanger clips, etc., required for a complete support system. Individual plastic pipes shall be secured to the rungs of the cable tray by strap clamps or fasteners similar to Globe, Model M-CAC; Husky-Burndy, Model SCR or equal. Spacing between clamps shall not exceed 9-ft. The cable trays shall provide continuous support along the length of the pipe. Individual clamps, hangers and supports in contact with plastic PVC pipe shall provide firm support but not so firm as to prevent longitudinal movement due to thermal expansion and contraction.

6. All vertical pipes shall be supported at each floor or at intervals of not more than 12-ft by approved pipe collars, clamps, brackets, or wall rests and at all points necessary to insure rigid construction. All vertical pipes passing through pipe sleeves shall be secured using a pipe collar.

7. Pipe supports shall not induce point loadings but shall distribute pipe loads evenly along the pipe circumference.

8. Supports shall be provided at changes in direction and elsewhere as shown in the Drawings or as specified herein. No piping shall be supported from other piping or from metal stairs, ladders and walkways, unless specifically directed or authorized by the Engineer.

9. Pipe supports shall be provided to minimize lateral forces through valves, both sides of split type couplings and sleeve type couplings and to minimize all pipe forces on pump housings. Pump housings shall not be utilized to support connecting pipes.

10. Effects of thermal expansion and contraction of the pipe shall be accounted for in the pipe support selection and installation.

L. Unless otherwise specified herein, pipe hangers and supports shall be standard catalogued components, conforming to the requirements of MSS-SP-58 and -69; and shall be as manufactured by Grinnell Co., Inc., Providence, RI; Carpenter & Patterson, Inc., Woburn, MA; F&S Central, Brooklyn NY; Elcen Metal Products Co., Franklin Park, IL and Unistrut Northeast, Cambridge, MA or equal. Any reference to a specific figure number of a specific manufacturer is for the purpose of establishing a type and quality of product and shall not be considered as proprietary.

M. Any required pipe supports for which the supports specified in this Section are not applicable shall be fabricated or constructed from standard structural steel shapes, concrete and anchor hardware similar to items previously specified herein and shall be subject to the approval of the Engineer.

N. Expansion anchors shall be equal to Kwik-Bolt as manufactured by the McCullock Industries, Minneapolis, MN or Wej-it by Wej-it Expansion Products, Inc., Bloomfield, CO. The length of expansion bolts shall be sufficient to place the wedge portion of the bolt a minimum of 1-in behind the steel reinforcement.

O. Hanger rods shall be hot rolled steel, machine threaded and galvanized after fabrication. The strength of the rod shall be based on its root diameter. Hanger rods shall be attached to concrete structures using concrete inserts similar to F&S, Figures 180, 571 or 150; or continuous concrete inserts per F&S. Inserts shall be malleable iron, or steel with galvanized finish. Beam clamps, C clamps or welded beam attachments shall be used for attaching hanger rods to structural steel members. Where necessary and approved by the Engineer, expansion anchors shall be used for attaching to concrete structures.

2.02 SINGLE PIPE HANGERS

A. Single pipes shall be supported by hangers suspended by hanger rods from structural steel members, concrete ceilings, bottom of trapeze hangers and wall mounted steel angle brackets.

B. Except as otherwise specified herein, pipe hangers shall be steel, of the adjustable clevis type similar to Grinnell, Figure No. 65, 260 and 590 as required.

C. Where pipes are near walls, beams, columns, etc., and located an excessive distance from ceilings or underside of beams, welded steel wall brackets similar to Carpenter and Patterson, Figure No. 69-68, 84 or 139 shall be used for hanging pipe. Where single pipes rest on top of bracket pipe supports, attachments shall meet requirements as specified under multiple pipe hangers.

2.03 MULTIPLE PIPE HANGERS

A. Suspended multiple pipes, running parallel in the same horizontal plane, which are adjacent to each other shall be suspended by trapeze type hangers or wall brackets. Trapeze hangers shall consist of galvanized structural steel channel supported from galvanized threaded rod or attached to concrete walls, columns or structural steel support members as required to meet the intent of this Section. Channel shall be similar to F&S, Figure 710, rods, concrete inserts, "C" clamps, beam clamps, welded beam attachments and expansion shields shall be as specified in Paragraph 2.02 above.

B. Except as otherwise specified herein pipe anchors used for attaching pipe to trapeze or multiple pipe wall brackets shall be anchor or pipe chairs similar to F&S, Figures 158, 419, 160A, 160B as required. Material of construction shall be galvanized steel. Chair "U" bolts shall be tightened to allow freedom of movement for normal expansion and contraction except where pipe must be anchored to control direction of movement or act as a thrust anchor.

2.04 SINGLE AND MULTIPLE PIPE SUPPORTS

A. Single pipes located in a horizontal plane close to the floor shall be supported by one of the methods as shown on the Drawings and as specified herein.

B. Pipes 3-in in diameter and larger shall be supported by adjustable stanchions similar to F&S, Figure 427. Stanchions shall provide at least 4-in adjustment and be flange mounted to floor.

C. Pipes less than 3-in in diameter shall be held in position by supports fabricated from steel "C" channel, welded post base similar to Unistrut, Figure P2072A and pipe clamps similar to Unistrut, Figures P1109 thru P1126. Where required to assure adequate support, fabricate supports using two vertical members and post bases connected together by horizontal member of sufficient load capacity to support pipe. Wherever possible supports shall be fastened to nearby walls or other structural member to provide horizontal rigidity. More than one pipe may be supported from a common fabricated support.

D. Where shown on the Drawings, pipe shall be supported using concrete anchor posts. Pipe shall be securely fastened to the posts using suitable metal straps as required and as approved.

2.05 WALL SUPPORTED PIPES

A. Single or multiple pipes located adjacent to walls, columns or other structural members, whenever deemed necessary, shall be supported using welded steel wall brackets similar to Carpenter and Patterson, Figure No. 69-78, 84, or 134; or "C" channel with steel brackets similar to Unistrut pipe clamps. All members shall be securely fastened to wall, column, etc., using double expansion shields or other method as approved by the Engineer. Additional wall bearing plates shall be provided where required.

B. Pipe shall be attached to supports using methods specified herein to meet the intent of this Section.

2.06 BASE ANCHOR SUPPORT

A. Where pipes change direction from horizontal to vertical via a bend, a welded or cast base bend support shall be installed at the bend to carry the load. The base bend shall be fastened to the floor, pipe stanchion, or concrete pedestal using expansion anchors or other method as approved by the Engineer.

B. Where shown on the Drawings, pipe bends shall be supported using concrete anchor posts. Pipes shall be securely fastened to the concrete supports with suitable metal bands as required and approved by the Engineer. A felt insert shall be used to isolate the piping from the poured concrete.

2.07 VERTICAL PIPE SUPPORTS

A. Where vertical pipes are not supported by a Unistrut system as specified in Paragraph 2.08 below, they shall be supported in one of the following methods.

1. For pipes ¼-in to 2-in in diameter, an extension hanger ring shall be provided with an extension rod and hanger flange. The rod diameter shall be as recommended by the manufacturer for the type of pipe to be supported. The hanger ring shall be steel or PVC clad depending on the supported pipe. The hanger ring shall be equal to Carpenter & Paterson, Figure No. 81 or 81CT. The anchor flange shall be galvanized malleable iron similar to Carpenter and Patterson, Figure No. 85.

2. For pipes equal to or greater than 2-in in diameter extended pipe clamps similar to Carpenter and Patterson, Figure No. 267 may be used. The hanger shall be attached to concrete structures using double expansion shields, or to steel support members using welding lugs similar to Carpenter and Patterson, Figure No. 220.

3. Pipe riser clamps shall be used to support all vertical pipes extending through floor slabs. Riser clamps shall be steel similar to Carpenter and Patterson, Figure No. 126. Copper clad or PVC coated clamps shall be used on copper pipes. Insulation shall be removed from insulated pipes prior to installing riser clamps. Insulation shall not be damaged by clamp installation.

4. Unless otherwise specified, shown, or specifically approved by the Engineer, vertical runs exceeding 12-ft shall be supported by base elbows/tees, clamps, brackets, wall rests and pipe collars, all located as required to ensure a rigid installation.

2.08 SPECIAL SUPPORTS

A. Pipe supports shall be provided for closely spaced vertical piping systems required to provide a rigid installation. The interval of vertical support spacing shall be as specified, but in no case shall vertical interval exceed 10-ft. The support system shall consist of a framework suitably anchored to floors, ceilings or roofs.

B. Vertical and horizontal supporting members shall be U shaped channels similar to Unistrut, Series P1000. Vertical piping shall be secured to the horizontal members by pipe clamps or pipe straps. All components shall be of steel.

C. For piping 3-in and smaller, the framework shall be as manufactured by the Unistrut Corporation; Globe-Strut as manufactured by the Metal Products Division of U.S. Gypsum or equal. For piping larger than 3-in, the support frame shall be fabricated from structural steel shapes and secured through the use of expansion anchors.

D. The assemblies shall be furnished complete with all nuts, bolts and fittings required for a complete assembly including end caps for all Unistrut's members.

E. The design of each individual framing system shall be the responsibility of the Contractor. Shop drawings, as specified above shall be submitted and shall show all details of the installation, including dimensions and types of supports. In all instances the completed frame shall be adequately braced to provide a complete rigid structure when all the piping has been attached.

F. Supports not otherwise described in this Section shall be fabricated or constructed from standard structural steel shapes in accordance with applicable provisions of Section 05 50 00, or Unistrut-type frame; have anchor hardware similar to items previously specified herein, shall meet the minimum requirements listed below and be subject to the approval of the Engineer.

1. Pipe support systems shall meet all requirements of this Section and all related Sections.

2. Complete design details of the pipe support system and system components shall be submitted for review and approval as specified in PART 1. No hanger or support shall be installed without the written approval of the Engineer.

3. The pipe support system shall not impose loads on the supporting structures in excess of the loads for which the supporting structure is designed.

2.09 SUPPORTS FOR GROOVED DUCTILE IRON PIPING

A. Grooved ductile iron piping systems proposed by the Contractor as substitute to the flanged ductile iron piping system shown on the Drawings and specified in Section 40 05 18 shall be acceptable, in part, subject to the following hanger and support system revised requirements.

1. Take extreme caution in any and all field cut grooves, due to the criticality of the dimensions and location of the grooves. No field grooved piping shall be assembled without the inspection and verification of the groove by the Contractor and in the presence of the Engineer. All couplings connected to a field groove shall be spot-painted.

2. At each change in direction the piping shall be restrained against the axial direction of movement and against resultant pressure thrust, due to potential joint movement due to out-of-spec grooving.

B. If in the course of testing or operation there is any pipe movement, it shall require the removal of the length of pipe.

2.10 SURFACE PREPARATION AND SHOP PRIME PAINTING

A. All surfaces shall be prepared and shop painted as specified in Division 9.

PART 3 EXECUTION

3.01 INSTALLATION

A. Proceed with the installation of piping and supports only after any building structural work has been completed and new concrete has reached its 28-day compressive strength.

B. The installation of pipe support systems shall in no way interfere with the operation of the overhead bridge cranes, monorails, access hatches, etc.

C. The installed systems shall not interfere with maintenance and operational access to any equipment installed under this Section, or any other related Section.

D. All pipes horizontal and vertical, requiring rigid support shall be supported from the building structure by approved methods. Supports shall be provided at changes in direction and elsewhere as shown in the Drawings or as specified herein. No piping shall be supported from metal stairs, ladders and walkways unless specifically directed or authorized by the Engineer.

E. All pipe supports shall be designed with liberal strength and stiffness to support the respective pipes under the maximum combination of peak loading conditions to include pipe weight, liquid weight, liquid movement and pressure forces, thermal expansion and contraction, vibrations and all probable externally applied forces. Prior to installation, all pipe supports shall be approved by the Engineer.

F. Pipe supports shall be provided to minimize lateral forces through valves, both sides of split type couplings and sleeve type couplings (within four pipe diameters) and to minimize all pipe forces on pump housings. Pump housings shall not be utilized to support connecting pipes.

G. Inserts for pipe hangers and supports shall be installed on forms before concrete is placed. Before setting these items, all Drawings and figures shall be checked which have a direct bearing on the pipe location. Responsibility for the proper location of pipe supports is included under this Section.

H. Continuous metal inserts shall be embedded flush with the concrete surface.

I. Apply anti-seize compound to all nuts and bolts. Supports installed without the approved compound shall be dismantled and correctly installed, at no additional cost to the Owner.

3.02 TESTING

A. All pipe support systems shall be tested for compliance with this Section. After installation, each pipe support system shall be tested in conjunction with the respective piping pressure tests. If any part of the pipe support system proves to be defective or inadequate, it shall be repaired or augmented under this Section to the satisfaction of the Engineer.

3.03 SUPPORTS CERTIFICATION

A. The pipe support analysis shall be sealed by a structural engineer licensed in the State the project is located and the pipe support analysis shall certify that all pipe support designs comply with all applicable codes and loads transmitted to the roof and other structural elements and do not exceed the loads allowed by applicable codes.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install electrical heat trace system and insulation on all outdoor exposed piping, valves, and other piping appurtenances as shown on the Drawings and as specified herein.

B. The manufacturer shall design and supply the entire heating system, including the schematic arrangements, heating cable, junction boxes, thermostats and other equipment necessary to complete the system as shown on the Drawings and as specified herein.

C. Furnish all labor and materials necessary to install and place in satisfactory operation a complete electric heat tracing system based on the actual piping installations and the manufacturer's installation drawings and recommendations.

1.02 RELATED WORK

A. Pipe testing, cleaning and disinfection is included in Section 01 45 28.

B. Piping and installation is included in Division 15.

C. Pipe hangers and supports are included in Division 15.

D. Pipe Insulation is included in Section 23 07 00.

1.03 SUBMITTALS

A. Submit to the Engineer, in accordance with Section 01 33 23, the following calculations and information:

1. Heat loss and operating power calculations.

2. Heat tracing circuit design and loading schedule.

3. Bill of materials.

4. Catalog data sheets for all components.

5. Typical installation details.

6. Diagrams of the proposed heat tracing patterns.

B. Submit the heat tracing system's power requirements for the design condition (extreme minimum ambient at required maintain temperature) and for the normal operating temperature (normally expected minimum ambient).

1.04 REFERENCE STANDARDS

A. The system shall be suitable for the specified industrial conditions, and shall be designed and installed in accordance with the latest applicable codes and standards. Pertinent standards are:

1. American National Standards Institute (ANSI)
2. Institute of Electrical and Electronics Engineers (IEEE)
3. American Society for Testing and Materials (ASTM)
4. National Fire Protection Association (NFPA)
5. National Electrical Code (NEC)
6. Factory Mutual (FM)
7. Underwriters Laboratories (UL)
8. National Electrical Manufacturers Association (NEMA)
9. Occupational Safety and Health Administration (OSHA)

B. Furnish copies of the necessary approvals for the heat tracing system and verify that the approvals are current.

C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. The heat tracing system manufacturer shall be required to demonstrate a minimum of 5 years' experience in the design and manufacture of industrial heat tracing systems similar to those described in this Section and shown on the Drawings.

B. The system manufacturer shall employ capable personnel to provide detail engineering, coordination, drafting and start-up services and shall provide warranty compliance for the period specified.

C. All heat tracing equipment furnished under this Section shall be supplied by a single manufacturer and shall have a minimum of 5 years of proven successful operation in the field under environmental conditions similar to those that will be encountered under the scope of this work.

1.06 MANUFACTURERS SERVICE

A. Provide manufacturer's technical and design services to layout the proposed heat tracing system and prepare shop drawings and information to be submitted under the requirements of this Section.

1.07 HAZARDOUS AREA CLASSIFICATION

A. Supply a heating system which is suitable for the specified industrial and electrical classification and shall be designed and installed in accordance with the latest local and/or National Electrical Code regulations.

B. Where heat tracing is installed in hazardous locations as shown on the Electrical Drawings, all heat tape, boxes, thermostats, etc. shall be suitably rated and approved for the designated classified area in which it is installed. The installations shall be in compliance with National Electrical Code. The heat trace designer shall indicate the hazardous locations on the heat trace design drawings and submittal.

1.08 DESIGN REQUIREMENTS

A. Provide a heating system capable of maintaining the specified temperature during the extreme of ambient temperature.

B. Design Parameters

1.	Voltage Available	120 Volts Single Phase
2.	Wind Velocity	30 mph
3.	Low Ambient Temperature	0 degrees F
4.	Maintain Temperature	50 degrees F, except caustic which is 60 degrees F

5. Piping and equipment lists and insulation types and thicknesses are found in Division 15 and on the Drawings.

C. Heat losses shall be calculated using the manufacturer's standard procedure in conjunction with the insulation requirements and equipment schedules. The design heat output of the tracing shall include a 10 percent factor of safety. Contractor is encouraged to suggest changes in insulation thickness to optimize total system economy.

D. Heating cables shall be run parallel to the pipe only. Spiral wrapping of the heat cables around the pipes shall not be permitted.

1.09 APPLICATIONS

A. The term "Freeze Protection System" shall mean the heating system installed on equipment such as pipes, valves, pumps, gauges, and controls to prevent the fluid from freezing when the ambient or surrounding temperature falls below 32 degrees F (0 degrees C). Freeze protection shall be provided for the following systems:

1. All outdoor exposed piping with a diameter of 8-inches or less as noted on the Drawings.

B. Parallel resistance self-limiting heat tracing cable shall be used for piping freeze protection system. The tape shall be rated 5 watts per foot at 50 degrees F.

C. When heating cables are installed in hazardous areas indicated on the Drawings, they shall be UL or FM listed for use in the particular atmosphere and degree of hazard involved.

D. The temperature of the heating cables shall be automatically controlled by line type thermostats specified herein. The thermostats shall switch a contactor to power the heating cables.

PART 2 PRODUCTS

2.01 MATERIALS

A. Parallel Resistance Self-Regulating Cable

1. The heater design shall be such that it can vary its output in response to temperature variations along a pipe due to heat sinks such as fittings or pipe supports, or changes in ambient conditions such as those occurring on pipes passing into or out of buildings or process areas. This variable output feature shall apply to each increment of the heater independent of each other increment.

2. Heat tracing should be of a type which can be field cut-to-length without any cold spots and can be overlapped at all power outputs without burning out.

3. The heat tracing should be capable of continuous reliable operation when hanging loose in free air during equipment removal or replacement.

4. The cable shall not require the use of heat transfer cement or compounds.

5. The cable shall operate on standard voltages without the use of special transformers. Line voltage fluctuations shall not appreciably affect the cable wattage output.

6. Heat tracing shall be a type which can be field designed to accommodate changes in field piping without compromising its FM or UL approvals.

B. Control Thermostats

1. Control thermostats shall be UL listed, heavy duty, industrial bulb and capillary type housed in a watertight, NEMA 4X cast aluminum enclosures (NEMA 7 rated for hazardous locations). Thermostats shall be provided with independently adjustable dual switches for control and low temperature alarm. Contact shall be resistive. Bulb and capillary shall be stainless steel, 10-ft long.

C. Power connection kits and junction boxes shall be NEMA 4X watertight cast aluminum (NEMA 7 rated for hazardous locations).

D. The heat tracing system shall be manufactured by Chemelex, or approved equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Heat tracing system shall be installed in accordance with manufacturer's approved shop drawings and recommendations.

B. Heating cables shall be run parallel to the pipe only. Spiral wrapping of the heat cables around the pipes shall not be permitted.

C. Power cables for heat tracing circuits running from the supply panel to circuit junction boxes located on each pipe shall be run in conduit. The heat tracing cable shall connect to the power cable in a junction box and be routed onto the pipe through a cable feeder connector with gland nut. The connector shall be two-piece construction with a tapered neoprene bushing and recessed flame-resistant interior gland. The connector shall be attached to the pipe with stainless steel J.B. support and pipe strap.

D. At each point where the junction box is attached to the lagging for heating cable entry to the pipe or device being protected and after the heating cable has been installed, the junction box stand-off shall be filled with clear Dow Corning TRV-732 compound or equal rated 500 degrees F, to provide a waterproof connection. The sealant compound shall also be forced into the voids in the insulation which were created during installation of the conduit hub. The sealant compound shall be placed to position all cables away from standoff sides and to separate cables away from one another. The sealant compound shall be applied in a clean, neat manner and in strict accordance with the manufacturer’s instructions for the sealant. When the installation is complete, check that none of the compound has been left on other than the prescribed areas.

E. Install "electrically traced line" warning signs every 25-ft along the outer pipe insulation jacket, Chemelex catalog number "ETL".

3.02 TESTING

A. Measure the resistance of heating cable system before and after pipe insulation.

B. Adjust and seal control thermostats to Owner’s and Engineer’s satisfaction after installation is complete.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. The Contractor shall procure the services of a Process Control System Supplier (PCSS) to furnish and install all materials, equipment, labor and services, required to achieve a fully integrated and operational system as specified herein, in the Specification Sections listed below, and in related drawings, except for those services and materials specifically noted.

1. Section No Title

40 90 21	Testing
40 96 45	Control Descriptions
40 94 43	PLC Hardware and Software
40 95 13	Control Panels and Panel Mounted Equipment
40 91 40	Instruments

B. Auxiliary and accessory devices necessary for system operation or performance, such as transducers, relays, signal amplifiers, intrinsic safety barriers, signal isolators, software, and drivers to interface with existing equipment or equipment provided by others under other Sections of these specifications, shall be included whether they are shown on the Drawings or not.

C. All equipment and installations shall satisfy applicable Federal, State and local codes.

D. Use the equipment, instrument, and loop numbering scheme shown on the Drawings and specifications in the development of the submittals. Do not deviate from or modify the numbering scheme without the Engineer's approval.

E. The PCSS shall be responsible for the following:

1. Furnish and install all instrumentation as shown on the Instrumentation Drawings and as detailed in 40 91 40.

2. Furnish new Programmable Logic Controller (PLC) in NEMA 4X enclosure. Size the PLC to accommodate all I/O as shown on the P&IDs. Program and configure PLC as detailed in 40 96 45. PLC shall include an 800 MHz Analog radio to be compatible with the existing SCADA system.

3. Provide a camera surveillance system as described in Section 28 20 00.

4. Modify the existing VTScada HMI SCADA graphics at the MBWWTP by adding new HMI screens for monitoring and control of new equipment as shown on the P&IDs.

1.02 RELATED WORK

A. Instrumentation and Controls conduit systems are specified in Section 26 05 33.

B. Instrumentation signal cable and alarm and status wiring are specified in Section 26 05 10.

C. Video Surveillance systems are specified in Section 28 20 00.

1.03 SUBMITTALS

A. General Requirements:

1. Refer to Section 01 33 23 for general submittal requirements.

2. Shop drawings shall demonstrate that the equipment and services to be furnished comply with the provisions of these specifications and shall provide a complete record of the equipment as manufactured and delivered.

3. Submittals shall be complete; giving equipment specifications, details of connections, wiring, ranges, installation requirements, and specific dimensions. Submittals consisting of only general sales literature shall not be acceptable.

4. Substitutions on functions or type of equipment specified shall not be acceptable unless specifically noted.

5. Separate submittals shall be made for each submittal listed below.

B. Qualifications, Project Plan, Deviation List, and Schedule Submittal:

1. Submit, within 45 calendar days after Notice to Proceed, the following. This submittal must be approved before further submittals shall be accepted.

2. Qualifications. Provide complete documentation of PCSS compliance with paragraph 1.06 of this Section.

3. The Project Plan shall, at a minimum, contain the following:
   a. Overview of the proposed control system describing the understanding of the project work, a preliminary system architecture drawing, interfaces to other systems, schedule, startup, and coordination. A discussion of startup, replacement of existing equipment with new, switchover (Maintaining Plant Operations during system transition), approach to testing and training, and other tasks as required by these specifications shall be included as applicable.
   b. Preliminary list PLC software and PLC hardware, including version numbers, solely to determine compliance with the requirements of the Contract Documents prior to beginning development of system programming. Review and approval of software and hardware systems as part of this Project Plan stage shall not relieve the PCSS of meeting all the functional and performance requirements of the system as specified

herein. Substitution of manufacturer or model of these systems after the submittal is approved is not allowed without Engineer approval.

c. Project personnel and organization including the PCSS project manager, project engineer, and lead project technicians. Include resumes of each these individuals and specify in writing their commitment to this project. These do not need to be submitted again if already submitted in the Qualification submittal.

4. Exceptions to the Specifications or Drawings shall be clearly defined in a Deviation List. The Deviation List shall consist of a paragraph by paragraph review of the Specifications indicating acceptance or any proposed deviations, the reason for exception, the exact nature of the exception and the proposed substitution so that an evaluation may be made by the Engineer. If no exceptions are taken to the specifications or drawings the PCSS shall make a statement as such. If there is no statement by the PCSS, then it is acknowledged that no exceptions are taken.

5. Project schedule shall be prepared in Gantt chart format clearly showing task linkages for all tasks and identifying critical path elements. PCSS schedule must be based on the General Contractor schedule and must meet all field installation, testing, and start-up milestones in that schedule. The project schedule shall illustrate I&C related major project milestones including the following:
   a. Schedule for all subsequent project submittals. Include the time required for Contractor submittal preparation, Engineer's review time, and a minimum of two complete review cycles.
   b. Proposed dates for all project coordination meetings.
   c. Hardware purchasing, fabrication, and assembly (following approval of related submittals).
   d. Software purchasing and configuration (following approval of related submittals).
   e. Shipment of instrument and control system equipment.
   f. Installation of instrument and control system equipment.
   g. Testing: Schedule for all testing.
   h. Schedule for all training including submittal and approval of O&M manuals, factory training, and site training.

C. Field Instruments Submittal:

1. Refer to section 40 91 40 for submittal requirements.

D. Hardware and Software Packages Submittal:

1. Refer to the sections below for specific Hardware and Software Packages submittal requirements:
   a. 40 94 43 - PLC Hardware and Software.
   b. 40 95 13 - Control Panels and Panel Mounted Equipment.

2. For each hardware and software packages component specified in the sections above, submit a cover page that lists, at a minimum, date, specification number, product name, manufacturer, model number, Location(s), and power required.

Preferred format for the cover page is ISA-TR20.00.01-2007, general data sheet; however, other formats will be acceptable provided they contain all required information.

E. Panel Layout Drawings and Wiring Diagrams Submittal:

1. Refer to section 40 95 13 section for submittal requirements.

F. Testing Plan Submittals:

1. Refer to Section 40 90 21 - Testing for specific testing submittal requirements.

G. Operations and Maintenance (O&M) Manuals:

1. Submit in accordance with Section 01 78 23.

2. The operations and maintenance manuals shall, at a minimum, contain the following information:
   a. Table of Contents:
      1) A Table of Contents shall be provided for the entire manual with the specific contents of each volume clearly listed. The complete Table of Contents shall appear in each volume.
   b. Instrument and Equipment Lists:
      1) The following lists shall be developed in Microsoft Excel format and provided not only as a hardcopy in O&M but also electronically on a CD.
      2) An instrument list for all devices supplied including tag number, description, specification section and paragraph number, manufacturer, model number, serial number, range, span, location, manufacturer phone number, local supplier name, local supplier phone number, completion year replacement cost, and any other pertinent data.
      3) An equipment list for all non-instrument devices supplied listing description, specification section and paragraph number, manufacturer, model number, serial number, location, manufacturer phone number, local supplier name, local supplier phone number, completion year replacement cost, and any other pertinent data.
   c. Equipment Operations and Maintenance Information:
      1) ISA-TR20.00.01-2007 data sheets shall be provided for all field instruments. For non-field instrumentation devices, provide a cover page for each device, piece of equipment, and OEM software that lists date, specification number, product name, manufacturer, model number, Location(s), and power required. Preferred format for the cover page is ISA-TR20.00.01-2007, general data sheet; however, other formats will be acceptable provided they contain all required information.
      2) Vendor O&M documentation for each device, piece of equipment, or OEM software shall be either new documentation written specifically for this project, or modified standard vendor documentation. All standard vendor documentation furnished shall have all portions that apply clearly indicated with arrows or circles. All portions that do not

apply shall be neatly lined out or crossed out. Groups of pages that do not apply at all to the specific model supplied shall be removed.

3) Provide the record documentation of the system audit as specified in Section 40 90 20- Testing.
4) Include the calibration forms developed as specified in Section 40 90 20 - Testing.

d. As-Built Drawings:
   1) Complete as-built drawings, including all drawings and diagrams specified in this section under the "Submittals" section. These drawings shall include all termination points on all equipment the system is connected to, including terminal points of equipment not supplied by the PCSS.
   2) As built documentation shall include information from submittals, as described in this Specification, updated to reflect the as-built system. Errors in or modifications to the system resulting from the Factory and/or Functional Acceptance Tests shall be incorporated in this documentation.

e. Original Licensed Software:
   1) Submit original software diskettes or CD-ROMs of all software provided under this Contract. Submit original paper based and electronic documentation for all software provided. Submit license agreement information including serial numbers, license agreements, User Registration Numbers and related information. All software provided under this Contract shall be licensed to the Owner at the time of purchase. Provide media in software sleeves within O&M manual.

f. Electronic O&M Information:
   1) In addition to the hard copy of O&M data, provide an electronic version of all equipment manuals and data sheets, along with any software back-up of configuration files, on CDROM or DVD. Electronic documents shall be supplied in Adobe Acrobat format.
   2) Provide electronic files for all custom-developed manuals including training manuals. Text shall be supplied in both Microsoft Office format and Adobe Acrobat format.
   3) Provide electronic files for all drawings produced. Drawings shall be in AutoCAD ".dwg" format and in Adobe Acrobat format. Drawings shall be provided using the AutoCAD eTransmit feature to bind external references, pen/line styles, fonts, and the drawing file into individual zip files.
   4) Each computer system hardware device shall be backed up onto CDROM or DVD after Substantial Completion and shall be turned over to the Owner.
   5) If specified in the training section, provide digital copies of all training videos. Videos shall be in a format that is readable by standard DVD players and by standard PC DVD drives. Format shall be a minimum of 800 by 600 pixels and shall include sound.

3. The cover and edge of each volume shall contain the information as specified in Section 01 78 23.

1.04 COORDINATION MEETINGS

A. Schedule the mandatory coordination meetings as described herein. The meetings shall be held at the Owner's designated location and shall include attendance by the Owner, the Engineer, the Contractor, and the PCSS's Project Engineer. Other Division 40 specifications may require additional meetings. Prepare and distribute an agenda for this meeting a minimum of one week before the scheduled meeting date. Meeting shall be scheduled a minimum of one week before the requested meeting date.

1. A project kickoff coordination meeting shall be held within two weeks after submitting the Project Plan. The purpose of the meeting shall be to discuss the PCSS's Project Plan, to summarize the PCSS's understanding of the project; discuss any proposed substitutions or alternatives; schedule testing and delivery deadline dates; provide a forum to coordinate hardware and software related issues; and request any additional information required from the Owner. The meeting will last up to one business day.

1.05 REFERENCE STANDARDS

A. Publications are referred to in the text by basic designation only. Where a date is given for reference standards, that edition shall be used. Where no date is given for reference standards, the latest edition in effect at the time of bid opening shall apply.

B. International Society of Automation (ISA):

1. ISA S5.2, Binary Logic Diagrams for Process Operations.

2. ISA S5.3, Graphic Symbols for Distributed Control/Shared Display Instrumentation Logic and Computer Systems.

3. ISA S5.4, Instrument Loop Diagrams.

4. ISA RP60.3, Human Engineering for Control Centers.

5. ISA RP60.6, Nameplates, Labels, and Tags for Control Centers.

6. ISA-99, Industrial Automation and Control Systems Security.

C. National Electrical Manufacturers Association (NEMA).

D. National Fire Protection Agency (NFPA):

1. NFPA 70, National Electrical Code (NEC).

2. NFPA 79, Industrial Control Equipment.

E. Underwriters Laboratories, Inc. (UL):

1. UL 508 - Industrial Control Equipment - for custom fabricated equipment.

2. A nationally recognized testing laboratory, as approved by the Authority having jurisdiction, may substitute for UL listing on commercial off the shelf products.

1.06 QUALITY ASSURANCE

A. The Process Control System Supplier (PCSS) shall be a "systems integrator" regularly engaged in the design and the installation of instrumentation systems and their associated subsystems as they are applied to the municipal water and wastewater industry. For the purposes of this Specification Section, a "systems integrator" shall be interpreted to mean an organization that complies with all of the following criteria:

1. Employs personnel on this project who have successfully completed ISA or manufacturer’s training courses on general process instrumentation and configuration and implementation of the specific programmable controllers, computers, and software proposed for this project. Key personnel shall hold ISA CCST Level 1 certification or have a minimum of 10 years of verifiable plant startup experience. Key personnel shall include, as a minimum, the lead field technician.

2. Has successfully completed work of similar or greater complexity on at least three previous projects within the last five years. Successful completion shall be defined as a finished project completed on time, without any outstanding claims or litigation involving the PCSS. Potential references shall be for projects where the PCSS's contract was of similar size to this project.

3. Has been actively engaged in the type of work specified in this Section for a minimum of five years.

B. The PCSS shall maintain a permanent, fully staffed and equipped service facility within 200 miles of the project site with full time employees capable of designing, fabricating, installing, calibrating, and testing the systems specified herein. At a minimum, the PCSS shall be capable of responding to on-site problems within 12 hours of notice. Provide an on-site response within 4 hours of notification starting at two months before scheduled startup to two months after startup completion.

C. PCSS shall hold a valid UL-508 certification for their panel fabrication facility.

D. Actual installation of the instrumentation system need not be performed by the PCSS's employees; however, the PCSS as a minimum shall be responsible for the technical supervision of the installation by providing on site supervision to the installers of the various components.

E. The selected PCSS shall be one of the following:

1. Revere Control Systems
6111 Heritage Park Dr, Suite B-100
Chattanooga, TN 37416

2. MR Systems, Inc.
   810 Royal Parkway, Suite 120
   Nashville, TN 37214

3. Approved Equal

F. Being listed in this specification does not relieve any potential PCSS from meeting the qualifications specified in this Section.

1.07 DELIVERY, STORAGE AND HANDLING

A. Delivery, storage, and handling shall be in accordance with Section 01 66 10.

B. Shipping Precautions:

1. After completion of shop assembly, factory test and approval of all equipment, cabinets, panels and consoles shall be packed in protective crates and enclosed in heavy duty (5 mil) polyethylene envelopes or secured sheeting to provide protection from damage, dust and moisture. Dehumidifiers shall be placed inside the polyethylene coverings. The equipment shall then be skid-mounted for final transport. Lifting rings shall be provided for moving without removing protective covering. Boxed weights shall be shown on shipping tags together with instructions for unloading, transporting, storing and handling at the job site.

2. Manufacturer's special instructions for field handling, storage and installation required for protection, shall be securely attached to the packaging for each piece of equipment prior to shipment. The instructions shall be stored in resealable plastic bags or other means of protection.

3. None of the HMI control and monitoring equipment shall be shipped to the site until the control room areas comply with specified ambient temperature and humidity. Have qualified personnel accept the equipment on delivery and supervise unloading within the control room areas.

4. If any apparatus has been damaged, such damage shall be repaired at no additional cost to the Owner.

1.08 NOMENCLATURE AND IDENTIFICATION

A. Field Instrument Tags:

1. See Section 40 91 40.

B. Panel Nameplates:

1. See Section 40 95 13.

1.09 WARRANTY

A. Provide warranty per Section 01 78 36.

1.10 PROJECT/SITE REQUIREMENTS

A. Environmental Requirements. Refer to Section 26 00 00 and Electrical Drawings for specific environmental and hazardous area classifications.

B. Elevation: Equipment shall be designed to operate at the project ground elevation.

C. Temperature:

1. Outdoor areas' equipment shall operate between 0 to 50 C degrees ambient.

2. Equipment located in indoor locations shall operate between 10 to 35 C degrees ambient minimum.

3. Storage temperatures shall range from 0 to 50 C degrees ambient minimum.

4. Additional cooling or heating shall be furnished if required by the equipment as specified herein.

D. Relative Humidity. Air conditioned area equipment shall operate between 20 to 95 percent relative, non-condensing humidity. All other equipment shall operate between 5 to 100 percent relative, condensing humidity.

PART 2 PRODUCTS

2.01 GENERAL

A. All instrumentation and electronic equipment shall be of the manufacturer's latest design, utilizing printed circuitry and epoxy or equal coating to prevent contamination by dust, moisture and fungus. The field mounted equipment and system components shall be designed for installation in dusty, humid and slightly corrosive service conditions.

B. All instruments shall be provided with mounting hardware and floor stands, wall brackets, or instrument racks unless otherwise noted. Fasteners for securing control panels and enclosures to walls and floors shall be either hot-dipped galvanized after fabrication or stainless steel. Provide stainless steel fasteners only in corrosive areas rated NEMA 4X on the Drawings or as defined under Section 26 00 00. Provide minimum size anchor of 3/8-inch.

C. All indicators shall be linear in process units, unless otherwise noted. All transmitters shall be provided with indicators in process units, accurate to two percent or better.

D. All equipment, cabinets and devices furnished shall be heavy-duty type, designed for continuous industrial service. The system shall contain similar products of a single manufacturer, and shall consist of equipment models, which are currently in

production. All equipment provided shall be of modular construction and shall be capable of field expansion.

E. All electronic/digital equipment shall be provided with radio frequency interference protection.

F. Electrical:

1. Equipment shall operate on a 60 Hertz alternating current power source at a nominal 120 volts, plus or minus 10 percent, except where specifically noted. Regulators and power supplies required for compliance with the above shall be provided between power supply and interconnected instrument loop. Where equipment requires voltage regulation, constant voltage transformers shall be supplied.

2. With the exception for field device network connected devices, all electronic instrumentation shall utilize linear transmission signals of isolated 4 to 20 mA DC (milliampere direct current) capable of driving a load up to 750 ohms, unless specified otherwise. However, signals between instruments within the same panel or cabinet may be 1-5 VDC (volts direct current).

3. Outputs of equipment that are not of the standard signals as outlined, shall have the output immediately raised and/or converted to compatible standard signals for remote transmission. No zero based signals will be allowed.

4. All switches shall have double-pole, double-throw contacts rated at a minimum of 600 VA, unless noted otherwise.

5. Switches and/or signals indicating an alarm, failure or upset condition shall be wired in a fail-safe manner. A fail-safe condition is an open circuit when in an alarm state.

6. Materials and equipment shall be UL approved whenever such approved equipment and materials are available.

7. All equipment furnished shall be designed and constructed so that in the event of power interruption, the systems specified herein shall go through an orderly shutdown with no loss of memory, and shall resume normal operation without manual resetting when power is restored, unless otherwise noted.

2.02 ELECTRICAL SURGE PROTECTION

A. General - Surge protection shall be provided to protect the electronic instrumentation system from induced surges propagating along the signal and power supply lines from lightning, utility, or the plant electrical system. The protection systems shall be such that the protective level shall not interfere with normal operation, but shall be lower than the instrument surge withstand level. Protection shall be maintenance free and self-restoring. Devices shall have a response time of less than 50 nanoseconds and be capable of handling a discharge surge current (at an 8x20μs impulse waveform) of at least 8 kA. Ground wires for all instrumentation device surge

protectors shall be connected to a low resistance ground in accordance with Section 33 79 00.

B. Provide protection of all analog signal (4-20 mA) circuits where any part of the circuit is outside of the building envelope. Circuits shall be protected at both the transmitter and the control system end of the circuit. Protection devices located near the transmitter shall be mounted in a separate NEMA 4X stainless steel enclosure (plastic is not acceptable) or conduit mounted,, and shall be Phoenix Contact PT Series, MTL Surge Technologies (Telematic) TP48, Citel TSP-10 series, or equal. Substitution of a single device to protect both 120 VAC and 4-20 mA wires to an instrument is acceptable. Protection devices in control panels shall be MTL Surge Technologies (Telematic) SD Series, Phoenix Contact PT Series, Citel DLA series, or equal.

C. Provide protection of all 120 VAC power feeds into control panels, instruments, and control room equipment. Surge arresters shall be Transtector ACP-100BW Series, Phoenix Contact "Mains-PlugTrab", MCG Surge Protection 400 Series, Citel DS40 series, or equal.

D. Non-Fiber Based Data Highway or Communications Circuits - Provide protection on all communication and data highway circuits that leave a building or are routed external to a building. Circuit protection shall be provided at both ends of the line. Surge protection devices shall be Phoenix Contact PlugTrab Series, Transtector FSP Series, MTL Surge Technologies (Telematic) NP Series, Citel DLA series or MJ8 series, or equal.

E. Inductive Loads - Provide coil surge suppression devices, such as varistors or interposing relays, on all process controller outputs or switches rated 120 VA or less that drive solenoid, coil, or motor loads.

2.03 SPARE PARTS

A. All spare parts shall be wrapped in bubble wrap, sealed in a polyethylene bag complete with dehumidifier, then packed in cartons and labeled with indelible markings. Complete ordering information including manufacturer's contact information (address and phone number), part name, part number, part ordering information, and equipment name and number(s) for which the part is to be used shall be supplied with the required spare parts. The spare parts shall be delivered and stored in a location directed by the Owner or Engineer.

B. Furnish one of each type of installed Surge protection devices.

C. Other spare parts are specified in each section. An overview follows:

1. Devices within Control Panels - See the control panels section.

2. PLC spare parts - See the PLC section.

3. Instrument related Spare Parts - see the Instrument section.

PART 3 EXECUTION

3.01 GENERAL INSTALLATION

A. Instrumentation and accessory equipment shall be installed in accordance with manufacturer instructions. The indicated locations of equipment, transmitters, alarms and similar devices indicated are approximate only. Exact locations of all devices shall be as approved by the Engineer during construction. Obtain in the field, all information relevant to the placing of process control equipment and in case of interference with other work, proceed as directed by the Engineer and furnish all labor and materials necessary to complete the work in an approved manner at no additional cost to the Owner.

B. Provide brackets and hangers required for mounting of equipment.

C. The shield on each process instrumentation cable shall be continuous from source to destination and be grounded at only one ground point for each shield.

D. Investigate each space in the building through which equipment must pass to reach its final location. If necessary, ship material in sections sized to permit passing through restricted areas in the building. Provide on-site service to oversee the installation, the placing and location of system components, their connections to the process equipment panels, cabinets and devices, subject to the Engineer's approval. Certify that field wiring associated with the equipment is installed in accordance with best industry practice. Coordinate work under this Section with that of the electrical work specified under applicable sections of Division 26.

E. Provide sunshades for equipment mounted outdoors in direct sunlight. Sunshades shall include standoffs to allow air circulation around the cabinet. Orient equipment outdoors to face to the North or as required to minimize the impact of glare and ultraviolet exposure on digital readouts.

3.02 TESTING

A. Refer to Section 40 90 21.

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required to complete the testing of all devices and systems furnished and installed as detailed on Drawings, and as specified herein.

B. Refer to Section 40 90 00 for other general requirements.

1.02 RELATED WORK

A. Refer to Section 40 90 00.

1.03 SUBMITTALS

A. Refer to Section 40 90 00.

B. Testing Submittals - Submit, in one submittal, the following testing related documents:

1. Status signoff forms:
    a. Develop and submit project specific I/O Status and Automatic Control Strategy signoff forms to be used during factory and field testing to organize and track each loop's inspection, adjustment, calibration, configuration, and testing status and sign off. Include sign-off forms for each testing phase showing all loops.
        1) Separate forms for factory and field testing can be used, or they can be combined, at the discretion of the PCSS.
        2) Submit testing forms prior to start of testing.

2. Testing Procedures:
    a. Submit detailed procedures proposed to be followed for each of the tests specified herein. The test procedures shall serve as the basis for the execution of the required tests to demonstrate that the system meets and functions as specified.
    b. Documents shall be shall be structured in an orderly and easy to follow manner to facilitate an efficient and comprehensive test.
    c. Test procedures shall indicate all pre-testing setup requirements, all required test equipment, and simulation techniques to be used.
    d. Test procedures shall be structured in a cause and effect manner where the inputs are indicated, and the outputs are recorded.
    e. Test procedures shall include the demonstration and validation under normal operating conditions and under various failure scenarios as specified in Contract Documents.
    f. Testing may not start until all Testing Submittals have been approved.

C. Test Documentation:

1. Upon completion of each required test, document the test by submitting a copy of the signed off Testing Status forms. Testing shall not be considered complete until the signed-off forms have been submitted and approved. Submittal of other test documentation, including "highlighted" wiring diagrams with field technician notes, are not acceptable substitutes for the formal test documentation.

1.04 MAINTENANCE

A. Refer to Section 40 90 00.

1.05 COST OF TRAVEL

A. Scheduled tests will only be attended once by Engineer /Owner. If test is not successful, all subsequent tests will be performed at Contractor's expense. Reimburse Owner for all costs, including labor and expenses, invoiced by Engineer and incurred by Owner for subsequent retests.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 TESTING - GENERAL

A. Refer to Section 40 90 00.

B. Results of all testing shall be tracked on a project specific status sign off form or similar document. PCSS shall be responsible for maintaining the sheet.

C. Tests the PCSS is required to perform are as follows:

1. Factory Testing:
   a. Unwitnessed Factory Test (UFT).
   b. Witnessed Factory Test (WFT).

2. Field Testing:
   a. Operational Readiness Test (ORT).
   b. Functional Demonstration Test (FDT).

D. Wherever possible, perform tests using actual process variables, equipment, and data. Where it is not practical to test with real process variables, equipment, and data, provide all special testing materials and equipment required for a suitable means of simulation.

E. PCSS shall coordinate all required testing with Contractor, affected Subcontractors, Engineer, and Owner.

F. No equipment shall be shipped to jobsite until Engineer or Owner has received all Factory Testing results and approved the system as ready for shipment.

G. Engineer reserves the right to test or re-test any functions.

H. Correction of Deficiencies:

1. Deficiencies in workmanship and/or items not meeting specified testing requirements shall be corrected to meet specification requirements at no additional cost to Owner.

2. Testing, as specified herein, shall be repeated after correction of deficiencies is made until specified requirements are met. This work shall be performed at no additional cost to Owner.

3.02 FACTORY TESTING - UNWITNESSED FACTORY TEST (UFT)

A. Purpose of UFT is for PCSS to check system prior to Engineer and/or Owner attending factory testing. This type of testing shall be part of any quality firm's internal QA/QC procedures.

B. Hardware to be tested shall include all control system devices shown on System Architecture drawings and provided by PCSS.

C. Tests to be performed shall include, but not be limited to, the following. Each of these tests shall be specifically addressed in Test Procedure submittal.

1. All panels and enclosures being provided shall undergo a thorough inspection to verify integrity of cabinet enclosures, frame structures, paint work and finish, etc. Review panel drawings to ensure they accurately reflect panel layout and wiring.

2. Perform a system audit to verify all components have been staged for test and have been documented properly with correct model numbers, serial numbers, etc. Following documentation of audit shall be provided at factory test and submitted as part of O&M Manual Documentation:
   a. For each workstation and server, list of all software installed (including the operating system), with software revision number, software improvement modules or patches installed, license number and owner registration information, warranty period, vendor and local distributor names and contacts.
   b. For each microprocessor-based component connected to control communication backbone in system (PLCs, managed switches, protocol converters, communication cards on final field devices, radios, etc.), list firmware revision, vendor and local distributor information, and system, warranty information, configuration parameters (e.g., communication settings, fail position settings, etc.)

3. Panel wire pull tests shall be performed to ensure all wiring has been connected with appropriate torque to prevent wires from coming loose.

4. UPS shall be tested to verify UPS switch power correctly while keeping all UPS powered loads online. Testing of UPS to determine if they have been sized correctly to maintain specified run time shall be performed during field testing.

5. A 100 percent I/O point checkout shall be performed to verify proper operation of input/output points from panel terminations to HMI and OIT nodes. At a minimum, I/O checkout shall consist of four steps.
   a. Discrete input signals shall be jumpered at field terminal blocks in control panels to verify proper status in HMI and OIT nodes.
   b. Analog input signals shall be connected to a signal generator at field terminal blocks in control panels to verify proper status in HMI and OIT nodes and signals shall be verified at zero percent, 50 percent, and 100 percent of full scale.
   c. Discrete output signals shall be tested by switching equipment to manual control at HMI and OIT nodes and turning the output on or other means to turn the output on. Then verify the output is on by connecting a digital multimeter to measure continuity at terminations, thus verifying command from PLC has properly executed contact closure.
   d. Analog output signals shall be tested by switching the equipment to manual control at HMI and OIT nodes and turning output on or other means to turn the output on. Then verify output by utilizing a digital multimeter to measure current or voltage generated at termination points.

6. For each hardware enclosure, inspection shall include, but not be limited to, cabinet enclosures, frame structure, paint work and finish, dimensions, and hardware operability (i.e., fans, door hinges, keylocks, etc.).

7. For each subpanel, inspection shall include, but not be limited to, I/O subsystem physical layout, power supply sizing and mounting, cable routing, wire runs across hinges properly installed, fans and blowers unobstructed and mounted to maximize air flow, power conditioning correctly installed, and overall layout and installation of components meets manufacturer's recommendations and standard industry accepted practices.

D. Upon successful completion of UFT, PCSS shall submit a record copy of test results as specified in PART 1. As part of this test results submittal, notify Engineer and Owner in writing that system is ready for WFT. No other notice of Factory test will be accepted. Engineer and/or Owner shall schedule a test date within 30 days of receipt of this submittal.

3.03 FACTORY TESTING - WITNESSED FACTORY TEST (WFT)

A. Purpose of WFT is to allow Engineer or Owner representatives to witness functionality, performance, and stability of entire hardware and software system as a complete integrated system. WFT shall be run by PCSS and conducted at PCSS's facility.

B. Required Documents for Test:

1. Clean set of approved panel drawings and wiring diagrams.

2. Set of Contract Documents - all drawings and specifications.

3. All design changes related documentation.

4. Master copy of the PCSS developed factory testing signoff forms.

5. Testing procedures.

C. System shall operate continuously throughout WFT without failure, except where initiated per established test procedures. Unanticipated failures may, at Owner or Engineer's option, result in overall WFT being deemed unsuccessful. All deficiencies identified during these tests shall be corrected and re-tested prior to completing WFT or shipment of panels to jobsite as determined by Owner/Engineer.

D. Tests to be performed during the WFT shall include, but not be limited to, the following:

1. A repeat of all tests specified in the UFT.

E. Daily schedule during these tests shall be as follows:

1. Morning meeting to review the day's test schedule.

2. Scheduled tests and sign-offs.

3. End of day meeting to review day's test results and to review or revise next day's test schedule.

4. Unstructured testing period by witnesses.

F. Upon successful completion of WFT, PCSS shall submit a record copy of test results as specified in PART 1.

3.04 FIELD TESTING - OPERATIONAL READINESS TEST (ORT)

A. Purpose of ORT is to check that process equipment, instrument installation, instrument calibration, instrument configuration, field wiring, control panels, and all other related system components are ready to monitor and control the processes. This test will determine if equipment is ready for operation.

B. This test shall take place prior to FDT and startup. Prior to starting this test, relevant process equipment shall be installed and mechanically tested, instruments installed, control panels installed, and field wiring complete.

C. Required Documents for Test:

1. Master copy of the PCSS developed field testing signoff forms.

2. Testing procedures.

3. Calibration forms.

D. These inspections, calibrations, and tests do not require witnessing. However, Engineer may review and spot-check testing process periodically. All deficiencies

found shall be corrected by PCSS prior to commencement of Functional Demonstration Test.

E. PCSS shall maintain Sign-off forms and Calibration forms at job site and make them available to Engineer/Owner at any time.

F. Following tests shall be performed as part of ORT:

1. Instrument calibration, configuration, and set-up.

2. Input/Output (I/O) Testing to HMI and OITs.

3. Testing of control strategies.

G. Instrument calibration, configuration, and set-up:

1. Calibrate, configure, and set-up all components and instruments to perform specified functions.

2. Calibration form:
   a. For any component or instrument requiring dip switch settings, calibration, or custom configuration, maintain a calibration form in field documenting this information. These forms shall provide a summary of the actual settings used in the field to allow an Instrument technician to replace the device entirely and configure it to function as it did before.
   b. This information shall be added to Instrument data sheet, shall be added to a copy of manufacturer's standard "Configuration Sheet", or a separate form shall be created.
      1) If a separate form, the form shall list Project Name, Loop Number, ISA Tag Number, I/O Module Address, Manufacturer, Model Number/Serial Number, Output Range and Calibrated Value.
   c. Some examples of required information are:
      1) For Discrete Devices: Actual trip points and reset points.
      2) For Instruments: Any configuration or calibration settings entered into instrument
      3) For Controllers: Mode settings (PID).
      4) For I/O Modules: Dip switch settings, module configuration (if not documented in native programming documentation).
   d. Maintain a copy of these forms in field during testing, and make them available for inspection at any time.
   e. For any device that allows a software back-up of configuration files to a laptop, make configuration files available to Engineer/Owner for inspection. Submit as part of Final System Documentation as specified in Section 40 90 00.

H. I/O Testing:

1. Purpose of I/O testing is to check that process equipment, instrument installation, calibration, configuration, field wiring, and control panels are set-up correctly to monitor and control the processes. This test is commonly referred to as a "loop test" or an I/O checkout.

2. PCSS in conjunction with Contractor shall test signals under process conditions. Preferred test method will always be to execute test wherever possible to end elements. For example, preferred test will prove valve open/close limit switches by operating valve, not by installing a jumper on limit switch contacts. However, if equipment or process is not available to test a signal over its entire calibrated range, PCSS may test using a simulation methods and make a note on sign-off form.

3. The following I/O tests shall be performed:
   a. Discrete Input: At device or instrument, change signal condition from inactive to active state. Observe results on all indicators within loop such as HMI screens, OIT screens, pilot lights, horns, beacons, etc.
   b. Analog Input: Test analog signal over entire engineering range at various intervals including 0, 50%, and 100% as well as on increasing and decreasing range. Observe results on all indicators within loop such as HMI screens, OIT screens, recorders, digital indicators, etc.
   c. Discrete output signals shall be tested by switching equipment to manual control at the HMI and OIT nodes and turning output on or using other means to turn output on. Then verify equipment responds accordingly.
   d. Analog output signals shall be tested by switching equipment to manual control at HMI and OIT nodes and turning output on or other means to turn output on. Then verify equipment responds accordingly.

I. Testing of Automatic Control Strategies:

1. All automatic control strategies shall be verified using actual process equipment and instruments, or other means, to verify logic performs as expected. Verify faults and logical failure scenarios for control strategies such as instrument failures, equipment failures, loss of communication between HMI Server and PLC, loss of peer-to-peer communication, out of range testing for analog inputs, loss of power, and all other strategies specified in control strategy document.

J. Repeat all systems tests specified under factory testing.

K. UPS shall be tested to verify UPS switch power correctly while keeping all UPS powered loads online. Also, test sizing of UPS by switching off line power to UPS and verify if they maintain specified run time.

L. For all panels with enclosures modified by this Contract, internal control panel temperature shall be tested under full running conditions to ensure proper cooling/ventilation is being provided.

M. Upon successful completion of ORT, PCSS shall submit a record copy of test results as specified in PART 1 and request scheduling of FDT.

3.05 FIELD TESTING - FUNCTIONAL DEMONSTRATION TEST (FDT)

A. After facility is started-up and running treatment process in automatic control to extent possible, a Functional Demonstration Test shall be performed. Purpose of FDT is to allow Engineer or Owner representatives to witness actual functionality, performance, and stability of system while connected to process equipment.

B. Required Documents for Test:

1. Set of panel drawings and wiring diagrams from ORT with corrections noted

2. Set of Contract Documents - all drawings and specifications.

3. All design change related documentation.

4. Signed-off master copy of the PCSS developed field testing signoff forms.

5. Testing procedures.

6. Copy of completed calibration forms.

7. One copy of all O & M Manuals for PCSS supplied equipment.

C. A witnessed FDT shall be performed on each process area. To extent possible, repeat testing performed during ORT.

D. Daily schedule specified to be followed during factory tests shall also be followed during FDT.

E. After coordinating with Operations, a "Black Start" of the plant shall be performed to confirm plant operation recovers as specified in Contract Documents. Black start means shutting off power to the plant and turning it back on. Separate tests shall be performed by recovering the plant while on generator (if a generator is specified) and while on utility power.

F. Punch list items and resolutions noted during test shall be documented on Punch list/Resolution form. In event of rejection of any part or function test procedure, PCSS shall perform repairs, replacement, and/or retest within 10 days.

G. Upon successful completion of the FDT, PCSS shall submit a record copy of test results as specified in "Part 1 - General".

END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. This Section covers the furnishing, installation, and services for instruments.

1.02 RELATED WORK

A. Refer to Section 40 90 00 “I & C - General Provisions.”

1.03 SUBMITTALS

A. Submit complete documentation of all field instruments using ISA-TR20.00.01-7 data sheet formats. Submit a complete Bill of Materials (BOM) or Index that lists all instrumentation equipment. The list shall be sorted by Loop Number.

B. Submit separate data sheets for each instrument including:

1. Plant Equipment Number and ISA tag number per the Drawings.
2. Product (item) name used herein and on the Drawings.
3. Manufacturer's complete model number.
4. Location of the device.
5. Input - output characteristics.
6. Range, size, and graduations in engineering units.
7. Physical size with dimensions, enclosure NEMA classification and mounting details in sufficient detail to determine compliance with requirements.
8. Materials of construction for enclosure and wetted parts.
9. Instrument or control device sizing calculations where applicable.
10. Certified calibration data for all flow metering devices.
11. Two-wire or four-wire device type as applicable.

C. Submit catalog cuts for all instruments. Submit descriptive literature for each hardware component, which fully describes the units being provided.

1.04 MAINTENANCE

A. Refer to Section 40 90 00.

1.05 INSTRUMENT TAGS

A. A permanent stainless steel or other non-corrosive material tag firmly attached and permanently and indelibly marked with the instrument tag number, as indicated in the Drawings, shall be provided on each piece of equipment supplied under this Section and related sections. Equipment shall be tagged before shipping to the site.

B. Provide 1/8-in by 3/8-in, Type 316 stainless steel button head machine screws.

C. All supplied instrument transmitters and instrument transmitter elements shall have a stainless steel identification tag attached to each transmitter and element prior to shipment. Tag shall be attached via stainless steel chain or stainless steel wire (24 gauge min) to a non-removable part of the device. The tag size shall be a minimum of 1.5 square inches. Tag shall include the ISA alphanumeric instrument number as indicated in the P&ID, loop, and detail drawings. The alphanumeric instrument number shall be stamped into the tag and shall have a minimum of 3/16-in high alphanumeric characters.

1.06 APPROVALS/CERTIFICATIONS

A. Instruments for hazardous locations shall have Factory Mutual (FM), Canadian Standards Association (CSA), and CENELEC approvals and certifications as specified herein and as indicated on the Drawings or in the Instrument Device Schedule. The instrument specifications in Part 2 state the Class, Division, and gas groups for FM/CSA approval, followed in parenthesis by the CENELEC certification; however, instruments provided are only required to have the approval/certification stated above. The instrument shall have a stainless steel tag identifying the relevant approval or certification.

PART 2 PRODUCTS

2.01 MAGNETIC FLOWMETER

A. Flow Element:

1. Type:
   a. Pulsed DC type.

2. Function/Performance:
   a. Operating Temperature: Process liquid temperatures of 0 to 140 degrees F or greater dependent upon liner and an ambient of minus 30 to 150 degrees F.
   b. Radio Frequency Interference (RFI) protection: RFI protection shall be provided as recommended by the manufacturer.
   c. Pressure rating: Equal to piping system where meter is installed.
   d. Additional: Meter shall be capable of running empty indefinitely without damage to any component.

3. Physical:
   a. Metering Tube: Type 304 stainless steel or equivalent.

b. Flanges: ANSI 150 lb. or DIN PN 16 carbon steel, as required by the piping system, unless otherwise indicated. ANSI 150 lb. or DIN PN 16 stainless steel flanges shall be used on all SS process pipes.
c. Liner: Polyurethane or composite elastomer unless otherwise indicated on the Drawings or in the Instrument Device Schedule.
d. Electrodes: Type 316 stainless steel standard minimum requirements. All electrodes to be compatible with process fluid as indicated on the Drawings or electrodes to be supplied as listed in the Instrument Device Schedule.
e. For sludge, polymer, or any slurry application where the electrodes will be coated, a self-cleaning or a removable electrode option must be provided with that meter.
f. Housing: For meters with remote mounted transmitters, meters below grade shall be suitable for submergence for up to 48 hours to a depth of 30 ft (9m). Meters above grade shall be NEMA 4X (IP65). Where hazardous areas are indicated on the Drawings, the equipment shall be rated for that area.
g. Finish: All external surfaces shall have a chemical and corrosion resistant finish.

4. Power Requirements:
   a. Meter shall be 24 VDC powered instrument, receiving its power from transmitter.

5. Accessories/Documentation Required:
   a. Factory calibration: All meters shall be factory calibrated. A copy of the calibration report shall be included in the O&M manual.
   b. Grounding: Meter shall be grounded in accordance with the manufacturer's recommendation. Provide ground ring, ground wires, gaskets, etc., as required. All materials shall be suitable for the liquid being measured and must be compatible with process fluid and with the process pipe.
   c. For meters with remote mounted transmitters, signal cable for installation between the flow tube and the transmitter. Length shall be as required by installation as indicated on the Drawings.

B. Flow Converter/Transmitter:

1. Type:
   a. Micro-processor based, intelligent transmitter compatible with flow tube provided.
   b. Integral mount or mounted remote from the flow tube as shown on the drawings or as required by the physical location.

2. Functional/Performance:
   a. Accuracy (including flow tube): Plus/minus 0.5 percent of flow rate or better.
   b. Operating Temperature: –20 to 140 degrees F.
   c. Output: Isolated 4-20 mA with HART protocol. Current output adjustable over the full range of the instrument. Provide a dry contact to indicate reverse flow.
   d. Diagnostics: Self diagnostics with on screen display of faults.
   e. Display: Digital indicator displaying flow in engineering units indicated in the Instrument Device Schedule.

f. Totalizer: A fully configurable totalizer integral to the transmitter. Totalized flow shall be displayed.
g. Empty Tube Zero: The transmitter shall include a feature that will lock the output at zero when no flow is detected. The empty tube zero feature shall be enabled automatically when the transmitter detects no flow or manually through a contact input.

3. Physical:
   a. Transmitter shall be suitable for surface or pipe stand mounting.
   b. Enclosure shall be NEMA 4X (IP65).

4. Power Requirements:
   a. The transmitter shall be 120 VAC powered instrument.

5. Accessories/ Required:
   a. Keypad where required for transmitter configuration.

C. Manufacturer:

1. ABB.

2. Approved equal.

D. Instrument Device Schedule:

1. FE/FIT-2020: Effluent Flow from Wet Weather Pump Station
   a. Range: 0-10.5 MGD
   b. Electrode Material: 316SS
   c. Flow Tube Size: 30”
   d. Drawing Reference: I-5

2.02 NON-CONTACT AREA VELOCITY FLOW TRANSMITTER

A. General:

1. The flow meter shall consist of three components; an electronics transmitter unit, sensor, and interconnecting cable. The sensor shall combine advanced radar velocity sensing technology with ultrasonic pulse echo level sensing to remotely measure open channel flow.

B. Sensors:

1. Type: The sensor shall consist of three transducers housed in a single polystyrene watertight enclosure. The sensor shall be of the non-contact type and be mounted above the flow surface. The three transducers shall be a digital Doppler radar for surface velocity, an ultrasonic pulse echo for fluid level, and a Piezo-resistive pressure measurement for surcharge level. The radar beam shall transmit signals, which interact with the fluid and reflect back at a different frequency. These reflected signals shall be compared with the transmitted frequency, resulting in a frequency shift. The frequency shift shall provide an accurate measurement of the flow velocity. Fluid level shall be measured with an ultrasonic pulse echo transceiver by transmitting a sound wave to the fluid

surface. The sensor shall accurately measure flows in circular and rectangular channels down to flow depths of 1/4- inch. A Piezo-resistive pressure sensor shall be used to measure the level of fluid above the sensor if a surcharge condition occurs. In addition to the standard sensor provide a fourth sensor, an electromagnetic sensor known as a Surcharge Velocity Sensor (SVS) which allows measurement of flow velocity when the sensor becomes submerged.

2. Functional/Performance:
   a. Flow Calculation:
      1) Method: Based on Continuity Equation, Q=V x A.
      2) Accuracy: ±5.0% of reading typical where flow is in a channel with uniform flow conditions and is not surcharged.
   b. Velocity Measurement:
      1) Method: Radar.
      2) Range: 0.75 to 20 ft/s (0.23 m/s to 6.10 m/s).
      3) Accuracy: ±0.5%; ±0.1 ft/s (±0.03 m/s).
   c. Velocity Measurement-SVS (Standard sensor w/ additional EM sensor):
      1) Method: Electromagnetic.
      2) Range: -5 to +20 ft/s (-1.5 to +6.1 m/s).
      3) Accuracy: 2% of reading.
      4) Zero Stability: ±0.05 ft/s (±15.2 mm/s).
   d. Level Measurement:
      1) Method: Ultrasonic.
      2) Operating Range: 0.25 to 60 in. (0.634 to 152.4cm).
      3) Optional Operating Range: 0 (0 cm) to 224" (5.7M) with 16" dead band).
      4) Temperature Compensated.
      5) Accuracy: ±0.25 in. (±0.64 cm).
      6) 1% Accuracy.
   e. Surcharge Level Measurement:
      1) Method: Piezo-resistive pressure transducer.
      2) Maximum Range: 138 inches (3.5 meters).
      3) Operating Temperature Range: 14°F to 122°F (-10° C to 50°C); Power requirements - Match to transmitter.

3. Physical: Material: Polystyrene (IP68) rated for submerged wastewater conditions.

4. Accessories/Options Required: Sensor Retrieval/Placement Pole (extends to 24 ft.) Sensor Retrieval Hook - Used with Sensor Retrieval/Placement Pole (above) Sensor Laser Alignment Tool - Recommended to properly align sensor during installation. Sensor Mount Hardware - (Available for Permanent or Temporary Installations) Includes mounting frame and hardware to mount sensor.

C. Transmitter/Electronics:

1. Type: Remote mounted, microprocessor based electronics with four lines of text display matched to flow, level, velocity, total, or any combination of any four channels containing data.

2. Functional/Performance: Power requirements - 120 VAC plus or minus 10 percent; Temperature -14 degrees F to 122 degrees F; Output - Four 4-20 mA

outputs; system-isolated, up to 600Ω load. Each output is selectable between flow, level, velocity or surcharge level. Additional dry contact closure rated for 0.5A @ 125 VAC with adjustable duration selectable for flow-proportional or alarm based on: flow, level, velocity, surcharge level, temperature, battery voltage, each sample, bad sample or analog input.

3. Physical: Housing - ABS plastic NEMA 4X rated enclosure.

D. Sensor Cable:

1. The standard sensor cable shall be abrasive resistant polyurethane jacket with a waterproof connector on the sensor end and pigtail leads on the electronics end. The connector shall allow for keyed connection to the sensor. The standard flow meter shall be provided with 30 feet of cable with additional sensor cable lengths up to 1,000 feet total. Vendor to provide appropriate amount of cable based upon electrical location drawings, approximately 500 feet.

E. Manufacturer:

1. Flo-Dar with Flo-Station as manufactured by Marsh-McBirney

F. Instrument Device Schedule:

1. FE/FIT–1030: Flow from Diversion Structure to the Pump Station

2.03 FLOAT SWITCHES

A. Type

1. Mercury free ball float switch.

B. Function/Performance

1. Differential: Less than 8 inch.

2. Switch Rating: 1 amps at 120 VAC or 100 VA @ 120 VAC

3. Provide NO or NC type contact for fail-safe operation per Section 40 90 00, Paragraph 2.01.F or as shown on the Drawings.

C. Physical

1. Float: Type 316 stainless steel, Teflon or non-stick coating, minimum 5 in diameter.

2. Totally encapsulated switch.

3. Cable shall be heavy-duty, PVC or equivalent jacketed integral to float.

D. Options/Accessories Required

1. Provide stainless steel hardware.

2. Lead wire shall be a waterproof cable of sufficient length so that no splice or junction box is required in the vault.

3. Provide cast-aluminum weatherproof junction box outside the sump pit with terminals for all floats and tapped as required for conduit connections.

E. Manufacturer(s)

1. Anchor Scientific Roto-Float SST-NM

2. Contegra FS 90

3. Flygt ENM-10

4. Or equal.

F. Instrument Device Schedule:

1. LSH-2000: Wet-Weather Wetwell High Level
   a. Drawing Reference: I-5

2. LSL-2000: Wet-Weather Wetwell Low Level
   a. Drawing Reference: I-5

2.04 SUBMERSIBLE LEVEL TRANSMITTER

A. Type:

1. Submersible, hydrostatic pressure type level transmitter.

B. Function/Performance:

1. Range: Range selected shall be the manufacturer's standard range closest to the span to be measured.

2. Temperature Compensation: Temperature compensated over a range of zero to 50 degrees C.

3. Accuracy: Plus or minus 0.25 percent of range.

4. Over Pressure: Transducer shall be protected for over pressure of 1.5 times the span.

5. Output: 4-20 mA proportional to the calibrated span.

C. Physical:

1. The transmitter assembly shall have a Type 316 stainless steel or titanium body with a bottom diaphragm.

2. Sensors shall be suspended by cable. Cable shall include a vent tube for the transducer.

3. Sensor shall be suspended with a tension-relieving mounting clamp from a four-inch (100 mm) flange. Clamp and flange shall be Type 316 stainless steel.

4. Sensor shall be submersible (IP68), and shall be CSA approved or CENELEC (EEx ia IIC T4) certified intrinsically safe when intrinsically safe barriers are provided for the instrument loop.

5. 24 VDC loop powered.

D. Accessories Required:

1. Sufficient manufacturer's cable for installation between the sensor and the transmitter as indicated on the Drawings. Cable shall be reinforced to support the weight of the transducer and cable.

2. Cable clamp for suspending instrument provided by instrument supplier.

3. Manufacture Supplied desiccant kit for keeping moisture out of vent tube. Install per manufacturer recommendation.

4. All fittings required for pressure calibration of the instrument.

E. Manufacturers:

1. Omega PX78

F. Instrument Schedule:

1. LT-1020: Wet-Weather Diversion Structure Level
   a. Range: 0-20 Ft
   b. Drawing Reference: I-4

2. LT-2000: Wet-Weather Pump Station Level
   a. Range: 0-20 Ft
   b. Drawing Reference: I-5

2.05 PRESSURE SWITCH

A. Type:

1. Diaphragm actuated.

B. Function/Performance:

1. Repeatability: Better than 1 percent of full scale.

2. Setpoint: Field adjustable and set between 30 and 70 percent of the adjustable range.

3. Dead Band: Fixed unless adjustable dead band requirement is noted in the Instrument Device Schedule.

4. Reset: Unit shall be of the automatic reset type unless noted otherwise in the Instrument Device Schedule.

5. Over Range Protection: Over range protection to 150 percent of the maximum process line pressure.

6. Output: Single pole double throw (SPDT) unless requirement for double pole double throw (DPDT) switch is shown on the instrument device schedule. Switch rating shall be 10 A at 230 VAC.

C. Physical:

1. Housing: NEMA 4X (IP65) for non-hazardous areas. For installation in hazardous areas, housing shall be explosion proof approved for Class 1, Division 1, Groups C and D (EEx d IIB).

2. Switch Assemblies: Hermetically sealed switches.

3. Wetted Parts: Type 316L stainless steel diaphragm, viton seals, Type 316 stainless steel connection port.

D. Accessories/Options Required:

1. Shutoff Valve: Provide a Type 316 stainless steel shutoff valve. Valve shall be by D/A Manufacturing, Anderson Greenwood, or Equal.

2. Where indicate on the instrument device schedule, provide a Type 316 stainless steel snubber for pulsation dampening.

E. Manufacturer(s):

1. Ashcroft.

2. Mercoid.

3. Or equal.

F. Instrument Device Schedule:

1. PSH-20101: Wet-Weather Wetwell Pump No. 1 Discharge Pressure High
   a. Set Point: 30 PSIG
   b. Drawing Reference: I-5

2. PSH-20102: Wet-Weather Wetwell Pump No. 2 Discharge Pressure High
   a. Set Point: 30 PSIG
   b. Drawing Reference: I-5

3. PSH-20103: Wet-Weather Wetwell Pump No. 3 Discharge Pressure High
   a. Set Point: 30 PSIG
   b. Drawing Reference: I-5

4. PSH-20104: Wet-Weather Wetwell Pump No. 4 Discharge Pressure High

a. Set Point: 30 PSIG
b. Drawing Reference: I-5

2.06 PRESSURE GAUGE

A. Type:

1. Bourdon tube actuated dial face pressure gauge.

B. Function/Performance:

1. Accuracy: Plus or minus 1.0 percent of span or better.

C. Physical:

1. Case: Phenolic shock resistant or Type 316 stainless steel for surface/stem mounting with a pressure relieving back. The case shall be vented for temperature/atmospheric compensation. Gauge shall be callable of being liquid filled in the field or at the factory.

2. Window: Clear acrylic or shatter proof glass.

3. Bourdon tube: Stainless steel.

4. Connection: 1/2 in. NPT.

5. Gauge size: Minimum 4-in. viewable.

6. Pointer travel: Not less than 200 degrees not more than 270-degree arc.

7. Range: As indicated in the instrument device schedule. Range may include inches of water vacuum.

D. Accessories/Options Required:

1. Shutoff valve: Each gauge shall have a process shutoff valve that can also be used as an adjustable pressure snubber.

2. Special scales: Engineer reserves the right to require special scales and/or calibration if the manufacturer's standard is not suitable for the application.

3. All gauges shall be furnished filled with clear glycerin or silicone oil.

E. Manufacturer(s):

1. Ashcroft.

2. Ametek US Gauge.

3. Weksler.

4. Or equal.

F. Instrument Device Schedule:

1. PI-20101: Wet-Weather Wetwell Pump No. 1 Discharge Pressure
   a. Range: 30 PSIG
   b. Drawing Reference: I-5

2. PI-20102: Wet-Weather Wetwell Pump No. 2 Discharge Pressure
   a. Range: 30 PSIG
   b. Drawing Reference: I-5

3. PI-20103: Wet-Weather Wetwell Pump No. 3 Discharge Pressure
   a. Range 30 PSIG
   b. Drawing Reference: I-5

4. PI-20104: Wet-Weather Wetwell Pump No. 4 Discharge Pressure
   a. Range: 30 PSIG
   b. Drawing Reference: I-5

2.07 LIMIT SWITCH

A. Type:

1. Direct opening 2 position snap action.

B. Function/Performance:

1. Minimum 2 double pole single throw (DPST) NO contacts or 2 double pole double throw (DPDT) contacts.

C. Physical:

1. Lever or button style spring return actuator.

2. Contact rating for 120 VAC/30 VDC, 100VA minimum.

D. Accessories/Options Required:

1. Non-corrosive, NEMA 4X.

2. If a sealed pre-wired switch is used, a separate connection or junction box of equal environmental protection rated will be supplied and installed.

E. Manufacturer(s):

1. Allen-Bradley.

2. Square D.

3. Or equal.

F. Instrument Device Schedule:

1. ZSC-20101: Wet-Weather Wetwell Pump No. 1 Check Valve Closed Switch
   a. Drawing Reference: I-5

2. ZSC-20102: Wet-Weather Wetwell Pump No. 2 Check Valve Closed Switch
   a. Drawing Reference: I-5

3. ZSC-20103: Wet-Weather Wetwell Pump No. 3 Check Valve Closed Switch
   a. Drawing Reference: I-5

4. ZSC-20104: Wet-Weather Wetwell Pump No. 4 Check Valve Closed Switch
   a. Drawing Reference: I-5

5. ZS-20801: Electrical Building Exterior Door Open Switch
   a. Drawing Reverence: I-6

6. ZS-20801: Electrical Building Exterior Double Door Open Switch
   a. Drawing Reverence: I-6

2.08 TEMPERATURE SWITCH

A. Type:

1. Bulb and capillary.

B. Function/Performance:

1. Set Point: Field adjustable and set between 20 and 80 percent of the adjustable range.

2. Deadband: Fixed deadband

3. Reset: Automatic reset

4. Over Range Protection: Over range protection to maximum process line temperature.

5. Switch Rating: 15 amps at 250 VAC.

C. Physical:

1. Switch Housing: Remotely mounted. NEMA 4X (IP66) for non-hazardous locations. Where indicated on the Drawings to be mounted in hazardous locations, the switch housing shall be explosion proof, approved for Class I, Division 1, Groups C and D (EEx d IIC).

2. Switching Arrangement: Single pole double throw (SPDT).

3. Wetted Parts: Type 316 stainless steel.

D. Manufacturer(s):

1. Ashcroft.

2. Or equal.

E. Instrument Device Schedule:

1. TSH-2090: Wet-Weather Pump Station Electrical Room High Temperature
   a. Drawing Reference: I-5

2.09 SPARE PARTS AND ACCESSORIES

A. General requirements for spare parts are specified in Section 40 90 00.

B. Furnish following field Instrument related Spare Parts:

1. One pressure switch of each type and range provided.

2. One pressure gauge of each type and range provided.

C. Furnish following Accessories:

1. All mounting hardware required for pipe stand, surface, or other mounting.

2. Each instrument shall be provided with a manufacturer installed stainless steel tag identifying the instrument tag number.

PART 3 EXECUTION

3.01 GENERAL

A. See execution requirements in Section 40 90 00.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. This Section includes programmable logic controllers for control of process equipment, process oriented machinery, and process systems.

1.02 RELATED WORK

A. Section 40 90 00 “Instrumentation and Controls - General Provisions.”

B. Section 40 95 13 “Control Panel Enclosures and Panel Equipment.”

1.03 SUBMITTALS

A. Refer to Section 40 90 00.

B. Descriptive literature, bulletins, catalog cuts and Drawings for the equipment specified herein.

C. Complete bill of materials for the equipment.

D. Any deviation of the hardware or software systems from the preliminary submittal included in the Project Plan shall be described in detail.

E. Spare parts list.

1.04 REFERENCE STANDARDS

A. ASTM D 999-91: Vibration.

B. (CFR) Title 47, Part 18 (European EN 55011 (formerly CISPR 11)).

C. CSA Certification Class I, Division 2, Group A, B, C, D Hazardous or non-hazardous locations.

D. IEC 60068-2.1 Environmental testing – Part 2-1: Tests - Test A: Cold, 2.2 Environmental testing - Part 2: Tests. Tests B: Dry heat, 2.3, 2.6 Environmental testing - Part 2: Tests - Test Fc: Vibration (sinusoidal) and 2.27 Environmental testing. Part 2: Tests. Test Ea and guidance: Shock.

E. IEC 61000 Electromagnetic compatibility (EMC) - Testing and measurement techniques:

1. Part 4-2: Electrostatic discharge immunity test.

2. Part 4-3: Radiated, radio-frequency, electromagnetic field immunity test.

3. Part 4-4: Electrical fast transient/burst immunity test.

4. Part 4-5: Surge immunity test.

5. Part 4-6: Immunity to conducted disturbances, induced by radio-frequency fields.

F. IEC 61131-3: Programmable controllers - Part 3: Programming languages.

G. IEC 801-3: RFI Immunity.

H. IEC 801-5: Ground Continuity.

I. IEC 801-2: Electrostatic Discharge.

J. IEEE 472-1974/ANSI C37.90/90A-1974 (Surge Withstand) IEEE Standard for Relays and Relay Systems Associated with Electric Power Apparatus.

K. MIL STD 461B CS02: RFI/EMI Susceptibility.

L. NEMA Pub No ICS2-230.42: Showering Arc Test.

M. NSTA Project 1A.

N. UL 508 and CSA Standard C22.2 No. 142 (Isolation Voltages).

1.05 DELIVERY, STORAGE AND HANDLING

A. Deliver PLC components in packaging designed to prevent damage from static electricity and physical damage.

B. Store PLC equipment according to manufacturer requirements. At a minimum, store indoors in clean, dry space with uniform temperature to prevent condensation. Protect PLCs from exposure to dirt, fumes, water, corrosive substances, and physical damage. Also, protect the PLC from all forms of electrical and magnetic energy that could reasonably cause damage.

1.06 NOMENCLATURE AND IDENTIFICATION DEFINITIONS

A. AI: Analog Input.

B. AO: Analog Output.

C. Fixed I/O: A PLC style consisting of a fixed number of I/O, a processor, and a power supply all in one enclosure. Some fixed PLCs have limited expansion ability.

D. CPU: Central Processing Unit.

E. DI: Discrete Input.

F. Distributed I/O: Hardware specially designed to function as Remote I/O.

G. DO: Discrete Output.

H. HMI: Human-Machine Interface.

I. I/O Input and/or Output.

J. Master/Slave: Communication between devices in which one device, the master, controls all communications. The other devices, the slaves, respond only when queried by the master. Typically used in a Remote I/O application.

K. Modular: A PLC style consisting of cards that are assembled to comprise a complete unit. All I/O, CPU, and Power Supply are dedicated cards. Typically, these cards are inserted into a chassis.

L. Peer to Peer: Communication between two or more devices, typically PLC's, in which each device can control the communication exchange.

M. PID: Control action, proportional plus integral plus derivative.

N. PLC: Programmable Logic Controller.

O. Remote I/O: I/O that is located remotely from the processor. Remote I/O can communicate over a variety of communication protocols and can use standard rack based I/O, or special Remote I/O hardware referred to as Distributed I/O.

P. SCADA: Supervisory Control and Data Acquisition.

1.07 SPARE I/O AND SLOTS

A. Each new panel containing PLC I/O shall include at least 20 percent (minimum of four) points of each type (AI, AO, DI, and DO) for future use, regardless of whether any of those point types are used in that panel or not. The spares shall be the same type of I/O modules supplied.

B. For chassis based PLC systems, provide at least two spare slots for addition of future I/O in each chassis provided. For non-chassis based PLC systems, provide adequate space to the right of the last I/O card in each row of I/O cards for at least two future I/O cards (width should be based on the widest I/O card provided in panel).

C. Spare output points that require the use of an external relay shall be supplied with the external relay.

D. Regardless of the spare requirement, all installed unused points on all I/O modules shall be wired to terminal blocks in the order that they occur on the I/O modules. Unwired spares shall not be acceptable.

PART 2 PRODUCTS

2.01 CHASSIS BASED PROGRAMMABLE LOGIC CONTROLLER SYSTEM

A. General:

1. Provide Programmable Logic Controller equipment with the required memory and functional capacity to perform the specified sequence of operation with the scheduled input and output points.

2. Processor Systems shall include processor, power supply, input/output modules, communication modules, redundancy modules, and remote interface modules as required to meet system requirements.

3. Furnish products listed and classified by Underwriters Laboratories (UL), CSA, or FM approval as suitable for purpose specified and indicated.

4. All equipment and devices furnished hereunder shall be 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.

5. All equipment furnished shall be designed and constructed so that in the event of power interruption the systems shall go through an orderly shutdown with no loss of memory, and resume normal operation without manually resetting when power is restored.

6. PLCs shall communicate between the operator workstation and field-mounted transducers, switches, controllers, and process actuators. Communications protocol shall be completely transparent to process operators at the Human Machine Interface (HMI).

7. PLC shall be capable of stand-alone operation in the event of failure of the communication link to the HMI subsystem.

8. Backup Processor Systems, if indicated on the drawings, shall consist of two chassis with power supplies, each containing a processor, redundancy module and communications module(s). Remote chassis shall be provided with communication modules to meet I/O and communication requirements.

9. Remote Input/Output Units shall include input/output modules, interface modules, communication modules, and power supply to meet system input and output requirements.

10. Agency and environmental specifications:
    a. Electrical supply voltage to the PLC shall be 120VAC, plus or minus "15 percent, 48 - 63Hz. PLC system power supplies shall be fused for overload protection.

b. Vibration: 3.5 mm Peak-to-Peak, 5 - 9 Hz: 1.0G, 9 - 150\Hz. The method of testing is to be based upon IEC 68-2-6 and JIS C 0911 standards for vibration. The system is to be operational during and after testing. Vibration Rating of 2.0G maximum peak acceleration for 10 to 500Hz. in accordance with at least one of the following:
   1) Installed rating: DIN rail mounted PLC: 10 - 57 Hz, amplitude 0.075 mm, acceleration 25-100 Hz.
   2) Panel or plate mounted PLC: 2 - 25 Hz, amplitude 1.6mm, acceleration 25 - 200 Hz.
   3) In compliance with IEC 60068 and IEC 61131.

11. Shock: 15G, 11 msec. Method of testing is to be based upon IEC 68-2-27 and JIS C 0912 standards for shock. The system is to be operational during and after testing.

12. Temperature: All PLC hardware shall operate at an ambient temperature of 0° to 60° C (32° to 140° F), with an storage ambient temperature rating of -25° to 70° C (-40° to 185° F).

13. Relative Humidity: Programmable Controller hardware shall function continuously in the relative humidity range of 10 percent to 95 percent non-condensing.

14. Noise Immunity: Programmable Controller system shall be designed and tested to operate in the high electrical noise environment of an industrial plant as governed by the following regulations: IEEE 472, IEC 801, MILSTD 461B, IEC 255-4, NEMA ICS 2-230.40, and ANSI/IEEE C-37.90A-1978.

15. Altitude:
    a. Operation: 0 - 6,500 feet.
    b. Storage: 0 - 9,800 feet.

16. Degree of protection: NEMA 1 (IP20).

17. All products shall have corrosion protection.

B. All major assemblies and sub-assemblies, circuit boards, and devices shall be identified using permanent labels or markings indicating:

1. Modules product type such as analog or digital.

2. Modules catalog number.

3. Modules major revision number.

4. Modules minor revision number.

5. Module manufacturer vendor.

6. Module serial number.

C. All necessary cables shall be included. All cables and connectors shall be as specified by the manufacturer. Cables shall be assembled and installed per the manufacturer recommendations.

D. Manufacturers:

1. The PLC system shall be Motorola ACE 3600 with 800 MHz Analog radio compatible with client's existing SCADA system, no equal.

E. Central Processing Unit (CPU):

1. CPU shall be, at a minimum, a 16-bit microprocessor that provides system timing and is responsible for scheduling I/O updates, with no user programming required to ensure discrete or analog update. It shall execute user relay ladder logic programs, communicate with intelligent I/O modules, and perform on-line diagnostics. The CPU shall consist of a single module which solves application logic, stores the application program, stores numerical values related to the application processes and logic, and interfaces to the I/O.

2. CPU shall sample all the discrete and analog inputs and outputs including internal coils and registers, and service special function modules every scan. The CPU shall process the I/O with user program(s) stored in memory, then control the outputs based on the results of the logic operation.

3. Supply the CPU with a battery-backed time of day clock and calendar.

4. CPU family shall allow for user program transportability from one CPU model to another.

F. Diagnostics:

1. CPU shall perform on-line diagnostics that monitor the internal operation of the PLC. If a failure is detected, the CPU shall initiate system shutdown and fail-over. The following, at a minimum, shall be monitored: Memory failure, memory battery low, and general fault, communications port failure, scan time over run, I/O failure, and analog or special function I/O module failure.

2. All diagnostic information shall be accessible to the host communications interfaces and to the PLC program.

3. PLC shall have indicators and on board status area to indicate the following conditions:
   a. CPU run.
   b. CPU error or fault.
   c. I/O failure or configuration fault.
   d. Status of Battery or back-up power module.
   e. Communications indicator.

G. Memory:

1. User program and data shall be contained in non-volatile battery backed memory of type CMOS RAM program memory or equivalent.

2. Memory Backup System: provide lithium battery backup or equivalent capable of retaining all memory for a minimum of three months and a Flash memory system capable of reloading program in the event of memory loss.
   a. Backup Storage: The backup battery or module shall be capable of being replaced without disrupting memory integrity. Provide a visual indication of low battery voltage or module error and an alarm bit in the PLC program.
   b. SD Memory Card: Memory card storage capacity shall be greater than processor memory capacity. Memory cards shall be installed in processors for factory testing.

3. Operating system shall be contained in non-volatile firmware. The memory containing the operating system shall be field updateable via a separate update tool.

H. Programming Environment:

1. On-Line programming: Application programs may be modified or stored while the CPU is running, with minimal impact on the scan time.

2. Online programming including runtime editing.

3. IEC 61131-3 programming languages supported: Ladder logic, function block, sequential function chart, and structure text.

4. Supply all hardware and software necessary to program the CPU in these languages.

I. Communication Ports:

1. CPU shall be expandable and supplied with additional modules to support the required communication interfaces.

J. Power Supplies:

1. PLC shall have chassis mounted power supplies to power the chassis backplane, and provide power for the processor and applicable modules.

2. Power supplies shall have a clearly visible LED to indicate that the incoming power is acceptable and the output voltage is present.

3. Power supplies shall feature over-current and over-voltage protection and should be designed to operate in most industrial environments without the need for isolation transformers.

4. Power supplies shall be sized to accommodate the anticipated load plus 30%.

5. DC power supplies shall be capable of handling ripple up to 2.4V peak to peak.

6. AC Line Voltage rating of 85 to 265Vac, 47 - 63Hz.

7. Power supplies shall allow for brown outs of at least 1/2 of a cycle, a harmonic rate of 10%, and will sustain continuous operation through momentary interruptions of AC line voltage of 10ms or less.

8. Automatically shut down the Programmable Controller system whenever its output power is detected as exceeding 125% of its rated power.

9. Provide surge protection, isolation, and outage carry-over up to 2 cycles of the AC line.

10. Redundant power supplies will comply with all the requirements of non-redundant power supplies in addition to the features stated below.
    a. Redundant power supplies shall be designed to share the current required by the chassis. In the event of a failure of one redundant power supply, the remaining supply will accommodate the entire load of the chassis without disruption to the chassis activity.
    b. Provide a failsafe fuse that is not accessible by the customer.
    c. Provide a solid state relay connection to allow for failure annunciation when wired to an input module.
    d. Diagnostic LED status indicators for Power and redundancy.

K. Chassis:

1. PLC system shall be chassis based.

2. All system and signal power to the CPU and support modules shall be distributed on the backplane. No interconnecting wiring between these modules via plug-terminated jumpers shall be acceptable.

3. All system modules, main and expansion chassis shall be designed to provide for free air flow convection cooling. No internal fans or other means of cooling, except heat sinks, shall be permitted.

4. All system modules including the processor shall be removable from the chassis or inserted in to the chassis while power is being supplied to the chassis without faulting the processor or damaging the modules.

5. Modules shall be designed to plug into a chassis and to be keyed to allow installation in only one direction. The design must prohibit upside down insertion of the modules as well as safeguard against the insertion of a module into the wrong slot or chassis via an electronic method for identifying a module. Electronic keying shall perform an electronic check to insure that the physical module is consistent with what was configured.

L. Discrete Input & Output Modules:

1. General:
    a. Digital input and output modules shall provide ON/OFF detection and actuation.

b. I/O count and type shall be as required to implement the functions specified plus an allowance for active spares, as noted below.
c. Modules shall be designed to be installed or removed while chassis power is applied.
d. Modules shall have indicators to display the status of communication, module health and input / output devices.
e. Each module shall have the following status indicators.
   1) On/Off state of the field device.
   2) Module's communication status.

2. Module Specifications (120VAC Input Module):
   a. Nominal Input Voltage: 120VACc.
   b. On-State Current: 15mA @132V AC, 47 - 63Hz maximum.
   c. Maximum Off-State Voltage: 20V.
   d. Maximum Off-State Current: 2.5mA.
   e. Number of Points per Card: 16.

3. Module Specification (120 VAC Solid State Output Module):
   a. Each triac type discrete output shall have an associated interposing relay located in the same control panel. 120 VAC power for relay outputs shall be provided from the associated motor starter control circuit (when used with motor starters) or other 120 VAC source (when I/O is not associated with a particular motor starter).
   b. Output Voltage Range: 74 - 265 VAC, 47 - 63 Hz.
   c. Output Current Rating:
      1) Per Point: 0.5A maximum @ 30 degrees C; 0.25 A maximum @ 60 degrees C; Linear Derating.
      2) Per Module: 4A maximum @ 30 degrees C; 2A maximum @ 60 degrees C; Linear Derating.
   d. Surge Current Per Point: 5A for 43ms each, repeatable every 2s @ 60 degrees C.
   e. Minimum Load Current: 10mA per point.
   f. Maximum On-State Voltage Drop: 1.5V peak @ 2.0A and 6V peak @ load less than 50mA.
   g. Maximum Off-State Leakage: 2.5mA per point.
   h. Number of Points per Card: 16.

4. Module Specifications (Individually Isolated, Relay Contact Output Module):
   a. Output Voltage Range: 10 - 265 VAC, 47 - 63 Hz, 5 - 125 VDC.
   b. Output Current Rating:
      1) Per Point: 2.5A maximum.
      2) Per Module: 16A maximum.
   c. Power Rating (Steady State): 250 VA maximum for 125 VAC inductive output.
   d. Maximum Off-State Leakage: 0 mA per point.
   e. Configurable States:
      1) Fault Per Point: Hold Last State, ON or OFF.
      2) Program Mode Per Point: Hold Last State, ON or OFF.
   f. Number of Points per Card: 16.

M. Analog Input & Output Modules:

1. General:
   a. Analog input modules shall convert an analog signal that is connected to the module's screw terminals into a digital value. The digital value representing the magnitude of the analog signal shall be transmitted on the backplane. Analog output modules shall convert a digital value that is delivered to the module via the backplane into an analog signal on the module's screw terminals.
   b. Modules shall be designed to be installed or removed while chassis power is applied.
   c. Modules shall have indicators to display the status of communication, module health and input / output devices.
   d. Each analog module shall provide both hardware and software indication when a module fault has occurred. Each module shall have an LED fault indicator and the programming software shall display the fault information.
   e. Analog modules shall be software configurable through the I/O configuration portion of the programming software.
   f. Following status shall be capable of being examined in ladder logic:
      1) Module Fault Word: Provides fault summary reporting.
      2) Channel Fault Word: Provides under-range, over-range and communications fault reporting.
      3) Channel Status Words: Provides individual channel under-range and over-range fault reporting for process alarm, rate alarms and calibration faults.
   g. 24 VDC power for analog instrument loops shall be provided as a part of the system. 24 VDC power supply shall be derived from the 120 VAC input power circuit to the PLC. Field side of the 24 VDC power sources(s) shall have individual or grouped (of logically associated circuits) fusing and be provided with a readily visible, labeled blown fuse indicator.

2. Isolated Analog Output Current Module:
   a. Output Current Range: 4 to 20 mA.
   b. Current Resolution: 12 bits across 20 mA.
   c. Open Circuit Detection: None.
   d. Output Overvoltage Protection: 24V ac/dc maximum.
   e. Output Short Circuit Protection: 20 mA or less (electronically limited).
   f. Calibration Accuracy: Better than 0.1% of range from 4 mA to 20 mA.
   g. Calibration Interval: 12 months typical.
   h. Number of Points per Card: 8.

2.02 PLC SOFTWARE

A. Provide a PLC configuration and application development software package complete with documentation and disks. The PLC software package and associated licensing and/or activation shall be installed on the computers shown on the Drawings.

B. Software package shall allow on-line/off-line program development, annotation, monitoring, debugging, uploading, and downloading of programs to the PLCs.

C. All required hardware (including cables, cable adapters, etc.) for connection to PLCs shall be furnished.

D. All software licenses required to achieve the functionality described in the Specifications shall be provided.

E. Software package shall include a software license agreement allowing the Owner the right to use the software as required for any current or future modification, documentation, or development of the PLCs furnished for this project.

F. Software provided shall be capable of the following IEC 61131-3 functions:

1. Ladder logic.

2. Function block.

3. Sequential function chart.

4. Structure text.

G. In addition to the above editors, an add-on instruction editor shall work with any of the above-mentioned editors to create custom reusable function blocks. This software shall allow any of the derived function blocks to be modified on-line.

H. Software shall be Microsoft Windows-based and run on the supplied computers.

I. Software shall include a security feature to prevent unauthorized personnel from modifying and downloading the programs.

J. Provide an I/O simulator which allows the PLC application load program to be tested on a PC with simulated analog and digital inputs and outputs, allowing I/O testing and debugging to be performed in a safe, isolated environment without the need for running the PLC CPU and process I/O boards.

2.03 SPARE PARTS

A. General requirements for spare parts are specified in Section 40 90 00.

B. The following PLC spare parts shall be furnished:

1. I/O Cards: Provide spares for each unique I/O module type installed. Provide two or 10 percent of installed quantity, whichever is greater.

2. PLC Power supplies: Provide spare power supplies for each unique power supply installed.

PART 3 EXECUTION

3.01 GENERAL INSTALLATION

A. Maintain area free of dirt and dust during and after installation of programmable controller products.

B. Anchor PLCs within enclosures as recommended by the PLC manufacturer.

C. Ventilation slots shall not be blocked, or obstructed by any means.

D. Examine areas, surfaces, and substrates to receive PLCs for compliance with requirements, installation tolerances, and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

E. Install in accordance with manufacturer's instructions.

F. Unload, unpack and transport equipment to prevent damage or loss.

G. Replace damaged components as directed by Engineer.

3.02 PANEL LAYOUT

A. Coordinate size and configuration of enclosure to meet project requirements. Drawings indicate maximum dimensions for PLCs, minimum clearances between PLCs, and adjacent surfaces and other items.

B. Comply with indicated maximum dimensions and clearances, or with PLC vendors required distances if they are greater than the distances indicated.

1. Provide spacing around PLC as required by the PLC manufacturer to ensure adequate cooling. Insure that the air surrounding the PLC has been conditioned to maintain the required temperature and humidity range.

2. Wires entering and exiting PLC components shall be sized to comply with the PLC manufacturers requirements. Doors on all components shall be able to be fully closed when all the wires are installed.

3. For chassis mounted PLCs, no wiring, wire ducts, or other devices shall obstruct the removal of cards from the rack.

4. PLC lights, keys, communication ports, and memory card slots shall be accessible at all times. Lights shall be visible at all times when enclosure door is opened.

C. Control panel designer shall provide independent line fuses or circuit breakers, per the PLC manufacturer recommendation, for each power supply, input module, output module, and other modules with separately derived power requirements.

D. Control panel designer shall insure that communication signals, 4-20 mA signals (including those with embedded HART), are properly conditioned for the PLC and protected from all sources of radiated energy or harmonics.

E. Where multiple sets of mechanical equipment are provided for process redundancy, arrange their field connections to I/O modules so that the failure of a single I/O module will not disable the redundant system. This applies to all I/O types. The acceptability of the I/O arrangement shall be at the discretion of the engineer.

F. Provide all required cables, cords, and connective devices for interface with other control system components.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Refer to Section 40 90 00.

B. Furnish and install control panels and panel mounted equipment as specified herein and shown on the Drawings.

C. All new panels and panel components shall match existing equipment makes and models wherever possible, so that system additions can be most easily integrated with respect to operation and maintenance training, spare parts inventory, and service contracts. Even when exact matches are not possible, equipment furnished must be fully compatible with the existing system. Color, size, and material of new panels should conform to that of existing panels.

D. Each panel shall be supplied with full sub-panels with the minimum specified dimensions regardless of the quantity of mounted components inside the panel. All panel mounted components shall be mounted on the single rear-of-panel sub-panel unless the density of devices exceeds the panel mounting space permitted by the minimum panel dimensions specified. Side panel mounted components shall only be permitted after review and approval of the Engineer.

E. Furnish the following panels [and consoles].

PANEL SCHEDULE

Panel Designation	Maximum Space Available	Enclosure Rating & Type
Wet Weather Pump Station PLC Panel	36” W x 72” H x 24” D	NEMA Type 4X, 316 stainless steel construction, Front Access Only

1.02 RELATED WORK

A. Refer to Section 40 90 00 “I & C - General Provisions.”

1.03 SUBMITTALS

A. Refer to Section 40 90 00.

B. Submit the following control panel information:

1. Descriptive literature, bulletins, catalog cuts and Drawings for the equipment specified herein.

2. Complete bill of materials for the equipment.

3. Spare parts list.

4. Panel Layout Drawings and Wiring Diagrams Submittal:
   a. Where direct hardwired interfaces exist between the PCSS control panels and vendor provided control panels furnished under other Divisions, Contractor shall provide to PCSS approved submittals in order for PCSS to provide complete wiring diagrams showing all wiring connections in the I/O system. This includes but is not limited to terminal block numbering, relay contact information, instruments, equipment, and control panel names. These drawings shall be included in Final O&M submittal. Leaving this information blank on Final Documentation drawings is not acceptable.
   b. Panel Layout Drawings: Submit Drawings for all panels, consoles, and equipment enclosures specified. Panel assembly and elevation drawings shall be drawn to scale and detail all equipment in or on the panel. Panel drawings shall be 11"x17" in size. At a minimum, the panel drawings shall include the following:
      1) Interior and exterior panel elevation drawings to scale.
      2) Nameplate schedule.
      3) Conduit access locations.
      4) Panel construction details.
      5) Cabinet assembly and layout drawings to scale. Assembly drawing shall include a bill of material on the drawing with each panel component clearly defined. Bill of material shall be cross-referenced to the assembly drawing so that a non-technical person can readily identify all components of the assembly by manufacturer and model number.
      6) Fabrication and painting specifications including color (or color samples).
      7) Construction details, NEMA ratings, intrinsically safe barrier information, gas sealing recommendations, purging system details, etc. for panels located in hazardous locations or interfacing to equipment located in hazardous areas.
      8) For every control panel, heating and cooling calculations for each panel supplied indicating conformance with cooling requirements of the supplied equipment and environmental conditions. Calculations shall include the recommended type of equipment required for both heating and cooling.
      9) Submit evidence that all control panels shall be constructed in conformance with UL 508 and bear the UL seal confirming the construction. Specify if UL compliance and seal application shall be accomplished at the fabrication location or by field inspection by UL inspectors. Costs associated with obtaining the UL seal and any inspections shall be borne by Contractor.
   c. Panel Wiring Diagrams: Panel wiring diagrams depicting wiring within and on the panel as well as connections to external devices. Panel wiring diagrams shall include power and signal connections, UPS and normal power sources, all panel ancillary equipment, protective devices, wiring and wire numbers, and terminal blocks and numbering. Field device wiring shall include the device ISA-tag and a unique numeric identifier. Diagrams shall identify all device terminal points that the system connects to, including terminal points where I/O wiring lands on equipment not supplied by the PCSS. Wiring labeling used on the drawings shall match that shown on the Contract Documents or as developed by the PCSS and

approved by the Engineer. I/O wiring shall be numbered with rack number, slot number, and point number. Two-wire and four-wire equipment shall be clearly identified and power sources noted. Submit final wire numbering scheme. Panel drawings shall be 11" x17" in size.

1.04 COORDINATION MEETINGS

A. Refer to Section 40 90 00.

1.05 REFERENCE STANDARDS

A. Refer to Section 40 90 00.

1.06 QUALITY ASSURANCE

A. Refer to Section 40 90 00.

1.07 DELIVERY, STORAGE AND HANDLING

A. Refer to Section 40 90 00.

1.08 NOMENCLATURE AND IDENTIFICATION

A. Refer to Section 40 90 00.

1.09 MAINTENANCE

A. Refer to Section 40 90 00.

B. Test Equipment:

1. Refer to Section 40 90 00.

1.10 WARRANTY

A. Refer to Section 40 90 00.

PART 2 PRODUCTS

2.01 GENERAL

A. Refer to Section 40 90 00.

2.02 LIGHTNING/SURGE PROTECTION

A. Refer to Section 40 90 00.

2.03 CONTROL PANEL GENERAL REQUIREMENTS

A. Dimensions within this Section and on Contract Drawings are for general reference only. Ensure that final enclosure sizing and panel arrangements accommodate all required equipment for a fully integrated and operational system as specified herein and in Contract Documents.

B. Each control panel and terminal cabinet shall bear the UL label. UL label shall apply to the enclosure, the specific equipment supplied with the enclosure, and the installation and wiring of the equipment within and on the enclosure. If required for UL labeling, provide ground fault protective devices, isolation transformers, fuses and any other equipment necessary to achieve compliance with UL 508 requirement. Drawings do not detail all UL 508 requirements.

C. Panel doors shall have a lock installed in door handle, or a hasp and staple for padlocking. Locks for all panels provided under this Contract shall be keyed alike.

D. Devices designated for rear-of-panel mounting shall be arranged within the panel according to respective panel drawings and in a manner to allow for ease of maintenance and adjustment. Heat generating devices such as power supplies shall be located at or near the top of the panel.

E. Panels shall be completely fabricated, instruments and devices installed and wired at the PCSS's facility.

F. Components shall be mounted in a manner that shall 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 mounting shall be oriented in accordance with manufacturer's recommendations. Internal components shall be identified with suitable plastic or metal engraved nametags mounted adjacent to (not on) each component identifying the component in accordance with the drawing, specifications, and PCSS's data.

G. Exterior panel mounted equipment shall be installed with suitable gaskets, faceplates, etc. required to maintain the NEMA rating of the panel.

H. Nameplates:

1. Panels and panel devices shall be supplied with suitable nameplates, which identify the panel and individual devices as required. Unless otherwise indicated, each device nameplate shall include up to three lines with the first line containing the device tag number as shown on the drawings, the second line containing a functional description (e.g., Recirculation Pump No. 1), and the third line containing a functional control description (e.g., Start).

2. Unless escutcheon plates are specified or unless otherwise noted on the Drawings, nameplates shall be 3/32-inch thick, black and white, Lamicoid with engraved inscriptions. The letters shall be White against a Black background

unless otherwise noted. Edges of the nameplates shall be beveled and smooth. Nameplates with chipped or rough edges will not be acceptable.

3. Nameplate fasteners and mounting shall be epoxy adhesive or stainless steel screws for cabinet mounted nameplates

4. For every panel, provide a panel nameplate with a minimum of 1-in high letters. Provide legend plates or 1-in by 3-in engraved nameplates with 1/4-in lettering for identification of door mounted control devices, pilot lights, and meters.

5. Single lamicoid nameplates with multiple legends shall be used for grouping of devices such as selector switches and pilot lights that relate to one function.

I. Mounting Elevations:

1. ISA Recommended Practice RP60.3 shall be used as a guide in layout and arrangement of panels and panel mounted components. Dimensions shall account for all housekeeping pads that panels will sit on once they are installed.

2. Centerline of indicators and controllers shall be located no lower than 48-inches or higher than 66-inches above the floor on a panel face.

3. Centerline of lights, selector switches, and pushbuttons shall be located no lower than 32-inches or higher than 70-inches above the floor on a panel face.

4. Tops of annunciators shall be located no higher than 86-inches above the floor on a panel face.

5. Installation of panel components shall conform to component manufacturers' guidelines.

2.04 PANEL MATERIALS AND CONSTRUCTION

A. Structure and Enclosure:

1. Panels shall be of continuous welded-steel or FRP construction as shown on the Panel Schedule. Provide angle stiffeners as required on the back of the panel face to prevent panel deflection under instrument loading or operation. Internally the panels shall be supplied with a structural framework for instrument support purposes and panel bracing. Internal framework shall permit panel lifting without racking or distortion. Provide removable lifting rings designed to facilitate simple, safe rigging, and lifting of the control panels during installation.

2. Each panel shall be provided with full height, fully gasketed access doors where shown. Doors shall be provided with a three-point stainless steel latch and heavy duty stainless steel locking handle. Panel access doors shall be provided with full length, continuous, piano type stainless steel hinges with stainless steel pins. Front access doors with mounted instruments or control devices shall be of sufficient width to permit door opening without interference from flush mounted instruments.

3. Panels, including component parts, shall be free from sharp edges and welding flaws. Wiring shall be free from kinks and sharp bends and shall be routed for easy access to other components for maintenance and inspection purposes.

4. Panel shall be suitable for top and bottom conduit entry as required by the Electrical Drawings. For top mounted conduit entry, panel top shall be provided with nominal one-foot square removable access plates, which may be drilled to accommodate conduit and cable penetrations. Conduit and cable penetrations shall be provided with ground bushings, hubs, gasketed locknuts, and other accessories as required to maintain the NEMA rating of the panel and electrical rating of the conduit system.

5. Panels in indoor, dry, non-corrosive environments shall be NEMA 12 unless otherwise noted. Panels in outdoor, wet, and non-chemically corrosive environments shall be NEMA 4 unless otherwise noted. Panels in chemically corrosive environments shall be NEMA 4X unless otherwise noted. Panels located in a hazardous location shall be rated for the type of hazard (e.g., NEMA 7 for Class 1, Division 1).

B. Freestanding and Floor-Mounted Vertical Panels:

1. Freestanding and floor-mounted vertical panels shall meet the NEMA classification as shown on the drawings or specified herein. Panels shall be constructed of 12 gauge sheet steel, suitably braced internally for structural rigidity and strength. All NEMA 4X rated panels shall be constructed of Type 316 stainless steel, unless FRP is specifically indicated to be provided. Front panels or panels containing instruments shall be not less than 10 gauge stretcher leveled sheet steel, reinforced to prevent warping or distortion.

C. Wall and Unistrut Mounted Panels:

1. Wall and Unistrut mounted panels shall meet the NEMA classification as shown on the Drawings or specified herein. Panels shall be constructed of not less than USS 14 gauge steel, suitably braced internally for structural rigidity and strength. NEMA 4X rated wall mounted panels shall be constructed of Type 316 stainless steel, unless FRP is specifically indicated. FRP panels shall be used in chlorine areas. FRP panels located in direct sunlight shall be provided with a protective coating and sun shield to prevent discoloration and cracking.

D. Finish Requirements:

1. Sections shall be descaled, degreased, filled, ground and finished. Enclosure when fabricated of steel shall be finished with two rust resistant phosphate prime coats and two coats of enamel, polyurethane, or lacquer finish which shall be applied by either the hot air spray or conventional cold spray methods. Brushed anodized aluminum, stainless steel, and FRP panels will not require a paint finish.

2. Panels shall have edges ground smooth and shall be sandblasted and then cleaned with a solvent. Surface voids shall be filled and ground smooth.

3. Immediately after cleaning, one coat of a rust-inhibiting primer shall be applied inside and outside, followed by an exterior intermediate and top coat of a two-component type epoxy enamel. A final sand-ing shall be applied to the intermediate exterior coat before top coating.

4. Apply a minimum of two coats of manufacturer's standard, flat light-colored lacquer, on the panel interior after priming.

5. Unless otherwise noted, the finish exterior colors shall be ANSI 61 gray with a textured finish.

E. Print storage pockets shall be provided on the inside of each panel. Storage pockets shall be steel, welded on to the door, and finished to match the interior panel color. Storage pocket shall be sufficient to hold all of the prints required to service the equipment, and to accommodate 8.5 inch by 11 inch documents without folding.

2.05 ENVIRONMENTAL CONTROL

A. The internal temperature of all panels shall be regulated to a range of 45 Deg F to 104 Deg F under all conditions. Under no circumstances shall panel cooling or heating equipment compromise the NEMA rating of the panel.

B. For panels with internal heat that cannot be adequately dissipated by other means, an air conditioner shall be provided. Air conditioners shall be suitable for NEMA 4X installation and shall include conformal coating on all exposed parts.

C. Outdoor enclosures and enclosures located in unheated areas indoors or in areas subject to humidity and moisture shall be provided with an integral heater, fan, and adjustable thermostat to reduce condensation and maintain the minimum internal panel temperature. Mount unit near bottom of the enclosure with discharge away from heat-sensitive equipment. Heater shall be Hoffman DAH or equal.

2.06 CORROSION CONTROL

A. Panels shall be protected from internal corrosion by the use of corrosion-inhibiting vapor capsules as manufactured by Northern Technologies International Corporation, Model Zerust VC; Hoffman Model AHCI; or equal.

2.07 CONTROL PANEL - INTERNAL CONSTRUCTION

A. Internal Electrical Wiring:

1. Interconnecting wiring shall be stranded, type MTW, and shall have 600 volt insulation and be rated for not less than 90 degrees Celsius. Wiring for systems operating at voltages in excess of 120 VAC shall be segregated from other panel wiring either in a separate section of a multi-section panel or behind a removable Plexiglas or similar dielectric barrier. Panel layout shall be developed such that technicians shall have complete access to 120 VAC and lower voltage wiring systems without direct exposure to higher voltages.

2. Power distribution wiring on the line side of fuses or breakers shall be 12 AWG minimum. Control wiring on the secondary side of fuses shall be 16 AWG minimum. Electronic analog circuits shall utilize 18 AWG shielded, twisted pair, cable insulated for not less than 600 volts.

3. Power distribution blocks shall be covered with protective guards to meet “finger-safe” requirements of IP20.

4. Power and low voltage DC wiring systems shall be routed in separate wireways. Crossing of different system wires shall be at right angles. Different system wires routed parallel to each other shall be separated by at least 6-inches. Different wiring systems shall terminate on separate terminal blocks. Wiring troughs shall not be filled to more than 60 percent visible fill.

5. Terminations:
   a. Wiring shall terminate onto single tier terminal blocks, where each terminal is uniquely and sequentially numbered. Direct wiring between field equipment and panel components is not acceptable.
   b. Multi-level terminal blocks or strips are not acceptable unless they are approved by the Engineer in advance of panel wiring diagrams. If approved, they shall be mounted on angled din rail elevated from the back panel.
   c. Terminal blocks shall be arranged in vertical rows and separated into groups (power, AC control, DC signal). Each group of terminal blocks shall have a minimum of 25 percent spares.
   d. Terminal blocks shall be the compression type, fused, unfused, or switched as shown on the Contract Drawings or specified elsewhere in Division 40.
   e. Discrete inputs and outputs (DI and DO) shall have two terminals per point with adjacent terminal assignments. All active and spare PLC and controller points shall be wired to terminal blocks.
   f. Analog inputs and outputs (AI and AO) shall have three terminals per shielded pair connection with adjacent terminal assignments for each point. The third terminal is for shielded ground connection for cable pairs. Ground the shielded signal cable at the PLC cabinet. All active and spare PLC and controller points shall be wired to terminal blocks.
   g. Wire and tube markers shall be the sleeve type with heat impressed letters and numbers.
   h. Only one side of a terminal block row shall be used for internal wiring. Field wiring side of the terminal shall not be within 6-inches of the side panel or adjacent terminal or within 8-inches of the bottom of free standing panels, or within 3-inches of stanchion mounted panels, or 3-inches of adjacent wireway.
   i. Circuit power from the SCADA cabinet out to field devices (switches, dry contacts etc.) that are used as discrete inputs to the PLC input cards shall be isolated with an isolating switch terminal block with flip cover that is supplied with a dummy fuse. Isolation switch block shall be an Allen Bradley Model 1492-H7 or equal. One isolating switch terminal block per loop numbered piece of equipment and one per spare I/O point is acceptable.

j. All PLC discrete outputs to the field shall be isolated with an isolating fuse switch terminal block with a flip cover and a neon blown fuse indicator. The single circuit fusible terminal block shall be an Allen Bradley 1492-H4 or equal.

6. Wiring to hand switches and other devices, which are live circuits independent of the panel's normal circuit breaker protection, shall be clearly identified as such.

7. Wiring shall be clearly tagged and color coded. Tag numbers and color coding shall correspond to panel wiring diagrams and loop drawings prepared by the PCSS. Power wiring, control wiring, grounding, and DC wiring shall utilize different color insulation for each wiring system used. Color coding scheme shall be:
   a. Incoming 120 VAC Hot – Black.
   b. 120 VAC Hot wiring downstream of panel circuit breaker – Red.
   c. 120 VAC Hot wiring derived from a UPS system – Red with Black stripe.
   d. Three phase power – Brown, Orange, Yellow, and Green ground or as specified in Division 16.
   e. 120 VAC neutral – White.
   f. Ground – Green.
   g. DC power or control wiring – Blue.
   h. DC analog signal wiring – Black (+), White (-).
   i. Foreign voltage – Yellow.

8. Provide surge protectors on all incoming power supply lines at each panel per requirements of Section 40 90 00.

9. Each field instrument furnished under Division 40 and shown on the Drawings as deriving input power from the control panel(s) shall have a separate power distribution circuit with a circuit breaker or fuse and blown fuse indication. Instruments requiring 120VAC power shall be powered from the UPS source in the panel where the instrument signals lands.

10. Provide redundant 24 VDC power supplies to power field instruments and panel devices. Power supplies shall be as specified in this Section.

11. Wiring trough for supporting internal wiring shall be plastic type with snap-on covers. Side walls shall be open top type to permit wire changing without disconnecting. Trough shall be supported to the subpanel by stainless steel screws. Trough shall not be bonded to the panel with glue or adhesives.

12. Each panel shall have a LED fixture, mounted internally to the ceiling of the panel. Light fixture shall be switched and shall be complete with the lamp.

13. Each panel shall have a specification grade duplex convenience receptacle with ground fault interrupter, mounted internally within a stamped steel device box with appropriate cover. Convenience receptacle shall not be powered from a UPS and shall be protected by a dedicated fuse or circuit breaker.

14. Each panel shall be provided with an isolated copper grounding bus for all signal and shield ground connections. Shield grounding shall be in accordance with the instrumentation manufacturer's recommendations.

15. Each panel shall be provided with a separate copper power grounding bus (safety) in accordance with the requirements of the National Electrical Code.

16. Each panel shall have control, signal, and communication line surge suppression in accordance with Section 40 90 00.

17. Each panel shall be provided with a circuit breaker to interrupt incoming power.

18. Additional electrical components including transformers, motor starters, switches, circuit breakers, etc. shall be in compliance with the requirements of Division 26.

2.08 SINGLE PHASE UPS - INTERNAL TO CONTROL PANELS

A. System Description:

1. Provide an industrially rated continuous-duty, on-line, solid state, line interactive, single-phase uninterruptible power system.

2. UPS shall provide power conditioning and power backup for PLC, communications hardware, and other critical electronic loads as indicated on Drawings.

3. UPS system shall consist of the following major components:
   a. Rectifier and battery charger.
   b. Inverter.
   c. Batteries.
   d. Other features as described in this Section and as indicated on Drawings.

4. UPS shall be:
   a. Allen Bradley 1609 series UPS.
   b. Sola Hevi-Duty SDU UPS.
   c. Or equal.

B. General Requirements:

1. Battery protection shall be provided an internal circuit breaker disconnect.

2. Current limiting circuitry shall protect inverter output under any load condition.

3. AC output neutral shall be electrically isolated from UPS chassis. UPS chassis shall have an equipment ground terminal. Provisions for installation of a bonding connector shall be provided.

4. UPS shall be suitable for installation in a UL508A listed panel without derating.

5. UPS shall be DIN rail mountable.

6. UL recognized components for industrial applications in accordance with UL508 without derating.

C. Performance Requirements:

1. Ratings:
   a. Output power: 350VA - 800VA.
   b. Battery runtime: 14 minutes at full-load, 34 minutes at half-load.

2. Environment:
   a. Ambient temperature: 0 to 50 degrees C.
   b. Elevation: Up to 500-ft above mean sea level.
   c. Relative humidity: 1 to 95 percent non-condensing.

3. System Input - Primary source:
   a. Single input: Nominal Input Voltage: 120 VAC.
   b. Frequency: 45 to 65 Hz.
   c. Input Power Factor: 0.95 lag minimum, 50 to 100 percent load.
   d. Input Surge Withstandability: Per IEEE 587/ANSI C62.41. Category A and B, (6 kV).

4. System Output:
   a. Nominal Output Voltage: 120 VAC
   b. Frequency: 60 Hertz plus or minus 3 Hertz.
   c. 100 percent load with 3:1 Crest Ratio
   d. Frequency Slew Rate: 1 Hz/second. (Adjustable at startup)

5. AC to AC Efficiency (100 percent load @ rated PF): 88 percent online, 86 percent on battery.

6. Acoustical Noise: Noise generated by UPS under normal operation shall not exceed 65 dBA (60 dBA typical) at one meter from any surface, measured at 25 degrees C (77 degrees F) and full load.

7. EMI Suppression: UPS shall meet FCC Rules and Regulation 47, Part 15, Subpart J, for Class A devices.

D. Modes of Operation:

1. UPS shall operate as a line interactive on-line, fully automatic system in the following modes:
   a. Normal: Critical load shall be continuously supplied with filtered and regulated AC power by inverter. Rectifier/battery chargers shall derive power from preferred AC source and supply DC power to inverter while simultaneously floats charge the batteries.
   b. Emergency: Upon failure of preferred AC power source, critical load shall continue to be supplied by inverter. Inverter power shall be supplied without switching from storage battery. There shall be no interruption to critical load upon failure or restoration of preferred ac sources. If AC source cannot be restored before battery discharges to its low voltage dropout value, UPS shall automatically shut itself down in an orderly manner.
   c. Recharge: Upon restoration of AC source, rectifier/battery charger shall power inverter and simultaneously recharge batteries. This shall be an automatic function causing no interruption to critical load.

2. Provide remote contacts for “AC Power Fail” and “UPS Low Battery/Fault” to be connected to digital input points within the control panel.

E. Rectifier/Charger:

1. Term rectifier/charger shall denote solid-state equipment and controls necessary to convert incoming AC power to regulated DC power for input to inverter and for battery charging. Rectifier/charger shall be a solid-state SCR/IGBT power transistor type with constant voltage/current limiting control circuitry.

F. Inverter:

1. Inverter shall include all solid-state equipment and controls to convert DC power from rectifier/charger or battery to a regulated AC power for powering critical load. Inverter shall use Insulated Gate Bipolar Transistors (IGBTs) in a phase-controlled, pulse width modulated (PWM) design capable of providing the specified AC output.

2. Inverter shall be capable of supplying current and voltage for overloads exceeding 100 percent. Inverter is to provide 150 percent of full load for 30 seconds and 125 percent of full load for 2 minutes. A status indicator and audible alarm shall indicate overload operation.

3. Output voltage shall be maintained to within plus or minus 5 percent.

4. Output voltage total harmonic distortion (THD) shall not be greater than 5 percent at full load.

G. Batteries:

1. Batteries shall be High Temperature sealed, maintenance-free, high-rate discharge, lead-acid cells suitable for use indoors with no off gassing, or water addition requirements. Batteries shall not require special ventilation. Battery shall consist of one or more battery banks with number of cells required to meet requirements of rest of these specifications.

2. Battery Design Life: 2-4 years.

2.09 GENERAL PURPOSE RELAYS AND TIME DELAYS

A. Type:

1. General purpose plug-in type.

B. Functional:

1. Contact arrangement/function shall be as required to meet the specified control function; Mechanical life expectancy shall be in excess of 10 million.

2. Duty cycle shall be rated for continuous operation; Units shall be provided with integral indicating light to indicate if relay is energized.

3. Solid state time delays shall be provided with polarity protection (DC units) and transient protection.

4. Time delay units shall be adjustable and available in ranges from .1 second to 4.5 hours.

C. Physical:

1. For 120 VAC service provide contacts rated 10 amps at 120 VAC, for 24 VDC service provide contacts rated 5 amps at 28 VDC, for electronic (milliamp/millivolt) switching applicator provide gold plated contacts rated for electronic service; relays shall be provided with dust and moisture resistant covers.

D. Options/Accessories Required:

1. Provide mounting sockets with pressure type terminal blocks rated 300 volt and 10 amps.

2. Provide mounting rails/holders as required.

E. Manufacturer(s):

1. Allen Bradley.

2. Potter & Brumfield.

3. Or equal.

2.10 SIGNAL ISOLATORS/BOOSTERS/CONVERTERS

A. Type:

1. Solid state, ASIC technology; electronic type.

B. Functional:

1. Accuracy: 0.15 percent.

2. Inputs: Current, voltage, frequency, temperature, or resistance as required.

3. Outputs: Current or voltage as required.

4. Isolation: There shall be complete isolation between input circuitry, output circuitry, and the power supply.

5. Adjustments: Zero and span adjustment shall be provided.

6. Protection: Provide RFI protection.

C. Physical:

1. Mounting: DIN Rail.

D. Manufacturer(s):

1. Action Instruments Slim Pak.

2. Acromag.

3. Or equal.

2.11 INTRINSIC SAFETY BARRIERS

A. Type:

1. Barriers shall be of the solid state electronic type in which the energy level of the sensing or actuation circuit is low enough to allow safe usage in hazardous areas.

2. Provide a barrier for instrumentation and equipment transmitting analog or digital signals that originate in a hazardous area as indicated in the design documents.

B. Options Required:

1. Barriers shall match power supply provided.

2. Barriers shall be located in non-hazardous areas.

C. Manufacturer(s):

1. Siemens Water Technologies – IS1 (4-20mA) and IS6 (dry contacts).

2. Gems – 54800 (4-20mA) and 65800 (dry contacts).

3. R. Stahl - Intrinspak

4. Or equal.

2.12 EMERGENCY ALARM BEACON AND AUDIBLE HORN

A. Beacon alarm light:

1. Type:
   a. Beacon alarm light.

2. Physical:
   a. Beacon alarm light for building exterior mounting shall be 120 VAC, flush mounted, weatherproof construction.
   b. A 750,000-candle power xenon strobe tube and red polycarbonate lens.

3. Manufacturer(s):
   a. Federal Signal.
   b. Edwards.

c. Wheelock.
d. Or equal.

B. Alarm Horn:

1. Type:
   a. Alarm horn shall be vibrating type for 120 Volts, 60 Hz.

2. Manufacturer(s):
   a. Federal Signal Corp.
   b. Edwards Co.
   c. Benjamin.
   d. Or equal.

2.13 24 VDC POWER SUPPLIES

A. Provide a 24 VDC power supply in the control panel to power field instruments, panel devices, etc., as required. Equip the power supply with a power on/off circuit breaker.

B. The 24 VDC power supply shall meet the following requirements:

1. Input power: 115 VAC, plus or minus 10 percent, 60 Hz.

2. Output voltage: 24 VDC.

3. Output voltage adjustment: 5 percent.

4. Line regulation: 0.05 percent for 10 volt line change.

5. Load regulation: 0.15 percent no load to full load.

6. Ripple: 3 mV RMS.

7. Operating temperature: 32 to 140 degrees Fahrenheit.

C. Size the 24 VDC power supply to accommodate the design load plus a minimum 25 percent spare capacity.

D. If power supply on/off status signal is shown, provide a relay contact (internal to the power supply or external if the power supply is not so equipped) to indicate on/off status of the power supply.

E. Provide output overvoltage and overcurrent protective devices with the power supply to protect instruments from damage due to power supply failure and to protect the power supply from damage due to external failure.

F. Mount the 24 VDC power supply such that dissipated heat does not adversely affect other panel components.

G. Manufacturer(s):

1. Acopian.

2. Lambda.

3. Or equal.

2.14 SPARE PARTS

A. General requirements for spare parts are specified in section 40 90 00.

B. The following control panel spare parts shall be furnished:

1. Timers and sockets - Two of each type installed.

2. Relays and sockets - Two of each type installed.

3. Fuses and circuit breakers - 10% (minimum of 10 fuses and 2 circuit breakers) of each type and size installed.

PART 3 EXECUTION

3.01 INSTALLATION

A. Panels shall be installed at locations as shown on the Contract Drawings.

B. Refer to Section 40 90 00.

3.02 TESTS

A. Refer to Section 40 90 00.

END OF SECTION

PART 1 GENERAL

1.01 GENERAL PROVISIONS

A. This Section is intended for use in developing the control system, in conjunction with the provisions of Sections 40 90 00 (General Conditions) and other related specifications, and the Instrumentation Drawings.

B. For all controlled devices such as pumps, valves, etc., if the device is commanded to Start or Stop (or Open or Close) by the PLC and the device feedback state does not match the commanded state within a preset time, an equipment Discrepancy Alarm is generated by the PLC for display and alarming at the HMI and the device is commanded to Stop (valves shall remain in the last state). If a duty pump, or system, is commanded to start and does not start within the preset time, the standby pump, or system, shall be commanded to start. Also, if a device feedback state does not match the commanded state at any time, excluding the change of state described above, an equipment Failure Alarm is generated by the PLC for display and alarming at the HMI and the device is commanded to Stop (valves shall remain in the last state). After the condition causing the Discrepancy Alarm has cleared, HMI command shall immediately be resumed over the equipment. ISS shall coordinate with Electrical to establish the correct time delays for all equipment that has automatic restart on power failure. All controlled devices with feedback shall indicate Failure alarms on the associated process graphic displays even if not shown on the loop drawings.

C. For all valves and gates, if the valve or gate is commanded to Open or Close by the PLC and the feedback state does not match the commanded state within a preset time, an equipment Discrepancy Alarm is generated by the PLC for display and alarming at the HMI and the commanded state shall remain the same. If a device feedback state does not match the commanded state at any time, excluding the change of state described above, an equipment Discrepancy Alarm is generated by the PLC for display and alarming at the HMI and the commanded state shall remain the same.

D. For all analog control signals, such as for variable speed pumps or modulating control valves or gates, if the device is commanded to a specific speed or position, and the feedback signal deviates from the commanded speed by a preset dead band for a preset time period, a Deviation Alarm is generated by the PLC for display and alarming at the HMI.

E. All analog alarms generated in the PLC or at the HMI (such as a high level alarm) shall be generated as follows. If the analog point's value exceeds or drops below the alarm limit value for a preset time period, then an alarm shall be generated. To eliminate excessive alarm reporting, the analog point shall remain in alarm until the analog point's value returns beyond the limit set by the analog limit dead band.

F. For all analog points, if the signal drops below 3.8mA or exceeds 20.2mA for a preset time period, a Loss of Signal Alarm shall be generated at the HMI. To eliminate excessive alarm reporting, the analog point shall remain in alarm until the analog point's value returns to within these limits. When an analog signal is providing feedback to a process control loop, the control loop shall use the last known good value before the signal was lost.

G. All tuning parameters for each PID in the PLC shall be available at the server/workstations for monitoring and adjustment. Tuning trends shall be provided to monitor the PID functions. However, these parameter settings shall be password protected to allow access by only those Operators who have been given clearance by the OWNER.

H. All alarm and control set points shall be adjustable by the Operator. However, these set points shall be password protected to allow access by only the Operators who have been given clearance by the OWNER.

I. Runtimes for all motorized equipment shall be totalized in the PLC and indicated at the HMI. The total runtime shall be resettable from the HMI; however, this reset shall be password protected to allow access by only the Operators who are given clearance by the OWNER.

J. Start Counts for all motorized equipment shall be totalized in the PLC and indicated at the HMI. The start counts shall reset on a daily basis.

K. All analog points shall be historically logged. The hourly maximum, minimum and average values for that point shall be calculated and stored.

L. All flows shall be totalized in the PLC. Yesterday's total flow and today's flow shall be indicated at the HMI. The total flows shall be resettable from the HMI; however, this reset shall be password protected to allow access by only the Operators who have been given clearance by the OWNER.

M. All analog process values shall be displayed out to two decimal places. Equipment run times shall be displayed in whole numbers of hours.

N. All I/O points shown on the P&IDs shall be programmed in the HMI/SCADA software unless otherwise indicated in the control narratives.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 STANDARD CONTROLS

A. Open/Close Valve or Gate

1. Valves (or gates) that are supplied for open/close service shall be equipped with a motorized operator, complete with Local-Remote and Open-Close selector switches and LEDs for valve full open and valve full closed status.

When the valve is in Local, the operator shall be able to open and close the valve with the Open-Close selector switch. When the valve is in remote, control of the valve shall be transferred to the PLC and shall operate as described in the specific control narrative for each loop.

2. Valve full open, valve full closed and valve in remote status signals shall be wired from each valve operator to the PLC. Valve open command and valve close command shall be wired from the PLC to each valve operator. Status and control shall be available at the SCADA graphics.

B. Modulating Valve or Gate

1. Valves (or gates) that are supplied for modulating service shall be equipped with a motorized operator, complete with Local-Remote and Open-Stop-Close selector switches and LEDs for valve full open and valve full closed status. The valve shall also indicate the current valve position percentage (0-100%) on the local digital display. When the valve is in Local, the operator shall be able to open, stop and close the valve with the Open-Stop-Close selector switch. When the valve is in remote, control of the valve shall be transferred to the PLC and shall operate as described in the specific control narrative for each loop. The valve shall receive a 4-20 mA signal from the PLC as a valve position reference and the valve shall automatically adjust its position to that reference. The valve shall provide a 4-20 mA signal to the PLC as a valve position feedback.

2. Valve full open, valve full closed, valve position feedback (range: 0-100%) and valve in remote status signals shall be wired from each valve operator to the PLC. Valve position command (range: 0-100%) shall be wired from the PLC to each valve operator. Status and control shall be available at the SCADA graphics.

C. Constant Speed Pump

1. Pumps that are supplied for constant speed service shall be equipped with a combination motor starter, either standalone or located in a motor control center (MCC), complete with Hand-Off-Auto selector switch and pilot lights for Pump Running and Pump Fail statuses. In addition, for submersible pumps, the motor starter shall also monitor for seal failure and motor high temperature, providing motor shut down circuit for each alarm condition and a pilot light to indicate the alarm status. All motor failure and shut down conditions shall be combined into a single common fault for connection to the PLC and monitoring at the SCADA graphics. When the pump is in Hand, the pump shall be called to start (if all permissives are present and all alarm conditions are cleared). When the pump is in Auto, control of the pump shall be transferred to the PLC and shall operate as described in the specific control narrative for each loop.

2. Pump run status, pump fail and pump in remote status signals shall be wired from each pump motor starter to the PLC. Pump start/stop command shall be wired from the PLC to each pump motor starter. Status and control shall be available at the SCADA graphics.

D. Variable Speed Pump

1. Pumps that are supplied for variable speed service shall be equipped with a variable frequency drive (VFD), either standalone or located in a motor control center (MCC), complete with Hand-Off-Auto selector switch, pilot lights for Pump Running and Pump Fail statuses, local speed indication and local speed adjustment from the VFD operator interface. In addition, for all pumps, the VFD shall monitor for check valve fail to open and high discharge pressure (when the pump is called to start after a time delay). For submersible pumps, the VFD shall also monitor for seal failure and motor high temperature. The VFD shall provide a motor shut down circuit for each alarm condition and a pilot light to indicate the alarm status. All motor failure and shut down conditions shall be combined into a single common fault for connection to the PLC and monitoring at the SCADA graphics. When the pump is in Hand, the pump shall be called to start (if all permissives are present and all alarm conditions are cleared) and shall ramp up to the local speed set point as adjusted through the VFD operator interface. When the pump is in Auto, control of the pump shall be transferred to the PLC and shall operate as described in the specific control narrative for each loop. The VFD shall receive a 4-20 mA signal from the PLC as a pump speed reference and the VFD shall automatically adjust its speed to that reference. The VFD shall provide a 4-20 mA signal to the PLC as a pump speed feedback.

2. Pump run status, pump speed (range: 0-100%), pump failure (VFD fail, check valve fail to open, seal failure, motor high temperature and/or low discharge flow) and pump in remote status signals shall be wired from each pump VFD to the PLC. Pump start/stop command and pump speed command (range: 0-100%) shall be wired from the PLC to each pump VFD. Status and control shall be available at the SCADA graphics.

3.02 NEW WET WEATHER PUMP STATION AND FORCE MAIN:

A. Loop 2000: Wet Weather Pump Station Wet Well Level

1. The wet well level shall be measured by a submersible pressure transducer (LT-2000). The wet well shall also contain float switches to indicate High and Low level (LSH-2000 and LSL-2000).

2. The level shall be monitored and recorded in the HMI, and shall be used to control the wet weather pumps (Loop 2010-X) in automatic mode.

3. High level and Low level shall be indicated (but not alarmed) in the HMI. If the level transducer experiences a Loss of Signal Alarm (see paragraph 1.01.F) while any wet well pump is running, the floats shall be used for backup control of the pumps until the level transducer signal is restored: all pumps shall be called to run at 100% speed on high level, and all pumps shall be called to stop on low-low level.

B. Loop 2010-1, 2, 3, 4: New Wet Weather Pumps

1. In automatic mode, the pumps shall be controlled as follows:
   a. Pumps shall be sequenced for Lead 1/Lead 2/Lag 1/Lag 2 operation. The operator shall select the Lead Pumps from the HMI, and each successive pump that is not in alarm shall be assigned to the next place in the sequence (e.g. if Pump 1 is Lead 1, Pump 2 shall be Lead 2, Pump 3 shall be Lag 1, etc.). The operator may select Automatic Sequence Rotation at the HMI, in which case the Lead pumps will rotate (e.g. from Pump 1 Lead 1 and Pump 2 Lead 2, to Pump 2 Lead 1 and Pump 3 Lead 2) each time all pumps have stopped. If any pump in the sequence experiences an alarm, or is taken out of Auto mode, the sequence will skip automatically to the next available pump.
   b. The Lead pumps shall start upon reaching a rising level Lead Start setpoint, and shall stop upon a falling level Lead Stop setpoint. These setpoints shall be operator-selected and initially set to match elevations show on Dwg M-7.
   c. The speed of all running pumps shall be controlled to meet a wet well level setpoint that is operator-selected.
   d. If the Lead pumps speed rises to 95% or above for 30 seconds, and the wet well level remains above the setpoint, the Lag 1 pump shall be called to start. The Lead pumps speed will ramp down as the Lag 1 pump speed ramps up, to match speeds. Additional pumps shall be started in the same manner if required.
   e. If the speed of all running pumps falls to 60% or below for 60 seconds, and the wet well level continues to remain below the setpoint, the last pump started shall be stopped. Additional pumps shall be stopped in the same manner if required with the exception that not less than two pumps shall be in operation. If the speed of the Lead Pumps falls to 60% or below for 60 seconds, and the wet well level continues to remain below the setpoint, the Lead Pumps shall be stopped simultaneously.

2. Additionally, the operator can manually start and stop pumps, and manually override the speed of any pump, from the HMI.

C. Loop 2020: New Wet Weather Pump Station Flow

1. The pumped flow from the Wet Weather Pump Station to the Existing 30” Force Main shall be monitored by a magnetic flow meter (FIT/FE-2020).

2. Flow shall be displayed, recorded, and totalized in the HMI as described in paragraph 1.01.L.

D. Loop 2030: New Wet Weather Pump Station Flushing System

1. At the end of a wet weather event, the new pump station wet well shall be flushed out to remove any standing solids. A wet weather event shall be considered ended after all wet weather pumps (Loop 2010-X) have been off for more than two hours. Alternately, the operator may initiate a flushing cycle manually from the HMI.

2. The flushing cycle sequence shall be as follows:
   a. Control valve PV-2030 on the non-potable water flushing line shall open. PV-2030 shall remain open for an operator-selected time (To be determined during start up).
   b. Grinder sump pump P-2000 will start when a user enter high level set point as measured by LT-2000 is activated and stop when user entered low level is reached. This will conclude the flushing cycle.
   c. The flushing cycle may also be interrupted by manual action from the HMI.

3. Once the flushing cycle is concluded, wet weather pumping controls as described in Loop 2010-X shall resume.

   Additionally, the operator can manually start and stop the grinder sump pump, and manually open and close the valves, from the HMI.

3.03 WET WEATHER DIVERSION STRUCTURE

A. General: The diversion structure will divert flows to the new wet weather pump station when flow exceeds the capacity of the interceptor (8.5 MGD). This flow is measured by an area-velocity flow meter (FIT/FE-1030). A vertical deflection screen and weir will control the flow and retain solids within the influent channel.

   If the diverted flow exceeds the upgraded capacity of the existing DuPont Pump Station (8.5 MGD), the flow will be passively diverted by a diversion weir to the new wet weather pump station.

B. Loop 10211: Diversion Structure Effluent Gate

   1. Gate position feedback (0-100% open) and control-in-remote status shall be displayed in the HMI. The operator can manually set the position of the gate from the HMI.

   2. In automatic mode, the effluent gate shall be modulated to maintain a maximum flow of 8.5 MGD.

C. Loop 1030: Dupont Pump Station Effluent Flow

   1. The flow out of the pump station to the Stuart Heights Interceptor is measured by an area-velocity flow meter (FIT/FE-1030).

   2. Flow shall be displayed, recorded, and totalized in the HMI as described in paragraph 1.01.L.

   3. In automatic mode, when the flow exceeds 8.5 MGD (during a wet weather event), the effluent gate (Loop 10211) will be modulated to limit the flow to 8.5 MGD.

D. Loop 1020-1, 2, and 3: Diversion Structure Weir Gates

1. Gate position feedback (0-100% open) and control-in-remote status shall be displayed in the HMI. The operator can manually set the position of the gate from the HMI.

3.04 ODOR CONTROL SYSTEMS

A. Loop 1050: Diversion Structure Odor Control System

1. The odor control system will pull air from the new diversion structure. This odor control system is to run continuously. The start/stop function will be via panel mounted pushbuttons mounted on the front of the vendor supplied panel.

2. Odor control System Run and Fault statues to be monitored at HMI.

END OF SECTION

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PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install, place in operation and field test four submersible wastewater pumps shown on the Drawings and specified herein. The equipment to be furnished and installed shall be as shown on the Drawings and shall include pumps, motors, VFDs, guide rails, access hatches, control panels and control systems, and appurtenances, all tested and ready for operation.

B. These Specifications are intended to give a general description of what is required, but do not cover all details which will vary in accordance with the requirements of the equipment as offered. It is, however, intended to cover the furnishing, factory testing, delivery and complete installation and field testing of all materials, equipment and appurtenances for the complete pumping units as herein specified, whether specifically mentioned in these Specifications or not.

C. Pump motors, cables and appurtenances shall be rated for operation in a Class I Division 1, Group D hazardous environment.

D. The pump manufacturer shall coordinate the design of the pump and motor with the variable frequency drives, as specified in Division 16.

1.02 RELATED WORK

A. Submittals are included in Section 01 33 23.

B. Operation and maintenance is included in Section 01 78 23.

C. Warranties are included in Section 01 78 36.

D. Concrete work and the installation of anchor bolts are included in Division 3; however, anchor bolts for these units as recommended by the pump manufacturer shall be furnished by the Contractor under this Section.

E. Instrumentation work is included in Division 40.

F. Pump operation and control shall be as described in Section 40 96 45.

G. Valves, mechanical piping and appurtenances and pipe hangers and supports are included in Division 40.

H. Electrical work is included in Division 26.

1.03 REFERENCE STANDARDS

A. Design, manufacturing and assembly of elements of the equipment herein specified shall be in accordance with, but not limited to, published standards of the following, as applicable:

1. American Gear Manufacturers Association (AGMA)
2. American Institute of Steel Construction (AISC)
3. American Iron and Steel Institute (AISI)
4. American Petroleum Institute (API)
5. American Society of Mechanical Engineers (ASME)
6. American National Standards Institute (ANSI)
7. American Society for Testing Materials (ASTM)
8. American Welding Society (AWS)
9. American Bearing Manufacturers Association (ABMA)
10. Hydraulic Institute Standards (current edition)
11. Institute of Electrical and Electronics Engineers (IEEE)
12. National Electric Code (NEC)
13. National Electrical Manufacturers Association (NEMA)
14. Occupational Safety and Health Administration (OSHA)
15. Steel Structures Painting Council (SSPC)
16. Underwriters Laboratories, Inc. (UL)
17. Factory Mutual (FM)

B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.04 SYSTEM DESCRIPTION

A. The system will pump raw wastewater. The equipment to be furnished under this Section shall include four submersible wastewater pumps, motors, and accessories such as guide rails, all as specified herein and as shown on the Drawings. Refer to section 40 90 00 for system description and control loop descriptions. Contractor shall coordinate and be fully responsible for proper operation and compatibility between items in this scope of work and items in Division 40 scope.

1.05 QUALIFICATIONS

A. To assure unity of responsibility, the pumps, motors, VFDs, guide rails and access hatches and other auxiliary equipment, and materials specified in this Section shall be furnished and coordinated by the pump manufacturer (Manufacturer) who shall assume responsibility for the satisfactory operation of the entire pumping system including pumps, motors, VFDs, and accessories.

B. The pumps and other equipment covered by this Specification shall be standard production units of the manufacturers, currently available and listed in the respective manufacturer's catalog. The pumps furnished shall be in accordance with the Hydraulic Institute Standards and shall be designed, constructed and installed in accordance with the best practice and methods, and shall operate satisfactorily when installed.

C. The Manufacturer shall have an authorized warranty center within a 300-mile radius of the job site, fully staffed with factory trained mechanics, and equipped with a stock of all necessary spare parts for each model of pump furnished under this Contract. The service facility shall be an established entity prior to delivery of equipment for this project.

D. The VFDs furnished shall have an established record of successful performance with the submersible motors supplied.

E. All equipment furnished under this Specification shall be new and unused, shall be the standard product of manufacturers having a successful record of manufacturing and servicing similar equipment and systems to that specified herein for a minimum of five years.

F. The pumping equipment shall be furnished complete with accessories required and shall meet the detailed requirements of the Specifications.

G. Prior to manufacture, a statement shall be submitted to the Engineer certifying that the required torsional and lateral dynamic vibration analyses have been completed or historical analysis results for the specified pump model, if matching the proposed pump/motor, are available to confirm that the first torsional and lateral critical speeds are at least 20 percent above the maximum pump speed and blade pass frequency or 20 percent below the minimum pump speed, assumed to be 50 percent of the FLS.

1. Lateral rotordynamic analysis/results - The lateral rotordynamic analysis/results for specified pump model, performed by Manufacturer, shall provide the first lateral critical speed to demonstrate 20 percent separation above and below specified speed range including vane pass frequency. Historical analysis results for the specified pump model, if matching the proposed pump/motor, can be provided.

2. Torsional rotordynamic analysis results - The torsional rotordynamic analysis results for specified pump model, performed by Manufacturer, shall provide the first torsional critical speed to demonstrate 20 percent separation above and below specified speed range including vane pass frequency. Historical analysis results for the specified pump model, if matching the proposed pump/motor, can

be provided. If a design modification (i.e., such as a shaft diameter change or number of impeller vanes) cannot resolve a separation margin deficiency or is not practical, a forced damped response analysis shall be performed to show that infinite life will be achieved with a safety factor of at least two.

H. The pumps shall operate throughout the entire operating range with the maximum vibration velocity in inches per second RMS, measured in the field, shall conform to the requirements of ANSI/HI 11.6.

1.06 SUBMITTALS

A. Copies of all materials required to establish compliance with the Specifications shall be submitted in accordance with the provisions of the General Conditions and Section 01 33 23. Submittals shall include at least the following:

1. Shop and erection drawings showing all important details of construction, dimensions and anchor bolt installation requirements. Submittal shall demonstrate that hatch clear opening is sufficient for the pump supplied.

2. Descriptive literature, bulletins, and/or catalogs of the equipment. Sufficient data shall be submitted to document previous production of each pump model proposed for use on this Contract.

3. Data on the characteristics and performance of each pump. Data shall include guaranteed performance curves to ANSI/HI 11.6 acceptance grade 1U, based on actual factory tests of similar units, which show that they meet the specified requirements for head, flow rate, efficiency, NPSH3, submergence and horsepower. Curves shall be submitted on 8-1/2-inch by 11-inch sheets, at as large a scale as is practical. Curves shall be plotted from zero flow at shut off head to pump flow rate at minimum specified total head (TH). The POR and AOR (refer to ANSI/HI 9.6.3) shall be clearly shown on the curves. Catalog sheets showing a family of curves will not be acceptable.

4. The total weight of the equipment including the weight of the single largest item.

5. Complete wiring diagrams and schematics of all power and control systems showing wiring requirements between all system components, motors, sensors, control panels, and related systems.

6. A complete total bill of materials of all equipment.

7. A list of the manufacturer's recommended spare parts to be supplied, with the manufacturer's current price for each item. Include gaskets, seals, etc. on the list. List bearings by the bearing manufacturer's numbers only.

8. All submittal data required by the General Conditions.

9. Complete motor data, including, but not limited to:
   a. Type of enclosure design
   b. Rated horsepower

c. Rated voltage
d. FLA
e. Starting current
f. LRA
g. LR KVA
h. NEMA starting code letter and insulation code letter
i. RPM
j. Input power in kW at nameplate rating
k. Starting calculations
l. Cable size
m. Efficiency at 50%, 75% & 100% load, and power factor at 50%, 75% & 100% load
n. Winding temperature rise
o. Vibration design limits
p. Speed torque curves
q. Recommended trip and alarm settings for temperature and vibration protective devices
r. Power and control cable size and materials of construction, details of cable sealing method, description and type of motor thermal protection, description of insulation system and service factor.
s. Submit a certified statement from the motor manufacturer that the motors are capable of continuous operation on the power supply from the variable frequency drives to be furnished without affecting their design life for bearings or windings. This requirement does not replace nor relieve submittal requirements under Division 16.

10. Submit a certified statement from the motor manufacturer that the motors are capable of a minimum of 12 variable frequency drive starts per hour and continuous operation on the power supply from the variable frequency drives to be furnished without affecting their design life for bearings and windings.

11. Certified agreement to the conditions of the warranty.

12. Submit description of factory test plan including test procedures and equipment.

13. Submit for approval results of factory testing and field testing.

14. Critical speed analyses report including the specified Campbell diagrams and a statement of guarantee that the critical speed analyses as required in Paragraph 1.05G of this Section have been completed and that the specified limitations will be met.

B. In the event that the equipment offered does not conform with all of the detailed requirements of the Specifications, describe completely all nonconforming aspects. Failure to describe any and all deviations from the specifications will be cause for rejection.

1.07 OPERATING INSTRUCTIONS

A. Operating and Maintenance Manuals shall be furnished. The manuals shall be prepared specifically for equipment furnished and installed on this Contract and shall include all required cuts, drawings, equipment lists, descriptions, etc. that are required to instruct operating and maintenance personnel unfamiliar with such equipment. The number and special requirements shall be as specified in the Section 01 78 23.

B. The Contractor shall include in his bid price the services of a pump factory representative for two eight hour sessions. The first eight hour period shall be to inspect for proper installation. The second eight hour period shall be to instruct the Owner's personnel for proper operation and maintenance of the pumps. VFD training shall be as specified in Division 26.

C. The Manufacturer shall provide detailed manuals to supplement the training courses. The manuals shall include specific details of equipment supplied and operations specific to the project.

D. The Manufacturer shall make use of teaching aids, manuals, slide/video presentations, etc. After the training services, such materials shall be delivered to Owner.

1.08 TOOLS AND SPARE PARTS

A. The Manufacturer shall furnish a complete list of recommended spare parts, gaskets, lubricants and sealants necessary for the first year of operation of each pumping system.

B. See Section 01 13 10 for additional requirements.

1.09 PRODUCT HANDLING

A. All equipment and parts shall be properly protected so that no damage or deterioration will occur during a prolonged delay from the time of fabrication, including storage in accordance with Manufacturer's requirements until final delivery to the job site.

B. Factory assembled parts and components shall not be dismantled for shipment unless permission is received in writing from the Engineer.

C. Finished surfaces of all exposed pump openings shall be protected by wooden blanks, strongly built and securely bolted thereto or by other approved means.

D. Finished iron or steel surfaces not painted shall be properly protected to prevent rust and corrosion.

E. After hydrostatic or other tests, all entrapped water shall be drained prior to shipment and proper care shall be taken to protect parts from the entrance of water during shipment, storage and handling.

F. Each box or package shall be properly marked to show its net weight in addition to its contents.

1.10 WARRANTY

A. All equipment supplied under this section shall be warranted for a period of one year by the Contractor and the Manufacturer. Warranty period shall commence on the date as outlined in Division 1 and in Division 0.

B. In addition, Manufacturer shall warrant the pump/motor for a period of five years, prorated after the initial 1.5 years. This Manufacturer warranty duration includes the warranty period identified above and as outlined in Divisions 1 and 0.

C. The equipment shall be warranted to be free from defects in workmanship, design and materials. If any part of the equipment should fail during the warranty period, it shall be replaced in the machine(s) and the unit(s) restored to service at no expense to the Owner.

D. The Manufacturer's warranty period shall run concurrently with the Contractor's warranty period. No exception to this provision shall be allowed.

E. Refer to Section 01 78 36 for additional warranty requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. The pumping units required under this Section shall be complete including pumps and motors with proper alignment and balancing of the individual units. All parts shall be so designed and proportioned as to have liberal strength, stability, and stiffness and to be especially adapted for the work to be done. Ample room shall be provided for inspection, repairs, and adjustments.

B. Each base elbow for each pump shall be designed to be rigidly and accurately anchored into position. All necessary anchor bolts, plates, nuts, and washers shall be furnished and installed by the Contractor in strict accordance with the Manufacturer's recommendations.

C. Stainless steel nameplates giving the name of the manufacturer, the rated flow rate, head, speed, and all other pertinent data shall be permanently attached to each pump and/or motor. Additional stainless steel nameplates shall be provided to be installed by the Contractor on the VFD enclosures or other above grade location as instructed by the Engineer such that the pumps do not need to be removed to gather the information.

D. The pumps shall be totally submersible, solids handling, rotodynamic pumps with submersible close coupled motors designed to pump raw, unscreened wastewater. The design shall be such that the pumping units shall be automatically connected to the discharge piping when lowered into place on the discharge connection, providing a water tight seal. The pumps shall be designed to be easily removed from their discharge connections and the wet well for inspection or service. Lifting the pumps from their discharge connections or the wet well shall require neither the removal of any bolts, nuts or other fastenings nor the need for personnel to enter the pump well.

2.02 CONDITIONS OF OPERATION

A. The pumps shall be as manufactured by Flygt Model 3312, Sulzer ABS Model XFP 305M or equal product meeting the detailed requirements of these specifications.

B. Each pump shall be designed for the conditions of service tabulated as follows and shall operate within the system head curve envelope as shown in Figure 11306-1. All pumps with specific speed less than 4,500 (US units) shall have a continuously rising head performance curve for stable pump operation from the minimum head operating point to the shut-off head. For pumps where specific speed is greater than or equal to 4,500, the intersection of the pump head and system head curves shall be used to demonstrate stable operation.

C. The pumps shall operate throughout the entire operating range with the maximum vibration velocity in inches per second RMS unfiltered, measured in the field, shall be less than the requirements of ANSI/HI 11.6-latest edition.

D. Each pump shall be designed for the conditions of operation tabulated as follows.

Item Description	Design Conditions
Number of Pumps (operating/standby)	4 (3/1)[1]
Maximum Motor Full Load Speed (FLS) (rpm)	1200
Maximum Allowable Motor (HP)	300
Motor Design Voltage/Phase/Frequency	460/3/60
Maximum Anticipated Pumped Fluid Temperature (degrees F.)	79
Minimum Pump Discharge Size (inches)	12
Minimum Base Elbow Discharge Size (inches)	12
Minimum Pump Shut-Off Head at Motor FLS (feet)	174
Minimum Secondary Flow Rate (gpm)	3500
Minimum TH at Secondary Flow Rate (feet)	130
Minimum Overall Efficiency at Secondary Flow Rate (%)[2]	62
Intermediate (Design) Flow Rate (gpm)	5200
Minimum TH at Intermediate (Design) Flow Rate (feet)	122
Minimum Overall Efficiency at Intermediate (Design) Flow Rate (%)[2]	74
Best Efficiency Point TH (feet)	76
Best Efficiency Point Flow Rate Range (gpm)	5500 to 7000
Maximum Primary TH (feet)	90
Minimum Flow Rate at Primary TH (gpm)	7500
Minimum Overall Efficiency at Primary Flow Rate (%)[2]	66

Item Description	Design Conditions
Maximum NPSH3 at Primary TH (feet)[3]	31
Minimum Submergence Above Pump Casing (feet)/Maximum Duration at Min. Submergence (minutes)	2/Continuous

[1] Not less than two pumps shall be in operation.
[2] Note that minimum overall efficiencies listed are "wire-to-water" in accordance with ANSI/HI 11.6 – latest edition.
[3] NPSH3 by HI definition is the required NPSH of a pump is the NPSH available that will cause the total head to be reduced by 3%.

E. Each pumping unit and its driving equipment shall be designed and constructed to withstand the maximum turbine run-away speed of the unit due to back flow through the pump.

2.03 PUMP CONSTRUCTION

A. The overall pump design shall combine high efficiency, low required NPSH3, the ability to handle high solids concentrations effectively. The impeller/casing design shall result in a passage free of surfaces to which solid or fibrous materials can adhere and shall be capable of passing fibrous and nonwoven materials as found in domestic wastewater. The design shall permit low liquid velocities and gradual acceleration and change of flow direction of the pumped media.

B. All external pump and motor parts shall be of close grained cast iron, ASTM A48 Class 35B construction, with all parts in contact with wastewater protected by corrosion resistant coatings. All external bolts and nuts shall be type 316 stainless steel.

C. Impellers shall be constructed of ASTM A890 cast stainless steel. Impellers shall be dynamically balanced.

D. The impeller shall be a rotodynamic a semi-open, solids handling type capable of passing solids either due to internal clearances or other features to facilitate solids processing including a wear plate with groove. The wear plate to impeller clearance shall be easily adjustable without the need for disassembly of the pump or the need to add or remove shims. The impeller may include pump out vanes on the upper shroud to reduce axial thrust and minimize clogging due to debris accumulation around the mechanical seal. The impeller shall be dynamically balanced to the ISO 1940 G6.3 standard and the ISO 1940 Grade G2.5 standard to provide smooth, vibration free operation.

E. Each pump shall be provided with a balanced tandem mechanical shaft seal system. The upper (inner) of the tandem set of seals shall operate in an seal lubricant chamber located just below the stator housing. At a minimum, this set shall contain one stationary silicon carbide and one positively driven rotating carbon ring and shall function as an independent secondary barrier between the pumped liquid and the stator housing. The lower (outer) of the tandem set of seals shall function as the primary barrier between the pumped liquid and the stator housing. This set shall consist of a stationary ring and a positively driven rotating ring, both of which shall be either

tungsten carbide or silicon carbide. Each interface shall be held in contact by its own Hastelloy-C® or Elgiloy® spring system. The seal body shall be Type 316 stainless steel. The o-rings shall be FKM (Viton)®. The seals shall require neither maintenance or adjustment, but shall be easily inspected and replaceable. Seal design shall provide pressure applied to the outside diameter of the face. Shaft seals with conventional double mechanical seals containing either a common single or double spring acting between the upper and lower units are not acceptable nor equal to the dual independent seal specified.

F. The minimum pump discharge size, shall be the minimum allowable nominal diameter of the discharge piping, as shown on the Drawings, except as allowed otherwise by this specification. Unless otherwise noted, the diameter of the opening at the connection between the pump and the discharge should normally be the same as the minimum specified discharge size.

G. A sliding guide bracket shall be an integral part of or bolted to the pumping unit. The pump casing shall have a machined connection system to attach to the ASTM A48, Class 35 cast iron discharge connection. The sealing system shall consist of two machined metal to metal flanges or flanges with a replaceable rubber seal, form fitted to the machined discharge coupling to ensure and guarantee a positive leak proof system and to provide ease of pump removal. The discharge connection shall be bolted to the floor of the wet well with type 316 stainless steel J-type cast-in anchor bolts, monel nuts and accessories and so designed as to receive the pump connection without the need of any bolts or nuts. The pump shall be tightly sealed against the discharge connection and shall be accomplished by a simple linear downward motion of the pump with the pumping unit guided by two guide rails as specified below. No portion of the pump shall bear directly on the wet well floor.

H. Each pump shall be fitted with a Type 316 stainless steel lifting cable and a short piece of suitably sized Type 316 stainless steel chain between the bail and cable. The lifting cable and chain shall be rated for five times the pump weight (minimum).The lifting cable and chain combined length shall be equal to the wet well depth (top slab finished grade to wet well bottom) plus six feet to permit raising the pump for inspection and removal.

I. The lifting cable shall be attached to a lifting bail on the pump. Eyebolts will not be considered as an acceptable alternate to a lifting bail.

2.04 SUBMERSIBLE MOTORS

A. Pump motors shall be inverter duty rated, housed in an air filled, water-tight casing, and shall have Class F or better non-hygroscopic insulated windings which shall be moisture resistant. Oil filled motor housing is not acceptable. The motors shall be suitable for use with the solid-state starters. The motor stator shall be dipped and baked three times in a VPI process and heat shrunk fitted into the stator housing. As an alternative, trickle impregnation method may be used for motor stator windings. The use of bolts, pins or other fastening devices requiring penetration of the stator housing is not acceptable. Motors shall be NEMA Design B, equipped with a 1.15 service factor, as defined in the NEMA MG1 standard, based upon the nameplate horsepower rating for across-the-line service. A service factor of 1.0 will be acceptable when driven by a

VFD (non-sinusoidal power supply). The motor insulation system shall be rated at 155° C or better. Motor shall be capable to operate in an ambient temperature of 40 ° C continuously with Class B temperature rise. The motor shall be NEMA Starting Code G or H, or better. Motors shall be non-overloading and capable of sustaining a minimum of ten starts per hour. Upper motor bearing shall be insulated. Motors shall be provided with a minimum power factor of 0.80 at full load. If motor is below this minimum power factor value then power factor correction capacitors shall be furnished by the Manufacturer for constant speed applications. The motor efficiency shall comply with the minimum established herein: 94% at full load to meet the wire-to-water efficiency specified in paragraph 2.02.

B. Pump motors shall have cooling characteristics suitable to permit continuous operation in a totally, partially, or non-submerged condition. Each motor shall incorporate three overheat sensing devices, one in each motor winding. These devices shall trip at 140°C. The sensing device shall be wired into the pump controls in a manner such that if the device operates, the pump will shut down. The temperature device shall be self-resetting.

C. The pump motor shall incorporate a closed-loop cooling circuit with an integrated cooling pump rated for continuous duty in a completely dry mode; as well as; in a fully submerged condition without damage. The cooling jacket shall be cast iron ASTM A48 class 30 or steel. The coolant pump impeller shall be mounted directly on the motor shaft between the tandem mechanical seals to circulate coolant fluid into the top inter-space between the cooling jacket and motor housing, over the surface of the motor, through ducts in the bearing housing and into a casing heat exchanger. Heat losses from the motor shall be transferred to the fluid pumped in the casing heat exchanger, which forms a structural unit together with the discharge cover of the pump. After passing through the volute-casing heat exchanger, the coolant shall return to the suction side of the internal coolant pump (impeller).

D. The pump motors shall be designed so that the pump will be capable of running continuously in a totally dry condition under full load without damage. Pump motor shall be non-overloading within the range of operation between shutoff and the low head run-out conditions shown on the pump conditions of operation data table above. For pumps where specific speed is greater than or equal to 4,500, the range from the pump head and system head curves intersection point and low-head run out conditions shall be used to demonstrate non-overloading over the range of operating conditions.

E. The pump/motor shaft shall be constructed of type 416, 420 or type 431 stainless steel. When operating at the pump design point, the shaft shall have a maximum deflection of 0.2 mm at the lower seal face and a maximum deflection of 0.45 mm at the wear ring area. The shaft shall rotate on permanently lubricated ball bearings properly sized to withstand the axial and radial forces. The ABMA Minimum L-10 bearing life shall be at least 30,000 hours rated at the pump BEP.

F. The pump motor with its appurtenances and cable shall be capable of continuous submergence underwater without loss of watertight integrity to a depth of 65 feet. All mated surfaces shall be machined, fitted with O-rings for watertight sealing.

G. The pumps shall be provided with a cable entry design that shall preclude specific torque requirements to insure a water tight and submersible seal. The cable entry shall be certified by UL or FM to have passed pull-testing requirements. The cable entry junction chamber and motor shall be separated by a stator lead, sealing gland or terminal board, which shall isolate the motor interior from foreign material gaining access to the pump motor top. The cable entry system shall be field serviceable. The power and control cable entry into the lead connection chamber may also be epoxy encapsulated for positive moisture sealing. A BUNA-N cable grommet shall be provided in addition to the epoxy sealed leads.

H. Cables, Conduits and Accessories

1. The pumps shall be supplied with power and sensor conductors. Pump motor cables shall be sized to meet applicable NEC requirements. The cable shall consist of a type SPC or SEOW insulated cable with a double jacketed protection system. The cable shall have a neoprene or chlorinated polyethylene outside and synthetic rubber inside, and shall exceed industry standards for oil, gas and sewage resistance. Individual conductors shall be of type RUW. Pump cables shall be provided of sufficient length so that the cables will be continuous between the pump and the disconnect with no splices being allowed.

2. If more than one cable is being provided per pump, the Contractor shall furnish and provide for the installation of the additional conduits, etc. as required for each additional cable. Only one cable per conduit will be allowed at the pump station. Conduit sized per manufacturers recommendations but not smaller than 3/4-inch.

3. Contractor shall furnish all required stainless steel conduit hardware and fittings.

4. Water tight connectors shall be equal to Crouse-Hinds Type "CGB", with neoprene lands shall be furnished with and installed in the control panel enclosure or disconnect to terminate each conduit and seal each cable entry.

5. Conduit seals shall be equal to Crouse-Hinds Type "EYS".

6. Coordinate the installation of the above materials with the Manufacturer.

2.05 VARIABLE FREQUENCY DRIVES

A. The speed control for variable speed pumps shall be Variable Frequency Drives, as specified in Section 26 29 23, suitable for installation as shown on the Drawings.

B. The Variable Frequency Drives shall be supplied by the Manufacturer and shall be completely coordinated with the pumps and pump driving motors and shall include all internal auxiliaries required to meet the functional specifications.

C. The Variable Frequency Drives shall conform to all requirements stipulated in this Section and Division 26, Electrical, and shall be designed for a speed range of 72% to 100% of full load motor speed.

D. The Variable Frequency Drives shall be compatible with the motors provided by the Manufacturer.

2.06 PUMP PROTECTION PANEL

A. A single pump protection panel shall house a pump protection module for each pump. The modules shall monitor machine vibration, temperature, and moisture. The system shall provide warning and shutdown protection and shall be UL listed. All of the pump/motor unit protective and monitoring sensors shall be connected to an electronic module which will provide a signal from the pump/motor sensors to the devices located in the pump protection panel. Modules shall be as manufactured by Flygt MAS 711 or equal. Alternate configurations that include a single panel that monitors each motor separately will be acceptable as long as the panel meets the remainder of the requirements in Paragraph 2.06. Alternate control panel configurations shall be clearly detailed in shop drawing submittals and must be approved by Owner and Engineer before installation. Alternate panel configurations, if approved, will be provided with no additional cost to the Project.

B. Detailed operational data shall be accessible using a standard web browser on a computer with no special software required. Alternatively, data shall be capable of easily being transferred to a higher level distributed control system such as a Supervisory Control and Data Acquisition (SCADA) system.

C. The pump protection panel shall monitor each pump/motor's temperature, vibration and moisture (leakage). The system shall be capable of sending a common fault signal to pump Variable Frequency Drives.

D. The pump protection panel shall be rack mounted in a NEMA 4X 316 stainless steel enclosure at the location shown on the Electrical Drawings. The pump/motor protection panel shall include soft-touch type navigation keypad, alarm acknowledgement keypad, amber warning lamp, red alarm lamp and a LCD digital display. The digital display shall provide the local readout of pump/motor sensor and alarm status and aid in navigation through the system during set-up.

E. Each pump/motor unit(s) shall be equipped with the following protection and monitoring sensors:

1. One PT-100 (Platinum, 100 ohm, 2 or 3-wire) temperature probe shall be installed in the bearing housing holding the outer race of the thrust bearing and lower support bearing to provide for accurate temperature monitoring of the bearings.

2. Three PT-100 (Platinum, 100 ohm, 2 or 3-wire) temperature probes, one installed in each motor stator phase winding, to provide direct stator temperature read-out of each phase winding.

3. One PT-100 (Platinum, 100 ohm, 2 or 3-wire) temperature probe shall be installed in the bearing housing holding the outer race of the upper support bearing to provide for accurate temperature monitoring of the bearing.

4. One Float-type Moisture (Leakage) Sensor (Stator FLS) shall be provided to detect water intrusion into the motor stator chamber. If activated, the FLS will activate an alarm.

5. One Float-type Moisture (Leakage) Sensor (Electrical Connection FLS) shall be provided to detect water intrusion into the motor electrical connection (cable junction) chamber. If activated, the FLS will activate an alarm.

6. One water-in-oil or water-in-air capacitive type moisture sensor installed in the mechanical seal lubrication chamber (between the inner and outer mechanical seals) to alarm should there be intrusion of water into the chamber.

7. One vibration sensor shall be installed in the power cable junction chamber of the pump/motor unit. The vibration sensor shall be capable of monitoring vibration velocity in in/sec RMS unfiltered. Alternatively, one vibration sensor shall be installed to the outside of the pump casing near the upper bearing housing in accordance with manufacturer's recommendations. A separate sensor mounting base equipped with mounting stud shall be connected to the pump with epoxy-based adhesive, to which the sensor shall be mounted. Sensor (accelerometer) shall be model SA6200UW as manufactured by Metrix or equal. Provide associated model 5535 signal conditioner/transmitter as manufactured by Metrix or equal to be mounted in the pump/motor protection panel.

8. All relays associated with the monitoring and protective devices furnished.

9. Manufacturer may submit alternate pump protection system to the Engineer. Submittal will be reviewed as part of the shop drawing review process prior to manufacturer of pumps and equipment. Manufacturer shall indicate any deviations from those outlined above at the time of submission. The alternate system shall provide the same level of protection for the pump and motor.

2.07 GUIDE RAILS AND PUMP LIFTING DEVICE

A. The pumping station shall be furnished with the necessary, stainless steel upper guide holder and level sensor cable holder.

B. Lower guide holders shall be integral with the discharge connection. Dual guide rails shall be of Schedule 40, welded three-inch minimum diameter, Type 316 stainless steel pipe of the length required by the Drawings. Single guide rails and guide cables are not acceptable.

C. Intermediate guide brackets shall be furnished and installed so that the maximum length of unsupported guide rails will be no longer than 20 feet, and shall be fabricated of Type 316 stainless steel.

D. Stainless steel cable holders including the cable hooks shall be fabricated from Type 316 stainless steel plate. Sharp corners and edges shall be ground smooth to prevent abrasion and cutting of electrical cable insulation. The cable holder shall be of sufficient length and strength to provide support for each separate cable, except that the pump

power and lift cables may use the same hook position, provided the cables do not foul one another and the lift cable is easily accessed from the hatch opening.

E. Guide rails and all accessories shall be non-sparking.

F. Provide a chain and latch device to facilitate pump removal from wet well without a series of incremental lifts. Device shall be designed to be lowered along the guide rails and shall be remotely latched to pump lifting bail without requiring wet well entry.

2.08 SHOP PAINTING

A. Each pump and associated equipment shall be shop-primed and finished-coated in accordance with the Manufacturer's standard practice prior to shipment. Color shall be selected by the Engineer and an adequate supply of touch-up paint shall be supplied by the Manufacturer.

B. All interior and exterior wetted surfaces of pumps, exterior and interior of cooling jacket and exterior of motor enclosure shall be thoroughly cleaned, dry and free of all rust, mill scale, grease, dirt, other foreign matter and supplied with Manufacturer’s standard coatings meeting the requirements in Sections 09 91 10 and 09 91 00.

C. All nameplates shall be properly protected during painting.

2.09 ACCESS HATCHES

A. Hatches shall be part of the Manufacturer's supply and shall be in accordance with Division 5.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation shall be in strict accordance with the Manufacturer’s instructions and recommendations in the locations shown on the Drawings. The Contractor shall furnish all required oil and grease for initial operation, if required, in accordance with the Manufacturer's recommendations. Anchor bolts shall be set in accordance with the Manufacturer's recommendations.

B. Upon completion of each pump application, the Manufacturer shall inspect the installation and submit a certificate stating that the installation of the equipment is satisfactory, that the equipment is ready for operation, and that the operating personnel have been suitably instructed in the operation, lubrication and care of each unit.

3.02 INSPECTION AND TESTING

A. General

1. The Engineer shall be notified in writing prior to initial shipment and/or testing, in ample time so that arrangements can be made for inspection by the Engineer.

2. Field tests shall not be conducted until such time that the pumping system, including controls, is complete and ready for testing.

B. Factory Pump Test

1. Each pump shall be factory tested as described in ANSI/HI 11.6, American National Standard for Rotodynamic Submersible Pumps for Hydraulic Performance Acceptance Tests, as specified herein.

2. The Manufacturer shall perform hydrostatic test on the pressure-containing components in accordance with ANSI/HI 11.6. Test shall be conducted on each pump prior to shipment.

3. Cast surfaces of all components shall be examined by visual inspection per MSS SP-55.

4. Factory pump tests shall be the basis of acceptance of the hydraulic performance of the pumps. The Manufacturer shall factory test all pumps prior to shipment in accordance with the Hydraulic Institute standards. Flow rate, total head, overall efficiency and input KW shall be tested and recorded for at least five points on the pump performance curve. Test shall be performed to demonstrate that the pumps meet ANSI/HI 11.6, acceptance grade 1U for specified (intermediate) design point and acceptance grade 1E for the other specified points. The five points shall include the points specified in Article 2.2. If any pump tested fails to meet any specification requirement it will be modified until it meets all specification requirements. If any pump tested fails to meet the flow rate, head or overall efficiency requirements for any of the conditions listed in Article 2.2 of this specification and all reasonable attempts to correct the inefficiency are unsuccessful, the pump(s) shall be replaced with a unit(s) that meets the specified requirements.

5. Submit certified pump performance curves, including total head, flow rate, overall efficiency and total brake horsepower for each pump supplied. Test data shall be submitted for approval by the Engineer prior to shipment.

6. If the Manufacturer does not have historical test records for NPSH3 at the specified design pump speed, one pump shall be tested to demonstrate NPSH3 versus flow rate.

7. All meters, gauges, and other test instruments shall be calibrated within the manufacturer's established time period prior to the scheduled test and certified calibration data shall be provided. If the Manufacturer has no ISO standard calibration period, Hydraulic Institute Standards shall govern.

8. The pumps shall be tested at 100 percent of the design speed. Reduced speed curves will be determined using affinity laws.

9. Each pump shall be tested through the specified range of flow, and head/flow rate/ efficiency curves plotted at maximum output speed. During each test, the pump shall be run at each head condition for sufficient time to accurately determine flow rate, head, power input, and efficiency. In addition, during the

tests, the overall efficiency shall be determined at each test point. The pump under test shall be modified until the specified conditions are met or replaced with a pump that will meet the specified conditions.

10. The pumps shall be witness tested by the Manufacturer in the presence of up to two persons designated by the Engineer or the Owner. All witness travel and out-of-pocket expenses shall be included in the Contractor's bid. Expenses include airfare, automobile expenses, lodging, meals, parking, tolls, taxi or car rental costs and the Engineer's time billed at $1,750 per day. Air travel shall be from the airport closest to the Owner's facility to the airport closest to the Manufacturer's test facility. If additional testing days are required, either because of Manufacturer's scheduling requirements or because a pump has to be retested, the Manufacturer, through the Contractor, shall reinburse the Engineer for all reasonable expenses which the Engineer will incur in order to witness the international/additional testing over that specified herein. The sum shall be deducted from payments due the Contractor by the Owner.

11. The Manufacturer shall perform the following test on each pump prior to shipment from factory:
    a. Megger motor and pump for insulation breaks or moisture.
    b. Prior to submergence, the pump shall be run dry and checked for correct rotation.
    c. Pump shall be run for a minimum of 30 minutes in a submerged condition.
    d. The pump shall be removed from test tank, meggered immediately for moisture and upper and lower seal unit shall be checked for water intrusion.
    e. A written certification test report regarding the above tests shall be submitted for approval prior to shipment.

C. Field Pump Test

1. As specified in Paragraph 1.07 B., the Manufacturer shall furnish the services of a representative who shall have complete knowledge of proper operation and maintenance to inspect the final installation and supervise the test run of the equipment. The Manufacturer shall include in his price, a minimum of eight hours of a representative's time for the above tests.

2. Written test procedures shall be submitted to the Engineer for approval 30 days prior to testing.

3. The Contractor shall furnish all water, power, facilities, labor, materials, supplies and test instruments required to conduct the field testing.

4. The Final Acceptance Test shall demonstrate that all items of these Specifications have been met by the equipment as installed and shall include, but not be limited to, the following tests:
    a. That the quick release lift out feature functions properly and allows the pump to be raised and lowered without draining the pit.
    b. That all units have been properly installed and are in correct alignment.

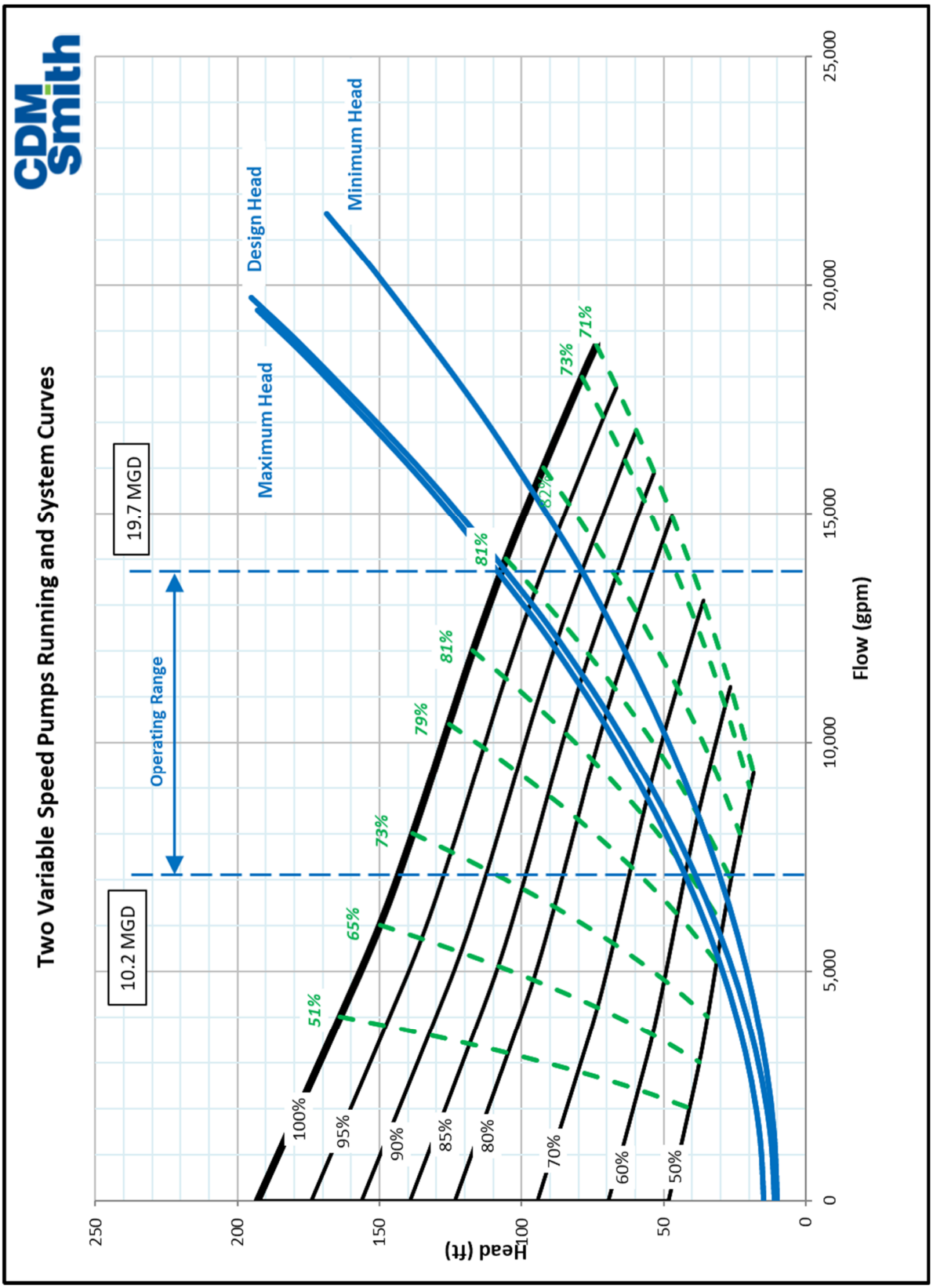
c. The Contractor shall check for correct lubrication in accordance with manufacturer's instructions. The Contractor shall check direction of rotation of all motors and reverse connections, if necessary.
d. That the units operate without overheating or overloading any parts and without objectionable vibration.
e. That there are no mechanical defects in any of the parts.
f. That the pumps can deliver the specified total head and flow rate to demonstrate that the pumps generally meet the requirements specified (factory performance test is the basis of pump acceptance).
g. That the pump sensors and controls perform satisfactorily as to sequence control, correct start and stop elevations, and proper level alarm functions.

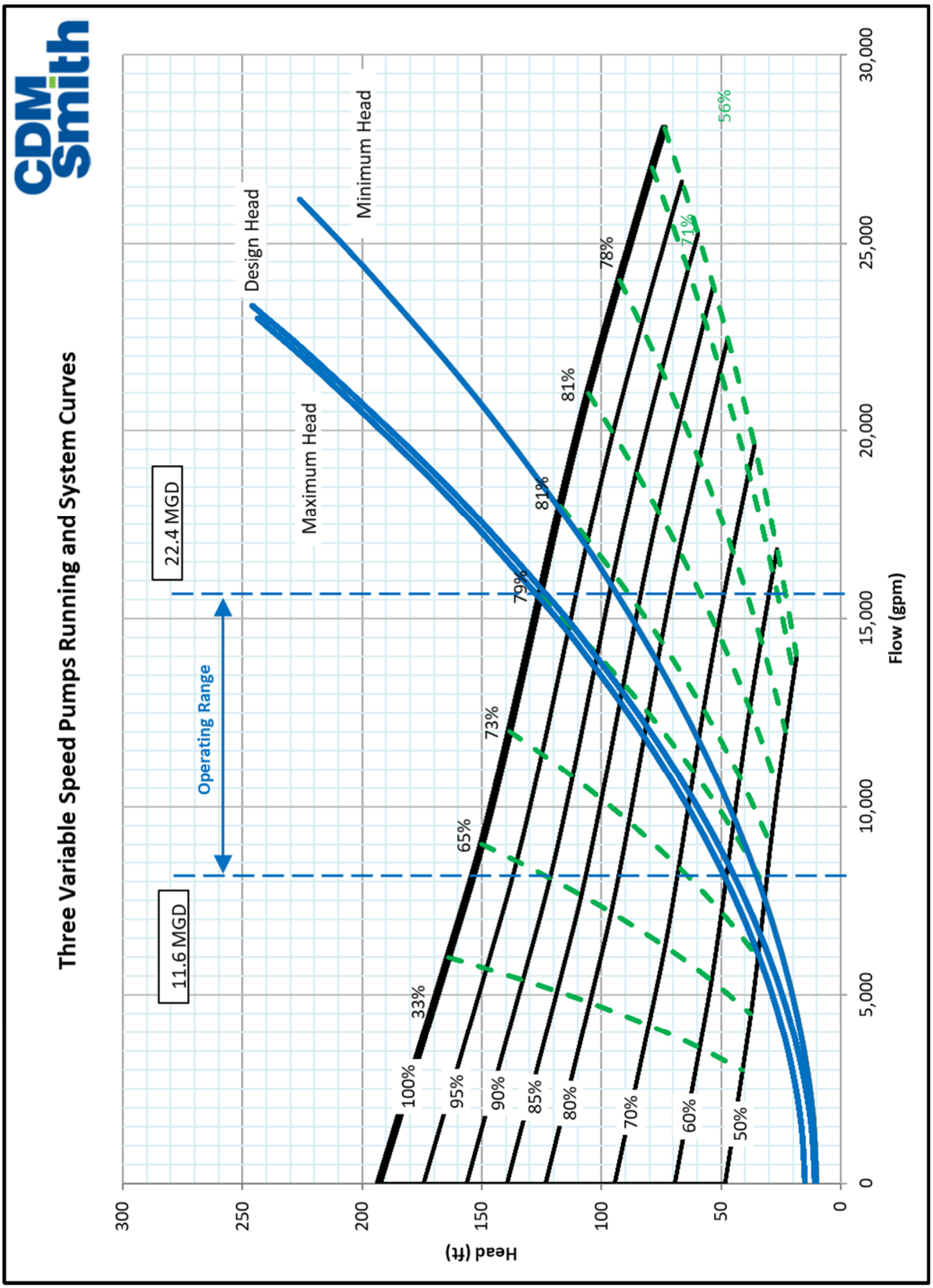
5. If the pump performance does not meet the specifications, corrective measures shall be taken or pumps shall be removed and replaced with pumps which satisfy the conditions specified.

6. A five-day continuous operating period of the pumps will be required before acceptance. If pumping system fails during the test period, the test shall be restarted (including reset of time to zero) after repair (or replacement) has been completed.

D. Field Vibration Testing

1. After installation and as soon as conditions permit full speed operation, and in the presence of the Engineer, have the vibration tests performed in accordance with ANSI/HI 11.6 on each unit to (a) prove compliance with specified limitations, and (b) prove that there are no field installed resonant conditions due to misalignment, the foundation, or the connecting piping and its supports, when operating at any speed within the specified operating range.


CDM Smith
Two Variable Speed Pumps Running and System Curves
Design Head
Minimum Head
Maximum Head
19.7 MGD
10.2 MGD
Operating Range
100%
95%
90%
85%
80%
70%
60%
50%
51%
65%
73%
79%
81%
81%
73%
71%
Head (ft)
Flow (gpm)
250
200
150
100
50
0
25,000
20,000
15,000
10,000
5,000
0



END OF SECTION

PART 1 GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required and install the activated carbon odor control system, including FRP carbon vessel, internal support system, interconnecting ductwork, isolation control damper, control panel, automatic smoke detector(s) (where indicated), centrifugal fan, fiberglass sound enclosure (where indicated), exhaust stack(s) and appurtenances as shown on the Drawings and as specified herein.

B. Electric motors shall be furnished as part of the work of this Section and shall conform to all applicable portions of Division 1.

1.02 RELATED WORK

A. Concrete foundation pads are included in Division 3

B. Fiberglass Ductwork and Accessories is included in Division 23.

C. Instrumentation and control is included in Division 40.

D. Electrical is included in Division 26.

E. Duct-mounted smoke detectors and fan shutdown controls are furnished and installed under Division 26.

F. Miscellaneous Metal is included in Section 05 50 00.

1.03 SUBMITTALS

A. Submit to the Engineer, in accordance with Section 01 33 23, shop drawings and product data. Submittals shall include the following:

1. Complete description of all materials.

2. Certified shop and installation drawings showing all details of construction, dimensions, and anchor bolt locations.

3. Descriptive literature, bulletins and/or catalogs of each item of equipment.

4. Design loads to the foundation for review and approval prior to fabrication

5. The weight of each major component (include weight of vessel when filled with media).

6. A complete bill of materials for all equipment.

7. A list of the manufacturer's recommended spare parts. Include gaskets, seals, etc., on the list.

8. Complete data on the head loss for the airflow through the activated carbon adsorption vessel at design airflow rate.

9. Complete independent third party certified data on the activated carbon and or other engineered adsorbent media showing it to be in conformance with this Section. Include a complete analysis of the capacity of the activated carbon to adsorb hydrogen sulfide. Also, include a complete description of the methods required to remove and replace the carbon.

10. Vessel manufacturer shall provide structural calculations sealed by a licensed P.E. in the State of Tennessee and detailed drawings showing anchor requirements and locations. Calculations will not be reviewed and are for record purposes only.

11. Submit fan data sheets with a description of the proposed fan, fan size, type, arrangement, materials of construction, weight, motor horsepower, motor type, power supply, frame size, sheave sizes, belts size, number and length. Each submittal shall include pertinent equipment dimensional data, and a performance curve showing the fan operating point and range. Minimum curve size shall be 8-in by 6-in. Faxed copies of curves are not acceptable. A list of accessories to be furnished shall be included. Copies of operating and maintenance manuals shall be submitted.

12. Complete description of surface preparation and shop painting of painted surfaces.

13. Complete Control Panel layout, including size, wiring, schematics internal and external equipment and device arrangement, nameplates and parts catalog cuts.

B. All details on shop drawings submitted for approval shall show clearly the relations of the various parts to the main members and lines of the structure and where correct fabrication of the work depends upon field measurement. Such measurements shall be made and noted on the drawings before being submitted for approval.

C. In the event that it is impossible to conform to certain details of this Section, describe completely all non-conforming aspects.

D. A 3-inch square sample of the fiberglass laminate shall be submitted. The sample shall be from plant production and shall be representative of the quality and hardness of the vessel to be furnished. If the vessel does not meet the standard of the sample, it may be rejected. A written certification that resin approved in the shop drawing submittal has been used in the manufacturing process.

E. A copy of equipment warranty.

F. Operation and Maintenance Data

1. Operating and maintenance instructions shall be furnished to the Engineer in accordance with Section 01 78 23. The instructions shall be prepared specifically for this installation and shall include all required cuts, drawings, equipment lists, descriptions, etc., that are required to instruct operating personnel that are unfamiliar with such equipment.

2. A factory representative who has complete knowledge of proper operation and maintenance shall be provided for one day to instruct representatives of the Owner and the Engineer on proper operation and maintenance of the equipment. This work may be done in conjunction with the inspection of installation and test run as provided under PART 3. If there are difficulties in operation of the equipment due to the manufacturer's design or fabrication, additional service shall be provided at no cost to the Owner.

1.04 REFERENCE STANDARDS

A. ASTM International

1. ASTM C582 – Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment

2. ASTM D2996 – Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting Resin) Pipe

3. ASTM D3299 – Standard Specification for Filament-Wound Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks

4. ASTM D 4167 – Standard Specification for Fiber-Reinforced Plastic Fans and Blowers

5. ASTM D3982 – Standard Specification for Contact Molded "Fiberglass (Glass Fiber Reinforced Thermosetting Resin) Duct and Hoods

6. ASTM D6646 - Standard Determination of the Accelerated Hydrogen Sulfide Breakthrough Capacity for Granular and Pelletized Activated Carbon

7. ASTM E679 – Standard Practice for Determination of Odor and Taste Thresholds by a Forced-Choice Ascending Concentration Series Method of Limits

8. ASTM E84 – Standard Test Method for Surface Burning Characteristics of Building Materials

9. ASTM 3982 – Contact Molded “Fiberglass” Ducts

B. American National Standards Institute (ANSI)

C. Occupational Safety and Health Administration (OSHA)

D. National Electrical Manufacturers Association (NEMA)

E. Underwriters Laboratories (UL)

1. UL 217 - UL Standard for Safety Single and Multiple Station Smoke Detectors

2. UL 268 - UL Standard for Safety Smoke Detectors for Fire Protective Signaling Systems

F. National Fire Protection Association (NFPA)

G. American Bearing Manufacturers Association (ABMA)

H. Air Movement and Control Association (AMCA)

I. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

A. All carbon adsorption equipment specified in this Section shall be furnished by a single manufacturer who is fully experienced, reputable and qualified in the design, construction and operation of odor control systems incorporating activated carbon. Provide evidence of successful operation of such units in commercial application for a period of at least 5 years.

B. The manufacturer shall supply a biannual analysis of the activated carbon, the results of which shall be reported as "remaining life of media under design flow rate and H2S concentration". The manufacturer shall furnish this service for 1 year from the date of substantial completion. The manufacturer shall furnish four appropriate containers and adequate instructions for taking samples from different locations of the carbon bed. The Owner shall be responsible for collecting the samples as instructed by the manufacturer, the cost of analysis shall be covered by the Manufacturer.

C. To ensure proper system operation, the equipment manufacturer/supplier shall provide written certification that the odor control system has been coordinated with and designed to operate satisfactorily with the odor control fan and ductwork as shown on the Drawings and as specified herein.

D. Should equipment which differs from this Section or as shown on the Drawings be offered and determined equal to that specified and shown, such equipment shall be acceptable only on the basis that any revisions to the design and/or construction of the structure, piping, appurtenant equipment, etc, required to accommodate such a substitution shall be made at no additional cost to the Owner and be as approved by the Engineer.

1.06 SYSTEM DESCRIPTION

A. The Wet-Weather Pump Station and Diversion Structure Carbon Adsorber Odor Control System (CA-1050)

1. Air shall be drawn from the Diversion Structure through the fan, through the carbon adsorption vessel and discharged through the stack.

2. The design criteria and requirements of the carbon vessel (CA-1050) are as follows:
    1) Maximum Design Capacity: 3,345 cfm with 10 ppm hydrogen sulfide
    2) Average Design Capacity: 3,345 cfm with 2 ppm hydrogen sulfide
    3) Diameter: 8 -ft.
    4) Pressure Differential: 6-in W.C. maximum across carbon bed
    5) Number of beds per vessel 1
    6) Bed Depth: 3 -ft.

B. The carbon shall be suitable for continually removing concentrations of hydrogen sulfide and organic compounds associated with raw wastewater.

C. Channeling of air through the carbon bed shall be minimized such that hydrogen sulfide removal is 99% or a maximum outlet concentration of 0.1 ppm, whichever is less stringent and odor removal is 99% or a maximum outlet concentration of 200 D/T, whichever is less stringent.

1.07 MAINTENANCE

A. Tools and Spare Parts

1. One set of all special tools required for normal operation and maintenance shall be provided. In addition, one set of spare belts, one set of fan shaft bearings and one shaft seal shall be provided.

2. All tools and spare parts shall be packaged and labeled as provided in Section 01 13 10.

1.08 WARRANTY

A. The FRP Vessels shall be warranted for a period of ten years and the fan and control system for a period of one year from the date of substantial completion as defined under the General Conditions to be free from defects in workmanship, design, or material. If the equipment should fail during the warranty period due to a defective part(s), it shall be replaced and the machine and the unit(s) restored to service at no additional cost to the Owner.

PART 2 PRODUCTS

2.01 GENERAL

A. The use of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired. The basis of design is Evoqua RJC-800.

B. Design and proportion all of the equipment specified herein to have adequate strength and stiffness and be suitable for continuous operation. Design the equipment to facilitate inspection, repair and adjustment.

C. Provide suitable attachments on all equipment which may require hoisting for installation and/or maintenance.

D. Attach 16-gauge stainless steel permanent tags at the factory for each vessel with the system supplier's name, model number, serial number, capacity, temperature and pressure design, date of manufacture, and any other pertinent data per this Section.

E. Attach permanent tags at the factory for each valve, instrument and control panel with the equipment number and name.

F. The carbon system shall be furnished by Evoqua Water Technologies; Daniel Company; BioAir, PureAir, ECS Environmental Solutions, or equal.

2.02 MATERIALS AND EQUIPMENT

A. Activated Carbon Unit

1. The carbon system manufacturer shall be responsible for furnishing a complete operational system including the carbon vessel, activated carbon, fan, damper, flexible connectors, controls and accessories as specified in this section.

2. The FRP vessel shall be manufactured in accordance with all provisions of ASTM C582, ASTM 3982 or ASTM D3299 except as specified below.

3. The vessel shall be designed for wind and seismic loads in accordance with ASCE 7-05 Minimum Design Loads for Buildings and Other Structures.

4. Vessel color shall be white.

5. The carbon adsorption vessel shall include inlet and outlet flanged openings, removable top plate, 20” manway, carbon sampling valves (three per bed), drain, differential pressure gauges (one per bed), and sufficient activated carbon to fill the vessel to the bed depth after accounting for initial settling and carbon bed support systems. Location shall be as shown on the Drawings.

6. The adsorption vessel nozzles shall be 150 psi rated flanged nozzles for pipe connections. Press molded or compression molded flanged nozzles will not be accepted.

7. Resins
   a. The resin used shall be resistant to corrosion by water, hydrogen sulfide and other corrosive gases present in wastewater treatment plants. A single, fire retardant resin shall be used throughout. Flame spread index shall not exceed 25 when tested in a Steiner Test Tunnel in accordance with ASTM E84 and smoke developed rating shall not be more than 50 in accordance with NFPA 91.
   b. Antimony or NYACOL additives shall not be used to achieve flame spread index.
   c. Acceptable products
      1) Vipel KO22-AC as manufactured by AOC Corrosion Resins.
      2) Derakane 510-A40 as manufactured by Ashland Chemical Company.

3) CoRezyn 8400 as manufactured by Interplastic Corporation.
4) Or Equal

8. The vessel shall be constructed of factory-fabricated fiberglass reinforced vinyl ester resin as follows:
   a. The shell shall consist of an interior layer, a corrosion barrier, a structural layer and an exterior layer.
   b. No thixotropic agents may be used in the corrosion barrier.
   c. Reinforcing material shall be commercial grade glass fiber containing a coupling agent to produce a suitable bond with the resin used.
   d. Interior layer shall be a minimum of 20 mils thick single layer Nexus surface veiling in a resin rich surface. Resin content shall be approximately 90 percent.
   e. Corrosion barrier shall be a minimum of 100 mils thick of Type E glass strand mat, applied in two layers of equal thickness. Resin content shall be approximately 70 percent.
   f. Structural layer shall be alternating layers of Type E glass, reinforced by interweaving of chopped strand mat and continuous filament winding glass. Resin content shall be approximately 60 percent.
   g. Exterior layer shall be a parafinated gel coat with UV inhibitors. There shall be no pigmentation added to the exterior layer.

9. All surfaces shall be finished so as to obtain complete cure of the resin without air inhibition. The finished laminate shall be as free as commercially practicable from visual defects such as foreign inclusions, dry spots, air bubbles, pinholes and pimples. The vessel shall be post-cured for a minimum of 4 hours at 93 degrees C (200 degrees F) and shall conform to the manufacturer's minimum standard for Barcol hardness.

10. The inner surface shall be free of cracks and crazing with a smooth finish and with an average of not over two pits per square foot, providing the pits are less than 1/8-in diameter and not over 1/32-in deep and are covered by sufficient resin to avoid exposure of inner surface fabric. Some waviness is permissible as long as the surface is smooth and free of pits.

11. The structural layer or body of the laminate shall be of chemically resistant construction suitable for the service, providing the additional strength necessary to meet the tensile and flexural requirements. Where separate layers such as matt, cloth, or woven roving are used, all layers shall be lapped a minimum of 1-in. Laps shall be staggered as much as possible. If woven roving or cloth is used, the layer of chopped-strand glass shall be placed as alternate layers. The exterior surface shall be relatively smooth with no exposed fibers or sharp projections. Handwork is acceptable, but enough resin shall be present to prevent fiber show.

12. Any grinding, repair, or sanding of surfaces shall be confined to no more than 1 percent of the total area and shall be similar to unrepaired surfaces. All exposed edges shall be healed with the same resin as used on the vessel and shall be fully post-cured.

13. There shall be no longitudinal joints in the axial direction of the cylindrical shell. The entire shell thickness shall be built up prior to removal of the shell from the mandrel.

14. The vessel shall have external circumferential reinforcing ribs and bottom knuckle reinforcement as per manufacturer's recommendations for rigidity and strength.

15. The vessel shall be equipped with the accessories as shown on the Drawings and as listed below:
    a. All necessary access doors, and other attachments. Vessel connection flanges shall be compatible with connecting piping and duct work and shall conform to the following:
        1) The gas outlets on the top shall have its flange face perpendicular to the centerline of the vessel. Tolerance on angle of flange face with respect to centerline shall be 1/2 degree.
        2) The area on the back of all flanges around each bolt hole shall be the diameter of a standard washer and shall be flat and parallel to the flange face. This area shall be spot faced, if necessary, to meet this requirement. Flanges shall be manufactured by the hand lay-up method and shall conform to ASTM 3982 standard dimensions for bolting.
        3) Blind flanges and access doors shall be the same thickness and material as the flanges to which they are attached. Tolerance as flatness shall be the same as for flanges.
        4) All access doors and bolted attachments shall be provided with 1/8-in thick Hypalon gaskets and 316 stainless steel nuts, bolts and washers.
    b. One 20-in FRP flanged inlet connection for each media level (CA-1050).
    c. One 18-in FRP outlet exhaust stacks and no loss discharge stack extension (CA-1050).
    d. One 20-in bolted access man-ways; one located on top of the vessel and the other located in the vessel wall opposite the air inlet duct (CA-1050).
    e. Minimum 4 lifting lugs for CA-1050.
    f. Minimum 3 tie-off anchors on top of each vessel.
    g. Three 2-in nozzles and PVC ball valves, located 6-in, 18-in and 30-in from the bottom of each carbon bed for extracting carbon samples. Provide a grain thief with which to extract samples from the middle of the bed.
    h. A 316 SS grounding rod shall be provided for each carbon bed. The manufacturer shall supply sufficient submittal details to demonstrate that the carbon beds are adequately grounded in the form of valid past experience or calculations sufficient to demonstrate adequate grounding

16. The vessel shall be arranged for air to enter the cylindrical portion below the carbon bed(s). The carbon bed(s) shall be supported by a fiberglass grate covered with a polypropylene mesh cloth barrier. The fiberglass grate(s) shall be supported by fiberglass structural beams laminated to the inside wall of the vessel.

17. The adsorption system shall include a pressure differential gauge for each bed to monitor pressure drop across the carbon bed(s). The gauges shall be diaphragm actuated, complete with two static pressure taps and 3-7/8-in diameter white dial with black figures and graduations indicating pressure drop

across the carbon bed. Stainless steel tubing shall be furnished for mounting the gauge; the tubing shall connect to a manifold with control valves that allows moisture to drain from the tubing when the gauges are off line. The differential gauge shall be Dwyer Magnehelic Series 2000 or equal.

B. Activated Carbon

1. The activated carbon shall be virgin high capacity activated carbon and shall be suitable for vapor phase adsorption of odors from raw wastewater.

2. Single use carbon regenerated in place or impregnated with caustic will not be allowed.

3. Sufficient activated carbon shall be provided to fill the carbon bed(s) to a depth of three feet.

4. The activated carbon shall meet or exceed the following specifications:

Moisture, Weight %	8	max
Hardness No.	95	min
Apparent Density, g/ml	1.5	min
Mean Particle Diameter, mm	3.4 – 4.3	
H2S Breakthrough Capacity, g H2S removed/cc Carbon*	0.20	Min

*The determination of H2S breakthrough capacity will be made by passing a moist (85% R.H.) air stream containing 1% H2S at a rate of 1,450 cc/min. through a 1-in diameter by 9-in deep bed of uniformly packed activated carbon and monitored to 50 ppm breakthrough. Results are expressed in grams H2S removed per cc of carbon.

5. The activated carbon media shall be: Midas, Darco H_2S by Norit Inc, or equal

C. Flexible Duct Connectors

1. Furnish flexible connectors at the inlet and outlet of the fan. Expansion and contraction shall permit up to 1-in movement under the specified environmental conditions.

2. Support duct on both sides of flexible connections.

3. Ends shall be flanged to match duct flanges. Only flanged connections are acceptable.

4. Flexible duct connections shall be constructed in multiple layers (two minimum) of vulcanized polyester tire cord fabric reinforcement sandwiched between EPDM inner and outer coats. All hardware shall be Type 316 SS Manufacturers:
   a. General Rubber Corp.
   b. RM-Holz Rubber Co.
   c. Mercer Rubber Co.
   d. Proco Products Inc.
   e. Daniel Company

f. Or equal

D. Fiberglass Reinforced Plastic Dampers

1. Furnish and install where indicated on the Drawings manually operated dampers with handle for manual operation and positive locking quadrant for balancing purposes. Dampers shall be flanged connection and fabricated from materials similar to those specified in Paragraph 2.02 A above.

2. All isolation dampers, as indicated on the Drawings, shall be licensed to bear the AMCA seal and shall be tested for leakage in accordance with AMCA Standard 500. Test results shall be submitted to the Engineer.

3. Locking quadrants shall have a positive method of holding the damper in its selected position such as a bolt through both the quadrant and the lever arm. Systems using springs or other devices that can vibrate loose are not acceptable. Any damper 6-ft above finished grade shall be provided with chain wheel gear operators. Dampers of size 24-inches and above shall be provided with gear operators.

4. Materials:
   a. Bearings: Teflon
   b. Blade: Fire-Retardant vinyl ester resin (Class 1 Flame Spread) FRP, angle reinforced. Blade shall fully encapsulated shaft. Blades that bolt to a single side of the shaft will not be accepted
   c. Frame: Fire-Retardant vinyl ester resin (Class 1 Flame Spread) FRP.
   d. Axles: Solid 316 stainless steel full length of damper
   e. Finish: Interior and exterior finishes same as duct
   f. Handle: Type 316 stainless Steel, or FRP
   g. Pins: Type 316 Stainless Steel
   h. Blade Stops: none, the blade shall close against an elastomer imbedded in the body of the damper.
   i. Bushings: Teflon
   j. Hardware: Type 316 Stainless Steel
   k. Angles: FRP

5. Manufacturer: Provide products of one of the following:
   a. Ershigs Incorporated.
   b. Daniel Mechanical.
   c. Belco Manufacturing Co. Inc.
   d. Or equal.

E. FRP Fan and Motor assembly

1. The fiberglass centrifugal fan shall be sized for a flow of each system as described in the Table below with sufficient pressure drop for the carbon system and all ductwork under fully loaded conditions. The minimum pressure capability shall be 10-in W.C. The fan shall be fabricated in accordance with Fan Schedule and shall be of spark resistant design in accordance with AMCA and NFPA requirements. The fans shall be Viron; Hartzell Fan Inc.; New York Blower Co. or equal.

Wet-Weather Pump Station and Diversion Structure Box OC System	
Airflow (cfm)	3,345
Duct Losses to the Fan (in.wc.)	1.5
Min. Static Pressure (in. wc)	10
Motor Size (HP)	7.5
Motor RPM	1,750
Voltage (V)	460
Phase	3
Hertz (hZ)	60
Classification	TEFC Class 1, Division 2
Fan Type	FRP Centrifugal
Discharge Sound Pressure	94 dBA @ 5 ft
Radiated Sound Pressure	85 dBA @ 5 ft
Sound Enclosure (SE) (Yes/No)	Yes
Estimated Discharge Sound Pressure w/ SE	74 dBA @ 5 ft
Estimated Radiated Sound Pressure w/ SE	65 dBA @ 5 ft

2. The use of a manufacturer's name and model of catalog number is for the purpose of establishing the standard quality, grade, type, size, physical arrangement, performance characteristics and availability.

3. Fans shall be centrifugal type with backward inclined fan wheel, factory assembled, complete with fan wheel, fan housing or cabinet, bearings, drives, drive guard, motor, motor base, unit base and vibration isolators, dampers and bird screens unless otherwise specified. All fans shall be provided with lugs, brackets or field supplied devices to allow the fan to be firmly bolted to the structure or fastened to specified vibration isolators. The lugs, brackets or field-supplied devices shall be sized to withstand the expected seismic loads for the area and type of application. Location of the attachments shall be based on the equipment being hung or base mounted as shown on the Drawings and the schedules.

4. All fans shall be statically and dynamically balanced prior to shipment from factory.

5. Where belt drives are used, motors shall be provided with adjustable slide bases. Adjustable sheaves and slide bases shall be selected so that the midpoint of the adjustable range matches the fan schedule data. Drives selected shall have a safety factor of 1.5 times motor horsepower.

6. The fan motor shall be horizontal, severe duty, squirrel cage induction type, 460 Volt, 3 Phase, 60 Hz with Class F insulation and a minimum 1.15 service factor, suitable for full voltage starting and continuous operation at 40 degrees C ambient temperature at the specified loads. The fan motor shall be TEFC, inverter duty, suitable for operation in a Class 1 Division 2 environment.

7. Motors shall be selected to be non-overloading for the entire fan curve range and for the reasonable expected temperature and humidity. Schedule motor sizes are minimum. If a larger motor is required for the fan proposed, the larger motor shall be provided at no additional cost.

8. Fans shall be assembled with OSHA shaft and motor guards. Provide access for greasing bearings, tachometer readings of fan and motor speed without removing the cover. Covers shall be properly ventilated to prevent motor overheating.

9. All fans shall be tested in accordance with AMCA 300 and shall be licensed to bear the AMCA seal for air performance and sound ratings. The noise level of the equipment operating in the field shall not exceed 87 DBA overall sound pressure level (referenced to 20 micro pascals) at a distance of 5-ft from equipment surfaces. Provide octave band sound data if another noise level is specified in the schedule or if sound data submission is specified in the schedules. Schedules will override this paragraph.

10. When bearings are not accessible, extended supply and relief fittings shall be supplied. Both supply and relief fittings shall terminate in the same location.

11. Provide housing construction that conforms to the standard thicknesses as stated by AMCA and in accordance with ASTM D4167. The housing shall have a flame spread factor of less than 25 as established by ASTM E84 Tunnel Test. Antimony or NYACOL additives shall not be used to achieve flame spread index. Fan housing, flanges and fan wheel shall be constructed of a fiberglass laminate consisting of an appropriate ultraviolet, corrosion resistant and fire-retardant resin and the proper fiberglass or synthetic veil (reinforcement) capable of resisting continuous temperatures and corrosive environment specified. The manufacturer shall state the types of resin used and confirm, with certified laboratory test data, it will perform satisfactorily under the chemical operating conditions as specified herein. Fan housing shall be rotatable to provide multiple discharge positions.
    a. All surfaces exposed to corrosive air stream shall be resin rich and contain not more than 20 percent of the appropriate surface veil, such as "C" grade fiberglass veil for most service conditions and Nexus surface veil with an additional coat of resin when fluorides are present. All surfaces exposed to the atmosphere shall be resin rich of a paraffinated resin stabilized against ultraviolet degradation and include a reinforcement not to exceed more than 20 percent of the "C" grade fiberglass to serve as protection against weathering, fumes, spillage and ultraviolet attack. Immediately beneath the surfacing veil of the interior and exterior surfaces of the laminate shall be a layer of chopped strand mat. The chopped strand mat shall be Type E glass of 1.5 oz/sq ft of weight. The woven roving shall be Type E glass of a nominal 24 oz/sq yd in weight and a 4 by 5 weave. All exterior fiberglass surfaces are to be ground smooth and a layer of "C" glass veil is to be applied, followed by a wax filled gel coat. Fans shall be electrically grounded by coating the interior surfaces of the fan with a carbon rich resin and providing a grounding strap from the fan surface to the steel fan base. Where environments such as water mist and/or abrasive particles exist in the air stream, a Hartkoate or equal coating shall be applied by the fan manufacturer.

12. Round flanged inlets and rectangular flanged outlets shall be furnished on all fans and shall be of 150-lb class fiberglass construction and shall be factory drilled. Flanges shall be ground flat at bolts. All exposed glass fiber surfaces shall be resin coated.

13. All fans shall be furnished with a gasketed access door positioned to avoid collection of condensation. All fans shall be furnished with a 1-in minimum flanged type drain connection and blind flange, positioned at the lowest portion of the fan scroll.

14. Fan wheels, unless otherwise specified, shall have true backwardly curved, single thickness air foil type blades with non-overloading horsepower characteristics and shall not exceed the brake horsepower as shown on the schedule. Fan wheels shall be made from one-piece solid fiberglass reinforced polyester with an aluminum hub, encapsulated within the impeller to provide a reliable connection with the drive shaft.

15. Bearings shall be double row, self-aligning, grease lubricated spherical roller bearing with horizontally split case iron pillow blocks, selected with a minimum 80,000 hours L10, as scheduled, at maximum operating conditions in accordance with standards set forth by ABMA.

16. Fans and motors shall be factory mounted on a structural channel sub base with integral motor slide rail base. An OSHA approved fiberglass motor and drive canopy shall be furnished and installed.

17. All fastening and hardware exposed to a corrosive environment shall be Type 316 stainless steel.

18. Fan shaft and hardware shall be Type 316 stainless steel and oversized to run below critical speed. Provide setscrews, keys, keyways for wheel and drive sheave attachment. Countersink fan shaft for tachometer readings. An aluminum hub encapsulated with fiberglass shall be provided to a point beyond the housing. Wheel and shaft assemblies shall be statically and dynamically balanced per ASTM D4167 to a maximum of 3 mils displacement at maximum fan speed prior to assembly and the fan test run prior to shipment at operating speed and re-balanced. Test report for all balancing will be furnished to the Engineer. Wheels shall be finished to a maximum 1/16-in tolerance for out-of-roundness.

19. The fan base shall be carbon steel with all exposed metal surfaces coated with vinyl or epoxy protective coating. Coating shall be suitable for the specified environment. Provide confirmation of coating suitability. No metal parts shall be exposed to the corrosive air stream.

20. Heat Slinger, Shaft Seal or Motor Heat Shield as required shall be provided for proper continuous fan operation by the fan manufacturer.

21. Brass or stainless steel nameplates giving the name of the manufacturer, model number, the rated capacity, SP, RPM and any other pertinent data shall be permanently attached to the fan.

22. Brass or stainless steel nameplates giving the name of the manufacturer, serial number, model number, horsepower, speed, voltage, amperes and other pertinent data shall be attached permanently to the motor.

F. Equipment Vibration Isolators and Mountings

1. Operating equipment that can transmit objectionable vibration and noise must be installed with special types of vibration isolators such as flexible connectors to ductwork, piping and wiring.

2. All equipment shall be provided with attachment points for floor or suspended mounting that will safely transmit all loads including seismic to the supports.

3. The vibration isolator manufacturer shall be responsible for the proper selection of vibration isolators suitable for the particular application. Selection of the vibration isolator shall include the following factors:
   a. Equipment Weight
   b. Equipment operating frequencies
   c. Type of building support structure
   d. Seismic forces as required by the applicable building codes to include shear, tension and compression due to the code specified loads

4. All floor mounted vibration isolators shall be bolted to the floor or framing on which they rest. Bolts shall be arranged to prevent transmission of vibration through the bolts.

5. All isolation devices for a single piece of equipment shall be selected for a uniform static deflection according to distribution of weight in the equipment.

6. After installation of equipment, isolators shall be adjusted for proper loading and distribution of weight.

7. Fans and their driving motors shall be mounted on structural steel channel members forming a rigid base. A common member, parallel to the V-belt drive, shall run the full length of the fan and motor and shall be of sufficient rigidity to resist the bending stress of belt pull. The structural steel base shall incorporate single or double deflection elastomer-in-shear elements or free-standing springs located for proper weight distribution. The base shall be drilled and tapped to accept the fan and motor and shall serve as a template

G. Fiberglass Reinforced Plastic Sound Enclosure

1. General Requirements
   a. Contractor shall furnish and install Fiberglass Reinforced Plastic Sound Enclosure for Headworks Odor Control Blower.
   b. Sound enclosures shall be as manufactured only by companies with a minimum of 5 years manufacturing experience of noise control equipment for fans, blowers, pumps and or compressors.
   c. Sound enclosure manufacturer shall guarantee a minimum of -20 dB”A" at 5 Feet insertion loss from noise producing equipment to be enclosed.

d. Sound Enclosure shall have as a minimum the following dynamic insertion loss:

OCTAVE BAND CENTER FREQUENCY (Hz)								
Freq - HZ	**0.063**	**0.125**	**0.25**	**0.5**	**1**	**2**	**4**	**8**
Enclosure DIL	-17	-24	-27	-33	-38	-43	-46	-45

e. Sound enclosure manufacturer shall obtain from the blower equipment manufacturer, the sound level ratings based on AMCA test standard 300, the housing radiated noise level and the inlet and discharge noise level ratings.

f. Sound enclosure manufacturer shall coordinate with the equipment manufacturer listed on schedule requirements for cooling, temperature rise and special provisions for Inlet ducting, discharge ducting, appurtenances such as dampers, Flexible duct connections, inlet or discharge silencers, intake filters, vibration isolators, seismic restraints, motors, drives and guards, electrical connections, and electrical safety disconnect switches. The sound enclosure manufacturer shall also make special provisions to allow access to serviceable items such as bearings, lubrication, seals, dampers, belts, motors and access doors.

g. Sound enclosure manufacturer will provide and place a 10" x 14" warning sign, on each access door, indicating equipment is to be shut down and locked out prior to entry.

2. Enclosure Material and Construction

a. The sound enclosure shall be a rigid complete enclosure using Fiberglass Reinforced Plastic and shall be lined with acoustical materials as listed below.

b. Sound adsorbing materials shall be a minimum of 1" thick, .5 Lbs/Sq.Ft. loaded vinyl barrier acoustic insulating foam, with a vinyl facing. Acoustic Insulation shall have a NRC rating of .48 and an STC rating of 39.

c. Acoustic lining shall be capable of being steam cleaned and shall be chemical resistant.

d. Exterior fiberglass structure shall have a Class I E 84 flame spread rating of 25 or less.

e. Sound Enclosure shall be provided with one (1) double Fiberglass Door with center support. Doors has to allow access and visual inspection of the fan bearings and motor belts. Doors shall be provided with stainless steel hinges and stainless steel door pull latches.

f. The doors shall be oriented to provide access to bearings and grease fittings.

g. The sound enclosure shall be vertically split in such a manner to allow one half of the enclosure of the enclosure to be removed without disturbing the intake or discharge duct connections. The 2 sections of the enclosure shall be flanged and joined by use of stainless steel hardware.

h. The sound enclosure shall be provided with factory pre-cut penetrations to facilitate intake and discharge ductwork or pipe. The precut penetrations shall be 2 Inches overall larger than the duct or pipe diameter. Additional Fiberglass Blanking Plates shall be provided with insulation to close off the

annular space between the enclosure opening and ductwork. Install Neoprene Adhesive Backed Gasketing between edge of blanking plates and duct pipe at enclosure wall to seal any gaps exposed.

i. Each sound enclosure shall be provided with one (1), spun aluminum AMCA Type B, roof mounted exhaust fan furnished with roof curb. The exhaust fan shall be selected to provide no less than 30 air changes per hour or 1 air change every 2 minutes. The exhaust fan shall have a single phase, 60 hZ, 115V, Explosion Proof Motor and be factory pre-wired to an external junction box. All electrical connections shall be UL rated for Class I, Division I, Group D.

j. Sound enclosure shall be fitted with an acoustical intake louver, located at low point of side wall of enclosure, near the Blower Motor. Louver shall be provided with insect screen and be sized for a minimum transmission noise loss and pressure drop.

k. Sound enclosure manufacturer shall provide certified drawings, sound test data showing transmission loss, Installation, operation and maintenance instructions and a minimum 2-year warranty.

l. Sound Enclosures shall be as manufactured by FanAir Company, Orange, California or equal.

H. Control Panels

1. One control panel shall be provided for the Wet-Weather Pump Station and Diversion Structure Carbon Adsorber Odor Control System.

2. The Control Panel shall be provided with a single 480V, 60 Hz, 3-phase, 3 wire, power feed. All electrical power for the equipment specified in this section shall be distributed from the control panel. The panel shall have a short circuit rating of not less than 65 kA. The Control Panel shall have a NEMA 4X 316SS enclosure with sun shield and air conditioning containing combination motor starter, local-off-remote (LOR) selector switch, start and stop push buttons, red run indicator lamp fault contact, green ready/running lamp contact, a contact for remote starting from the PLC, alarm horn and beacon, control transformer, fan VFD, a 120 volt, 30 milliamp GFCI, 20 amp circuit breaker for heat tracing power for duct and fan drains, a 120 volt, manual on/off starter with thermal overload, lockable in the off position for the sound enclosure exhaust fan, externally operable main disconnect switch interlocked with main circuit breaker, delay fuse and panel anti-condensation heater element. All other requirements for the control panels are listed in Section 2.02, Control Systems, in specification 26 19 00.

3. See Specification 40 96 45 for Control Descriptions.

4. The Control Panels shall conform to the requirements of Division 26 and Instrumentation Sheets I-4 and I-5.

5. The Control Panels shall be UL Listed.

I. Smoke Detectors

1. A smoke detector will be supplied for the Wet-Weather Pump Station and Diversion Structure Adsorber Odor Control System.

2. Photo-electronic type smoke detection device shall operate on the forward light scattering principle using a pulsed infrared light emitting diode light source and a photo diode sensor. The detectors shall be of the locking type and have an alarm verification circuit requiring several successive signals exceeding the alarm threshold value prior to transmitting an alarm. A visible LED indicator shall blink to indicate power on and normal operation. On alarm the indicator shall turn on and remain on until the detector is reset. Photo-electronic smoke detection device shall be four wire type.
   a. Explosion-proof smoke detection device shall be typical 1.5 percent fixed-sensitivity. The unit's detection chamber shall extend beyond the main housing into the protected area to provide maximum protection from any direction and shall be surface mounted. The detector light source shall have SPST alarm contacts for connection to the fire alarm system and shall be an explosion proof design to meet Class 1, Division 1, Groups C and D hazardous area.

3. Ionization type smoke detection device shall be of the dual-chamber, locking type. The dual-chamber shall be highly sensitive to products of combustion and shall allow for compensation for pressure and humidity changes. The detectors shall be equipped with a solid-state regulator to maintain detection sensitivity over a wide range of input voltages. A visual indication of an alarm shall be given by a LED on the detector grille. Ionization smoke detection device shall be four-wire type.

J. Emergency Alarm Beacon and Audible Horn

1. Beacon alarm light:
   a. Type:
      1) Beacon alarm light.
   b. Physical:
      1) Beacon alarm light for installation on exterior of control panel shall be 120 VAC, flush mounted, weatherproof construction.
      2) A 750,000 – candle power xenon strobe tube and red polycarbonate lens.
   c. Manufacturer(s):
      1) Federal Signal Corp.
      2) Edwards Co.
      3) Wheelock.
      4) Or equal.

2. Alarm Horn:
   a. Type:
      1) Federal Signal Corp.
      2) Edwards Co.
      3) Benjamin.
      4) Or Equal.

K. All portions of the equipment which require paint for protection of metal surfaces shall be factory finish painted with a corrosion resistant paint.

PART 3 EXECUTION

3.01 SHIPPING

A. Secure, crate and protect all equipment against damage during shipment and delivery. All pipe ends and tapped holes shall be capped or plugged before equipment leaves factory for shipment. All shipping containers or crates shall be clearly marked on the outside as to order number, contents, equipment number and name.

3.02 INSTALLATION

A. Installation shall be in strict accordance with the manufacturer's instructions and recommendations in the location as shown on the Drawings.

3.03 START-UP AND TESTING

A. After installation of the carbon vessel is complete, but prior to installation of the carbon bed, the vessel shall be shall be operated and checked to assure that there is no air leakage from the vessel. The manufacturer's representative shall correct any defective workmanship and perform the test again to assure the system is tight and free from leaks.

B. Furnish the services of a manufacturer's representative, as required under Section 01 75 16, who has complete knowledge of proper installation, operation, and maintenance of the equipment to inspect the final installation, supervise test runs of the equipment and instruct representatives of the OWNER in the proper operation and maintenance.

C. Installation of the carbon bed support system and activated carbon shall be done under the direction of the manufacturer's representative in order to assure proper placement of the activated carbon. The manufacturer's representative shall instruct personnel in the proper safety precautions concerning handling of activated carbon.

D. The manufacturer's representative witnessing the field tests shall furnish the Owner, through the Contractor, a written report certifying that the odor control system:

1. Has not been damaged by transportation or installation.

2. Has been properly installed and accurately aligned.

3. Have no mechanical defects.

4. Is free from any undue stress imposed by connecting piping and/or anchor bolts.

5. Is free of overheating of any parts.

6. Is free of objectionable vibration and noise.

7. The Contractor has accurately recorded the data obtained during the field test.

E. The Contractor shall retain a testing and balancing company to balance and confirm the airflow to each odor control system prior to final mechanical and performance testing.

F. The system shall be tested for its ability to remove H2S in accordance with Paragraph 1.06 D. Furnish two Odalog H2S analyzers and Sycamore Box pumping system complete with all accessories required to take inlet and outlet samples over a four-hour period. Two duplicate odor samples shall be taken during the H2S sampling for analysis by St. Croix Sensory, Stillwater, MN, 1-800-879-9231. All testing shall be supervised by a factory representative and shall be in the presence of representatives of the Owner and the Engineer. The inlet air shall not be spiked with H2S. The system shall be considered acceptable if it meets 99% H2S removal or a maximum outlet concentration of 0.1 ppmv H2S, whichever is less stringent and an odor emission limit of 200 D/T.

G. If any item of equipment does not meet the specified requirements, corrective measures shall be taken and the unit shall be removed and replaced with one that satisfies the conditions specified.

H. Upon successful completion of testing, a manufacturer's representative shall provide two 2-hour days of operations and maintenance instruction to plant staff. The number of required days listed above is exclusive of travel time and does not relieve the Contractor of sufficient service to place equipment in satisfactory operation.

3.04 WARRANTY

A. Upon successful demonstration of operation and head loss with clean media, the OWNER will issue a Certificate of Acceptance to the system supplier. The warranty period shall commence on that date. The system supplier shall promptly repair and/or replace a defective FRP vessel at no additional cost to the Owner for a period of ten years from the date on Certificate of Acceptance.

(*Equipment Data Sheets follow*)

Equipment Data Sheet	
Diversion Structure and Pump Station Odor Control	
Activated Carbon Adsorber Designation	CA-1050
Drawing Numbers	
Specification Section	44 31 16
Location	Pump Station
Operation	Duty
Equipment Package	Activated Carbon Adsorber with a Fan and Electrical Controls
Service	Duty
Total Capacity (CFM)	3,345
Number of Adsorbers (#)	1
Flow per Vessel (CFM)	3,345
Vessel Dimensions, Dia. (ft) X SSH (ft)	9 X 8.5
Vessel Material	FR Vinyl Ester
Stages	1
Operating Temperature (°F)	20 - 120
Max. Operational Pressure Drop, Fan to Stack (in.wc.)	6
Inlet H2S, peak/avg. (ppm)	10/1
Performance, %/ maxppm)	99.0/0.1
Inlet TRS, peak/avg. (ppm)	2/1
Performance, %/max ppm	99/0.1
Fans	
Specification Section	44 31 16
Number	1 Duty
HP	7.5
Voltage/Phase/Hz	460/6/60
RPM	1,750
VFD (Yes/No)	YES, located in local control panel
Motor Rating	TEFC, Class 1 Div 2
Drive Type	Belt

END OF SECTION