City of Hailey, ID

Woodside WRF - Headworks Improvements

Construction Documents
Project Manual

Volume 2
Divisions 07 - 46

Issued for Review

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HDR Project No. 10381996

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DIVISION 07

THERMAL AND MOISTURE PROTECTION

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CRYSTALLINE CEMENTITIOUS WATERPROOFING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Surface-applied crystalline cementitious waterproofing.

B. Related Requirements: Include but are not necessarily limited to:

1. Section 03 31 30 - Concrete Materials and Proportioning.

1.2 REFERENCES

A. Terminology: The following terms are not defined terms and are not indicated with initial capital letters, but, when used in this Section, have the meanings indicated below, applicable to the singular and plural thereof.

1. “Dry side” means the surface exposed to subgrade, granular base material, or other dry material.
2. “Wet side” means the surface subject to immersion in liquid or slurry, exposed to precipitation, or exposed to soil or other fill material that is constantly or frequently moist or wet due to groundwater or other water condition.

B. Reference Standards

1. American Concrete Institute (ACI):
   a. 117 - Standard Tolerance for Concrete Construction and Materials.
2. ASTM International (ASTM):
   a. C1202 - Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.

1.3 QUALITY ASSURANCE

A. Qualifications

1. Installer (Applicator):
   a. Shall be experienced in performing work of the type required by this Section, for structures similar in type, construction, service environment, and moisture exposure to the Work required by this Section.
   b. Installer/applicator shall be expressly approved, within the past 12 months, by manufacturer of product(s) proposed for installing or applying such product(s).
   c. Submit documentation of compliance with qualifications requirements.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:

1. Product Data:
   a. Printed product literature including manufacturer’s catalog information, specifications, service applications, and other relevant information on each product proposed for use.
   b. Manufacturer’s express, written representation of the reference standards with which the product complies. Expressly so indicate if the proposed product does not comply with one or more specific reference standards indicated int this Section.

B. Informational Submittals: Submit the following:

1. Certifications:

a. Prior to application of waterproofing, manufacturer's authorized representative shall observe concrete surfaces to be waterproofed and certify, in writing, that surface defects have been repaired properly and surface is acceptable for application of material. Submit such certification to Engineer.

2. Supplier's Instructions:
   a. Manufacturer's instructions for handling, storing, mixing with concrete or other materials, and installing/applying materials.
3. Qualifications Statements:
   a. Installer/Applicator:
      1) Documentation of compliance with qualifications requirements of the Contract Documents, relative to experience and past projects.
      2) Written approval of installer/applicator by manufacturer.
   b. Resumes of personnel assigned to this Project relative to the type of Work required by this Section.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Products and Manufacturers: Subject to compliance with the Contract Documents, provide necessary quantity of one of the following:

1. Master Builders Solutions: MasterSeal 500.
2. Euclid Chemical Company: Vandex.
3. PENETRON.
4. Xypex Chemical Corporation.
5. Or equal.

B. Materials:

1. Crystalline Cementitious Waterproofing:
   a. Factory blended dry powder compound consisting of Portland cement, treated aggregate, and active chemicals.
2. Water: Potable, in accordance with Laws and Regulations.

C. Admixtures:

1. Requirements (if any) for admixtures that may be used to provide crystalline cementitious waterproofing are in Section 03 31 30 - Concrete Materials and Proportioning.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Preparation:

1. Concrete surfaces shall be clean; free from scale, form oil, laitance, curing compounds and other foreign matter.
2. Repair of Surface Defects:
   a. Form tie holes, honeycombs, defective joints, cracks, and other non-compliant surface defects., shall be remedied in accordance with manufacturer's written instructions and other relevant requirements of the Contract Documents, including the Specifications of Division 03 - Concrete.
   b. Verify that non-acrylic latex based liquid bonding agent mixture was used for patching mortar for repairing concrete defects in area to be coated with crystalline cementitious waterproofing.
3. Pre-Installation Cleaning:

a. Abrasive blast or high pressure water blast concrete, as required by manufacturer, to provide clean absorbent surface.
    1) Minimum surface profile: ICRI 310.2R, CSP-2.
b. Horizontal surfaces shall not be troweled or power floated and shall have broom finish.

4. Cure and prepare all surfaces in accordance with manufacturer's written instructions.

3.2 APPLICATION

A. Application Requirements – General:

1. Install items in accordance with the Contract Documents, manufacturer's written instructions, and Laws and Regulations. Where such requirements conflict, obtain interpretation or clarification from Engineer prior to commencing the associated Work.
2. Mix materials to be installed in proportions, and using procedures and equipment, in accordance with product manufacturer's written instructions.
3. Apply and cure crystalline waterproofing in accordance with manufacturer's written instructions.
4. Do not apply materials in temperature less than 50 degrees F.
5. Fill and seal all coves, joints, and sealing strips in accordance with manufacturer's written instructions.
6. Provide two coats of material to face of concrete slabs where shown or indicated on the Drawings.

B. Provide crystalline cementitious waterproofing at the locations shown and indicated on the Drawings.

C. Protection of Installed Work:

1. Do not place fill or backfill against surfaces to which crystalline waterproofing was applied for not less than 36 hours after waterproofing application, unless approved in writing by manufacturer's authorized representative and Engineer.

3.3 FIELD QUALITY CONTROL

A. Supplier's Services:

1. Retain services of crystalline waterproofing manufacturer's technical representative to perform the following services at the Site:
    a. Instruct Contractor's personnel in storing, handling, mixing, and applying materials.
    b. Inspecting surfaces to receive crystalline waterproofing prior to application of materials, and directing contractor on necessary repairs.
    c. Post-installation inspection of installed crystalline waterproofing and directing Contractor regarding remedial actions needed, if any.

END OF SECTION

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SECTION 07 21 00
BUILDING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Building insulation.
    a. Does not include roof insulation or roof vapor retarder; see Specification Section 07 54 25 - Fully Adhered TPO Roofing.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 04 05 23 - Masonry Accessories.
2. Section 04 22 00 - Concrete Masonry.
3. Section 07 54 25 - Fully Adhered TPO Roofing.
4. Section 09 29 00 - Gypsum Board.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. ASTM International (ASTM):
    a. C272/C272M, Standard Test Method for Water Absorption of Core Materials for Structural Sandwich Constructions
    b. C423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
    c. C518, Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
    d. C578, Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
    e. C665, Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing.
    f. C1289, Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board.
    g. D1621, Standard Test Method for Compressive Properties of Rigid Cellular Plastics.
    h. E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.
2. Underwriters Laboratories, Inc. (UL):
    a. Building Materials Directory.

B. Mock-Ups:

1. Provide insulation for mock-ups required in Specification Section 04 22 00.

1.3 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
    a. Acknowledgement that products submitted meet requirements of standards referenced.
    b. Manufacturer's installation instructions.
    c. Manufacturer's recommendations on sealants, tapes and mastics.

B. Samples:

C. Contract Closeout Information:

1. Operation and Maintenance Data:

a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

D. Informational Submittals:

1. Certification from insulation manufacturer stating that insulation proposed is acceptable for intended use per the Drawings.

1.4 SITE CONDITIONS

A. For purposes of this Specification Section, design frost line for this Project is 24 inches below grade per Hailey, ID Code of Ordinances.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Rigid extruded polystyrene (XPS) board insulation:
   a. Dow.
   b. DiversiFoam Products.
   c. Owens Corning.
2. Rigid polyisocyanurate foam board insulation:
   a. Dow.
   b. Dyplast Products.
   c. Hunter Panels.
   d. Other manufacturers meeting the requirements of this Specification Section.
3. Blanket or batt thermal insulation:
   a. Owens Corning.
   b. USG Corporation.
   c. CertainTeed.
4. Vapor retarder:
   a. Raven Industries, Inc.
   b. Reef Industries, Inc.
   c. Fortifiber Building Systems Group, Inc by Henry Company.
   d. Alumiseal.
5. Polystyrene masonry block core inserts:
6. CBIS/KorfilFoamed plastic insulation:
   a. Polymaster.
   b. Icynene, Inc.

2.2 MATERIALS

A. General:

1. Foam plastic insulation used in buildings and structures shall comply with the requirements of the building code.
   a. Surface burning characteristics: ASTM E84.
   b. Flame spread index: Maximum 75.
   c. Smoke developed: Maximum 450.

B. Rigid Polystyrene Board Insulation:

1. Extruded: ASTM C578, Type IV.
   a. Water vapor transmission: ASTM E96/E96M, 1.1 perm-IN maximum.

b. Water absorption: ASTM C272/C272M, 0.3% maximum.
c. Thermal resistance: ASTM C518 at 75 degrees F mean temperature, 5.0/IN.

2. Provide insulation designed for intended use.
   a. Perimeter insulation and protection board.
      1) Similar to Dow "Styrofoam PERIMATE."
      2) Compressive strength: ASTM D1621, 30 psi.
      3) Thickness:
         a) Perimeter insulation: 2 inches.
         b) Protection board: 1 inch.
      4) Edges:
         a) Long edge: Shiplap.
         b) Short edge: Square.
   b. Cavity insulation:
      1) Similar to Dow "CAVITYMATE."
      2) Compressive strength: ASTM D1621, 15 psi.
      3) Thickness: 2 inches.
      4) Edges: Square.
3. Hi-R-H Block Insulation:
   a. Concrete Block Insulation Systems, Inc. expanded polystyrene insulation. Insulation made from flame-retardant threated expandable polystyrene, similar to “KORFIL Inserts” or Icon Universal Inserts which are pre-installed in CMU’s prior to delivery to jobsite.
   b. Physical Properties of EPS:
      1) Compressive strength: ASTM C578, 1.05-1.50 pcf.
      2) Thermal Resistance (R) per inch: 5.00.
         a) Minimum R value = 13.3.
      3) Water Vapor Permeance: 1.10.
      4) Water Absorption% volume: < 1.0.
      5) Flame Spread Rating: < 5.00.
   c. Additonal Properties of EPS Inserts:
      1) Rot and Vermin resistance: Produced from expanded polystyrene – Full resistant to rot; does not attract vermin, termites, or rodents.
      2) Components: Insulation shall Contain no fluorocarbons and no formaldehyde.
      3) Shape: Two-Piece, interlocking insert shall overlap at both head and bed joints with edges of adjacent inters of the same type. Keyway shall be provided for butt welded cross-rods of 16” on center ladder-type horizontal wall reinforcement.

C. Rigid Polyisocyanurate Foam Board Insulation:
   1. ASTM C1289, Type 1 Class 1.
   2. Compressive Strength: ASTM D1621, Minimum 20 psi.
   3. CFC and HCFC free.
   4. Ozone depletion potential: 0.
   5. Foil facers or foil/kraft/foil facer on front and back side.
      a. Facers shall be treated to eliminate corrosive action of aluminum foil contacting masonry, mortar and concrete.
   6. Fire resistance: ASTM E84.
      a. Flame spread: Less than 25.
      b. Smoke developed: Less than 450.

7. Provide insulation designed for intended use.

D. Polystyrene Masonry Block Core Inserts, ASTM C578:

1. Individually molded inserts designed to fit against both inside faces of concrete block cores.
2. Designed to be used with vertical reinforcing and grout filled cores without affecting the structural strength of the wall.
3. Installed in the factory or at the project site.
4. Density: 1.0 pcf.
5. Thermal Conductivity (K-Factor): 0.26 (BTU/HR)/(SQFT)(DEGF)/(IN).
6. Water vapor transmission: ASTM E96/E96M, maximum 5.0 perm IN.
7. Absorption: Maximum 4.0%.

E. Sealant and Mastic (for setting polystyrene and/or polyisocyanurate insulation board): Manufacturer's recommended standard.

F. Blanket or Batt Thermal Insulation:

1. Glass or other inorganic fibers and resinous binders formed into flexible blankets or semi-rigid sheets.
2. Unfaced:
   a. ASTM C665, Type 1.
3. Kraft faced:
   a. ASTM C665, Type 1, Class C.
4. Minimum thickness as noted on Drawings.

G. Vapor Retarder:

1. Fire rated, reinforced, 3 ply, Class 1 material.
2. Perm rating: Not exceeding 0.035 grains/HR-FT^2-IN-Hg when determined in accordance with ASTM E96/E96M.
3. Griffolyn "TX-1200FR."

H. Vapor Retarder Tape: As recommended by vapor retarder manufacturer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. General:

1. Insulate full thickness over surfaces to be insulated.
2. Fit tightly around obstructions, fill voids.
3. Cover all penetrations (electrical junction boxes, switch boxes, piping, conduits, etc.) with insulation, taking care not to compromise the workings of the device.
4. Fit butted joints of batt or blanket insulations tightly together.
5. Apply single or double layer to achieve total thickness.
   a. If double layer is provided, stagger all joints minimum 12 inches.
6. Do not use broken or torn pieces of insulation.
7. Install so that completed installation is vapor tight.
   a. Seal all joints.
   b. Seal to abutting materials to maintain vapor retarder integrity.
   c. Provide manufacturer’s recommended vapor retarder tape for use with faced batt insulation or separate vapor retarder.

1) If vapor retarder tape fails to adhere to any surface, apply sprayed-on adhesive as recommended by tape manufacturer to promote adhesion.

d. Provide manufacturer's recommended solvent-free sealant compatible with insulation board for rigid board insulation.

1) Tape is not acceptable for use with rigid board insulation.

C. Blanket or Batt Insulation using Separate Vapor Retarder Sheet in Exterior Stud Wall Systems:

1. Verify that all piping, conduit, electrical box and other in-wall work is complete prior to installing insulation and vapor retarder.
2. Install insulation friction fit between studs.
3. Tightly butt ends.
4. Install vapor retarder to warm side of building exterior wall.
   a. Completely seal each wall area to surrounding construction.
5. Install vapor retarder vertically.
   a. Use widest practical sheet.
   b. Install in continuous sheets, floor to structure above, without horizontal joints.
   c. Fold flaps of vapor retarder over studs.
   d. Tape flaps together continuously.
   e. Tape bottom and top edges to structure continuously.
   f. After installation of any additional conduit, boxes, piping or other items within wall system, repair all tears or penetrations of vapor retarder with vapor retarder tape prior to installation of gypsum board.

D. Rigid Board Insulation in Cavity Walls:

1. Do not proceed with installation until subsequent work which conceals insulation is ready to be performed.
2. Set each piece of insulation flush with the abutting piece to eliminate ledges in the face of the insulation.
3. Install mastic on face of concrete or masonry back-up in accordance with mastic and insulation manufacturer's recommendation.
4. Press courses of insulation between wall ties (horizontal reinforcing) with edges butted tightly both ways.
5. Set units firmly into mastic.
6. Seal all horizontal and vertical joints with sealant recommended by insulation manufacturer.
7. Do not use damaged insulation.

E. Rigid Insulation at Perimeter Below Grade:

1. Install insulation below grade on outside face of foundation walls.
   a. Install in mastic with tight joints.
2. Where footings are located below the design frost line, extend insulation down to the design frost line.
   a. Where indicated on the Drawings, extend beyond the design frost line.
3. Where footings are located at the design frost line, extend insulation down to top of footing or as indicated on Drawings.
4. Protect insulation from damage and/or displacement during backfilling and/or pouring of floor slab.

F. Polystyrene Masonry Block Core Inserts:

1. Install inserts in all exterior wall concrete masonry block cores (except bond beams, cores noted to be grouted solid and cores having vertical reinforcing) unless noted otherwise on Drawings.

2. Install inserts in all interior wall concrete masonry block cores where specifically noted on the Drawings.
3. Inspect all inserts as units are installed.
    a. Do not install damaged inserts.
4. Install all inserts in accordance with manufacturer's recommendations.
5. Ensure that all inserts fit tightly to face of block core.

3.2 FIELD QUALITY CONTROL

A. Repair or replace damaged insulation and/or vapor retarder as directed by Engineer.

B. Provide minimum cover of 5/8 inches Type X gypsum board over foam insulation exposed to the building interior.

1. See Specification Section 09 29 00.

END OF SECTION

SECTION 07 26 00
UNDER SLAB VAPOR RETARDER

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Under slab vapor retarder.

B. Related Specification Sections include but are not necessarily limited to:

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Concrete Institute (ACI):
   a. 302.2R, Guide for Concrete Slabs that Receive Moisture-Sensitive Flooring Materials.
2. ASTM International (ASTM):
   a. E1643, Standard Practice for Selection, Design, Installation, and Inspection of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs.
   b. E1745, Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill Under Concrete Slabs.

1.3 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Product data sheet on vapor retarder sheet and vapor retarder tape.
   c. All accessories proposed for use.
   d. Manufacturer's installation instructions.

B. Samples:

1. Provide two, 6 inches x 6 inches samples of vapor retarder material taped together using the vapor retarder tape proposed.
2. Provide two samples of all accessories proposed for use.

C. Informational Submittals: Manufacturer's recommendation on vapor retarder tape.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Vapor retarder:
   a. Fortifiber Building Systems Group, Inc. by Henry Company.
   b. Layfield Group, Ltd.
   c. ISI Building Products.
   d. Raven Industries, Inc.
   e. Reef Industries, Inc.
   f. Stego Industries, LLC.
   g. W.R. Meadows, Inc.

2.2 PERFORMANCE REQUIREMENTS

A. Vapor Retarder:

1. ASTM E1745, Class A.
2. Thickness: Minimum 15 mil.
3. Water vapor permeance: 0.02 maximum.

2.3 ACCESSORIES

A. Pipe Boots: Manufacturer's standard boot fabricated to maintain the integrity of the vapor retarder system.

B. Vapor Retarder Tape: As recommended by vapor retarder manufacturers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Base material over which vapor retarder is to be installed shall be level, compacted and free of debris, foreign objects or other deleterious materials.

B. Surfaces at perimeter and penetrations of vapor barrier shall be clean, smooth and free of sharp objects, fins or projections.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions, ASTM E1643 and ACI 302.2R.

B. Provide vapor retarder where indicated on the Drawings.

1. Place continuous vapor retarder above granular fill subgrade material, unless noted otherwise.

C. Lap minimum 6 inches and seal in accordance with ASTM E1643 and manufacturer's recommendations.

D. Extend to extremities of area and seal to adjacent elements.

E. Seal all penetrations: Provide pipe boot for all pipes or conduit penetrating the floor slab.

3.3 FIELD QUALITY CONTROL

A. Ensure proper precautions are implemented to prevent damage to installed vapor retarder membrane prior to and during pouring of concrete floor slab.

B. Inspect vapor retarder immediately prior to placement of concrete.

1. Patch all punctures, tears, holes, etc.
    a. Patch small punctures with vapor retarder tape as allowed by ASTM E1643 and manufacturer's recommendations.
    b. Repair larger damage with additional layer of vapor retarder.
        1) Lap repairs minimum 6 inches beyond extent of damage in all directions.
        2) Seal perimeter of patch with vapor retarder tape or as recommended by manufacturer.

END OF SECTION

SECTION 07 54 25
FULLY ADHERED TPO ROOFING

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Fully Adhered TPO Roofing in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 QUALITY ASSURANCE

A. Manufacturer authorized roofing installer.

B. Component products made by single manufacturer or approved for use with warranted system.

C. ASTM International (ASTM):

1. ASTM C1289, Standard Specification for Faced Rigid Cellular Polyisocyanurate Thermal Insulation Board.
2. ASTM C1303 Standard Test Method for Predicting Long-Term Thermal Resistance of Closed-Cell Foam Insulation
3. ASTM D6878 .

D. American National Standards Institute (ANSI) / Single Ply Roofing Industry (SPRI):

1. ANSI/SPRI ES-1 Wind Design Standard for Edge Systems Used with Low Slope Roofing Systems

E. National Roofing Contractors Association (NRCA):

1. Roofing and Waterproofing Manual.

F. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):

1. Architectural Sheet Metal Manual.

G. Underwriters Laboratories (UL):

1. UL 790, Standard for Tests for Fire Resistance of Roof Covering Materials.

H. Concrete Moisture Vapor Testing:

1. Coordinate maximum moisture allowed in concrete deck with roofing manufacturer.
2. Test concrete decks for moisture.
3. If moisture content exceeds manufacturer’s recommendation, install moisture control system.

I. Fire Resistance Rating:

1. UL 790, Class A.
2. Assembly in conformance with fireproofing as specified.

1.3 SUBMITTALS

A. Shop Drawings:

1. Roof layout showing insulation thicknesses and details.
2. Indicate location of expansion joints, crickets, saddles, curbs, walkways, safety tiebacks, vents, drains and other penetrations.
3. Indicate slope direction, slope amount, and key vertical elevation points.
4. Profiles of flashing assemblies.
5. Installation Drawings.

B. Product Data:

1. Manufacturer standard literature for vapor barrier, insulation, and roofing system components, including adhesives and accessories indicating compliance with specification requirements.
2. Manufacturer standard literature for roof coping system indicating components and accessories including anchor plate configuration.

C. Samples:

1. Roofing manufacturer's facsimile of each sheet metal color for pre-selection.
2. 3 inches x 5 inches 75 mm x 125 mm samples of roofing manufacturer's sheet metal color for final approval.

D. Project Information:

1. Minutes from Preinstallation Conference.

E. Contract Closeout Information:

1. Warranty.
2. Maintenance Data:
   a. See Section 01 78 23.

1.4 WARRANTY

A. Fifteen (15) year warranty of weathertightness signed by roofing materials manufacturer.

1. Warranty to include coverage for peak gusts of wind to:
   a. 55 mph at 33 feet above ground.
2. Warranty to include the entire system: membrane, flashings, adhesives, sealants, counterflashings, insulation, fasteners, fastener plates, fastener strips, hard rubber or metal edging, metal termination bars, sheet metal copings and edge metal, and other material authorized by manufacturer.

B. Twenty (20) year warranty on 70 percent PVDF (Kynar 500) coatings on edge metal and copings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Fully Adhered TPO Roofing:

1. Base:
   a. Carlisle SynTec
2. Optional:
   a. Firestone Building Products, Holcim Elevate
   b. GAF
   c. Johns Manville

B. Vapor Barrier:

1. Base:
   a. Same as Membrane Manufacturer.

C. Sheet Metal Coping and Edge Metal:

1. Base:
   a. Provided by manufacturer of roofing system.

D. Other Materials:

1. Manufacturers as noted.

E. Other manufacturers desiring approval comply with Section 01 62 00.

2.2 DESIGN CRITERIA

A. Determine per Wind Load Design Guide for Low Sloped Flexible Membrane Roofing Systems published by SPRI.

B. Design roof system and anchorage fastener type and spacing needed to resist uplift pressures including roof covering and metal edge securement to meet design loads and satisfy requirements of applicable building codes, local amendments, and ANSI/SPRI ES-1.

C. Wind loads: Use the greater of the following:

1. Wind pressures as required per local building code based on wind speed, exposure factor and importance factor noted in Structural Drawings.

D. Requirements applicable to designated warranty.

E. Roof height and parapet height: As indicated.

F. Static pressure of building interior: Approximately negative 0.1 inches water column.

2.3 MATERIALS

A. Vapor Barrier:

1. Rubberized asphalt membrane adhered to polyethylene or polyolefin top sheet.
2. 30 mil thick, minimum.
3. Vapor Permeance: Not exceeding 0.05 Perm.
4. UV protected for 90 day exposure.
5. Primer or adhesive as recommended for substrate by manufacturer.
6. Base Product: Carlisle 725TR.

B. Roof Insulation:

1. Furnished by roofing manufacturer.
2. UL listed for assembly indicated.
3. Provide crickets and saddles as required.
4. Polyisocyanurate (PISO) roof insulation:
    a. Rigid, closed cell foam core bonded to heavy-duty glass fiber mat facers.
    b. ASTM C1289 Type II, Class 1.
    c. R-value: 5.6 per inch in accordance with ASTM C1303, CAN/ULC S770.
5. Foam plastic insulation used in buildings and structures shall comply with the requirements of the building code.
    a. Surface burning characteristics: ASTM E84.
    b. Flame spread index: Maximum 25.
    c. Smoke developed: Maximum 450.
    d. Compressive Strength: 20 psi minimum per ASTM D1621, Grade 2.
    e. Dimensional stability: 2 percent maximum linear change in seven days per ASTM D2126.
    f. Minimum insulation thickness:
        1) Areas where tapered insulation is indicated:
            a) Minimum R-30 at roof drains.
            b) Taper to provide slope of 1/4 inches per FT 1 mm per 48 mm.
        2) Areas with uniform insulation thickness (sloped structures):
            a) Minimum R-30 at roof drains.
    g. Base Product: HP-H Polyisocyanurate by Carlisle SynTec.

C. Cover Board:

1. Moisture resistant gypsum core with fiberglass mat and non-asphaltic surfacing.
2. Minimum Thickness: 5/8 inches.
3. Base Product: DensDeck Prime Roof Board by Georgia-Pacific.

D. TPO Roofing Membrane:

1. Material: Thermoplastic Polyolefin (TPO) single-ply roofing membrane.
   a. Fire Retardant.
   b. Polyester fabric reinforced.
2. Color: White.
3. Thickness: 60 mil thick, minimum.
4. Minimum Physical Properties:
   a. Thickness over scrim: 15 mil by ASTM D4637.
   b. Tearing Strength: 55 pounds MIN by ASTM D751.
   c. Breaking Strength: 225 pounds by ASTM D751.
   d. Heat Aging: retain 90 percent of original Breaking Strength and Elongation values.
   e. Weather Resistance: 10,080 kJ/m2 by ASTM G155.
5. Base Product: SureWeld by Carlisle SynTec.

E. Membrane flashings, fasteners, adhesives, tapes, cements, and sealants:

1. Roofing manufacturer's standard.

F. Edge Metal and Coping:

1. Roofing Manufacturer's pre-engineered, prefabricated system for termination of roofing membrane.
2. Field fabricated components approved by roofing manufacturer for warranted system.
3. Fasteners concealed from view.
4. Concealed splice plates, with color matching snap-on covers.
5. Anchor cleats:
   a. Material: G90 galvanized steel.
   b. Thickness: 20 GA.
6. Snap-on cover:
   a. Material: G90 galvanized steel.
   b. Thickness:
      1) For dimensions less than 10 inches: 24 GA.
      2) For dimensions 10 to 24 inches: 22 GA.
   c. Finish: 70 percent PVDF Kynar 500.
   d. Color:
      1) To be selected from manufacturers standard colors by Owner.
7. Wind Rating: Design for pressure indicated for balance of roof system.
8. Coverage of these items to be included in roof system warranty.
9. Comply with applicable standards.
10. Roof Edge/Fascia:
    a. Match profiles indicated.
    b. Include accessories such as pre-fabricated inside and outside corners, Overflow and Downspout Scuppers, Edging Extensions, Fascia Sumps, and other items indicated.
    c. Base: SecurEdge 2000 Fascia by Carlisle SynTec.
11. Coping:

a. Match profiles indicated.
b. Include accessories such as pre-fabricated inside and outside corners (seamed), End Caps, Saddles, Tee's, Crosses, Transition Pieces and Radiused Copings, and other items indicated.
c. Base Product: SecurEdge 200 Coping by Carlisle SynTec.

G. Nailing Strips:
1. As detailed and required.

H. Pipe Flashings:
1. Provide for each pipe penetration; include clamps, adhesive and sealants.

I. Underlayment for Pavers:
1. As recommended by roofing manufacturer.

J. Adhesives, Cleaners, and Primers:
1. As recommended by roofing manufacturer.

K. Fire-Retardant Treated (FRT) Wood Blocking:
1. See Section 06 10 00.

L. Other Materials as required by manufacturer for complete system warranty.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine entire area to be roofed for acceptability.

B. Ensure substrate for insulation or roofing membrane is clean, smooth, dry, and free of projections or contaminants that would prevent proper application of or be incompatible with the new installation, such as fins, sharp edges, and foreign materials.

C. Correct unsatisfactory conditions.

D. Commencement of roofing activities constitutes acceptance of all conditions affecting installation and roofing system performance.

3.2 INSTALLATION

A. Vapor Barrier:
1. Install in largest practical widths.
2. Bond vapor retarder to substrate using approved adhesive.
3. Install continuously.
a. Ensure surfaces to be taped are clean and dry.
b. Ensure that no discontinuities occur, including at seams, penetrations, and edge terminations.
c. Join sections of vapor retarder and lap seams in direction of water flow.
d. Continuously seal roof vapor retarder to wall air and moisture retarder.
4. Seal around pipes, conduits, curbs, safety tie-backs, and other penetrations with pipe boots in accordance with manufacturer's instructions.
5. Maintain continuity of vapor retarder over expansion joints.
6. Repair holes in vapor retarder with method and material recommended by manufacturer.
7. Protect vapor retarder from damage until covered with insulation.

B. Wood Nailers:
1. Design to resist a minimum of 200 pounds/LF in any direction per SPRI Test Method RE-1.

2. Provide where indicated or required for proper securement of roofing system.
3. Install top of blocking flush with top of insulation.

C. Insulation:

1. Where required thickness of insulation is greater than 2 inches: Install insulation in at least 2 layers.
2. Stagger board joints in successive layers laterally and longitudinally.
3. Butt joints tightly.
4. Cut insulation neatly to fit around roof penetrations and projections.
5. Secure insulation with approved adhesive.

D. Membrane:

1. Unroll and position membrane without stretching.
   a. Allow membrane to relax prior to bonding.
2. Position sheets to accommodate contours of roof deck.
3. Apply bonding adhesive in accordance with the manufacturer's instructions, to exposed underside of the membrane and the corresponding substrate area.
4. Protect membrane from stains/discoloring caused by adhesives.
5. Membrane Splices:
   a. Hot air weld TPO membrane sheets using Automatic Hot Air Welding Machine or Hot Air Hand Welder in accordance with the manufacturer's hot air welding procedures.
   b. Locate field splices away from low areas and drain sumps.
   c. Shingle field splices to avoid bucking water.
   d. Probe seams once the hot air welds have thoroughly cooled.
   e. Repair seam deficiencies same day they are discovered.
   f. Apply sealant of type recommended by membrane manufacturer on cut edges of reinforced membrane where scrim reinforcement is exposed after seam probing is complete.
6. Secure membrane along the perimeter of each roof level, roof section, curb, skylight, penthouse, and other penetrations as recommended by membrane manufacturer.
7. Flashing:
   a. Follow manufacturer's typical flashing procedures for wall, curb, and penetration flashing including metal edging/coping and roof drain applications.
   b. Flashing of parapets, curbs, expansion joints and other parts of roof must be performed using reinforced TPO membrane.
   c. Manufacturer's standard, non-reinforced TPO membrane can be used for flashing pipe penetrations, sealant pockets, scuppers, as well as inside and outside corners when use of pre-fabricated accessories is not feasible.
   d. Terminate base-of-wall flashings in accordance with manufacturer's approved details.
   e. Pre-flashing at sheet metal parapet copings:
      1) Extend TPO membrane, flashing or both over top of parapet prior to capping with sheet metal.
   f. Expansion Joints:
      1) Extend TPO membrane across roofing expansion joints.
      2) Include adequate slack in membrane to accommodate anticipated movement.
8. Hot or Cold Weather Procedures:
   a. Comply with manufacturer's instructions.

3.3 INSTALLATION - EDGE METAL AND COPING

A. Sub-flash details with a layer of TPO membrane prior to installation of edge metal or coping system.

B. Secure anchor cleat to blocking as recommended, using corrosion-resistant fasteners.

C. Install splice plates and snap-on covers.

3.4 INSTALLATION – WALKWAYS

A. Install walkways at traffic concentration points, such as roof hatches, access doors, rooftop ladders, or locations as indicated.

B. Do not locate within 10 feet 3 M of roof edge.

C. Clean surfaces to be bonded.

D. Secure by heat welding as recommended by membrane manufacturer.

3.5 PROTECTION

A. When completion of flashings and terminations is not achieved by end of workday, seal system to temporarily prevent water infiltration.

B. Remove temporary water cutoffs prior to proceeding with Work.

C. Remove and replace wet insulation.

3.6 SCHEDULE OF ROOF SYSTEMS

A. Roof System 3 – Fully Adhered TPO over Concrete Deck at Precast Concrete Pavers:

1. Vapor Barrier.
2. PISO Insulation.
3. Cover Board.
4. TPO Membrane.

END OF SECTION

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SECTION 07 62 00
FLASHING AND SHEET METAL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Architectural flashing and sheet metal work.
2. Factory formed coping system(s).

B. Related Specification Sections include but are not necessarily limited to:

1. Section 04 05 23 - Masonry Accessories.
2. Section 07 54 25 – Fully Adhered TPO Roofing.
3. Section 07 92 00 - Joint Sealants.
4. Section 09 96 00 - High Performance Industrial Coatings.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. Aluminum Association (AA):
   a. DAF 45, Designation System for Aluminum Finishes.
2. American Architectural Manufacturers Association (AAMA):
   a. 2605, Voluntary Specification, Performance Requirements and Test Procedures for Superior Performing Organic Coatings on Aluminum Extrusions and Panels.
3. American National Standards Institute/Single Ply Roofing Industry (ANSI/SPRI):
   a. ES-1, Wind Design Standard for Edge Systems Used with Low Slope Roof Systems.
4. ASTM International (ASTM):
   a. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.
   b. A666, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
   c. B32, Standard Specification for Solder Metal.
   d. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
5. FM Global (FM).
6. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
   a. Architectural Sheet Metal Manual.

B. Qualifications:

1. Sheet metal fabricator shall have minimum 10 years experience in fabrication of sheet metal items similar to items specified.
2. Sheet metal installer shall have minimum five years experience installing sheet metal items specified.

1.3 DEFINITIONS

A. Installer or Applicator:

1. Installer or applicator is the person actually installing or applying the product in the field at the Project site.
2. Installer and applicator are synonymous.

B. PVDF: Polyvinylidene fluoride.

1.4 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
    a. Acknowledgement that products submitted meet requirements of standards referenced.
    b. Manufacturer's installation instructions.
2. Fabrication and/or layout drawings.
    a. Scaled drawing showing expansion joint locations, special conditions, profile, fastening and jointing details.
        1) Minimum plan scale: 1/8 inches = 1 foot.
        2) Minimum detail scale: 1-1/2 inches = 1 foot.
3. Fabricator qualifications.
4. Installer qualifications.

B. Samples:

1. Finish and color samples for each product specified for Engineer preliminary color selection.
2. For final color selection, provide two, 2 inches x 3 inches colored metal samples for each color selected during the preliminary color selection.

C. Informational Submittals:

1. Warranty: Manufacturer's sample warranty language.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Pre-finished sheet metal:
    a. Carlisle SynTec Systems.
    b. Holcim Elevate.
    c. Petersen Aluminum Corporation.
2. Factory-formed coping system.
    a. Hickman Edge Systems.
    b. Metal Era.
3. Butyl sealant:
    a. Pecora Corporation.
    b. Sika.
    c. Tremco Commercial Sealants & Waterproofing.

2.2 MATERIALS

A. Sheet Metal:

1. Aluminum: ASTM B209.
2. Stainless Steel: ASTM A666.
    a. Type 304.

B. Fasteners: Non-ferrous compatible with sheet metal.

C. Sealants:

1. Non-curing Butyl Sealant:
    a. Pecora "BA-98".
    b. Sika "SikaLastomer 511".

c. Tremco "TremPro JS-773".

2. Building sealants:
   a. See Specification Section 07 92 00.

D. Fasteners: Non-ferrous compatible with sheet metal.

E. Retainer Clips and Continuous Cleats: Stainless steel.

F. Solder: ASTM B32.

G. Dissimilar Metal Protection: Comply with Specification Section 09 96 00.

H. Reglets: See Specification Section 04 05 23.

2.3 MANUFACTURED ITEMS

A. Factory Formed Coping System:

1. Formed coping piece which locks to anchor plate fastened to top of wall.
2. ANSI/SPRI ES-1 tested.
3. FM approved.
4. Coping cover:
   a. Aluminum.
      1) Thickness: 0.050 inches.
5. Anchor plate: Galvanized steel, minimum 20 GA.
6. Splice plates: Aluminum, minimum 0.032 inches.
   a. Continuous, minimum 6 inches long.
   b. Front and back legs with extruded butyl seal.
   c. Finish: Match coping.
7. Factory fabricated accessories, including but not limited to:
   a. Corners, end caps, end terminations.
   b. All accessories to be factory mitered and welded.
8. Profile:
   a. Metal-Era "Perma-Tite Tapered."
   b. Front leg: 6 inches.
   c. Back leg: 5 inches.

B. Finish:

1. PVDF coating with minimum 70% resin content.
   a. Meet requirements of AAMA 2605.
      1) Color: To be selected by Owner. Provide manufacturer's list of available color in submittal.

2.4 FABRICATED ITEMS

A. General:

1. Shop fabricate items to maximum extent possible.
   a. Fabricate true and sharp to profiles and sizes indicated on Drawings.
      1) Shop fabricate and weld or solder all corners.
2. Pre-finished aluminum:
   a. Thickness: Minimum 0.050 inches.
   b. Texture: Smooth.
   c. Coated on exposed face with PVDF coating having a minimum 70% resin content and a minimum 1.0 mil dry film thickness.
      1) Meet requirements of AAMA 2605.

2) Color: Match coping and fascia.

3. .

B. Retainer Clips and Continuous Cleats:

1. 0.050 inches stainless steel.

PART 3 - EXECUTION

3.1 PREPARATION

A. Provide items to be built into other construction to Contractor in time to allow their installation.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions, SMACNA, and as indicated on Drawings.

B. Weld aluminum to achieve weathertight joints and required details.

1. Do not weld slip joints.
2. Touch-up damaged prefinished items.

C. Set top edges of membrane flashing and sheet metal flashing into reglets wherever practicable.

1. Surface applied terminations will be allowed only where specifically detailed or otherwise approved in writing by the Engineer.
2. Provide counterflashing at all reglets.
3. Seal reglets and counterflashings in accordance with Specification Section 07 92 00.

D. Fasten materials at intervals recommended by SMACNA.

E. Install slip joints to allow for thermal movement as recommended by SMACNA and manufacturer.

1. Maximum spacing: 10 feet on-center.
2. Provide slip joint 24 inches from corners.
3. Provide slip joint at each vertical expansion joint location in wall.
   a. Provide break in continuous cleat at each vertical expansion joint.
   b. The above expansion joints do not include brick veneer expansion joints.

F. Seal slip joints with two beads of non-curing butyl sealant on each side of slip joint overlap.

G. Form flashings to provide spring action with exposed edges hemmed or folded to create tight junctures.

H. Provide dissimilar metals and materials protection where dissimilar metals come in contact or where sheet metal contacts mortar, concrete masonry or concrete.

I. Provide all miscellaneous sheet metal items not specifically covered elsewhere, as indicated or required to provide a weathertight installation.

1. Provide all components necessary to create weather-tight junctures between roofing and sheet metal work.

END OF SECTION

SECTION 07 84 00
FIRESTOPPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Firestopping of joints in fire resistance-rated construction, including through-wall penetrations, and membrane penetrations.
2. Smokestopping of joints, through-wall penetrations, and membrane penetrations of smoke-rated construction.
3. Firestopping assemblies.
4. Engineering Judgments furnished by manufacturers of firestopping materials.
5. Special Inspections.
6. Labeling of Firestopping Assemblies.

B. Related Requirements: Include but are not necessarily limited to the following:

1. Section 09 96 00 - High-Performance Industrial Coatings.
2. Section 10 14 00 - Identification Devices.

1.2 REFERENCES

A. Terminology:

1. Terminology indicated below are not defined terms and are not indicated with initial capital letters, but when used in this section have the meaning indicated below:
   a. “Engineering judgement” means an evaluation of the anticipated performance of a firestopping materials or assembly that has not been fire tested (including but not limited to firestopping materials or systems that do not have a UL listing). Engineering judgements shall be governed by the International Firestop Council (IFC) Guidelines referenced in this Section, and are based on the performance of listed firestopping materials and assemblies and generally accepted engineering principles. As indicated in the IFC guidelines, engineering judgements are issued by a firestopping product manufacturer’s technical engineering employee. Relative to this term, engineering judgements are not issued by and are not the responsibility of Engineer.
   b. “Firestopping” means material or combination of materials used to retain integrity of fire-rated construction by maintaining an effective barrier against the spread of flame, smoke, and hot gases through penetrations in fire rated wall and floor assemblies. The word “firestop” has the same meaning as “firestopping”.
   c. “Smokestopping” means material or combination of materials used to retain integrity of smoke-rated construction by maintaining an effective barrier against the spread of smoke, and hot gases through penetrations in smoke-rated partitions and barrier assemblies. The word “smokestop” has the same meaning as “smokestopping”.

B. Reference Standards: Standards referenced in this section include, but are not necessarily limited to, the following:

1. ASTM International (ASTM):
   a. E119, Fire Tests of Building Construction and Materials.
   b. E814, Standard Method of Fire Tests of Through Penetration Fire Stops.
   c. E1399, Standard Test Method for Cyclic Movement and Measuring the Minimum and Maximum Joint Widths of Architectural Joint Systems.
   d. E1966, Standard Test Method for Fire Resistive Joint Systems.
   e. E2174, Standard Practice for On-site Inspection of Installed Fire Stops.

f. E2393, Standard Practice for On-site Inspection of Installed Fire Resistive Joint Systems and Perimeter Fire Barriers.

2. Firestop Contractors International Association's (FCIA):
   a. Firestop Manual of Practice (MOP).
3. FM Global (FM):
   a. MF 4991, Approval Standard for Firestop Contractors.
   b. FM Approvals Guide (online product directory).
4. International Firestop Council (IFC):
   a. Recommended IFC Guidelines for Evaluating Firestop Systems in Engineering Judgments (EJs), referred to herein as IFC Recommended Guidelines.
   b. Firestop Inspection Pocket Guide.
5. National Fire Protection Association (NFPA):
   a. 820, Fire Protection in Wastewater Treatment and Collection Facilities.
6. Underwriters Laboratories (UL):
   a. 263, Fire Tests of Building Construction and Materials.
   b. 1479, Fire Tests of Through Penetration Fire Stops.
   c. 2079, Standard for Tests for Fire Resistance of Building Joint Systems.
7. UL Solutions Product iQ (Online Product Directory):
   a. Through Penetration Firestop Systems (XHEZ).
   b. Joint Systems (XHBN).
   c. Fill, Void, or Cavity Materials (XHHW).
   d. Firestop Devices (XHJI).
   e. Forming Materials (XHKU).
   f. Wall Opening Protective Materials (CLIV).
   g. Fire Resistance Ratings (BXRH).

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate the Work required by this Section with other construction that must be performed prior to or concurrent with the Work of this Section.
2. Materials and assemblies furnished as part of the Work of this Section shall be furnished by a single manufacturer. Supplier shall ensure compatibility of all materials and assemblies furnished under this Section and compatibility with other materials with which the Work of this Section will come into contact.

B. Sequencing and Scheduling:

1. Perform installation of firestopping and smokestopping after completing installation of penetrating items and prior to covering or concealing of openings.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements:

1. For required firestopping applications for which no qualified previously tested materials or system is commercially available through Supplier, submit to authority having jurisdiction an engineering judgment derived from similar qualified tested system designs or other tests for approval by the authority having jurisdiction prior to installation. Upon Engineer's request, submit to Engineer copy of such engineering judgements and approval by the authority having jurisdiction.
2. Engineering judgment documents shall comply with requirements of International Firestop Council.

B. Qualifications:

1. Design Professional:
    a. Where Contractor proposes providing firestopping materials or assemblies that have not been fire tested (including but not limited to, firestopping materials or systems that do not have a UL listing), Supplier shall prepare engineering judgement, submit to, and obtain approval or acceptance by authority having jurisdiction. Such engineering judgement shall be prepared by, or under the direct, personal, supervision and control of design professional registered and licensed in the same jurisdiction as the Site, appropriate for the type of firestopping required.
    b. Design professional shall be qualified and experienced, and shall possess or be covered by current, valid professional liability insurance in accordance with the Contract Documents. Required limits of professional liability insurance coverage shall not have been previously eroded by prior claims under the policy.
    c. Submit evidence of design professional's compliance with Contract requirements regarding licensure, registration, and insurance.
    d. Engineering judgements shall bear design professional's seal, signature, and date.
2. Installer:
    a. Entity that selects and installs firestopping materials and assemblies shall be an organization regularly engaged in and experienced in firestopping construction of the types and complexities similar to that required for the Work. Such entity shall be appropriately experienced in the type of Work required and shall possess current, valid, licensure and qualifications, in accordance with Laws and Regulations (where applicable) for the type of firestopping required.
    b. Entities that select and install firestopping materials and assemblies shall possess one or more of the following as current, valid accreditations:
        1) Hilti Accredited Firestop Specialty Contractor (HAFSC), or
        2) Firestop Contractors International Association (FCIA) Levels 1 – 4.
    c. In addition, entity selecting and installing firestopping materials and systems shall possess one or more of the following as current, valid certifications:
        1) Approved Firestop Contractor in accordance with FM4991.
        2) Qualified Firestop Contractor by UL Solutions
    d. Should Contractor propose as entity selecting and installing firestopping an organization with alternative qualifications, accreditation, or certification submit for Engineer's approval appropriate substitution request in accordance with the Contract Documents.
    e. Submit to Engineer documentation demonstrating installer's compliance with qualifications requirements of this provision.

1.5 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:
    a. Firestopping schedule (table) indicating the following:
        1) Numerical designation for each penetration.
        2) Type of construction penetrated, such as wall, floor, shaft, head of wall, or other appropriate designation.
        3) F and T ratings for each penetration.
        4) W and L ratings, where applicable.
        5) For each penetration, indicate appropriate designation by UL, FM, Intertek, or other applicable rating organization.
        6) Product name and manufacturer for each product used at each penetration.
    b. Plan-view drawings indicating the location of fire-rated and smoke-rated construction and the location of each penetration with serialized numerical designator for each penetration aligning with the Firestopping Schedule.

c. Firestopping detail drawings for each type of firestopping assembly proposed.
d. Installation detailed drawings for each type of Work element.

2. Product Data:
a. Manufacturer's listed firestopping product "design number".
b. For each item required under this Section, submit manufacturer's published product information, including data sheet (as applicable), clearly indicating materials, limitations, optional features that will be furnished and those options or features that will not be furnished.
c. Manufacturer's specifications:

B. Informational Submittals: Submit the following:

1. Engineering Judgements:
a. When UL or third-party listing is not available, provide a written engineering judgment in accordance with IFC Recommended Guidelines and requirements of this Section. Submit to Engineer copy of engineering judgement, sealed, signed, and dated by Supplier's design professional, together with documentation of approval or acceptance by authority having jurisdiction.

2. Supplier Instructions:
a. Serial numbers of items furnished.
b. Instructions for handling, installing, and startup.

3. Field Quality Control Submittals:
a. Results of tests, inspections, and other quality control activities required by the Contract Documents and performed at the Site.

4. Suppliers Site Visit Reports:
a. Report of each visit to the Site by Supplier, summarizing purpose of visit, activities while onsite, problems encountered, advice given to Contractor or Subcontractor, and actions taken.

5. Qualifications Statements:
a. Entity selecting and installing firestopping, in accordance with this Section's "Quality Assurance" Article.
b. Design professional in responsible charge of preparing engineering judgements, if any.

C. Closeout Submittals: Submit the following:

1. Record Documentation:
a. Written statement that all fire-rated penetrations were sealed using products in accordance with UL or FM requirements for required rating.
b. Documentation of listed materials and systems installed and engineering judgments.
c. Indicate appropriate revisions for firestopping on record Drawings required in accordance with Section 01 78 39 - Project Record Documents.
d. Firestopping Schedule (table), submitted as part of the Shop Drawings, revised to show and indicate as-constructed conditions.
e. Photographs:
1) Photograph of each penetration through fire resistance-rated construction showing pre-firestopping and Substantial Completion conditions.
2) Pre-firestopping and Substantial Completion condition photographs shall be taken in a manner to ensure similar photograph orientation to allow for photographic comparison.
f. Building code sections relevant to firestop systems.

1.6 DELIVERY, STORAGE AND HANDLING

A. Delivery and Acceptance Requirements:

1. In addition to requirements of Section 01 65 00 - Product Delivery Requirements, properly label packaging of firestopping and smokestopping materials and assemblies with associated UL label where applicable.

1.7 FIELD CONDITIONS

A. Work at Wastewater Facilities:

1. Perimeter of, and all penetrations through, walls separating unclassified rooms and rooms classified in accordance with NFPA 820, shall be gas-tight to be compliant with NFPA 820's definition of "physically separated".
2. NFPA 820- See Drawings for classified space identification.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with the Contract Documents, provide the required quantity of materials and assemblies by one of the following for each of the associated material or assembly types required:

1. Through Penetration Firestop Systems:
   a. Hilti.
   b. Rectorseal.
   c. 3M.
   d. Specified Technologies. (STI).
   e. Tremco.
   f. Or equal.
2. Fire Resistive Joint Systems:
   a. Hilti.
   b. Rectorseal.
   c. 3M.
   d. Specified Technologies. (STI).
   e. Tremco.
   f. Or equal.
3. Firestop Track Seal or Gasket:
   a. Hilti.
   b. 3M.
   c. Specified Technologies. (STI).
   d. Or equal.
4. Firestop Devices:
   a. Hilti.
   b. 3M.
   c. Specified Technologies. (STI).
   d. Or equal.
5. Intumescent Pads, Wall Opening Protective Materials:
   a. Hilti.
   b. Rectorseal.
   c. 3M.
   d. Specified Technologies. (STI).
   e. Tremco.
   f. Or equal.

6. Fire Rated Cable Pathways:
    a. Hilti.
    b. 3M.
    c. Specified Technologies. (STI).
    d. Or equal.
7. Firestop Putty:
    a. Hilti.
    b. Rectorseal.
    c. 3M.
    d. Specified Technologies. (STI).
    e. Tremco.
    f. Or equal.
8. Firestop Blocks and Plugs:
    a. Hilti.
    b. 3M.
    c. Specified Technologies. (STI).
    d. Or equal.
9. Firestop Pillows:
    a. 3M.
    b. Specified Technologies. (STI).
    c. Or equal.
10. Forming Materials:
    a. Johns Manville – MinWool.
    b. Rockwool - Roxul.
    c. Or equal.
11. Composite Sheet:
    a. Hilti.
    b. 3M.
    c. Specified Technologies. (STI).
    d. Or equal.
12. Duct Wrap.
    a. 3M.
    b. UniFrax – FyreWrap.
    c. Or equal.

2.2 MATERIALS

A. Materials - General:

1. Installer of the Work under this Section shall select specific materials and systems appropriate for each specific firestopping and smokestopping application required, in accordance with the Contract Documents and Laws and Regulations.
2. Provide firestopping materials and assemblies in accordance with ASTM E814, ASTM E1399, ASTM E2307, UL 1479 and UL 2079, as applicable.
3. Provide tested firestopping materials and assemblies that provide a fire rating equal to that of the construction being penetrated.
4. Firestopping materials and assemblies shall comply with Laws and Regulations, including applicable building code.
5. Previous Testing Required: Furnish only materials and assemblies where identical items were previously tested, under controlled conditions for specific fire-rated construction

conditions conforming to construction assembly type, penetrating item type, annular space requirements, and fire resistance rating involved for each separate item. Such testing shall be in accordance with the following as applicable:

a. Openings and Penetrations: UL 1479 or ASTM E814.

b. Building Joint Systems: ASTM E1966 and ASTM E1399, or UL 2079.

c. Perimeter Fire Barrier Systems: ASTM E2307.

6. Where firestopping is not exposed to view, provide materials and assemblies of manufacturer's standard color.

B. Forming Materials:

1. Comply with ANSI/UL 263.
2. UL listed.
3. Product category BZJZ, Batts and Blankets.

C. Firestop Silicone Elastomer:

1. UL-listed.
2. Fill, Void or Cavity Materials: Product category XHHW.
3. Through Penetration Firestop Systems: Product category XHEZ.

D. Firestop Sealant:

1. UL-listed.
2. Provide as required by the item’s associated UL-listed design.

E. Firestop Putty:

1. UL-listed.
2. Product category QCSN or CLIV, Wall Opening Protective Materials.

F. Firestop collars:

1. UL-Listed.
2. Provide as required by the item’s associated UL-listed design.

G. Fire Rated Cable Pathways:

1. UL-Listed.
2. Steel raceway and intumescent pads with adjustable smoke seal sleeve.
3. Fire resistance rating equal to rating of barrier penetrated.
4. Pathway devices:
   a. Allow 0 to 100 percent fill of cables.
   b. Firestopping shall adjust automatically to cabling installation and removal.
5. Size of firestopping shall accommodate quantity and size of cabling required by the Contract Documents plus and equal quantity of cabling installed in the future.
6. Provide cable management devices with gang plates for single or multiple devices.

H. Fire Barrier Pillows:

1. UL listed.
2. Provide pillow that are removable and reusable.
3. Provide pillows have self-locking feature.

I. Backer rod and compressible filler: UL listed, product category XHHW, Fill, Void or Cavity Materials.

J. Identification Labels:

1. Comply with Section 10 14 00 - Identification Devices.

2. Identify through-penetration firestop systems by providing pressure-sensitive, self-adhesive, preprinted labels complying with the following.
    a. Tamper proof.
    b. Permanent and weatherproof.
    c. UV stabilized labelling, text, and colors.
    d. Provide labels with preprinted text. Handwritten text on labels is unacceptable.
3. Each firestopping label shall clearly indicate the following:
    a. Firestop Joint Systems:
        1) The words “Warning-Firestop System-Do Not Disturb. Notify Building Management of Any Damage.”
    b. Through-Penetration Firestop Systems:
        1) The words “Warning-Through Penetration Firestop System-Do Not Disturb. Notify Building Management of Any Damage.”
    c. Name and telephone number of Contractor and installer.
    d. Through-Penetration firestop listing designation or EJ number.
    e. Date of Installation, in the form of month, date, year.
    f. Through-Penetration firestopping materials and system manufacturer.
    g. Installing Technician’s Name.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions:

1. Verify existing conditions and substrates before starting the Work of this Section. Remedy unsatisfactory conditions before proceeding.

B. Installing the Work constitutes Contractor’s approval of underlying work, substrates, and field conditions prevailing at the time of the Work.

3.2 INSTALLATION

A. Installation - General:

1. Provide the Work of this Section in accordance with the Contract Documents, Laws and Regulations (including applicable building code), and material, system manufacturer’s written installation instructions, and UL listing requirements to provide required fire-resistance rating. When UL listing is not available, install in accordance with approved written engineering judgment. When any such requirements conflict, obtain written interpretation or clarification from Engineer before proceeding further.
2. Provide firestopping materials and systems in accordance with ASTM E814, ASTM E1399, ASTM E2307, UL 1479 and UL 2079, as applicable.
3. Where firestopping will be exposed to view, provide materials and systems of colors matching adjacent construction. Alternatively, if approved by manufacturer of materials and systems and following inspection and approval by authority having jurisdiction, field-paint materials and systems to match color of adjacent construction. Such field-painting shall be in accordance with Section 09 96 00 - High-Performance Industrial Coatings.
4. Do not install firestopping or smokestopping materials or assemblies when the ambient temperature of the installation location does not comply with manufacturer’s written installation instructions for duration of installation and curing.
5. During installation, provide masking and drop cloths to prevent firestopping materials from contaminating or marring adjacent surfaces.

B. Openings and Penetrations:

1. Provide firestopping materials and assemblies for each opening, through-penetration, and membrane penetration in fire-resistant rated construction.
2. Provide Flame (F), Thermal (T), Smoke (L), and Water (W) rated assemblies as necessary to comply with Laws and Regulations (including applicable building code).
3. Comply with Section 01 73 20 - Openings and Penetrations in Construction.

C. Building Joint Systems:

1. Provide firestopping materials and assemblies for each joint assembly in or between fire-resistance-rated walls, floors or floor/ceiling assemblies and roofs or roof/ceiling assemblies.

D. Identification

1. Install firestopping labelling permanently to surfaces of penetrated construction on both sides of each firestop system installation where labels will be readily visible.
2. Provide identification in accordance with FCIA MOP and FM 4991.

3.3 FIELD QUALITY CONTROL

A. Field Tests and Inspections:

1. Special Inspections of firestopping and smokestopping Work will be in accordance with Chapter 17 of the applicable building code and Section 01 45 33 - Code-Required Special Inspections and Procedures.

END OF SECTION

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SECTION 07 92 00
JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sealing all joints which will permit penetration of dust, air or moisture.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 07 84 00 - Firestopping.
2. Section 09 96 00 - High Performance Industrial Coatings.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Concrete Institute (ACI):
   a. 302.1R, Guide for Concrete Floor and Slab Construction.
2. ASTM International (ASTM):
   a. C834, Standard Specification for Latex Sealants.
   b. C920, Standard Specification for Elastomeric Joint Sealants.
   c. C1521, Standard Practice for Evaluating Adhesion of Installed Weatherproofing Sealant Joints.
3. National Fire Protection Association (NFPA).
   a. 820, Fire Protection in Wastewater Treatment and Collection Facilities.
4. Underwriters Laboratories, Inc. (UL).

B. Qualifications: Sealant applicator shall have minimum five years experience using products specified on projects with similar scope.

C. Mock-Ups:

1. Before sealant work is started, a mock-up of each type of joint shall be sealed where directed by the Engineer.
   a. The approved mock-ups shall show the workmanship, bond, and color of sealant materials as specified or selected for the work and shall be the minimum standard of quality on the entire project.
   b. Each sample shall cure for a minimum of seven days at which time the sealant manufacturer's authorized factory representative shall perform adhesion tests on each sample joint.
      1) Perform adhesion tests per ASTM C1521.
      2) If mock-up is not acceptable or if adhesion test fails, provide additional mock-up and adhesion testing as required until acceptable to Engineer.

1.3 DEFINITIONS

A. Corrosive Areas Include: Screen Room, Headworks Building.

B. Defect(ive): Failure of watertightness or airtightness.

C. Finish sealant: Sealant material per this specification applied over face of compressible sealant or expanding foam sealant specified, to provide a finished, colored sealant joint.

D. Installer or Applicator:

1. Installer or applicator is the person actually installing or applying the product in the field at the Project site.

2. Installer and applicator are synonymous.

E. "Interior wet areas": Entire Screen Room is considered wet.

F. "Seal," "sealing" and "sealant": Joint sealant work.

1.4 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Manufacturer's installation instructions.
   c. Manufacturer's recommendations for joint cleaner, primer, backer rod, tooling and bond breaker.
2. Certification from sealant manufacturer stating product being used is recommended for and is best suited for joint in which it is being applied.
3. Certification of applicator qualification.

B. Test Results:

1. Provide adhesion test results for each sealant sample including adhesion results compared to adhesion requirements.
2. Manufacturer's authorized factory representative recommended remedial measures for all failing tests.

C. Samples:

1. Cured sample of each color for Engineer's color selection.
2. Color chart not acceptable.

D. Informational Submittals:

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver material in manufacturer's original unopened containers with labels intact: Labels shall indicate contents and expiration date on material.

1.6 PROJECT CONDITIONS

A. Schedule installation of sealant work after completion of penetrating item installation but prior to covering or concealing of openings.

B. Verify existing conditions and substrates before starting work. Correct unsatisfactory conditions before proceeding.

C. Do not proceed with the installation of sealant materials when the ambient temperature is outside the manufacturer’s recommended limitations for installation and curing times as printed on the product label and product data sheet.

D. During installation provide masking and drop cloths to prevent sealant materials from contaminating any adjacent surfaces.

E. Perimeter of, and all penetrations through, walls separating unclassified rooms and rooms classified per NFPA 820, shall be gas-tight to meet the definition of “Physically Separated”.

1. Classified rooms include the following:
   a. Screen Room, Headworks Building.
2. The remainder of the building is unclassified.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Compressible sealant:
    a. Schul International Company, LLC.
    b. Emseal by Sika.
    c. Norton.
    d. Sandell Moisture Protection Systems.
2. Expanding foam sealant:
    a. M-D Building Products, Inc.
    b. DAP Products, Inc.
    c. FAI International, Inc.
    d. Power Fasteners.
3. Polyether sealants:
    a. Master Builders Solutions.
    b. Chem Link.
    c. Tremco Commercial Sealants & Waterproofing.
4. Polysulfide rubber sealant:
    a. Pecora Corporation.
    b. Master Builders Solutions.
    c. PolySpec by ITW Polymers Sealants.
5. Polyurea joint filler:
    a. Dayton Superior Corporation.
    b. Euclid Chemical Company.
    c. L&M by LATICRETE International, Inc.
    d. Master Builders Solutions.
6. Polyurethane sealants:
    a. Pecora Corporation.
    b. Sika.
    c. Master Builders Solutions.
    d. Tremco Commercial Sealants & Waterproofing.
7. Silicone sealants:
    a. Chem Link.
    b. GE Silicones.
    c. Dow.
    d. Tremco Commercial Sealants & Waterproofing.
8. Backer rod, compressible filler, primer, joint cleaners, bond breaker:
    a. As recommended by sealant manufacturer.

2.2 MATERIALS

A. Sealants - General:

1. Provide colors matching materials being sealed.
2. Where compound is not exposed to view in finished work, provide manufacturer's color which has best performance.
3. Nonsagging sealant for vertical and overhead horizontal joints.

4. Sealants for horizontal joints: Self-leveling pedestrian/traffic grade.
5. Joint cleaner, primer, bond breaker: As recommended by sealant manufacturer.
6. Sealant backer rod and/or compressible filler:
    a. Closed cell polyethylene, polyethylene jacketed polyurethane foam, or other flexible, nonabsorbent, non-bituminous material recommended by sealant manufacturer to:
        1) Control joint depth.
        2) Break bond of sealant at bottom of joint.
        3) Provide proper shape of sealant bead.
        4) Serve as expansion joint filler.

B. Compressible Sealant:

1. For joints exposed to wastewater fumes or vapor:
    a. Closed cell ethylene vinyl acetate (EVA) foam with epoxy adhesive.
    b. Schul "HydroStop".
2. For all other applications: Foamed polyurethane strip saturated with polymerized polybutylene waterproofing coated on front face with nonreactive release agent that will act as bond breaker for applied sealant.
    a. Schul "Sealtite B".
3. Adhesive: As recommended by sealant manufacturer.

C. Expanding Foam Sealant:

1. One or two component moisture cured expanding urethane.
2. Shall not contain formaldehyde.
3. Density: Minimum 1.5 pcf.
4. Closed cell content: Minimum 70%.
5. R-value: Minimum 5.0/IN.
6. Flame spread: Less than 25.
7. Smoke developed: Less than 25.

D. Polyether Sealant:

1. Silyl-terminated polyether polymer.
2. ASTM C920, Type S, Grade NS, Class 50, Use NT, M, A, and O.
    a. Master Builders Solutions MasterSeal 150.
    b. Chem Link DuraLink.
    c. Tremco Dymonic FC.

E. Polysulfide Rubber Sealant:

1. One or two component.
2. Meet ASTM C920.
    a. Pecora Synthacalk GC2+.
    b. PolySpec THIOKOL 2235.

F. Polyurea Joint Filler:

1. Two component, semi-rigid material for filling formed or saw-cut control joints in interior concrete slabs.
    a. Dayton Superior Corporation "Joint Fill, Joint Seal, Joint Saver II" as required for condition and recommended by manufacturer.
    b. Euclid Chemical Company "EUCO QWIK" joint.
    c. L&M "Joint Tite 750".
    d. Master Builders Solutions MasterSeal “CR100" control joint filler.

2. Comply with ACI 302.1R performance recommendations regarding control and construction joints.
3. Color: Gray.

G. Polyurethane Sealant:

1. One or two components.
2. Paintable.
3. Meet ASTM C920 Type S or Type M, Grade NS or P, Class 25, Use NT, T, M, A and O.
   a. Pecora Dynatrol-IXL, Dynatrol II, Urexpan NR-200, NR-201.
   b. Sika Chemical Corporation Sikaflex-1a, Sikaflex-2C NS/SL.
   c. Master Builders Solutions MasterSeal NP-1, NP-II, SL-1 SL-2.
   d. Tremco Dymonic or Dymeric, Vulkem 116,227,45,245.

H. Silicone Sealant:

1. One component.
2. Meet ASTM C920, Type S, Grade NS, Class 25, Use NT, G, A, O.
   a. Chem Link DuraSil.
   b. GE Silpruf, Silglaze II.
   c. GE Sanitary 1700 sealant for sealing around plumbing fixtures.
   d. Dow 786 for sealing around plumbing fixtures.
   e. Dow 7565, 790, 791, 795.
   f. Tremco Spectrem 1, Spectrem 3, Tremsil 600.
3. Mildew resistant for sealing around plumbing fixtures.

PART 3 - EXECUTION

3.1 PREPARATION

A. Before use of any sealant, investigate its compatibility with joint surfaces, fillers and other materials in joint system.

B. Use only compatible materials.

C. Where required by manufacturer, prime joint surfaces.

1. Limit application to surfaces to receive sealant.
2. Mask off adjacent surfaces.

D. Provide joint depth for joints receiving polyurea joint filler in accordance with manufacturer's recommendations.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions and UL requirements.

B. Clean all joints.

C. Make all joints water and airtight.

D. At changes in direction of joints, joint intersections and where sealant joints interface with other construction, install continuous sealant as necessary to ensure a weather-tight seal.

E. Make depth of sealing compounds, except expanding foam and polyurea sealant, not more than one-half width of joint, but in no case less than 1/4 inches nor more than 1/2 inches unless recommended otherwise by the manufacturer.

F. Provide correctly sized backer rod, compressible filler or compressible sealant in all joints to depth recommended by manufacturer:

1. Take care to not puncture backer rod and compressible filler.

2. Provide joint backer rod as recommended by the manufacturer for polyurea joint filler.

G. Apply bond breaker where required.

H. Tool sealants using sufficient pressure to fill all voids.

I. Upon completion, leave sealant with smooth, even, neat finish.

J. Where piping, conduit, ductwork, etc., penetrate wall, seal each side of wall opening.

K. Install compressible sealant to position at indicated depth.

1. Size so that width of material is twice joint width.
2. Take care to avoid contamination of sides of joint.
3. Protect side walls of joint (to depth of finish sealant).
4. Install with adhesive faces in contact with joint sides.
5. Install finish sealant where indicated.

L. Install expanding foam sealant to minimum 4 inches depth or thickness of wall being penetrated if less than 4 inches or as indicated on Drawings.

1. Provide adequate backing material as necessary.
2. Hold material back from exposed face of wall as necessary to allow for installation of backer rod and finish sealant.
    a. Allow expanding foam sealant to completely cure prior to installing backer rod and finish sealant.
3. Trim off excess material flush with surface of the wall if not providing finished sealant.

3.3 SEALANT WORK

A. General:

1. Work includes but is not limited to: Sealing all joints which will permit penetration of dust, air, or moisture.
2. Refer to SCHEDULE for materials to be used.
3. See Specification Section 07 84 00 for firestopping.

B. Concrete joints:

1. Flooring joints.
2. Isolation joints.
3. Joints between paving or sidewalks and building.
4. Construction, control and expansion joints.
5. Joints between precast roof units and between precast roof units and walls.
6. Joints between precast wall panels.
7. Precast panel bearing joints:
    a. At panels bearing at or above grade, seal both sides of panel base joint.
    b. At panels bearing below grade:
        1) Seal exterior panel base joint prior to backfilling and/or placement of site paving.
        2) Provide compressible filler and sealant or backer rod and sealant as appropriate for interior slab condition.

C. Masonry:

1. Masonry control joints.
2. Brick expansion joints.
3. Cast stone coping and sill head joints.
4. Glass masonry joints.
5. Between masonry and other materials.

D. Flashing, reglets and retainers.

E. Wood siding and trim.

F. Openings:

1. Perimeters of door and window frames, louvers, grilles, etc.
2. Door thresholds shall be set in a full bed of sealant.

G. Plumbing fixtures.

H. Penetrations of walls, floors and decks.

I. Other joints where sealant, expanding foam sealant or compressible sealant is indicated.

3.4 FIELD QUALITY CONTROL

A. Adhesion Testing:

1. Perform adhesion tests in accordance with ASTM C1521 per the following criteria:
   a. Water bearing structures: One test per every 1000 linear foot of joint sealed.
   b. Exterior precast concrete wall panels: One test per every 2000 linear foot of joint sealed.
   c. Building expansion joints: One test per every 500 linear foot of joint sealed.
   d. All other type of joints except butt glazing joints: One test per every 3000 linear foot of joint sealed.
   e. Manufacturer's authorized factory representative shall recommend, in writing, remedial measures for all failing tests.

3.5 SCHEDULE

A. Furnish sealant as indicated for the following areas:

1. Exterior areas:
   a. Above grade: Polyether.
   b. Below grade: Polyurethane.
2. Interior areas:
   a. Noncorrosive areas:
      1) Wet exposure: Polyether.
         a) Toilet rooms, locker rooms, janitor closets or similar areas: Mildew resistant silicone.
      2) Dry exposure: Polyether, unless noted otherwise.
         a) Sound insulated construction: Acoustical sealant.
   b. Corrosive areas:
      1) Wet exposure: Polysulfide.
      2) Dry exposure: Polyurethane.
   c. Sealant exposed to or having the potential of being exposed to concentrated chlorine gas or chlorine liquid: Polysulfide.
   d. Casework, countertops and solid surface materials: Silicone.
      1) Sinks, fixtures or other areas subject to potential splash, spillage or condensation: Mildew Resistant Silicone.
3. Immersion:
   a. Prolonged contact with or immersion in:
   b. Potable water:
      a) Polysulfide.
      b) NSF 61 approved.
      2) Non-potable water, wastewater or sewage: Polysulfide.

4. Compressible sealant: Where indicated.
5. Exterior wall penetrations: Expanding urethane foam, with finish sealant.
    a. Finish sealant:
        1) Exterior side:
            a) Above grade: Polyether.
            b) Below grade: Polyurethane.
        2) Interior side:
            a) Noncorrosive area:
                (1) Wet exposure: Polyether.
                (2) Dry exposure: Polyether, unless noted otherwise.
            b) Corrosive area:
                (1) Wet exposure: Polysulfide.
                (2) Dry exposure: Polyurethane.
6. Interior concrete slab formed or saw-cut control joints: Polyurea joint filler.

END OF SECTION

DIVISION 08

OPENINGS

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SECTION 08 11 00
HOLLOW METAL DOORS AND FRAMES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal doors and frames.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 08 70 00 - Finish Hardware.
2. Section 09 96 00 - High Performance Industrial Coatings.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. ASTM International (ASTM):
   a. A653, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
2. National Association of Architectural Metal Manufacturers (NAAMM):
   a. Hollow Metal Manufacturers Association (HMMA).
3. Steel Door Institute (SDI):
   a. 117, Manufacturing Tolerances for Standard Steel Doors and Frames.
   b. All SDI publications.
4. Steel Door Institute/American National Standards Institute (SDI/ANSI):
   a. A250.6, Recommended Practice for Hardware Reinforcing on Standard Steel Doors and Frames.
   b. A250.7, Nomenclature for Standard Steel Doors and Steel Frames.
   c. A250.8, Specifications for Standard Steel Doors and Frames.
   d. A250.10, Test Procedure and Acceptance Criteria for Prime Painted Steel Surfaces for Steel Doors and Frames.
   e. A250.11, Recommended Erection Instructions for Steel Frames.

B. Qualifications: Manufacturer must be current member of SDI, and NAAMM (HMMA).

C. Wipe coat galvanized steel is not acceptable as substitute for galvanizing finish specified.

1.3 DEFINITIONS

A. As identified in SDI/ANSI A250.7.

1.4 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Manufacturer's installation instructions.
2. Schedule of doors and frames using same reference numbers as used on Drawings.
3. SDI certification.

B. Contract Closeout Information:

1. Operation and Maintenance Data:
   a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store doors and frames in accordance with SDI/ANSI A250.11.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Metal doors and frames:
    a. Ceco Door by ASSA ABLOY.
    b. Steelcraft by Allegion PLC.
    c. Curries by ASSA ABLOY.

2.2 MATERIALS

A. Steel Sheet: Hot-dipped galvannealed steel, ASTM A653, A60 coating.

B. Frames: Hot-dipped galvannealed steel, ASTM A653, A60 coating.

C. Supports and Reinforcing: Hot-dipped galvannealed steel, ASTM A653, A60 coating.

D. Inserts, Bolts and Fasteners: Manufacturer's standard.

E. Primer: Manufacturer's standard coating meeting SDI/ANSI A250.10.

F. Galvannealed Coating Repair: See Specification Section 09 96 00.

G. Thermal Insulation: Polyurethane, CFC free.

H. Sound Insulation: Fiberglass batt insulation or impregnated Kraft honeycomb.

2.3 ACCESSORIES

A. Frame Anchors:

1. Jamb anchors:
    a. Masonry wire anchors: Minimum 0.1875 inches wire, galvanized.
    b. Existing wall anchor: Minimum 18 GA, galvanized.
    c. Stud partition and base anchors: Minimum 18 GA, galvanized.

2.4 FABRICATION

A. General:

1. SDI/ANSI A250.8.
2. Fabricate rigid, neat in appearance and free from defects.
3. Form to sizes and profiles indicated on Drawings.
    a. Beveled edge.
4. Fit and assemble in shop wherever practical.
5. Mark work that cannot be fully assembled in shop to assure proper assembly at site.
6. Continuously wire weld all joints, dress exposed joints smooth and flush.
7. Fabricate doors and frames to tolerance requirements of SDI 117.
8. Fit doors to SDI clearances.
9. All doors shall be handed.
10. Hinge cut-out depth and size on doors and frames shall match hinge specified in Specification Section 08 70 00.
11. Design and fabricate doors to requirements of the building code.

B. Hollow Metal Doors:

1. General:
    a. 1-3/4 inches thick.
    b. Fabricate with flush top caps.
        1) Thickness and material to match door face.
        2) Exterior doors: Seal weld top cap to door face and grind smooth and flush.
        3) Interior doors:
            a) Attach top cap to door with concealed fasteners or by welding.
            b) Factory seal if attached with fasteners.
            c) No exposed fasteners will be accepted.
    c. Continuously wire weld all joints and dress, smooth and flush.
2. Exterior:
    a. Doors 48 inches wide, or less: SDI/ANSI A250.8, Level 3, and physical performance level A, Model 2.
        1) Face sheet minimum thickness: 16 GA.
        2) Insulated: Minimum R-10.

C. Hollow Metal Frames:

1. Door frames:
    a. Provide 2 inches face at all heads, jambs and mullions for frames in stud walls.
    b. Provide 4 inches face at head where noted on Drawings or required by wall construction.
    c. 26 GA galvannealed steel boxes welded to frame at back of all hardware cutouts.
    d. Steel plate reinforcement welded to frame for hinge, strikes, closers and surface-mounted hardware reinforcing.
        1) All plate reinforcement shall meet size and thickness requirements of SDI/ANSI A250.8.
    e. Split type frames not acceptable.
        1) All horizontal and vertical mullions and transom bars shall be welded to adjacent members.
    f. Conceal all fasteners.
    g. Frames shall be set up, all face joints continuously wire welded and dressed smooth.
    h. Exterior (up to 4 feet wide): 16 GA.
    i. Exterior (over 4 feet wide): 14 GA.
    j. Interior: 16 GA.
    k. Provide removable spreaders at bottom of frame.

D. Prepare for finish hardware in accordance with hardware schedule, templates provided by hardware supplier, and SDI/ANSI A250.6.

1. Locate finish hardware in accordance with SDI/ANSI A250.8.
2. See Specification Section 08 70 00 for hardware.
3. Prepare doors for swing direction indicated.
    a. Preparing doors for non-handed hinges is not acceptable.

E. After fabrication, clean off mill scale and foreign materials and prime with rust inhibiting primer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install doors and frames in accordance with SDI/ANSI A250.11, the building code and manufacturer's instructions.

B. Plumb, align, and brace frames securely until permanently anchored.
    1. After completion of walls, remove temporary braces and spreaders.
    2. Anchor frames with minimum of three anchors per jamb.
        a. Number and location of anchors shall be in accordance with SDI and frame manufacturer's recommendations.

C. At new masonry or metal stud construction, place frames in conjunction with construction of walls or partitions.
    1. Masonry construction: Anchor frames using masonry wire anchors.
    2. Metal stud construction:
        a. Anchor frames using steel stud anchors.
        b. Attach wall anchors with self-tapping screws.

D. At concrete, precast concrete or existing masonry construction, place frames in rough opening using existing opening anchors.

E. Use plastic plugs to keep silencer holes clear during construction.

F. Immediately after erection, sand smooth rusted or damaged areas.
    1. Touch-up with rust-inhibiting primer.
    2. Finish paint door and frame in accordance with Specification Section 09 96 00.

G. Install three silencers on strike jamb of single door frame and two on head of double door frame.
    1. See Specification Section 08 70 00.

H. Protect doors and frames during construction.

END OF SECTION

SECTION 08 31 00
ACCESS DOORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. H-20 loading doors.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 09 96 00 - High Performance Industrial Coatings.
2. Section 33 05 15 - Precast Concrete Utility Structures.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Association of State Highway and Transportation Officials (AASHTO).
2. ASTM International (ASTM):
   a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   b. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   c. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   d. A480/A480M, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
   e. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   f. A666, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
   g. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   h. B221, Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.

1.3 DEFINITIONS

A. Clear Opening Size: Space within the opening having no obstructions. Furnish model that will provide the minimum clear opening indicated.

B. Standard Duty: Will support live load of 150 psf.

C. Heavy Duty: Will support live load of 300 psf.

D. H-20 loading: As defined in AASHTO Guidelines.

1.4 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Manufacturer's installation instructions.

B. Contract Closeout Information:

1. Operation and Maintenance Data:
   a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. H-20 loading doors:
    a. The BILCO Company.
    b. Dur-Red Products.
    c. Halliday Products.
    d. USF Fabrication by Eagle Manufacturing Company.

2.2 MATERIALS

A. Aluminum:

1. Sheet and Plate: ASTM B209.
2. Extruded shapes: ASTM B221.

B. Steel:

1. Sheet Metal: G90 Galvanized, ASTM A653/A653M.
2. Fabrications: Hot-Dip Galvanized, ASTM A123/A123M.
3. Hardware: Hot-Dip Galvanized, ASTM A153/A153M.

C. Stainless Steel: ASTM A240/A240M or A666.

2.3 MANUFACTURED UNITS

A. General:

1. All access doors shall be provided by the same manufacturer when possible.
2. Coat all aluminum components in contact with concrete or masonry with manufacturer's standard bituminous coating.

B. H-20 Loading Doors:

1. Frame: 1/4 inches mill finish aluminum channel with anchor tabs.
    a. 1-1/2 inches diameter drain coupling.
2. Cover:
    a. 1/4 inches mill finished diamond plate aluminum.
    b. Reinforce cover with aluminum stiffeners.
        1) Reinforced for AASHTO H-20 wheel loading for use in off street applications.
        2) Deflection: Maximum 1/150 of span.
3. Hardware:
    a. All hardware to be stainless steel.
    b. Positive hold open arm that engages automatically when door reaches full 90 degree open position.
    c. Slam lock and removable key handle.
4. The BILCO Company, Type "J H-20 inches or "JD H-20."
    a. Size(s): Refer to the SCHEDULES Article in PART 3 of this Specification Section.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

3.2 SCHEDULES

A. See Drawings for precast concrete structures requiring access doors and sizes.

END OF SECTION

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SECTION 08 33 23
STEEL ROLLING OVERHEAD DOORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel rolling overhead doors.
2. Manual Operators.
3. Control Systems.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 01 61 03 - Equipment - Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American National Standards Institute (ANSI).
2. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE):
   a. 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
3. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   c. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   d. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   e. A307, Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength.
   f. A500/A500M, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
   g. A501/A501M, Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
   h. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   i. E90, Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
   j. E283, Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen.
   k. E330, Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference.
   l. F3125/F3125M, Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions.
4. Door & Access Systems Manufacturers' Association, International (DASMA):
   a. ANSI/DASMA 108, Standard Method for Testing Sectional Garage Doors and Rolling Doors: Determination of Structural Performance Under Uniform Static Air Pressure Difference.
5. International Energy Conservation Code (IECC).

6. National Electrical Manufacturers Association (NEMA):
    a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
7. Underwriters Laboratories, Inc. (UL):
    a. 325, Standard for Door, Drapery, Gate, Louver, and Window Operators and Systems.

B. Qualifications:

1. Installer to be licensed or approved in writing by door manufacturer.

1.3 DEFINITIONS

A. Installer or Applicator:

1. Installer or applicator is the person actually installing or applying the product in the field at the Project site.
2. Installer and applicator are synonymous.

1.4 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
    a. Acknowledgement that products submitted meet requirements of standards referenced.
    b. Manufacturer's installation instructions.
    c. Manufacturer's standard color charts.
2. Schedule of doors using same reference number for openings as indicated on Drawings.
3. Motor operator and accessories technical data including complete wiring and control diagrams.
4. Certifications:
    a. Certification of installer qualifications.
5. Test Reports:
    a. Test report showing compliance with ASTM E330 or ANSI/DASMA 108 for the design pressure based on the wind speed specified.

B. Samples:

1. Actual metal color samples of manufacturer's full line of colors available.

C. Contract Closeout Information:

1. Operation and Maintenance Data:
    a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

D. Informational Submittals:

1. Warranty.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Steel rolling overhead doors:
    a. CornellCookson.
    b. Wayne Dalton.
    c. Overhead Door Corporation.
    d. Raynor Garage Doors.

2.2 PERFORMANCE AND DESIGN REQUIREMENTS

A. Design Wind Load:

1. Test door assemblies in accordance with ASTM E330 or ANSI/DASMA 108.
2. Exterior doors:
   a. Determine static pressure in accordance with applicable test method.
   b. Basic Wind Load Design Criteria: See Section 01 81 10.
3. Interior doors: 20 psf minimum.

B. Air Infiltration:

1. Meet ASHRAE 90.1 and IECC 2012/2015 C402.4.3.
2. Air leakage: <1.00 cfm/SQFT.

C. Thermal performance:

1. NFRC test report: U-factor: 0.10.

D. Sound Rating:

1. ASTM E90.
2. Minimum assembly rating: STC-21.

2.3 MATERIALS

A. Steel:

1. Hot dipped galvanized:
   a. Fasteners: ASTM A153/A153M.
   b. All other components: ASTM A123/A123M.
2. Bars, shapes, and plate: ASTM A36/A36M.
3. Pipe: ASTM A53/A53M or A501/A501M.
4. Tubing: ASTM A500/A500M.
5. Bolts and nuts: ASTM A307 or F3125/F3125M.

B. Insulation:

1. Closed cell polyurethane foam.
2. CFC free.

C. Weatherproofing:

1. Resilient: Neoprene or vinyl.
2. Brush type: Nylon or polypropylene.

D. Fasteners: Same material as door construction.

2.4 MANUFACTURED UNITS

A. Door Curtain:

1. Insulated flat profile:
   a. Overhead Door Corp. "592 Series".
   b. 2-5/8 inches high.
   c. Interlocking face sheets:
      1) Exterior face: 0.040 inches.
      2) Interior face: 0.024 inches.
   d. Galvanized endlocks.
   e. Core: Insulated.
2. Bottom bar:

a. Two structural angles bolted back-to-back.
1) Minimum 1/8 inches thick.

B. Operation:
1. Chain hoist operated.

C. Guides:
1. Manufacturer's standard structural angle guide system for size of door specified.
a. Galvanized Steel.
b. Furnish curtain wind locks as necessary for design wind load.
2. Mounting:
a. Interior face of wall.
3. Cold-rolled guides are not acceptable.

D. Headplates:
1. Sized to support counterbalance assembly, curtain, manual operator and hood.
a. Field verify headroom and side clearances and coordinate motor operator mounting accordingly.

E. Counterbalance Assembly:
1. Pipe barrel:
a. Galvanized Steel.
b. Maximum deflection: 0.03 inches/FT.
2. Torsion springs:
a. Oil-tempered helical torsion springs on cast anchors.
b. 100,000 cycle.
3. Adjustable tension wheel.

F. Hood:
1. Minimum 24 GA.
2. Air baffle extending full length.

G. Weatherstripping:
1. Guide tracks: Exterior and interior weatherseal.
2. Lintel: Brush-type weatherseal.
3. Bottom seal:
a. Manually-operated doors: Resilient weather seal.

H. Finish:
1. Powder coat:
a. Factory prime and finish coats.
b. Prime coat: Minimum 0.2 mil baked-on prime paint.
c. Finish coat: Minimum 0.6 mil baked-on polyester powder coat.
d. Color: To be selected by Engineer from manufacturer's complete offering.
2. Trim Pieces: Material and finish to match door curtain.

2.5 ACCESSORIES

A. Chain Hoist:
1. Chain keeper locks for chain hoist operation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Installation shall be done by manufacturer's authorized representative.

C. Provide all required trim, weatherstripping, closures etc., for complete weather tight installation.

D. Adjust for proper counter balance.

E. Seal along bottom of vertical track (guides), seal the vertical joint between the two separate track angles (if not filled by welding) and seal all holes in vertical track (not being used for fasteners) to provide a completely weather tight track and door system.

1. At fastener locations provide steel washers under bolt head to completely cover the slotted holes in the vertical track.

a. Finish of steel washer shall match finish of track (guides).

F. Electrical disconnect and conduit and wiring from standard three pushbutton control to motor operator is provided in the Electrical Design.

G. Provide bracing for motor operator to eliminate vibration.

3.2 ADJUSTMENT

A. Prior to occupancy, adjust door for smooth operation.

END OF SECTION

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SECTION 08 70 00
FINISH HARDWARE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Finish hardware.
2. Inspection and testing of door operation.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 08 11 00 - Metal Doors and Frames.

1.2 QUALITY ASSURANCE

A. All door hardware shall be provided by a single hardware supplier.

1. Hardware is to be provided under this Specification Section, unless noted otherwise, for doors specified in:
    a. Specification Section 08 11 00.

B. Referenced Standards:

1. Americans with Disabilities Act (ADA):
    a. Accessibility Guidelines for Buildings and Facilities (ADAAG).
2. American National Standards Institute/Builders Hardware Manufacturers Association (ANSI/BHMA):
    a. A156.1, Butts and Hinges.
    b. A156.3, Exit Devices.
    c. A156.4, Door Controls -Closers.
    d. A156.6, Architectural Door Trim.
    e. A156.8, Door Controls - Overhead Stops and Holders.
    f. A156.13, Mortise Locks.
    g. A156.16, Auxiliary Hardware.
    h. A156.18, Materials and Finishes.
    i. A156.21, Thresholds.
3. American National Standards Institute/Steel Door Institute (ANSI/SDI).
    a. A250.8, Specifications for Standard Steel Doors and Frames (SDI-100).
4. Door and Hardware Institute (DHI).
5. National Fire Protection Association (NFPA):
    a. 101, Life Safety Code.

C. Qualifications:

1. Installation shall be inspected by a certified Architectural Hardware Consultant (AHC).

1.3 DEFINITIONS

A. AHC: Architectural Hardware Consultant, certified by DHI.

B. Installer or Applicator:

1. Installer or applicator is the person actually installing or applying the product in the field at the Project site.
2. Installer and applicator are synonymous.

C. All weather: Capable of operation from -50 to +120 degrees F.

D. Active Leaf: Right-hand leaf when facing door from keyed side unless noted otherwise on Drawings.

1.4 SUBMITTALS

A. Shop Drawings:

1. Qualifications
   a. AHC qualifications.
2. Certification from AHC stating:
   a. All door hardware has been reviewed by AHC and verified to be compatible with doors and frames.
   b. All electrified door hardware has been reviewed by AHC and has been coordinated with power supply and access control system.
   c. No submittals will be reviewed until Engineer has received AHC certification.
3. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Manufacturer's installation instructions.
4. Schedule of all hardware being used on each door.
   a. Number hardware sets and door references same as those indicated on Drawings.
5. Technical data sheets on each hardware item proposed for use.
6. Warranty information for all hardware devices having extended warranties.

B. Informational Submittals:

1. Certifications:
   a. Certification from AHC stating all door hardware has been provided per approved Shop Drawings, has been installed in accordance with manufacturer's recommended installation instructions and all doors have been inspected and tested and found to be in proper working order.
      1) Door assemblies required to swing in the direction of egress have been inspected and tested in accordance with NFPA 101.

C. Contract Closeout Information:

1. Operation and Maintenance Data:
   a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

1.5 WARRANTY

A. Provide all individual manufacturers' extended warranties as advertised.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Hinges:
   a. Hager Companies.
   b. McKinney Manufacturing Co.
   c. Stanley by dormakaba Holding, Inc.
2. Locksets and latchsets:
   a. Best Access Solutions, Inc. by dormakaba Holding, Inc.
   b. Corbin Russwin, Inc. by ASSA ABLOY.

3. Exit devices:
    a. Corbin Russwin, Inc. by ASSA ABLOY.
    b. PRECISION by dormakaba Holding, Inc.
    c. SARGENT Manufacturing Company by ASSA ABLOY.
    d. Von Duprin by Allegion PLC.
4. Closers:
    a. Corbin Russwin, Inc. by ASSA ABLOY.
    b. LCN by Allegion PLC.
    c. Norton by ASSA ABLOY.
5. Door stops and holders:
    a. Trimco.
    b. Rockwood by ASSA ABLOY.
    c. IVES by Allegion PLC.
6. Overhead stops:
    a. Glynn-Johnson by Allegion PLC.
    b. Rockwood by ASSA ABLOY.
    c. Trimco.
    d. Rixson by ASSA ABLOY.
7. Weatherstripping and thresholds:
    a. Pemko by ASSA ABLOY.
    b. Reese Enterprises, Inc.
    c. Zero International, Inc.
    d. National Guard Products.
8. Door bolts, coordinators and strikes:
    a. IVES by Allegion PLC.
    b. Trimco.
    c. Hager Companies.
    d. Rockwood by ASSA ABLOY.
    e. dormakaba.
9. Other materials: As noted.

2.2 MATERIALS

A. General: As indicated in the FABRICATION Article in PART 2 of this Specification Section.

B. Fasteners: Stainless steel or aluminum.

C. Closers:

1. Corrosion resistant closer:
    a. Body: Aluminum.
    b. All other components and fasteners: Stainless steel.
    c. Closer arm bushing: Bronze.

D. Kickplates:

1. Stainless steel.

E. Thresholds: Aluminum.

F. Overhead Stops and Wall Stops: Stainless steel or aluminum.

G. Keys: Brass or bronze.

H. Weatherstripping and Smoke Seals: Polypropylene, neoprene, or EPDM.

I. Pulls and Push Plates: Stainless steel.

J. Silencers: Rubber.

2.3 COMPONENTS

A. Hinges:

1. Butt hinges:
   a. ANSI/BHMA A156.1.
      1) A5111: Stainless steel, full-mortise, anti-friction bearing, Grade 1.
   b. Ball bearing.
   c. Flat button tips.
   d. Butt hinges:
      1) Hager BB1199.
      2) McKinney T4B3386.
   e. Hinge size:
      1) Doors up to and including 46 inches wide: 4.5 inches x 4.5 inches.
      2) Doors over 46 inches up to and including 60 inches wide: 5 inches high x 4.5 inches.

B. Mortise Locks and Latches:

1. ANSI/BHMA A156.13, Series 1000, Operational Grade 1, Security Grade 1.
   a. Meet requirements of ADA.
2. Antifriction two-piece mechanical latchbolt with stainless steel anti-friction insert.
   a. One-piece stainless steel deadbolt, minimum 1-1/4 inches x 9/ 16 inches thick with 1 inch throw.
   b. 2-3/4 inches backset.
   c. Cylinder: Brass, 6-pin, with interchangeable core.
      1) Match existing keyway.
   d. ADA compliant thumb turn lever.
3. Locking, latching and retracting mechanism and lock case:
   a. Steel, unless noted otherwise.
      1) Chrome or zinc dichromate plated.
   b. Corrosion resistant: Non-ferrous lock case.
      1) Provide non-ferrous lock case on doors scheduled to receive corrosion resistant closers.
4. Trim design: Corbin Russwin, Inc. "NSP" or equal.
   a. Functions as indicated in following table in accordance with ANSI/BHMA A156.13.

MORTISE LOCK NUMBERS		
ANSI	FUNCTION	CORBIN RUSSWIN, INC.
F01	Passage	ML2010
F19	Privacy	ML2030
F05	Classroom	ML2055
F07	Storeroom	ML2057
F13	Entrance or Office	ML2065

C. Exit Devices:

1. ANSI/BHMA A156.3, Grade 1.
2. Single doors: Mortise.
3. Pairs of doors: Concealed vertical rods.
4. Trim: Sargent “ET”.
    a. Lever operation.
    b. Lever style: Sargent "L".
5. Sargent "80 Series".
    a. Function as indicated on Hardware Schedule.

D. Bolts:

1. ANSI/BHMAA 156.16.
2. Surface bolts: Rockwood 580 Series with top and bottom strikes.

E. Door Closers:

1. ANSI/BHMA A156.4, Grade 1.
2. Size door closers to comply with ANSI recommendations for door size and location.
3. Fabricate all closers with integral back check.
4. Provide integral stop unless noted otherwise.
    a. Do not provide integral stop at closers indicated to be installed on pull side of door.
    b. Provide all weather fluid for all closers used in exterior doors .
5. Full cover.
    a. Manufacturer's standard plastic cover.
6. Arms, brackets, and plates: As required for complete installation.
7. Closers:
    a. Corrosion resistant: Norton 7500 SS Series.
8. Provide manufacturer's standard 10 year warranty.

F. Door Stops:

1. ANSI/BHMA A156.16.
    a. Wall stops: IVES WS406-CVX or WS406-CCV.

G. Overhead Door Holders/Stop:

1. ANSI/BHMA A156.8.
2. Provide 'hold-open' function on all stops unless noted otherwise.
    a. Do not provide ‘hold-open’ function at fire rated doors.
3. Surface mounted stops: Rockwood N14400 Series or Glynn Johnson 90 Series.
4. Concealed stops: Rockwood N11000 Series or Glynn Johnson 100 Series.

H. Kickplates:

1. ANSI/BHMA A156.6.
2. 8 inches high x 2 inches less than door width.
3. Beveled on all edges.
1. Thickness:
    a. Stainless steel: 0.050 inches.

I. Thresholds:

1. ANSI/BHMA A156.21.
2. One-piece unit.
3. Height: 1/2 inches high maximum.
4. Width: 4 inches.

5. Provide required bolt cutouts.

J. Weatherstripping:

1. Weather seal at jambs and head:
   a. Self-adhesive strip: Reese #797.
   b. Color: Black.
2. Sweep at bottom of doors:
   a. Reese 701.
   b. Color: Clear anodized.
3. Weather seal astragal at meeting edges of pairs of doors:
   a. Reese 92 each leaf.
   b. Color: Clear anodized.

2.4 ACCESSORIES

A. Silencers:

1. Hollow metal frames: Trimco 1229A or Rockwood 608.
2. Self-adhesive silencers are not acceptable.

B. Keying:

1. Establish keying with Owner.
   a. Provide and set up complete visible card indexed system with key tags and control slips.
   b. Tag and identify keys.
   c. Provide two keys for each lock or cylinder.
   d. Master key and key in groups as directed.
   e. Provide construction master keys for all exterior doors.
   f. Key to existing master key system.

C. Strikes:

1. Curved lips.
   a. Extended lips when required.
2. Furnish strike boxes.
3. Appropriate for function and hardware listed.

2.5 FABRICATION

A. General:

1. Generally prepare for Phillips head machine screw installation.
2. Exposed screws to match hardware finish or, if exposed in surfaces of other work, to match finish of other work as closely as possible.
3. Provide concealed fasteners unless thru bolted.
4. Through bolt closers on all doors.
5. Furnish items of hardware for proper door swing.
6. Furnish lock devices which allow door to be opened from inside room without a key or any special knowledge.

B. Hardware:

1. Provide following ANSI/BHMA A156.18 finishes:
   a. Locksets, latchsets and strikes: 630.
   b. Door pulls, push bars, push plates: 630.
   c. Kickplates:

1) Stainless steel: 630.

d. Exit devices: 630 where available; 626 if 630 is not available.

1) Provide 630 finish on trim.

e. Butt hinges: 630.

f. Door stops, dead locks, mortise bolts, and miscellaneous hardware: 630 where available, 626 if 630 not available.

g. Door overhead stops: 630.

h. Closers: 600 prime coat with 689 finish coat, unless noted otherwise.

1) Corrosion resistant closers: 630.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's installation instructions.

1. Perform installation by or under the direct supervision of an AHC.

B. Provide all hardware in accordance with the building code.

C. Fit hardware before final door finishing.

D. Permanently install hardware after door finishing operations are complete.

E. Locate hardware in accordance with ANSI/SDI A250.8.

F. Butt Hinges:

1. Provide non-removable pin (NRP) at:
   a. Exterior doors.
   b. Reverse handed doors equipped with locks.
2. Quantities:
   a. Door height 61 - 90 inches: Three.
   b. Door height 91 - 114 inches: Four.
3. Provide power transfer as necessary where electrified lockset or exit device is specified or as otherwise indicated in Hardware Schedule.

G. Closers:

1. Mount closers on push side of doors unless noted otherwise.

H. Provide coordinator when required by hardware specified.

I. Overhead Stops:

1. Provide overhead stop when corrosion resistant closer is specified.
2. Provide concealed overhead stop on doors scheduled to receive closer mounted on pull side of door.
3. Provide at interior doors not scheduled to receive a closer as follows:
   a. Doors that swing more than 105 degrees without encountering a wall or obstruction.
      1) Stop shall limit swing of door from impacting wall or obstruction.
   b. Inactive leafs of pairs of doors.

J. Wall Mount Door Stops:

1. Provide where specifically indicated on Hardware Schedule and at doors not otherwise indicated to receive:
   a. Overhead stop.
   b. Closer with integral stop.

K. Floor mounted stops are not acceptable unless noted otherwise in this Specification Section.

L. Provide silencers for door frames.

1. Hollow metal frames: See Specification Section 08 11 00.

M. Provide weather seal, door sweep and threshold at all exterior doors and where scheduled on interior doors.

1. Set thresholds in a full bed of sealant.
2. Mount door sweeps on exterior face of door.
3. Mount weather seal astragal at meeting edges of pairs of doors on the exterior face of the doors.

N. Provide smoke seals on all fire rated doors.

O. Mount kickplates on push side of doors.

3.2 FIELD QUALITY CONTROL

A. Adjust and check each operating item of hardware to assure proper operation or function.

1. Lubricate moving parts with lubricant recommended by manufacturer.

B. During week prior to startup, make a final check and adjustment of all hardware items.

1. Clean and lubricate as necessary to assure proper function and operation.
2. Adjust door control devices to compensate for operation of heating and ventilating equipment.

C. Inspection and Testing:

1. AHC shall inspect and test all door assemblies and provide written certification that door assemblies are in proper working order.
   a. Door assemblies required to swing in the direction of egress shall be inspected and tested in accordance with NFPA 101.
2. Submit documentation and certification of testing in accordance with the certifications paragraph in the SUBMITTALS Article in PART 1 of this Specification Section.

3.3 SCHEDULES

A. Hardware Schedule:

HARDWARE SCHEDULE			
Hardware Set	Quantity	Unit	Description
HW-1 Single Doors	1 1/2	PR	Butt Hinges
	1	EA	Mortise Latchset – Classroom Function
	1	EA	Exit Device
	1	EA	Closer with Stop – Push Side Mounted
	1	EA	Kickplate
	1	EA	Theshold
	1	EA	Sweep
	1	EA	Weatherstripping
	3	EA	Silencers

HARDWARE SCHEDULE			
Hardware Set	Quantity	Unit	Description
HW-2 Double Doors	1 1/2	PR	Butt Hinges with NRP
	1	EA	Mortise Latchset – Classroom Function
	1	EA	Surface Bolts – Top and Bottom
	1	EA	Exit Device
	1	EA	Closer with Stop – Push Side Mounted
	2	EA	Kickplates
	1	EA	Theshold
	1	EA	Sweep
	1	EA	Weatherstripping
	4	EA	Silencers

B. Nonferrous Lock Case Schedule:

1. Provide nonferrous lock case on doors located in Screen Room. See Door and Frame Schedule in Drawings.

END OF SECTION

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SECTION 08 90 00
LOUVERS AND VENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Louvers and vents.

B. Related Sections include but are not necessarily limited to:

1. Section 07 62 00 - Sheet Metal Flashing and Trim.
2. Section 07 92 00 - Joint Sealants.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. Aluminum Association (AA):
   a. DAF 45, Designation System for Aluminum Finishes.
2. Air Movement and Control Association (AMCA).
3. ASTM International (ASTM):
   a. B221, Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.

1.3 SUBMITTALS

A. Shop Drawings:

1. Drawing showing location of each louver or vent, indicating size and arrangement of blank-off plates if required.
2. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Manufacturer's installation instructions.
   c. Color chart showing manufacturer's full line of colors including exotic and special colors for color selection by Engineer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Louvers:
   a. Airolite Company LLC.
   b. Construction Specialties, Inc.
   c. Ruskin Company.
   d. Industrial Louvers, Inc.
   e. American Warming and Ventilating.

2.2 MANUFACTURED UNITS

A. Louvers:

1. 4 inches deep.
2. Drainable with blades at 37-1/2 degrees.
3. Continuous blade appearance.

4. ASTM B221 extruded aluminum, alloy 6063T5, minimum 0.081 inches thick.
5. Minimum free area: 8.58 square feet for 4 x 4 feet louver.
6. Maximum pressure drop: 0.10 inches of water at 700 fpm.
7. Water penetration: 0.01 oz/SQFT at 873 fpm.
8. AMCA certified.
9. Ruskin "ELF 375DX".
10. Insect screen:
    a. 18-16 mesh aluminum.
    b. Install in standard aluminum frame.

B. Anchors, Fasteners, Reinforcing: Aluminum or stainless steel.

C. Finish:

1. Architectural Class 1 coating per AA DAF 45.
    a. AA-M12C22A41 clear anodized.

D. Size: Refer to Mechanical Drawings for louver size, and refer to Architectural Drawings for louver shapes.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install anchoring and bracing accessories as required.

C. Seal around perimeter on exterior and interior.

1. See Section 07 92 00.

D. Install 0.040 inches aluminum flashing at sill to match louver.

1. See Section 07 62 00.

END OF SECTION

DIVISION 09

FINISHES

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SECTION 09 22 16
NON-STRUCTURAL METAL FRAMING

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, tools, equipment, and services for Non-Structural Metal Framing in accordance with provisions of Contract Documents.

B. Completely coordinate with work of other trades.

1.2 REFERENCES

A. The American Iron and Steel Institute (AISI):

1. AISI S220 North American Standard for Cold-Formed Steel Framing – Nonstructural Members.

B. ASTM International (ASTM):

1. ASTM C635 Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings
2. ASTM C645 Standard Specification for Nonstructural Steel Framing Members.
3. ASTM A653 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
4. ASTM C754 Standard Specification for Installation of Steel Framing Members to Receive Screw-Attached Gypsum Panel Products.
5. ASTM A1003 Standard Specification for Steel Sheet, Carbon, Metallic and Nonmetallic-Coated for Cold-Formed Framing Members.

C. Gypsum Association (GA):

1. GA-216 Application and Finishing of Gypsum Panel Products.
2. GA-234 Control Joints for Fire-Resistance Rated Systems.

1.3 SUBMITTALS

A. Shop Drawings:

1. Sizes and spacing of typical framing members and opening framing.
2. Show locations and sizes of atypical framing members, wall framing sections, and opening elevations.
3. Methods of fastening framing members to each other and to supporting systems.
4. Details of vertical deflection connections to structures.
5. Locations and spacing of lateral bracing and structural bracing systems.
6. Accessory products required for complete installation.

B. Product Data:

1. Manufacturer’s specifications for each type of material and accessory.
    a. Where fire resistance classification is indicated, submit copies of nationally recognized testing laboratory listings of products proposed for use.
2. Where EQ coatings are used, submit copies of nationally recognized testing laboratory results showing conformance with ASTM A653 and AISI S220.
    a. Include data required to show specification compliance.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Member of Certified Steel Stud Association (CSSA), Steel Framing Industry Association (SFIA), or Steel Stud Manufacturers Association (SSMA).

A. Code-Compliance Certification of Studs and Tracks:

1. Provide documentation that framing members are certified according to the product-certification program of the Certified Steel Stud Association, the Steel Framing Industry Association, or the Steel Stud Manufacturers Association.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Non-Structural Metal Framing:

1. Base:
   a. ClarkDietrich Building Systems
2. Optional:
   a. CEMCO Steel Framing and Metal Lath
   b. Custom Stud Inc.
   c. Marino/WARE
   d. MBA Metal Framing
   e. MRI Steel Framing LLC
   f. Telling Industries
   g. The Steel Network

B. Flexible Track:

1. Base:
   a. ClarkDietrich Building Systems
2. Optional:
   a. The Steel Network
   b. Flex-Ability Concepts

C. Isolation Strip Material:

1. Base:
   a. Reflectix, Inc.
2. Optional:
   a. Saint-Gobain

D. Knee Wall Brace:

1. Base:
   a. Pittcon Industries
2. Optional:
   a. ClarkDietrich Building Systems

E. Interlocking Grid Support Systems for Gypsum Board Ceilings:

1. Base:
   a. USG Corporation
2. Optional:
   a. Armstrong
   b. Chicago Metallic

F. Other manufacturers desiring approval comply with Section 01 61 00.

G. Products proposed for use in fire-rated assemblies:

1. Approved by nationally recognized testing laboratory.

2.2 DESIGN CRITERIA

A. Select steel studs in accordance with manufacturer's standard load tables and following design pressures and maximum deflections:

Performance Criteria		
Use Condition [2]	Design Pressure	Maximum Deflection
Wall enclosing stairs, elevator hoistways, and other vertical shafts	10 pounds/SF 480 Pa	L/240
Wall enclosing vestibules, ground floor lobbies, and similar spaces subject to intermittent exposure to exterior wind conditions	15 pounds/SF 720 Pa	L/240
Walls scheduled with Tile Backer Board, Moisture-Resistant, Impact-Resistant, or Abuse-Resistant Gypsum Wallboard	5 pounds/SF 240 Pa	L/360
Walls scheduled to receive Tile, lath and plaster, or veneer plaster. [1]		L/360
Typical Interior Walls/Partitions (those not listed above)	5 pounds/SF 240 Pa	L/240
Interior Ceilings, Soffits and Bulkheads	5 pounds/SF 240 Pa	L/360

Footnotes

1. Limit deflection to L/360 where wall cladding on either face is any of the following: Ceramic Tile, Stone Tile, Porcelain Tile, Thin Brick, Lath & Plaster, Simulated Masonry, Adhered Stone, Veneer Plaster, and similar brittle finishes which are prone to movement induced cracking.
2. Where elements meet multiple conditions; Use most stringent Deflection and Design Pressure values.

2.3 MATERIALS

A. Metal Studs and Floor Tracks:

1. C-shaped, roll formed studs and tracks conforming to ASTM C645.
2. Steel design standard: 33KSI 227 MPa.
3. Galvanized: G40 or G40EQ conforming to ASTM A653 and AISI S220.
4. Stud and track depths: As indicated by wall type.
5. Minimum flange width: 1-1/4-inch 6 mm.
6. Minimum thickness: 30 mil (20 GA) 0.752, except as follows:
   a. Increase member thickness to comply with performance criteria.
   b. Decrease member thickness to minimum 18 mil (25 GA) 0.46 mm studs at following condition:
      1) Where walls do not extend to overhead structural deck and supporting diagonal bracing or horizontal stiffeners are used.
7. In lieu of increased member thickness, design may employ diagonal braces above ceiling to reduce overall span.
   a. Coordinate locations with building services items.
   b. Do not employ studs with member thickness less than allowed by fire resistance rated assemblies.
8. High strength 50 ksi 345 MPa or 70 ksi 483 MPa studs shall comply with design criteria of equivalent thickness standard 33 ksi 227 MPa studs listed.
9. At walls designated STC 40 and above, use only studs with physical characteristics of studs used in documented STC testing.
10. Base product: ProSTUD Drywall Framing by ClarkDietrich.
11.

B. Flexible Track:

1. Adjustable segmented track fabricated from same material, gauge, and width as specified for straight track.
2. Use at curved walls and soffits.
3. Base product: 360Trak by ClarkDietrich.

C. Head of Wall Accessories:

1. Configure to accommodate deflection of superstructure without inducing axial loading on partition wall.
2. Maintain structural integrity, fire and smoke-resistance, and sound control as required by each wall.
3. Slotted top deflection track:
   a. Deep leg, vertically slotted track.
   b. Cold-formed sheet steel; galvanized; G60.
   c. Thickness: 30 mil (20 GA) 0.752 mm minimum.
   d. Width: As required for stud sizes indicated.
   e. Depth: Minimum 2-1/2-inch 63 mm down-standing legs with 1/4-inch 6 mm wide by 1-1/2-inch 38 mm high slots spaced 1 inch 25 mm on center.
   f. Base product: MaxTrak by ClarkDietrich.
4. Z-bars, cold formed channels, and clips:
   a. Accommodate thickness of spray-applied fire-resistive materials.
5. UL-listed fire-resistant components tested for compliance with requirements indicated.
6. Firestopping Materials:
   a. Sealants, sprays, intumescent strips and forming materials.
   b. Coordinate with sealants specified in Section 07 84 00 and Section 07 92 00.
   c. Intumescent applications:
      1) Factory or field applied.
   d. Base product: Blazeframe by ClarkDietrich.

D. Shaftwall Framing:

1. C-T or C-H shaped studs with U or J shaped tracks.
2. Material: Galvanized steel; G40 or certified equivalent.
3. Thickness: 30 mil (20 GA) 0.752 mm minimum.
4. Size: 2-1/2, 4, and 6 inches 63, 100, and 150 mm minimum as indicated.
5. Structural design criteria:
   a. Select stud with properties necessary to limit deflection to L/240 deflection at load of 10 psf 480 Pa.
   b. Use larger size and thickness to satisfy span and deflection criteria.
6. Shaftwall assembly with gypsum wallboard specified in Section 09 29 00:
   a. Fire resistance tested in accordance with ASTM E119.
   b. Sound transmission loss: Tested in accordance with ASTM E90.
7. Base product: Shaftwall System by ClarkDietrich.

E. Z-Bar Standoff Clips:

1. 30 mil (20 GA) 0.752 mm galvanized steel.
2. Provide Z-bars for attachment of top track to superstructure elements which are to be protected with sprayed fireproofing.
   a. Size: 2 by 2 by 2 inch 50 mm x 50 mm x 50 mm.
3. Length:

a. As required to accommodate beam and deck fireproofing.
    1) At structural steel member: Length equal to flange width of structural steel member.
    2) At steel deck: Minimum length equal to partition width, or as required to span steel deck flutes.
b. Extend length of Z-bar to accommodate partition offset that will not clear fireproofed steel beam.

F. Furring Channels:
1. Hat shaped sections.
2. Galvanized: G40 or certified equivalent.
3. Sizes: 7/8 inch 22 mm and 1-1/2 inch 38 mm, as indicated.
4. Minimum Thickness: 30 mil (20 GA) 0.752 mm; Use heavier gauge as dictated by conditions.
5. Base product: Furring Channel/ Hat Channel by ClarkDietrich.

G. Metal Backing:
1. General:
    a. See Drawings for applications of backing types listed and further details.
    b. Use heavier gauge as necessary for items to be supported.
    c. Comply with manufacturer's backing requirements if capacity exceeds types listed.
2. Flat Plate (Type A):
    a. Flat, sheet metal stock per ASTM A1008.
    b. G40 galvanized or certified equivalent.
    c. Thickness: 43 mil (18 GA) 1.27 mm minimum.
3. Metal Backing (Type B):
    a. C-shaped modified track runners.
    b. G40 galvanized or certified equivalent.
    c. Backing height: 6 inches 150 mm minimum.
    d. Flange width: 1-1/4-inch 32 mm minimum.
    e. Thickness: 30 mil (20 GA) 0.95 mm minimum.
    f. May be installed continuously across multiple stud spaces.
    g. Use where no other type of backing is designated.
4. Metal Backing (Type C):
    a. C-shaped modified track runners.
    b. G40 galvanized or certified equivalent.
    c. Backing height: 8 inches 200 mm minimum.
    d. Flange width: 1-1/4-inch 32 mm minimum.
    e. Thickness: 54 mil (16 GA) 1.5 mm minimum.
    f. Install at single stud space with properly oriented studs.
5. Hospital and Laboratory casework and wall mounted medical equipment without specific backing requirements:
    a. Type B backing as listed above with revised minimum thickness.
    b. Thickness: 54 mil (16 GA) 1.5 mm minimum.
        1) Use heavier gauge as necessary for items to be supported.

H. Accessory Items:
1. Wire Ties:
    a. Minimum thickness: 43 mil (18 GA) 1.09 mm soft annealed, galvanized.

2. Track Fasteners:
    a. Power driven type, to withstand minimum 190 pounds 86 kg shear when driven.
3. Knee Wall Brace:
    a. Steel tube and baseplate bolted to concrete floor slab with tube projecting vertically; concealed within framed walls to provide structural stability for knee walls.
    b. Design components compatible with wall type.
    c. Material: Cold-rolled steel tube and base plate.
    d. Fully welded.
    e. Overall height: Wall height less 2 inches 50 mm.
    f. Spacing as recommended by manufacturer.
    g. Base product: SKB Series by Pittcon Industries.

I. Support Systems for Gypsum Ceilings:

1. Interlocking Grid Systems:
    a. ASTM C635, direct-hung system composed of T-Shaped framing members designed to carry load of screw-applied gypsum ceiling board.
    b. Tabs on Cross-Tees to interlock into slots in Main Runners where intersections occur.
    c. Base Product: Drywall Suspension System by USG Corporation.
2. Track and Channel Systems:
    a. ASTM C645 roll-formed steel with G40 galvanized coating.
    b. Thickness: 30 mil (20 GA) 0.752 mm minimum; Use heavier gauge as dictated by conditions.
    c. Carrying channels:
        1) Size: 1-1/2-inch 38 mm.
    d. Furring channels:
        1) Sizes: 7/8-inch and 1-1/2-inch 22 mm x 38 mm, as indicated.
3. Stud-Framed Ceiling/Soffit Systems:
    a. C-shaped studs or joists; roll-formed.
    b. Galvanized: G40.
    c. Frame member depth: 3-5/8-inch 92 mm minimum, unless otherwise indicated.
        1) Use wider stud sections if ceiling span and support requires.
    d. Flange width: 1-1/4-inch 32 mm minimum.
    e. Stud thickness: 33 mil 0.838 mm minimum.
4. Tie Wire:
    a. ASTM A641, Class 1 zinc coating, soft temper.
    b. Diameter, single strand: 62 mil (14 GA) 1.575 mm minimum.
    c. Diameter, double strand: 42 mil (18 GA) 1.067 mm minimum.
5. Wire Hangers:
    a. ASTM A641, Class 1 zinc coating, soft temper.
    b. Diameter: 97 mils (12 GA) 2.46 mm minimum.
6. Anchors in Concrete:
    a. Anchors of type and material indicated below, with holes or loops for attaching hangers of type indicated and with capability to sustain, without failure, a load equal to 5 times that imposed by ceiling construction, as determined by testing per ASTM E488 or ASTM E1512 as applicable.
    b. Acceptable types: Cast-in-place, post-installed expansion anchors and post-installed bonded anchors.

c. Material: Carbon-steel components zinc plated to comply with ASTM-B633, Class Fe/Zn 5 for Class SC 1 service condition.

7. Powder-Actuated Fasteners in Concrete:
   a. Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hangers of type indicated, and with capability to sustain, without failure, a load equal to 10 times that imposed by ceiling construction, as determined by testing per ASTM E1190.
   b. Comply with seismic design requirements where applicable.
8. Other items including suspension wire, tie wire, attachment devices: As specified and indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine supporting structure and conditions under which system will be installed.

B. Correct conditions detrimental to proper installation.

C. Installation constitutes acceptance of responsibility for performance.

3.2 INSTALLATION - GENERAL

A. Layout and install metal framing accurate to dimensions indicated in drawings.

B. Installation Standard: ASTM C754, except comply with framing sizes and spacing indicated.

1. Gypsum Board Assemblies: Comply with additional requirements in ASTM C840 relative to framing installation.

C. Install supplementary framing, and blocking to support fixtures, equipment services, heavy trim, grab bars, toilet accessories, wall stops, furnishings, or similar construction.

D. Install bracing at terminations in assemblies.

E. Do not bridge building control and expansion joints with non-load-bearing steel framing members. Frame both sides of joints independently.

F. Where studs are installed directly against exterior masonry walls or dissimilar metals at exterior walls, install isolation strip between studs and exterior wall.

G. Extend framing full height to structural supports.

1. Exception: Where partitions are indicated to terminate at, or just above, suspended ceilings.
2. Continue framing around ducts and similar items which penetrate partitions.

H. Position studs vertically engaging floor track and head of wall deflection track.

1. Align stud knockouts to facilitate running of wires and conduit.

I. Space studs maximum 16 inches 400 mm on center.

1. Stud spacing at Shaftwall: 24 inches 610 mm on center.

J. Provide additional studs at corners, partition intersections and terminations of partitions, and at each side of control joints.

K. Positively anchor studs to floor tracks with self-tapping pan head screws, or stud clinching tool per ASTM C754.

L. Anchor studs to deflection track with wafer head screws on both flanges of each stud.

1. Maintain deflection gap between top of stud and top of slotted track.
2. Install screws at centerline of slot and secure allowing vertical movement.

M. Anchor fire rated partitions as required by fire resistance design, and firestopping design.

N. Where partitions abut vertical structural elements, provide perimeter relief per Gypsum Association GA-600 Strain Relief System details.

O. Head-of-Wall:

1. Provide slotted top track for walls extended to structure.
2. Configure to resist lateral loads while accommodating deflection of overhead building superstructure without inducing axial loading on partition framing.
3. Secure deflection track to structure in accordance with industry standards and regulatory requirements.
4. Secure at corners and at ends.
5. Cut vertical studs 5/8-inch 16 mm short to create a deflection gap when installed into top track.
    a. Secure vertical studs to top track with framing screw at each stud, screwing through track slots for positive stud connection.
6. Secure Gypsum Wallboard to vertical studs; do not secure Gypsum Wallboard to top track directly.
7. Where partitions attach to structural elements that are scheduled to receive Spray-applied Fire Resistive Materials (SFRM):
    a. Install Z-bar to underside of steel beams and steel deck before application of sprayed fireproofing.
    b. Locate Z-bars perpendicular to line of partition, spaced maximum 16 inches on center.
    c. Attach each Z-bar with two 0.145 by 1-inch 3.7 mm x 25 mm powder-actuated fasteners located minimum 1 inch from ends of Z-bar.
    d. After fireproofing, secure top track to Z-bars with No. 8 x 5/8-inch wafer head framing screws spaced maximum 16 inches 400 mm on center.
8. Where fire-rated partitions are offset and will not clear fireproofed steel beam, extend Z-bar outrigger horizontally from bottom of beam out to minimum 2 inches 50 mm beyond width of head-of-wall.
    a. Attach 3/4 inch 19 mm expanded metal lath continuous, width of top of Z-bar outriggers prior to fireproofing steel beam to accommodate sprayed fireproofing.
9. Prepare wall for installation of seals, firestopping, or both:
    a. Fire-rated Walls: Prepare for fire-resistive joint assemblies specified in Section 07 84 00.
    b. Non-fire rated partitions including Smoke Partitions: Prepare for Acoustical Sealant specified in Section 07 92 00.

P. Furring Channels:

1. Attach furring channel systems directly to parent walls.
2. Install channels at maximum 16 inches 400 mm OC.
3. Provide additional framing at openings, cutouts, corners, and control joints.
4. Space fasteners not more than 24 inches 610 mm OC, staggered on opposite flanges of furring channels.

3.3 FRAMING AT OPENINGS

A. Control Joints (CJ):

1. Install additional stud, maximum 1/2 inch 13 mm from jamb studs.
2. Do not fasten extra stud to track or jamb stud.
3. Refer to specification Section 09 29 00 for control joint locations.

B. Prefabricated headers, jambs, and sill framing systems option:

1. Proprietary opening framing systems may be used as an alternative to conventionally fabricated framing.

2. Pre-approved Products:
    a. HDS Framing System by ClarkDietrich.
    b. Quick Frame Rough Opening System by Marino/ Ware.

C. Door Openings:

1. Screw vertical studs at jambs to jamb anchor clips on door frames; install runner track section for cripple studs at head and secure to jamb studs. Screw into web of jamb stud.
2. Unless indicated otherwise, extend jamb studs through suspended ceilings and secure laterally to overhead structure.
3. Jamb Studs:
    a. Minimum thickness of jamb studs: 30 mil (20 GA) 0.752 mm at openings.
    b. Install two studs at each jamb, toe-to-toe unless otherwise indicated.
        1) Securely attach first stud to frame.
        2) Fill cavity between studs with acoustic batt insulation where required by acoustical rating of wall.
        3) Join second stud to first stud on each face with 30 mil (20 GA) 0.752 mm screw attached steel straps at 42 inches 1070 mm on center maximum.
4. Headers:
    a. Openings less than 4 feet 6 inches 1.37 M wide:
        1) Cut-to-length section of floor runner above and below wall openings.
        2) Cut flanges and bend webs at ends.
        3) Overlap and screw attach jamb studs to frames.
    b. Openings over 4 feet 6 inches 1.37 M wide:
        1) Cut-to-length, horizontal box beam studs above and below wall openings.
        2) Design for actual span and loading.
    c. Incorporate miscellaneous steel members, specified in Section 05 50 00, and wood blocking, specified in Section 06 10 00, where indicated.
5. Control Joints at head of jambs:
    a. Install cripple studs at head adjacent to each jamb stud, with a minimum 1/2-inch 13 mm clearance from jamb stud to allow for installation of control joint in finished assembly.
    b. Gypsum Wallboard control joints as specified in Section 09 29 00.

D. Other Framed Openings:

1. Frame openings other than door openings the same as required for door openings, unless otherwise indicated.
2. Cripple Studs:
    a. Install cut-to-length intermediate vertical studs above and below openings.
    b. Spacing: As indicated for typical full-length studs.
    c. Match stud framing below sills of openings to framing installed above opening.
3. Incorporate miscellaneous steel members, specified in Section 05 50 00, and wood blocking, specified in Section 06 10 00, where indicated.

3.4 WALL BACKING AND BLOCKING

A. Provide in-wall backing reinforcement where following items are mounted to interior walls and interior face of exterior walls:

1. Crash rails, chair rails, wall bumpers, and similar wall protection devices.
2. Wall-mounted door stops.
3. Contractor or Owner furnished equipment indicated to be wall mounted.
4. Toilet accessories that do not include proprietary backing devices.

5. Toilet partitions and lockers.
6. Markerboards, tackboards, and chalkboards.
7. Other wall-mounted items where backing is indicated by details or specification.

B. Metal Wall Backing requirements are described as Accessory Items in Part 2 of this section.

C. Wood Wall Blocking may be used where allowed by Code and Manufacturer of item to be supported. Specified in Section 06 10 00.

D. Verify metal stud framing has been installed to support wall-mounted items specified in Section 05 50 00.

E. Coordinate mounting height, location, and coverage with item to be supported.

F. Determine material width according to item to be supported.

G. Provide in-wall metal wall backing material to interior metal stud walls specified herein and Exterior stud walls specified in Section 05 40 00.

H. Attachment: Minimum 2 - #10 sheet metal screws at each stud.

3.5 CEILING FRAMING

A. Install in compliance with manufacturer's recommendations.

B. Provide required items to support and trim out neatly, flush or recessed mechanical and electrical items.

C. Frame openings in ceiling support system to accommodate access panels and similar openings and penetrations.

1. Completely frame openings with closed channel side of stud facing opening for support of recessed mechanical and electrical items.

3.6 CEILING SUPPORT SYSTEMS

A. Install suspension system components in sizes and spacing indicated on Drawings, but not less than required by referenced installation standards for assembly types and other assembly components indicated.

B. Isolate suspension systems from building structure where abutting or penetrated by building structure.

C. Suspend hangers from building structure as follows:

1. Install hangers plumb and free from contact with insulation or other objects that are not part of supporting structural or suspension system.
    a. Splay hangers only where required to miss obstructions and offset resulting horizontal forces by bracing, counter-splaying, or other equally effective means.
2. Where width of ducts and other construction within ceiling plenum interfere with locations of hangers required to support standard suspension system members, install supplemental suspension members and hangers in the form of trapezes or equivalent devices.
    a. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced installation standards.
3. Wire Hangers: Secure by looping and wire tying, either directly to structures or to inserts, eye screws, or other devices and secure fasteners appropriate for substrate.
4. Flat Hangers: Secure to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices and secure fasteners appropriate for structure and hanger.
5. Do not attach hangers to steel roof deck.
6. Do not attach hangers to permanent metal forms. Furnish cast-in-place hanger inserts that extend through forms.
7. Do not attach hangers to rolled-in hanger tabs of composite steel floor deck.

8. Do not connect or suspend steel framing from ducts, pipes, or conduit.

D. Grid Suspension Systems:

1. Attach perimeter wall track or angle where grid suspension systems meet vertical surfaces.
2. Mechanically join main beam and cross-furring members to each other and butt-cut to fit into wall track.
3. Install suspension systems that are level to within 1/8-inch 3 mm in 12 feet 3.66 M measured lengthwise on each member that will receive finishes and transversely between parallel members that will receive finishes.
4. Coordinate support requirements for in-ceiling devices with capacity of ceiling grid system.

END OF SECTION

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SECTION 09 29 00
GYPSUM BOARD

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Gypsum board.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 06 10 00 - Rough Carpentry.
2. Section 07 92 00 - Joint Sealants.
3. Section 09 22 16 - Non-Structural Metal Framing.
4. Section 09 96 00 - High Performance Industrial Coatings.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. ASTM International (ASTM):
   a. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   b. C475/C475M, Standard Specification for Joint Compound and Joint Tape for Finishing Gypsum Board.
   c. C840, Standard Specification for Application and Finishing of Gypsum Board.
   d. C1002, Standard Specification for Steel Self-Piercing Tapping Screws for Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs.
   e. C1047, Standard Specification for Accessories for Gypsum Wallboard and Gypsum Veneer Base.
   f. C1396/C1396M, Standard Specification for Gypsum Board.
   g. D3273, Standard Test Method for Resistance to Growth of Mold on the Surface of Interior Coatings in an Environmental Chamber.
2. Gypsum Association (GA):
   a. GA-214, Recommended Levels of Gypsum Board Finish.
3. Underwriters Laboratories, Inc. (UL):
   a. Building Materials Directory.
   b. Fire Resistance Directory.

1.3 SUBMITTALS

A. Shop Drawings:

1. Drawings of unusual conditions.
   a. Control joint layout.
2. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Manufacturer's installation instructions.
3. Manufacturer's adhesive, joint treatment compound and tape recommendations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Gypsum board and accessories:
    a. American Gypsum.
    b. Georgia-Pacific Gypsum LLC.
    c. National Gypsum.
    d. USG Corporation.

2.2 MATERIALS

A. General:

1. Provide UL Listed materials in fire-resistant rated construction.
2. Furnish in lengths as long as practicable.

B. Gypsum Board (GB):

1. ASTM C1396/C1396M.
2. Thickness: 5/8 inches unless noted otherwise.
3. Edges: Tapered.
4. Fire-rated board: Type X.
1. Water and Mold Resistant Gypsum Board (WRGB):
    a. Water-resistant core and treated paper facers.
        1) Smooth face for finishing similar to standard gypsum board.
    b. Mold-resistant: ASTM D3273.
    c. USG "Sheetrock Mold Tough".

2.3 ACCESSORIES

A. Trim:

1. ASTM C1047.
2. Galvanized: ASTM A653/A653M G-60, unless noted otherwise.
3. Corner bead:
    a. Standard type with perforated flanges.
    b. ClarkDietrich "#103 Deluxe Corner Bead".
4. Casing and trim bead:
    a. ClarkDietrich "#200-A Metal U-Trim.
5. Control and expansion joints:
    a. ClarkDietrich "#093 Zinc Control Joint."

B. Fasteners:

1. Gypsum board:
    a. ASTM C1002.
    b. Self-drilling, corrosion-resistant bugle head screws.
        1) For fastening gypsum board to metal framing: Type S.

C. Adhesive: As recommended by board manufacturer.

D. Joint Tape:

1. ASTM C475/C475M.
2. Recommended by manufacturer for specified board type and location.

E. Joint Treatment Compound:

1. ASTM C475/C475M.
2. Recommended by manufacturer for specified board type and location.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:

1. Verify that metal stud framing has been installed plumb, true, and in accordance with the Contract Documents.
2. Prior to application of gypsum board, ensure that all blocking, backing and bracing has been installed as necessary for the support of appurtenant items.
3. Install gypsum board in accordance with ASTM C840.
4. Install board in fire-rated construction in accordance with UL requirements.
    a. Self-adhesive applied fire rated tape is not acceptable for use on board joints in fire rated walls.
    b. Tape all joints using conventional fire rated joint tape and joint treatment compound.
5. Erect all board vertically with edges over supporting members.
    a. See Specification Section 09 22 16 - Non-Structural Metal Framing.
6. Secure to each support or framing member with screws.
    a. Provide fasteners of sufficient length to penetrate framing member or stud not less than 3/8 inches.
7. In areas having gypsum board ceilings and walls, install ceiling first.
8. Bring boards into contact, but do not force into place.
9. Fit neatly and carefully.
10. Stagger edge joints on opposite side of a partition so they occur on different framing members.
11. Hold board in firm contact with support while fasteners are being driven.
12. Proceed with attachment from center of board toward ends and edges.
13. Scribe board prior to cutting.
14. Where gypsum board abuts concrete, masonry, metal deck, exterior doors and windows, or other dissimilar material; provide 3/8 inches joint between edge of gypsum board and abutting material.
    a. Provide continuous casing bead trim on edge of board.
    b. Seal joint with sealant and backer rod.
    c. See Specification Section 07 92 00 for sealant.
15.

B. Installation:

1. Set fasteners between 3/8 and 1/2 inches from edges and 2 inches in from board corner.
    a. Space maximum of 12 inches on center at edges and in field of board.
    b. Where board butts at wall/ceiling juncture, hold fasteners back 6 inches from edges.
    c. Space fasteners closer if required by UL.
2. Install fasteners, in gypsum board, so that head rests in a slight dimple without cutting face paper or fracturing core or as recommended by board/panel manufacturer.

C. Control Joints:

1. Install prefabricated control joints to provide following maximum unjointed lengths or areas:
    a. Partitions: 30 feet, maximum straight run, and at lock side of jamb from head of each door, borrow lite, or window opening to top of partition.

1) Control joints are not required at openings where the partition forms a cross-corridor condition.
2) At borrow lites, windows or similar conditions, extend control joints at jamb from sill to floor.

b. Ceilings:
1) 50 feet maximum in one direction,
2) At change of direction or irregular shapes.
3) Ceiling area: 2500 square feet, maximum.

2. Seal control joints.
a. Use color to match wall or ceiling color as closely as possible.
3. Where control or expansion joints occur in fire or sound rated assemblies, install suitable backing material to maintain required rating.
4. Where a partition or ceiling abuts a structural element or dissimilar wall or ceiling, install corner bead, casing bead or other trim as required.

D. Gypsum Board Finishing:

1. Securely attach continuous corner beads to all external corners in accordance with manufacturer's recommendations.
2. Provide the following minimum levels of gypsum board finish in accordance with GA-214.
a. Areas exposed to view:
1) Surfaces to receive painted finish: Level #5.
b. Areas not exposed to view:
1) Fire rated partitions: Level #2 unless a higher grade of finish is required by UL.
2) Non-fire rated partitions: Level #2.
c. Provide additional coats of joint compound as required to completely conceal joints, fasteners and accessories.
1) Joint photographing will not be acceptable.
3. Sand each coat to remove excess joint compound.
a. Avoid roughing paper facing on board.
4. Finish surface shall be smooth and free of tool marks and ridges.
5. Prime gypsum board surfaces in accordance with Specification Section 09 96 00.
a. After primer has been applied, inspect surfaces and repair and refinish all areas which show defects.
6. Refer to ASTM C840 for additional finishing requirements.

END OF SECTION

SECTION 09 96 00
HIGH PERFORMANCE INDUSTRIAL COATINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. High performance industrial coatings (HPIC).
2. Any other coating, thinner, accelerator, inhibitor, etc., specified or required as part of a complete System specified in this Specification Section.
3. Minimum surface preparation requirements.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 01 61 03 - Equipment - Basic Requirements.
2. Division 03 - Concrete.
3. Division 04 - Masonry.
4. Division 05 - Metals.
5. Section 09 29 00 – Gypsum Board.
6. Division 23 - Heating, Ventilating, and Air-Conditioning (HVAC).
7. Division 26 - Electrical.
8. Division 40 - Process Interconnections.
9. Section 40 05 00 - Pipe and Pipe Fittings - Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American National Standards Institute/Steel Door Institute (ANSI/SDI):
   a. A250.10, Test Procedure and Acceptance Criteria For Prime Painted Steel Surfaces for Steel Doors and Frames.
2. ASTM International (ASTM):
   a. B499, Standard Test Method for Measurement of Coating Thicknesses by the Magnetic Method: Nonmagnetic Coatings on Magnetic Basis Metals.
   b. D3359, Standard Test Methods for Rating Adhesion by Tape Test.
   c. D4258, Standard Practice for Surface Cleaning Concrete for Coating.
   d. D4259, Standard Practice for Abrading Concrete.
   e. D4261, Standard Practice for Surface Cleaning Concrete Masonry Units for Coating.
   f. D4262, Standard Test Method for pH of Chemically Cleaned or Etched Concrete Surfaces.
   g. D4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.
   h. D4414, Standard Practice for Measurement of Wet Film Thickness by Notch Gages.
   i. D4541, Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers.
   j. D6132, Standard Test Method for Nondestructive Measurement of Dry Film Thickness of Applied Organic Coatings Using an Ultrasonic Gage.
   k. D6677, Standard Test Method for Evaluating Adhesion by Knife.
   l. D7091, Standard Practice for Nondestructive Measurement of Dry Film Thickness of Nonmagnetic Coatings Applied to Ferrous Metals and Nonmagnetic, Nonconductive Coatings Applied to Non-Ferrous Metals.

m. D7234, Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers.

n. E337, Standard Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures).

o. F1869, Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.

p. F2170, Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes.

3. Environmental Protection Agency (EPA).

4. International Concrete Repair Institute (ICRI):

a. 310.2, Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair.

5. National Association of Pipe Fabricators (NAPF):

a. 500-03, Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings:

1) 500-03-04, Abrasive Blast Cleaning for Ductile Iron Pipe.

2) 500-03-05, Abrasive Blast Cleaning for Cast Ductile Iron Fittings.

6. The Society for Protective Coatings (SSPC):

a. PA 2, Procedure for Determining Conformance to Dry Coating Thickness Requirements.

b. SP 1, Solvent Cleaning.

c. SP 2, Hand Tool Cleaning.

d. SP 3, Power Tool Cleaning.

e. SP 16, Brush-off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.

7. The Society for Protective Coatings/ NACE International (SSPC/ NACE):

a. SP 5/ NACE No. 1, White Metal Blast Cleaning

b. SP 6/ NACE No. 3, Commercial Blast Cleaning.

c. SP 7/ NACE No. 4, Brush-off Blast Cleaning.

d. SP 10/ NACE No. 2, Near-White Blast Cleaning.

e. SP 13/ NACE No. 6, Surface Preparation of Concrete.

B. Qualifications:

1. Coating manufacturer's technical representative shall be a NACE Certified Coatings Inspector, Level 3 minimum.

2. Applicators shall have minimum of 10 years of experience in application of similar products on similar project.

a. Provide references for minimum of three different projects completed in last five years with similar scope of work.

b. Include name and address of project, size of project in value (coating) and contact person.

3. NACE inspector shall be NACE Certified Coatings Inspector Level 3 minimum and shall have minimum of five years of experience of conducting inspections and tests as indicated in this Specification Section.

C. Mock-Ups:

1. Construct sample floor areas demonstrating varying degree of slip resistance for Engineer review and acceptance.

a. Provide one sample of each texture of slip resistant material for Engineer's selection.

b. Size: minimum 2 feet by 2 feet each.

2. If not acceptable, construct additional sample floor areas as required.
    a. After sample floor area is accepted destroy all other sample floor areas not accepted.
3. Accepted sample floor area shall constitute minimum standard of quality for actual construction.
4. Maintain sample floor area during construction and protect from damage.
5. Subject to approval by Engineer, approved sample may be incorporated into the Work.

D. Miscellaneous:

1. Furnish coating through one manufacturer unless noted otherwise.

E. Deviation from specified MIL thickness or product type is not allowed without written authorization of Engineer.

F. Material shall not be thinned unless approved, in writing, by coating manufacturer's technical representative.

1.3 DEFINITIONS

A. Applicator:

1. Applicator is the person actually installing or applying the product in the field, at the Project site, or at an approved shop facility.

B. Approved Factory Finish: Finish on a product in compliance with the finish specified in the Specification Section where the product is specified or in Specification Section 01 61 03.

C. Appurtenant Surface: Accessory or auxiliary surface attached to or adjacent to a surface indicated to be coated.

D. Corrosive Environment:

1. Immersion in or subject to:
    a. Condensation, spillage or splash of a corrosive material such as water, wastewater or chemical solution.
    b. Exposure to corrosive caustic or acidic agent, chemicals, chemical fumes, chemical mixture, or solutions.
    c. For purposes of this Specification Section, corrosive environments include:
        1) Outdoor areas not otherwise identified as highly corrosive.
        2) Piping galleries.
        3) Surfaces within 2 feet of high water level.

E. Outdoor Atmosphere or Surface: Outdoor atmosphere or surface exposed to weather and/or direct sunlight.

F. Finished Area: A room or area that is listed in or has finish called for on Room Finish Schedule or is indicated on Drawings to be coated.

G. Highly Corrosive Environment:

1. Immersion in or subject to:
    a. Condensation, spillage or splash of a highly corrosive material such as wastewater, or chemical solution.
    b. Exposure to highly corrosive caustic or acidic agent, chemicals, chemical fumes, chemical mixture, or solutions.
    c. For purposes of this Specification Section, highly corrosive environments include:
        1) Exposure to hydrogen sulfide (H2S) gas. Entirety of Screen Room in Headworks Building shall be considered Highly Corrosive.

H. Holiday:

1. A void, crack, thin spot, foreign inclusion, or contamination in the coating that significantly lowers the dielectric strength of the coating.
2. May also be identified as a discontinuity or pinhole.

I. HPIC: High performance industrial coatings.

1. Epoxies, urethanes, vinyl ester, waterborne vinyl acrylic emulsions, acrylates, silicones, alkyds, acrylic emulsions and any other coating listed as a HPIC.

J. Indoor Atmosphere or Surface: Indoor atmosphere or surface not exposed to weather and/or direct sunlight.

K. Immersion Service:

1. Any surface immersed in water or some other liquid.
2. Surface of any pipe, valve, or any other component of the piping system subject to frequent wetting.
3. Surfaces within two feet above high water level in water bearing structures.

L. Piping System: Pipe, valves, fittings and accessories.

M. Surface Hidden from View:

1. Within pipe chases.
2. Between top side of ceilings and underside of floor or roof structures above.

N. Vapor Space: Interior space within tankage, closed structures, or similar elements that is above the low liquid line and subject to the accumulation of fumes, vapor and/or condensation.

1.4 SUBMITTALS

A. Certifications:

1. Applicator experience qualifications.
   a. No submittal information will be reviewed until Engineer has received and approved applicator qualifications.
2. NACE inspector certification.
3. NACE inspector experience qualifications.
4. Certification that High Performance Coating Systems proposed for use have been reviewed and approved by a NACE Certified Coatings Inspector employed by the coating manufacturer.
   a. Submittals not including this certification will be returned without review.

B. Shop Drawings:

1. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Manufacturer's surface preparation instructions.
   c. Manufacturer's application instructions.
      1) Manufacturer's standard details, including but not limited to penetrations, transitions, and terminations for:
         a) High-build coatings on concrete.
         b) Other special conditions as applicable.
   d. If products being used are manufactured by Company other than listed in the MATERIALS Article of this Specification Section, provide complete individual data sheet comparison of proposed products with specified products including:
      1) Application procedure.
      2) Coverage rates.
      3) Certification that product is designed for intended use and is equal or superior to specified product.

e. Contractor's written plan of action for containing airborne particles created by blasting operation and location of disposal of spent contaminated blasting media.
f. Coating manufacturer's recommendation on abrasive blasting.
g. Coating manufacturer's technical representative's written statement attesting that applicator has been instructed on proper preparation, mixing and application procedures for coatings specified.
h. Manufacturer's recommendation for universal barrier coat.
i. Manufacturer's recommendation for providing temporary or supplemental heat or dehumidification or other environmental control measures.

2. Manufacturer's statement regarding applicator instruction on product use.

C. Samples:

1. Manufacturer's full line of colors for Engineer's preliminary color selection.
2. After preliminary color selection by Engineer provide two, 3 x 5 inches samples of each final color selected.

D. Informational Submittals:

1. Approval of application equipment.
2. Applicator's daily records:
   a. Submit daily records at end of each week in which coating work is performed unless requested otherwise by Engineer's on-site representative.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver in original containers, labeled as follows:

1. Name or type number of material.
2. Manufacturer's name and item stock number.
3. Contents, by volume, of major constituents.
4. Warning labels.
5. VOC content.

B. Store materials in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 degrees F.

1.6 PROJECT CONDITIONS

A. Pre-application Conference:

1. Prior to commencement of surface preparation or coating application, the Contractor shall convene a pre-application conference with all affected parties, including but not limited to: the applicator, coating manufacturer's technical representative, Owner's representative, and Engineer's representative(s).
2. The meeting shall discuss all aspects of the Project including but not limited to:
   a. Schedule.
   b. Material storage and handling.
   c. Examination of surfaces to be coated.
   d. Protection of surfaces not to be coated.
   e. Surface preparation.
   f. Coating application:
      1) Environmental conditions for application of coatings.
      2) Temporary environmental controls.
   g. Field quality control requirements:
      1) Manufacturer's technical representative responsibilities.
      2) Contractor performed testing.

a) Instrumentation requirements.
b) Frequency of testing.
c) Record keeping.

3) NACE inspector performed testing.

B. Verify that atmosphere in area where coating is to take place is within coating manufacturer's acceptable temperature, humidity and sun exposure limits.

1. Provide temporary heating, shade and/or dehumidification as required to bring area within acceptable limits.
   a. Provide temporary dehumidification equipment properly sized to maintain humidity levels required by coating manufacturer.
   b. Provide clean heat with heat exchanger type equipment sufficient in size to maintain temperature on a 24 hour basis.
      1) Vent exhaust gases to outdoor environment.
      2) No exhaust gases shall be allowed to vent into the space being coated or any adjacent space.
2. Do not apply coatings in snow, rain, fog or mist.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. High Performance Industrial Coatings:
   a. Carboline Protective Coatings.
   b. PPG.
   c. The Sherwin-Williams Company.
   d. Tnemec.
   e. AkzoNobel.

B. "Or-Equal" Submittals:

1. Materials by other manufacturers are acceptable provided that they are established as being compatible with and of equal quality to the coatings of the manufacturers listed.
2. Provide satisfactory documentation from the proposed "or-equal" manufacturer that proposed materials meets or exceeds the following:
   a. Is of the same generic resin.
   b. Requires comparable surface preparation.
   c. Has comparable application requirements.
   d. Meets the same VOC levels or better.
   e. Provides the same finish and color options.
   f. Is suitable for the intended service.
   g. Resistance to abrasion and physical damage.
   h. Resistance to chemical attack.
   i. Resistance to UV exposure.
   j. Ability to recoat in future.
   k. Dry film thickness per coat.
      1) Where manufacturer’s product data sheet indicates a minimum MIL thickness per coat that is greater than specified herein, MIL thickness for entire coating system shall be increased proportionately.
   l. Minimum and Maximum time between coats.

m. Compatibility with other coatings.
n. Temperature limitations in service and during application.
o. Type and quality of recommended undercoats and topcoats.
p. Ease of application.
q. Ease of repairing damaged areas.
r. Stability of colors.

3. The cost of all testing and analyzing of the proposed substitute materials shall be borne by the CONTRACTOR.

2.2 MATERIALS

A. Coatings used for indoor finishes shall meet the requirements of the building code and NFPA 101.

1. Wall and ceiling finishes: ASTM E84 or ANSI/UL 723.
   a. Class A: Flame spread index 25 or less; smoke-developed index 450 or less.
2. Indoor floor finishes: NFPA 253 or ASTM E648.
   a. Class II: Critical radiant flux not less than 0.22W/CM^2 but less than 0.45W/CM^2.

B. Coatings shall comply with the VOC limits of EPA.

C. For unspecified materials such as thinner, provide manufacturer's recommended products.

D. High Performance Industrial Coatings:

COATING CODE	GENERIC DESCRIPTION	MANUFACTURER	
		TNEMEC	SHERWIN WILLIAMS
AAE	Acrylic/Acrylate Emulsion	Series 180 WB Tneme-Crete	Cement Plex 875
AREC	Abrasion-Resistant Epoxy Coating	Series 435 Perma-Glaze	Duraplate 5900
AAP	Aliphatic Acrylic Polyurethane	Series 1095 Endurashield	Acrolon Ultra
AP	Acrylic Polymer	Series 1029 Enduratone	Pro Industrial Acrylic Coating
CRM	Cementitious Repair Mortar	Series 217 MortarCrete	Cemtec Silatec MSM
CRU	Corrosion Resistant Urethane	Series 290 CRU	Polylon HP
DFA	Dry-fall Acrylic	Series 115 Uni-Bond DF	DFA Dry Fall Acrylic
EBF	Epoxy Block Filler	Series 1254 Epoxoblock WB	Kem Cati Coat HS
ESF	Epoxy Surfacer/Filler	Series 215 Surfacing Epoxy	Steel Seam FT 910
EMM	Epoxy Modified Cementitious Mortar	Series 218 MortarClad	Duraplate 2300
EF	Epoxy Flooring	Series 237 Power-Tread	GP3746
GFRE	Glass Flake Reinforced Epoxy	Series 142	Sher-Glass FF

COATING CODE	GENERIC DESCRIPTION	MANUFACTURER	
		TNEMEC	SHERWIN WILLIAMS
HRE	H2S-Resistant Epoxy	Series 132 Protuff Mastic	Duraplate 235
HREM	H2S-Resistant Epoxy Mortar	Series 434 Perma-Shield H_2S	Duraplate 5900 Mortar
MIO	MIO Polyurethane	Series 1 Omnithane	Corothane 1 milesO
MPE	Multi-Purpose Epoxy	Series N69 Hi-Build Epoxoline II	Macropoxy 646
MTEP	Moisture-Tolerant Epoxy Primer	Series 201 Epoxoprime	Corobond 100
PVA	PVA Drywall Primer	Series 51 PVA Sealer	ProMar 200 Zero VOC Interior Latex Primer
SCN	Secondary Containment Novolac	Series 282	Cor Cote HCR
SCE	Secondary Containment Epoxy	Series 237SC Chembloc	Cor Cote HP
SCEP	Secondary Containment Epoxy Primer	Series 206SC Chembloc	GP3552
STEP	Surface-Tolerant Epoxy Primer	Series 135 Chembuild	Macropoxy 646
UHSE	Ultra-High Solids Epoxy (NSF 61)	Series 22 Epoxoline	Duraplate UHS
VEP	Vinyl Ester Primer	Series 251SC Chembloc	Corobond Vinyl Ester Primer
VESC	Vinyl Ester Secondary Containment	Series 252SC Chembloc	Cor Cote VEN FF
ZRU	Zinc-Rich Urethane	Series 94-$H_2$0 Hydro-Zinc	Corothane 1 Galvapak

2.3 COATING SYSTEMS:

A. The following tables indicate coating systems by material and environment unless a specific application is indicated.

B. Ferrous Metals (Structural and Miscellaneous Metals):

Environment/ Application	Surface Preparation	Prime Coat	Intermediate Coats	Finish Coat
Indoor atmospheric (highly corrosive environment)	SSPC-SP 10/ NACE No. 2, min. 2 mil anchor profile	2.5 to 3.5 mil ZRU	3.0 to 4.0 mil MPE	2.0 to 3.0 mil CRU
Immersion - Wastewater (abrasion resistant)	SSPC-SP 10/ NACE No. 2 min. 3 mil anchor profile	15 to 20 mil AREC		15 to 20 mil AREC
Immersion - non NSF	SSPC-SP 10/ NACE No. 2	3.0 to 4.0 mil MPE	3.0 to 4.0 mil MPE	3.0 to 4.0 mil MPE
Outdoor atmospheric	SSPC-SP 6/ NACE No. 3	3.0 to 4.0 mil MPE	3.0 to 4.0 mil MPE	2.5 to 3.5 mil AAP

Environment/ Application	Surface Preparation	Prime Coat	Intermediate Coats	Finish Coat
Hollow Metal Doors	SSPC-SP 3	2.5 to 3.5 mil STEP		2.5 to 3.5 mil AAP

C. Galvanized Steel:

Environment/ Application	Surface Preparation	Prime Coat	Intermediate Coats	Finish Coat
Indoor atmospheric	SSPC-SP 16	4.0 to 6.0 mil STEP		2.0 to 3.0 mil MPE
Immersion - non NSF	SSPC-SP 16	4.0 to 6.0 mil STEP	2.0 to 3.0 mil MPE	2.0 to 3.0 mil MPE
Outdoor atmospheric	SSPC-SP 16	4.0 to 6.0 mil STEP		2.5 to 3.5 mil AAP
Field cut pipe threads	SSPC-SP 3	4.0 to 6.0 mil STEP	Coat per exposure above	Coat per exposure above

D. Non Ferrous Metals, including piping:

Environment/ Application	Surface Preparation	Prime Coat	Intermediate Coats	Finish Coat
Dissimilar Materials Protection	SSPC-SP 2	4.5 to 5.5 mil MPE		
Indoor atmospheric	SSPC-SP 2	3.0 to 4.0 mil MPE		3.0 to 4.0 mil MPE
Vapor space at covered clarifiers, digesters and similar structures	SSPC-SP 10/ NACE No. 2 min. 3 mil anchor profile	5 to 7 mil HRE		30 to 40 mil AREC
Immersion - Wastewater (abrasion resistant)	SSPC-SP 16			40 to 45 MIL AREC
Immersion - non NSF	SSPC-SP 16	3.0 to 4.0 mil MPE		5.0 to 6.0 mil MPE
Outdoor atmospheric	SSPC-SP 2	4.0 to 6.0 mil MPE		2.5 to 3.5 mil AAP

E. Ferrous Piping:

Environment/ Application	Surface Preparation	Prime Coat	Intermediate Coats	Finish Coat
Indoor atmospheric	SSPC-SP 6/ NACE No. 3	2.5 to 3.5 mil ZRU	3.0 to 4.0 mil MPE	3.0 to 4.0 mil MPE

Environment/ Application	Surface Preparation	Prime Coat	Intermediate Coats	Finish Coat
Vapor space at covered clarifiers, digesters and similar structures	SSPC-SP 10/ NACE No. 2 min. 3 mil anchor profile	5 to 7 mil HRE		30 to 40 mil AREC
Immersion - Wastewater (abrasion resistant)	SSPC-SP 10/ NACE No. 2, min 3 mil anchor profile	15 to 20 mil AREC		15 to 20 mil AREC
Immersion - non NSF	SSPC-SP 5/ NACE No.1	3.0 to 4.0 mil MPE	3.0 to 4.0 mil MPE	3.0 to 4.0 mil MPE
Outdoor atmospheric	SSPC-SP 6/ NACE No. 3	3.0 to 4.0 mil MPE	3.0 to 4.0 mil MPE	2.5 to 3.5 mil AAP

F. Ductile Iron Piping:

Environment/ Application	Surface Preparation	Prime Coat	Intermediate Coats	Finish Coat
Indoor atmospheric	Pipe: NAPF 500-03-04 Fittings: NAPF 500-03-05	3.0 to 4.0 mil MPE	3.0 to 4.0 mil MPE	3.0 to 4.0 mil MPE
Vapor space at covered clarifiers, digesters and similar structures	SSPC-SP 10/ NACE No. 2 min. 3 mil anchor profile	5 to 7 mil HRE		30 to 40 mil AREC
Immersion - Wastewater (abrasion resistant)	Pipe: NAPF 500-03-04 Fittings: NAPF 500-03-05	15 to 20 mil AREC		15 to 20 mil AREC
Immersion - non NSF	Pipe: NAPF 500-03-04 Fittings: NAPF 500-03-05	3.0 to 4.0 mil MPE	3.0 to 4.0 mil MPE	3.0 to 4.0 mil MPE
Outdoor atmospheric	Pipe: NAPF 500-03-04 Fittings: NAPF 500-03-05	3.0 to 4.0 mil MPE	3.0 to 4.0 mil MPE	2.5 to 3.5 mil AAP

G. Cast Iron Piping:

Environment/ Application	Surface Preparation	Prime Coat	Intermediate Coats	Finish Coat
Indoor atmospheric	SSPC-SP 1	4.0 to 6.0 mil STEP	2.0 to 3.0 mil MPE	2.0 to 3.0 mil MPE
Outdoor atmospheric	SSPC-SP 1	4.0 to 6.0 mil STEP	2.0 to 3.0 mil MPE	2.5 to 3.5 mil AAP

H. Concrete:

1. For repair of deteriorated existing concrete, provide additional surface preparation as specified in PREPARATION article in this Specification Section.

Environment/ Application	Surface Preparation	Filler/Surfacer	Prime Coat	Intermediate Coat(s)	Finish Coat
Walls, ceilings, and appurtenant surfaces Indoor atmospheric	SSPC-SP 13/ NACE No. 6 ICRI CSP 5	ESF and/or EMM as necessary to fill holes and depressions	100 to 150 square feet/GAL MPE		100 to 150 square feet/GAL MPE
Indoor floors	SSPC-SP 13/ NACE No. 6 ICRI CSP 5	ESF as necessary to fill holes and depressions	175 to 225 square feet/GAL EF clear	200 to 250 square feet/GAL EF pigmented	200 to 250 square feet/GAL EF pigmented
			broadcast slip-resistant aggregate into wet intermediate coat on walking surfaces		
Indoor Safety Striping	SSPC-SP 13/ NACE No. 6 ICRI CSP 3	ESF and/or EMM as necessary to fill holes and depressions			6.0 to 8.0 mil EF Pigmented
Vapor space at covered clarifiers, digesters and similar structures	SSPC-SP 13/ NACE No. 6 ICRI CSP 5	1/16 to 1/4 inches EMM			30 to 45 mil AREC
Outdoor atmospheric Corrosive Environment	SSPC-SP 13/ NACE No. 6 ICRI CSP 5	ESF and/or EMM as necessary to fill holes and depressions	150 to 175 square feet/GAL AAE		150 to 175 square feet/GAL AAE

I. Concrete Masonry:

1. Coverage rates indicated are based on smooth-face normal weight CMU.
2. Provide increased coverage rates in accordance with manufacturer's recommendations for more porous surfaces.

Environment/ Application	Surface Preparation	Filler/Surfacer	Prime Coat	Intermediate Coat(s)	Finish Coat
Indoor atmospheric	Refer to PART 3	100 to 150 square feet/Gal EBF	75 to 100 square feet/Gal MPE		75 to 100 square feet/Gal MPE
Outdoor atmospheric Corrosive Environment	Refer to PART 3	100 to 150 square feet/Gal EBF	175 to 200 square feet/Gal MPE		275 to 300 square feet/Gal AAP
Outdoor atmospheric Highly Corrosive Environment	Refer to PART 3	100 to 150 square feet/Gal EBF	175 to 200 square feet/Gal MPE	175 to 200 square feet/Gal MPE	275 to 300 square feet/Gal AAP

J. Gypsum Board:

Environment/ Application	Surface Preparation	Prime Coat	Intermediate Coats	Finish Coat
Paper-faced gypsum board walls, ceilings, and appurtenant surfaces	Refer to Section 09 29 00	350 to 400 SF/GAL PVA	250 to 300 SF/GAL AP	250 to 300 SF/GAL AP

PART 3 - EXECUTION

3.1 ITEMS TO BE COATED

A. Outdoor Surfaces, including but not limited to:

1. Piping, valves, fittings, hydrants and supports:
   a. As scheduled in Specification Section 40 05 00.
   b. Process piping scheduled to be insulated.
   c. Field welded connections of factory coated piping.
2. Pumps and motors.
3. Ferrous metal process equipment.
   a. Gates and operators.
4. Structural steel:
   a. Columns, beams and bracing.
   b. Field welded connections of factory coated structural steel.
5. Miscellaneous ferrous metal surfaces:
   a. Pipe Bollards.
   b. Embed Plates.
   c. Railings.
   d. Loose lintels.
   e. Steel components of concrete lintels.
   f. Items specifically noted on Drawings to be coated.
6. Miscellaneous galvanized steel surfaces:
   a. Pipe Bollards.
   b. Embed Plates.
   c. Loose lintels.
   d. Steel components of concrete lintels.
   e. Items specifically noted on Drawings to be coated.
7. Doors and frames:
   a. Hollow metal doors and frames
   b. Sectional overhead doors.
8. Appurtenant surfaces attached to or adjacent to a surface indicated to be coated:
   a. Conduit, boxes, covers and supports.

B. Indoor Areas:

1. Refer to Room Finish Schedule on Drawings.
   a. If space is scheduled to be coated, coat all appurtenant surfaces within the space unless specifically noted otherwise. Appurtenant surfaces include but are not limited to:
      1) Columns.

2) Equipment pads.
3) Equipment supports.
4) Underside of roof or floor decks above:
a) Including semi-exposed or concealed from view unless noted otherwise.
5) Conduit, boxes, covers and supports.
6) Miscellaneous ferrous metal surfaces.

2. Concrete masonry.
3. Piping, valves, fittings, hydrants and supports:
a. Do not coat piping scheduled to be insulated.
4. Pumps and motors.
5. Ferrous metal tankage.
6. Ferrous metal process equipment.
a. Clarifier mechanisms.
b. Equipment bridges.
c. Gates and operators.
d. Items specifically noted on Drawings to be coated.
7. Miscellaneous galvanized steel surfaces:
a. Pipe Bollards.
b. Embed Plates.
c. Loose lintels.
d. Steel components of concrete lintels.
e. Seismic angles at masonry partitions.
f. Items specifically noted on Drawings to be coated.
8. Doors and frames:
a. Hollow metal doors and frames
b. Sectional overhead doors.
9. Safety Striping:
a. Equipment Pads: Coat vertical face and return 3 inches onto horizontal surface of pad.
b. Pipe supports, columns, piers and similar vertical elements: 3 inches each face of corners, up to 48 inches above finished floor.
c. As shown on Drawings.

3.2 ITEMS NOT TO BE COATED

A. General: Do not coat items listed in this Article, unless noted otherwise.

B. Items with Approved Factory Finish: These items may require repair of damaged coated areas or coating of welded connections.

C. Electrical Equipment.

D. Moving parts of mechanical and electrical units where coating would interfere with the operation of the unit.

E. Code labels, equipment identification or rating plates and similar labels, tagging and identification.

F. Contact surfaces of friction-type structural connections.

G. Stainless Steel Surfaces, except:

1. Dissimilar metals in immersion service.
2. Piping where specifically noted to be coated.
3. Banding as required to identify piping.

H. Aluminum Surfaces, except:

1. Where specifically shown in the Contract Documents.
2. Where in contact with concrete.
3. Where in contact with dissimilar metals.
4. Appurtenant surfaces as described in the ITEMS TO BE COATED article.

I. Fiberglass Surfaces, except:

1. Fiberglass piping where specifically noted to be coated.
2. Piping supports where specifically noted to be coated.
3. Appurtenant surfaces as described in the ITEMS TO BE COATED article.

J. Mechanical piping scheduled to be insulated.

K. Interior of Pipe, Ductwork, and Conduits.

1. See Division 23 for ductwork.
2. See Division 40 for pipe linings.

L. Galvanized Steel Items, unless specifically noted to be coated.

M. Architectural Finishes:

1. Outdoor concrete indicated to receive another finish.
2. Precast concrete surfaces, unless specifically indicated to be coated.
3. Prefinished masonry surfaces:
    a. Pre-colored masonry (outdoor face).
        1) Interior face shall be coated where scheduled.
    b. Burnished (ground face) concrete masonry.
    c. Prefaced masonry.
    d. Face brick.
    e. Glass masonry.
4. Plastic laminate.
5. Solid surface material.
6. Standing and running trim.
7. Fiberglass fabrications.
8. Anodized aluminum.
9. PVDF coated metals.
10. Factory finished doors and frames.
11. Aluminum windows, curtainwall and storefront framing systems.
12. Finish hardware.
13. Glass and glazing.
14. Ceramic, porcelain, quarry tile or natural stone.
15. Acoustical materials.
16. Building specialties.
17. Louvers.
18. Casework and countertops.
19. Pipe insulation and jacketing.
20. Standing seam metal roof, fascia, trim, soffit and accessories.

3.3 EXAMINATION

A. Concrete:

1. Test pH of surface to be coated in accordance with ASTM D4262.

a. If surface pH is not within coating manufacturer's required acceptable range, use methods acceptable to coating manufacturer as required to bring pH within acceptable range.
b. Retest pH until acceptable results are obtained.

2. Verify that moisture content of surface to be coated is within coating manufacturer's recommended acceptable limits.
   a. Test surface to be coated in accordance with ASTM D4263 to determine the presence of moisture.
      1) If moisture is detected, test moisture content of surface to be coated in accordance with ASTM F1869 or ASTM F2170.
      2) Provide remedial measures as necessary to bring moisture content within coating manufacturer’s recommended acceptable limits.
      3) Retest surface until acceptable results are obtained.

B. Concrete Unit Masonry:

1. Test pH of surface to be coated in accordance with ASTM D4262.
   a. If surface pH is not within coating manufacturer's required acceptable range, use methods acceptable to coating manufacturer as required to bring pH within acceptable limits.
   b. Retest pH until acceptable results are obtained.
2. Verify that moisture content of surface to be coated is within coating manufacturer's recommended acceptable limits.
   a. Test surface to be coated in accordance with ASTM D4263 to determine the presence of moisture.
      1) If moisture is detected, test moisture content of surface to be coated in accordance with ASTM F1869.
      2) Provide remedial measures as necessary to bring moisture content within coating manufacturer’s recommended acceptable limits.
      3) Retest surface until acceptable results are obtained.

3.4 PREPARATION

A. General:

1. Prepare surfaces to be coated in accordance with coating manufacturer's instructions and this Specification Section unless noted otherwise in this Specification Section.
   a. Where discrepancy between coating manufacturer's instructions and this Specification Section exists, the more stringent surface preparation shall be provided unless approved otherwise, in writing, by the Engineer.
2. Remove all dust, grease, oil, compounds, dirt and other foreign matter which would prevent bonding of coating to surface.
3. Adhere to manufacturer's recoat time surface preparation requirements.
   a. Surfaces that have exceeded coating manufacturer's published recoat time and/or have exhibited surface chalking shall be prepared prior to additional coating in accordance with manufacturer's published recommendations.
      1) Minimum SSPC-SP 7/ NACE No. 4 unless otherwise approved by Engineer.

B. Protection:

1. Protect surrounding surfaces not to be coated.
2. Remove and protect hardware, accessories, plates, fixtures, finished work, and similar items; or provide ample in-place protection.
3. Protect code labels, equipment identification or rating plates and similar labels, tagging and identification.

C. Prepare and coat before assembly all surfaces which are inaccessible after assembly.

D. Ferrous Metal:

1. Prepare ductile iron pipe in accordance with pipe manufacturer's recommendations and NAPF.
    a. All piping, pumps, valves, fittings and any other component used in the water piping system that requires preparation for coating shall be prepared in accordance with requirements for immersion service.
    b. Prepare all areas requiring patch coating in accordance with recommendations of manufacturer and NAPF.
    c. Remove bituminous coating per piping manufacturer, coating manufacturer and NAPF recommendations.
        1) The most stringent recommendations shall apply.
2. Complete fabrication, welding or burning before beginning surface preparation.
    a. Chip or grind off flux, spatter, slag or other laminations left from welding.
    b. Remove mill scale.
    c. Grind smooth rough welds and other sharp projections.
3. Solvent clean in accordance with SSPC-SP 1.
4. Restore surface of field welds and adjacent areas to original surface preparation.

E. Galvanized Steel and Non-ferrous Metals:

1. Solvent clean in accordance with SSPC-SP 1 followed by brush-off blast clean in accordance with SSPC-SP 16 to remove zinc oxide and other foreign contaminants.
    a. Provide uniform 1 mil profile surface.

F. Hollow Metal Doors and Frames:

1. Verify factory-applied prime coat is in accordance with ANSI/SDI A250.10.
2. Prepare as indicated in COATING SYSTEMS Article.

G. Concrete:

1. Cure for minimum of 28 days.
2. Concrete surfaces shall be cleaned in accordance with ASTM D4258.
3. Repair deteriorated concrete surfaces in accordance with ICRI 310.1R.
    a. Remove unsound concrete, loose materials, existing coatings, or other bond-inhibiting materials in accordance with SSPC-SP13/NACE No. 6 to minimum ICRI 310.2 CSP 6.
    b. Where steel reinforcing or embeds are exposed:
        1) Remove concrete minimum 3/4 inches around entire circumference of bar or perimeter of embed.
        2) Abrasive blast steel to SSPC-SP10/NACE No. 2 or Power Tool Clean to SSPC-SP11.
        3) Coat steel with minimum 5.0 mil DFT Multi-Purpose Epoxy (MPE) scheduled in MATERIALS article of this Specification Section.
    c. Restore surface using EMM or CRM scheduled in MATERIALS article of this Specification Section.
        1) Dry-pack flush to original concrete plane.
4. Abrasive blast concrete surfaces in accordance with ASTM D4259 and SSPC-SP 13/ NACE No. 6.
    a. Provide profile per ICRI 301.2 as listed in MATERIALS article of this Specification Section.
5. Test pH and moisture content in accordance with EXAMINATION article in this Specification Section.

H. Concrete Masonry:

1. Cure for minimum of 28 days.
2. Remove all mortar spatters and protrusions.
3. Clean concrete masonry in accordance with Specification ASTM D4261.
4. Test pH and moisture content in accordance with EXAMINATION article in this Specification Section.

I. Preparation by Abrasive Blasting:

1. Schedule the abrasive blasting operation so blasted surfaces will not be wet after blasting and before coating.
2. Provide compressed air for blasting that is free of water and oil.
    a. Provide accessible separators and traps.
3. Protect nameplates, valve stems, rotating equipment, motors and other items that may be damaged from blasting.
4. All abrasive-blasted ferrous metal surfaces shall be inspected immediately prior to application of coatings.
    a. Inspection shall be performed to determine cleanliness and profile depth of blasted surfaces and to certify that surface has been prepared in accordance with these Specifications.
5. Perform additional blasting and cleaning as required to achieve surface preparation required.
    a. Re-blast surfaces not meeting requirements of these Specifications.
    b. Prior to coating, re-blast surfaces allowed to set overnight and surfaces that show rust bloom.
    c. Surfaces allowed to set overnight or surfaces which show rust bloom prior to coating shall be re-inspected prior to coating application.
6. Profile depth of blasted surface: Not less than 1 mil or greater than 2 mils unless required otherwise by coating manufacturer.
7. Ensure abrasive blasting operation does not result in embedment of abrasive particles in coating.
8. Confine blast abrasives to area being blasted.
    a. Provide shields of polyethylene sheeting or other such barriers to confine blast material.
    b. Plug pipes, holes, or openings before blasting and keep plugged until blast operation is complete and residue is removed.
9. Abrasive blasting media may be recovered, cleaned and reused providing Contractor submits, for Engineer's review, a comprehensive recovery plan outlining all procedures and equipment proposed in reclamation process.
10. Properly dispose of blasting material contaminated with debris from blasting operation.

J. All Plastic Surfaces:

1. Sand using 80-100 grit sandpaper to scarify surfaces.

3.5 APPLICATION

A. General:

1. Thin, mix and apply coatings by brush, roller, or spray in accordance with manufacturer's installation instructions.
    a. Application equipment must be inspected and approved in writing by coating manufacturer.
    b. Hollow metal shall be spray applied only.
2. Temperature and weather conditions:

a. Do not coat surfaces when surface temperature is below 50 degrees F unless product has been formulated specifically for low temperature application and application is approved in writing by Engineer and coating manufacturer's technical representative.
b. Avoid coating surfaces exposed to hot sun.
c. Do not coat damp surfaces.
d. Apply coating to concrete or masonry surfaces in descending temperatures, in accordance with coating manufacturer's application instructions.

3. Apply materials under adequate illumination.
4. Provide complete coverage to MIL thickness specified.
   a. Thickness specified is dry MIL thickness.
5. Evenly spread to provide full, smooth coverage.
   a. All coating systems are "to cover."
      1) In situations of discrepancy between manufacturer's square footage coverage rates and MIL thickness, MIL thickness requirements govern.
   b. When color or undercoats show through, apply additional coats until coating is of uniform finish and color.
   c. Finished coating system shall be uniform and without voids, bugholes, holidays, laps, brush marks, roller marks, runs, sags or other imperfections.
6. If so directed by Engineer, do not apply consecutive coats until Engineer has had an opportunity to observe and approve previous coats.
7. Work each application of material into corners, crevices, joints, and other difficult to work areas.
8. Provide coating manufacturer’s recommended details at all terminations, penetrations, embedments, cracks, joints and changes in substrate direction.
9. Avoid degradation and contamination of blasted surfaces and avoid inter-coat contamination.
   a. Clean contaminated surfaces before applying next coat.
   b. Intercoat surface cleanliness shall be inspected and approved by the Engineer prior to application of each coat.
10. Smooth out runs or sags immediately, or remove and recoat entire surface.
11. Allow preceding coats to dry before recoating.
    a. Recoat within time limits specified by coating manufacturer.
    b. If recoat time limits have expired re-prepare surface in accordance with coating manufacturer's printed recommendations.
12. Allow coated surfaces to cure prior to allowing traffic or other work to proceed.
13. Coat all aluminum in contact with dissimilar materials.
14. When coating rough surfaces which cannot be backrolled sufficiently, hand brush coating to work into all recesses provided that the maximum DFT is not exceeded.
15. Backroll surfaces if coatings are spray applied.

B. Employ services of coating manufacturer's technical representative to ensure that field-applied coatings are compatible with factory-applied or existing coatings.
   1. Certify through material data sheets.
   2. Perform test patch.
      a. Prepare existing coating surface to receive specified coating system.
      b. Apply coating to a minimum 1 square feet area and allow to cure in accordance with manufacturer's recommendations.
      c. Evaluate adhesion to existing coating:
         1) Concrete or Masonry substrates: ASTM D4541.
         2) All other substrates: ASTM D6677 and ASTM D3359 (X-cut method).

3. If field-applied coating is found to be not compatible, require the coating manufacturer's technical representative to recommend, in writing, product to be used as barrier coat, thickness to be applied, surface preparation and method of application.
    a. Perform test patch as described above.
4. At Contractor's option, coatings may be removed, surface re-prepared, and new coating applied using appropriate coating system listed in the MATERIALS Article, Coating Systems paragraph of this Specification Section.
    a. All damage to surface as result of coating removal shall be repaired to original condition or better by Contractor at no additional cost to Owner.

C. Prime Coat Application:

1. Apply structural steel and miscellaneous steel prime coat in the factory.
    a. Finish coats shall be applied in the factory.
    b. Prime coat referred to here is prime coat as indicated in this Specification.
        1) Prime coating applied in factory (shop) as part of Fabricator's standard rust inhibiting and protection coating is not acceptable as replacement for specified prime coating.
    c. Application of all factory-applied coatings(s) on structural steel and miscellaneous steel shall be continually observed and certified by NACE coatings inspector.
2. Prime all surfaces indicated to be coated.
    a. Apply prime coat in accordance with coating manufacturer's written instructions and as written in this Specification Section.
3. Prime ferrous metals embedded in concrete to minimum of 1 inch below exposed surfaces.
4. Apply zinc-rich primers while under continuous agitation.
5. Brush or spray bolts, welds, edges and difficult access areas with primer prior to primer application over entire surface.
6. Touch up damaged primer coats prior to applying finish coats.
    a. Restore primed surface equal to surface before damage.
7. All surfaces of steel lintels and steel components of concrete lintels used in wall construction shall be completely coated with both prime and finish coats prior to placing in wall.

D. Finish Coat Application:

1. Apply finish coats in accordance with coating manufacturer's written instructions and in accordance with this Specification Section; manufacturer instructions take precedent over these Specifications.
2. Touch up damaged finish coats using same application method and same material specified for finish coat.
    a. Prepare damaged area in accordance with the PREPARATION Article of this Specification Section.
3. Broadcast abrasive aggregate into top coat of floor coatings as required to achieve degree of skid resistance desired by the Owner.

3.6 COLOR CODING

A. Color code piping in accordance with the SCHEDULE Article of this Specification Section.

3.7 FIELD QUALITY CONTROL

A. Application Deficiencies:

1. Surfaces showing runs, laps, brush marks, telegraphing of surface imperfections or other defects will not be accepted.
2. Surfaces showing evidence of fading, chalking, blistering, delamination or other defects due to improper surface preparation, environmental controls or application will not be accepted.

a. Epoxy surfaces showing evidence of chalking or amine blush shall be prepared and recoated as follows:
    1) Solvent clean surfaces in accordance with SSPC-SP1 and abrasive blast in accordance with SSPC-SP7/ NACE No. 4.
    2) Recoat with intermediate and finish coats in accordance with coating system specified herein.

B. Provide protection for coated surfaces.
    1. Surfaces showing soiling, staining, streaking, chipping, scratches, or other defects will not be accepted.

C. Contractor Performed Testing:
    1. Provide ongoing testing and inspection, including but not limited to the following:
        a. Measurement and recording of environmental conditions as specified herein.
        b. Measurement and recording of substrate conditions as specified herein.
        c. Thickness Testing:
            1) Wet film thickness during application in accordance with ASTM D4414.
            2) Dry Film Thickness (DFT) in accordance with SSPC-PA 2.
            3) Engineer may measure coating thickness at any time during project to assure conformance with these Specifications.
        d. Bond Strength:
            1) Bond strength testing will be required by the Engineer and/or Owner where there is reason to suspect the integrity of the coating system.
            2) Measure bond strength of the coating in accordance with:
                a) Steel substrate: ASTM D4541.
                b) Concrete substrate ASTM D7234.
            3) The number of test sites and locations to be tested shall be determined by the Engineer and/or Owner after application of coating. The Contractor will apply the dollies, perform the tests and repair the coating in the presence of the Owner.
                a) For each test that fails, two additional tests shall be performed in the adjacent area.
                b) Further bond tests may be performed to determine the extent of potentially deficient bonded areas at no additional cost to the Owner.
            4) Repairs shall be made by applicator in strict accordance with manufacturer's recommendations. Any coated areas that do not pass the bond strength tests shall be removed and replaced at the expense of the Contractor.

D. NACE inspection:
    1. The Owner reserves the right to retain a NACE Level 3 coating inspector to perform observation, inspection and testing as deemed necessary to document the quality of the Work.
        a. All work shall be done to the satisfaction of the Owner's inspector.
        b. Any portion of the coating that does not satisfactorily pass the inspection and testing requirements shall be repaired or replaced by the Contractor at no additional cost to the Owner.
        c. Additional testing and/or inspection may be done at the discretion of the Owner.
            1) The Contractor will provide all equipment, materials, and labor to perform the testing.
    2. Inspection, testing or observation by the Owner's inspector shall not relieve the Contractor of responsibility for surface preparation, inspection or quality control specified herein.

E. Instrumentation:

1. Provide instrumentation as necessary to measure and record atmospheric and substrate conditions, including but not limited to:
    a. Dry Film Thickness Gauge:
        1) Ultrasonic: ASTM D6132.
        2) Magnetic: ASTM B499.
    b. Wet Film Thickness Gauge: ASTM D4414.
    c. Sling Psychrometer: ASTM E337.
    d. Surface Temperature Gauge.
    e. Anemometer.
    f. Moisture Meter.
    g. Adhesion test apparatus:
        1) Steel: ASTM D4541.
        2) Concrete: ASTM D7234.

F. Maintain Daily Records:
1. Record the following information during application:
    a. Date, starting time, end time, and all breaks taken by applicators.
    b. Air temperature.
    c. Relative humidity.
    d. Dew point.
    e. Moisture content and pH level of concrete or masonry substrates prior to coating.
    f. Surface temperature of substrate.
    g. Provisions utilized to maintain work area within manufacturer's recommended application parameters including temporary heating, ventilation, cooling, dehumidification and provisions utilized to mitigate wind-blown dust and debris from contaminating the wet coating.
    h. For outdoor coating, also record:
        1) Sky condition.
        2) Wind speed and direction.
    i. Record environmental conditions, substrate moisture content and surface temperature information not less than once every 4 hours during application.
        1) Record hourly when temperatures are below 50 degrees F or above 100 degrees F.
2. Record the following information daily for the coating manufacturer's recommended curing period:
    a. Date and start time of cure period for each item or area.
    b. For outdoor coating, also record:
        1) Sky conditions.
        2) Wind speed and direction.
        3) Air temperature.
            a) Dry Bulb.
            b) Wet Bulb.
        4) Relative humidity.
        5) Dew point.
        6) Surface temperatures.
    c. Record environmental conditions not less than once every 4 hours.
        1) Record hourly when temperatures are below 50 degrees F or above 100 degrees F.
    d. Provisions utilized to protect each item or area and to maintain areas within manufacturer's recommended curing parameters.

3. Format for daily record to be computer generated.

G. Provide wet paint signs.

3.8 CLEANING

A. Clean coating spattered surfaces.

1. Use care not to damage finished surfaces.

B. Upon completion of coating, replace hardware, accessories, plates, fixtures, and similar items.

C. Remove surplus materials, scaffolding, and debris.

3.9 COLOR SCHEDULE

A. Pipe Bollards: Safety Yellow.

B. Piping:

1. Refer to Specification Section 10 14 00 for the piping system and banding material and refer to this Specification Section and this Schedule for the banding colors.

C. Process Piping and Pipe Banding Color Schedule:

SERVICE	PIPE COLOR	BANDING COLOR
Wastewater Piping:		
Raw Sewage (RS)	Gray	Black
Degritted Sewage (DGS)	Gray	Brown
Mixed Liquor (ML)	Gray	Safety Green
Secondary Effluent (SE)	Gray	Red
Filtered Effluent (FE)	Gray	International Orange/Black
UV Disinfection Effluent (UV)	Gray	International Orange/Brown
Plumbing drains (D, RD, SD, V)	Gray	Safety Blue
Filter backwash (D)	Gray	Safety Yellow
Pumped Drainage (PD)	Gray	White
Sludge Piping:		
Waste Activated Sludge (WAS) Scum (SC)	Brown	Gray/Black
Return Activated Sludge (RAS)	Brown	Gray/Red waste activated
Thickened Sludge (THS)	Brown	Red/Black
Grit (GR)	Dk. Brown	07SF-Red
Water Piping:		
Utility (non-potable; UW)	-	32GR-Gray
Recycled Water (RUS)	Purple, Pantone 512	White
Potable Water (W1)	-	35GR/07SF-Black/Red
Potable Water Cold (CW)	-	35GR/07SF-Black/Red
Potable Water Hot (HW)	-	05SF-International Orange
Potable Water Tempered (TW)	-	05SF-International Orange
Gas and Fuel Piping:		

SERVICE	PIPE COLOR	BANDING COLOR
L-P or natural (NG)	Safety Yellow	Safety Red/Black
Fuel oil/Diesel	Safety Yellow	Safety Red/Safety Green
Ozone	Safety Yellow	InternationalOrange
Vacuum	Safety Yellow	Safety Blue
Nitrogen	Safety Yellow	Safety Green
Exhaust (ODA)	Safety Yellow	White/Black
Low Pressure Process Air (LPA)	-	White/Gray
Chemical Piping:		
Polymer (POL)	White	Black/Gray
Soda Ash Solution (SAS)	White	Black/Brown/Red
Alum (AS)	White	Black/Brown/International Orange

3.10 ROOM FINISH SCHEDULE

A. See Interior Finish Schedule on Drawings.

END OF SECTION

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DIVISION 10

SPECIALTIES

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SECTION 10 14 00
IDENTIFICATION DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Tag, tape and stenciling systems for equipment, piping, valves, pumps, ductwork and similar items.
2. Hazard and safety signs.

B. Related Specification Sections include but are not necessarily limited to:

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Society of Mechanical Engineers (ASME):
   a. A13.1, Scheme for the Identification of Piping Systems.
2. The International Society of Automation (ISA).
3. National Electrical Manufacturers Association/American National Standards Institute (NEMA/ANSI):
   a. Z535.1, Safety Color Code.
   b. Z535.2, Environmental and Facility Safety Signs.
   c. Z535.3, Criteria for Safety Symbols.
   d. Z535.4, Product Safety Signs and Labels.
4. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 704, Standard System for the Identification of Hazards of Materials for Emergency Response.
5. Occupational Safety and Health Administration (OSHA):
   a. 29 CFR 1910.145, Specification for Accident Prevention Signs and Tags.

1.3 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
   a. Catalog information for all identification systems.
   b. Acknowledgement that products submitted meet requirements of standards referenced.
2. Identification register, listing all items in PART 3 of this Specification Section to be identified, type of identification system to be used, lettering, location and color.
3. Schedule of Hazard and Safety Signage indicating text and graphics.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. W.H. Brady Co.
2. Panduit.
3. Seton.
4. National Band and Tag Co.

5. Carlton Industries, Inc.

2.2 MANUFACTURED UNITS

A. Type A1 - Round Metal Tags:

1. Materials:
   a. Aluminum or stainless steel.
   b. Stainless steel shall be used in corrosive environments.
2. Size:
   a. Diameter: 1-1/2 inches minimum.
   b. Thickness: 0.035 inches (20 GA) minimum.
3. Fabrication:
   a. 3/16 inches minimum mounting hole.
   b. Legend: Stamped and filled with black coloring.
4. Color: Natural.

B. Type A2 - Rectangle Metal Tags:

1. Materials: Stainless steel.
2. Size:
   a. 3-1/2 inches x 1-1/2 inches minimum.
   b. Thickness: 0.036 inches (20 GA) minimum.
3. Fabrication:
   a. 3/16 inches minimum mounting hole.
   b. Legend: Stamped and filled with black coloring.
4. Color: Natural.

C. Type A3 - Metal Tape Tags:

1. Materials: Aluminum or stainless steel.
2. Size:
   a. Width 1/2 inches minimum.
   b. Length as required by text.
3. Fabrication:
   a. 3/16 inches minimum mounting hole.
   b. Legend: Embossed.
4. Color: Natural.

D. Type B1- Square Nonmetallic Tags:

1. Materials: Fiberglass reinforced plastic.
2. Size:
   a. Surface: 2 x 2 inches minimum.
   b. Thickness: 100 mils.
3. Fabrication:
   a. 3/16 inches mounting hole with metal eyelet.
   b. Legend: Preprinted and permanently embedded and fade resistant.
4. Color:
   a. Background: Manufacturer standard or as specified.
   b. Lettering: Black.

E. Type B2 - Nonmetallic Signs:

1. Materials: Fiberglass reinforced or durable plastic.

2. Size:
    a. Surface: As required by text.
    b. Thickness: 60 mils minimum.
3. Fabrication:
    a. Rounded corners.
    b. Drilled holes in corners with grommets.
    c. Legend: Preprinted, permanently embedded and fade resistant for a 10 year minimum outdoor durability.
4. Color:
    a. Background: Manufacturer standard or as specified.
    b. Lettering: Black.
5. Standards for OSHA signs: NEMA/ANSI Z535.1, NEMA/ANSI Z535.2, NEMA/ANSI Z535.3, NEMA/ANSI Z535.4, OSHA 29 CFR 1910.145.

F. Type C - Laminated Name Plates:

1. Materials: Phenolic or DR (high impact) acrylic.
2. Size:
    a. Surface: As required by text.
    b. Thickness: 1/16 inches.
3. Fabrication:
    a. Outdoor rated and UV resistant when installed outdoors.
    b. Two layers laminated.
    c. Legend: Engraved through top lamination into bottom lamination.
    d. Two drilled side holes, for screw mounting.
4. Color: Black top surface, white core, unless otherwise indicated.

G. Type D - Self-Adhesive Tape Tags and Signs:

1. Materials: Vinyl tape or vinyl cloth.
2. Size:
    a. Surface: As required by text.
    b. Thickness: 5 mils minimum.
3. Fabrication:
    a. Indoor/Outdoor grade.
    b. Weather and UV resistant inks.
    c. Permanent adhesive.
    d. Legend: Preprinted.
    e. Wire markers to be self-laminating.
4. Color: White with black lettering or as specified.
5. Standards for OSHA signs: NEMA/ANSI Z535.1, NEMA/ANSI Z535.2, NEMA/ANSI Z535.3, NEMA/ANSI Z535.4, OSHA 29 CFR 1910.145.

H. Type E - Heat Shrinkable Tape Tags:

1. Materials: Polyolefin.
2. Size: As required by text.
3. Fabrication:
    a. Legend: Preprinted.
4. Color: White background, black printing.

I. Type F - Underground Warning Tape:

1. Materials: Polyethylene.
2. Size:
    a. 6 inches wide (minimum).
    b. Thickness: 3.5 mils.
3. Fabrication:
    a. Legend: Preprinted and permanently imbedded.
    b. Message continuous printed.
    c. Tensile strength: 1750 psi.
4. Color: As specified.

J. Type G - Stenciling System:

1. Materials:
    a. Exterior type stenciling enamel.
    b. Either brushing grade or pressurized spray can form and grade.
2. Size: As required.
3. Fabrication:
    a. Legend: As required.
4. Color: Black or white for best contrast.

K. Underground Tracer Wire:

1. Materials:
    a. Wire:
        1) 12 GA AWG.
        2) Solid.
    b. Wire nuts: Waterproof type.
    c. Split bolts: Brass.

2.3 ACCESSORIES

A. Fasteners:

1. Bead chain: #6 brass, aluminum or stainless steel.
2. Plastic strap: Nylon, urethane or polypropylene.
3. Screws: Self-tapping, stainless steel.
4. Adhesive, solvent activated.

2.4 MAINTENANCE MATERIALS

A. Where stenciled markers are provided, clean and retain stencils after completion and include in extra stock, along with required stock of paints and applicators.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Install identification devices at specified locations.

B. All identification devices to be printed by mechanical process, hand printing is not acceptable.

C. Attach tags to equipment with sufficient surface or body area with solvent activated adhesive applied to back of each tag.

D. Attach tags with 1/8 inches round or flat head screws to equipment without sufficient surface or body area, or porous surfaces.

1. Where attachment with screws should not or cannot penetrate substrate, attach with plastic strap.

E. Single items of equipment enclosed in a housing or compartment to be tagged on outside of housing.

1. Several items of equipment mounted in housing to be individually tagged inside the compartment.

F. Tracer Wire:

1. Attach to pipe at a maximum of 10 feet intervals with tape or tie-wraps.
2. Continuous pass from each valve box and above grade at each structure.
3. Coil enough wire at each valve box to extend wire a foot above the ground surface.
4. 1,000 feet maximum spacing between valve boxes.
5. If split bolts are used for splicing, wrap with electrical tape.
6. If wire nuts are used for splicing, knot wire at each splice point leaving 6 inches of wire for splicing.
7. Use continuous strand of wire between valve box where possible.
    a. Continuous length shall be no shorter than 100 feet.

3.2 SCHEDULES

A. Hazard and Safety Signage:

1. Permit Required Confined Space signage:
    a. Tag Type: Type B2 - Nonmetallic Signs.
    b. Fastener: Screw or adhesive.
    c. Size: 10 inches x 14 inches.
    d. Location: Woodside Influent Lift Station lid, to the southwest of the access hatches.
    e. Legend:
        1) OSHA Danger sign.
        2) Description of hazard: “PERMIT REQUIRED CONFINED SPACE DO NOT ENTER”.
2. Confined Space signage:
    a. Tag Type: Type B2 - Nonmetallic Signs.
    b. Fastener: Screw or adhesive.
    c. Size: 10 inches x 14 inches.
    d. Locations:
        1) Woodside Influent Lift Station valve vault.
        2) Influent Flow Meter vault.
        3) Batch Tank pumping valve and flow meter vaults (Bid Alternate – Batch Tank Pumping).
    e. Legend:
        1) OSHA Danger sign.
        2) Description of hazard: “CONFINED SPACE DO NOT ENTER”.
3. Entrance to classified process rooms:
    a. Tag Type: Type B2 - Nonmetallic Signs.
    b. Fastener: Screw or adhesive.
    c. Size: 10 inches x 14 inches.
    d. Locations: D-4, D-6, D-8.
    e. Legend:
        1) OSHA Danger sign.
        2) Description of hazard: “WARNING, COMBUSTIBLE OR TOXIC GAS MAY BUILD UP WITHIN SPACE WHEN RED LIGHT IS FLASHING”.

4. Non-Potable Water signage:
    a. Tag Type: Type B2 - Nonmetallic Signs.
    b. Fastener: Screw or adhesive.
    c. Size: 10 inches x 14 inches.
    d. Locations: All new yard hydrants and hose bibbs as shown on Drawings.
    e. Legend:
        1) OSHA Danger sign.
        2) Description of hazard: “DANGER, NON-POTABLE WATER DO NOT USE FOR DRINKING, WASHING, OR COOKING”.
5. Miscellaneous OSHA hazard signage:
    a. Tag Type: Type B2 - Nonmetallic Signs.
    b. Fastener: Screw or adhesive.
    c. Size: 10 inches x 14 inches.
    d. Location: Field located as directed by Owner.
        1) Allowance: Provide 10 OSHA Danger, Caution, Safety Instruction or Biohazard signs as directed by Owner.
    e. Legend:
        1) Description of hazard shall be determined by Owner.
        2) Provide international graphic symbology where indicated.

B. Process Systems:
1. General:
    a. Provide arrows and markers on piping.
        1) At 20 feet maximum centers along continuous lines.
        2) At changes in direction (route) or obstructions.
        3) At valves, risers, "T" joints, machinery or equipment.
        4) Where pipes pass through floors, walls, ceilings, cladding assemblies and like obstructions provide markers on both sides.
    b. Position markers on both sides of pipe with arrow markers pointing in flow direction.
        1) If flow is in both directions use double headed arrow markers.
    c. Apply tapes and stenciling in uniform manner parallel to piping.
2. Trenches with piping:
    a. Tag type: Type F - Underground Warning Tape
    b. Location: Halfway between top of piping and finished grade.
    c. Letter height: 1-1/4 inches minimum.
    d. Natural gas:
        1) Color: Yellow with black letters.
        2) Legend:
            a) First line: “CAUTION CAUTION CAUTION”
            b) Second line: “BURIED GAS LINE BELOW”
    e. Potable water:
        1) Color: Blue with black letters.
        2) Legend:
            a) First line: “CAUTION CAUTION CAUTION”
            b) Second line: “BURIED WATER LINE BELOW”
    f. Storm and sanitary sewer lines:
        1) Color: Green with black letters.

2) Legend:
a) First line: “CAUTION CAUTION CAUTION”
b) Second line: “BURIED SEWER LINE BELOW”

g. (Non-potable) water piping, except 3 inches and smaller irrigation pipe:
1) Color: Green with black letters.
2) Legend:
a) First line: “CAUTION CAUTION CAUTION”
b) Second line: “BURIED NON-POTABLE WATER LINE BELOW”

h. Chemical feed piping (e.g., chlorine solution, polymer solution, caustic solution, etc.):
1) Color: Yellow with black letters.
2) Legend:
a) First line: “CAUTION CAUTION CAUTION”
b) Second line: “BURIED CHEMICAL LINE BELOW”

i. Other piping (e.g., compressed air, irrigation, refrigerant, heating water, etc.):
1) Color: Yellow with black letters.
2) Legend:
a) First line: “CAUTION CAUTION CAUTION”
b) Second line: “BURIED PIPE LINE BELOW”

3. Yard valves, buried, with valve box and concrete pad:
a. Tag type: Type A2 - Rectangle Metal Tags.
b. Fastener: 3/16 inches x 7/8 inches plastic screw anchor with 1 inch #6 stainless steel pan head screw.
c. Legend:
1) Letter height: 1/4 inches minimum.
2) Valve designation as indicated on the Drawings (e.g., “V-xx-xx”).

4. Concrete pump station with submersible pumps:
a. Tag type: Type A2 - Rectangle Metal Tags.
b. Fastener: 3/16 inches x 7/8 inches plastic screw anchor with 1 inch #6 stainless steel pan head screw.
c. Legend:
1) Letter height: 1/4 inches minimum.
2) Pump designation as indicated on the Drawings (e.g., “P-xx-xx”).

5. Concrete vault with flow meters:
a. Tag type: Type A2 - Rectangle Metal Tags.
b. Fastener: 3/16 inches x 7/8 inches plastic screw anchor with 1 inch #6 stainless steel pan head screw.
c. Legend:
1) Letter height: 1/4 inches minimum.
2) Flow meter designation as indicated on the Drawings (e.g., “FE-xx-xx”).

6. Valves and slide gates:
a. Tag type:
1) Outdoor locations: Type B1 - Square Nonmetallic Tags.
2) Indoor noncorrosive:
a) Type A1 - Round Metal Tags.
b) Type B1 - Square Nonmetallic Tags.
3) Indoor corrosive:
a) Stainless steel Type A1 - Round Metal Tags.

b) Type B1 - Square Nonmetallic Tags.

b. Fastener:
   1) Type A1: Chain of the same material.
   2) Type B1: Stainless steel chain.
c. Color: Per ASME A13.1 corresponding to the piping system.
d. Legend:
   1) Letter height: 1/4 inches minimum.
   2) Valve or gate designation as indicated on the Drawings (e.g., “V-xx-xx”).

7. Process equipment (e.g., pumps, pump motors, blowers, air compressors, bar screens, clarifier drive mechanism, etc.):
   a. Tag type:
      1) Type B2 - Nonmetallic Signs.
      2) Type D - Self-Adhesive Tape Tags and Signs.
      3) Type G - Stenciling System.
   b. Fastener:
      1) Self.
      2) Screws.
      3) Adhesive.
   c. Legend:
      1) Letter height: 1/2 inches minimum.
      2) Equipment designation as indicated on the Drawings (e.g., “Primary Sludge Pump P-xx-xx”).
8. Piping systems:
   a. Tag type:
      1) Outdoor locations: Type G - Stenciling System.
      2) Indoor locations:
         a) Type D - Self-Adhesive Tape Tags and Signs.
         b) Type G - Stenciling System.
   b. Fastener: Self.
   c. Color: Per ASME A13.1.
   d. Legend:
      1) Letter height: Manufacturers standard for the pipe diameter.
      2) Mark piping in accordance with ASME A13.1.
      3) Use piping designation as indicated on the Drawings.
      4) Arrow: Single arrow.
9. Process tanks (over 1000 GAL) and basins, (e.g., chemical storage, clarifiers, trickling filters, digesters, etc.):
   a. Tag type:
      1) Type B2 - Nonmetallic Signs.
      2) Type G - Stenciling System.
   b. Fastener:
      1) Screw.
      2) Self.
   c. Location as directed by Owner.
   d. Legend:
      1) Letter height: 4 inches minimum.
      2) Equipment designation as indicated on the Drawings (e.g., “Clarifier CL-xx-xx”).

10. Tanks (less than 1000 GAL) (e.g., break tanks, chemical tanks, hydro-pneumatic tanks, air receivers, etc.):
    a. Tag type:
        1) Type D - Self-Adhesive Tape Tags and Signs.
        2) Type G - Stenciling System.
    b. Fastener: Self.
    c. Legend:
        1) Letter height: 2 inches minimum.
        2) Equipment designation as indicated on the Drawings (e.g., “Polymer Storage Tank T-xx-xx”)
11. Equipment that starts automatically:
    a. Tag type:
        1) Type B2 - Nonmetallic Signs.
        2) Type D - Self-Adhesive Tape Tags and Signs.
    b. Fastener:
        1) Type B2 - Screw or adhesive.
        2) Type D - Self-Adhesive Tape Tags and Signs.
    c. Size: 5 inches x 7 inches
    d. Location:
        1) Influent Screens: SCRN-02-01, SCRN-02-02.
        2) Grit Classifier: GC-03-01.
    e. Legend:
        1) OSHA Warning Sign.
        2) Description of Warning: “THIS MACHINE STARTS AUTOMATICALLY”.

C. Instrumentation Systems:
1. Instrumentation Equipment (e.g., flow control valves, primary elements, etc.):
    a. Tag type:
        1) Outdoor locations: Type B1 - Square Nonmetallic Tags.
        2) Indoor noncorrosive:
            a) Type A1 - Round Metal Tags.
            b) Type B1 - Square Nonmetallic Tags.
        3) Indoor corrosive:
            a) Stainless steel Type A1 - Round Metal Tags.
            b) Type B1 - Square Nonmetallic Tags.
    b. Fastener:
        1) Type A1: Chain of the same material.
        2) Type B1: Stainless steel chain.
    c. Legend:
        1) Letter height: 1/4 inches minimum.
        2) Equipment ISA designation as indicated on the Drawings (e.g., “FIT-xx-xx”).
2. Enclosure for instrumentation and control equipment, (e.g., PLC control panels, etc.):
    a. Tag type: Type C - Phenolic Name Plates.
    b. Fastener: Screws.
    c. Legend:
        1) Letter height: 1/2 inches minimum.
        2) Equipment name (e.g., "PLC CONTROL PANEL PCP-xx-xx").

3. Components inside equipment enclosure, (e.g., PLC's, control relays, contactors, and timers):
    a. Tag type: Type D - Self-Adhesive Tape Tags.
    b. Fastener: Self.
    c. Legend:
        1) Letter height: 3/16 inches minimum.
        2) Description or function of component (e.g., "PLC-xx-xx" or "CR-xx-xx").
4. Through enclosure door mounted components (e.g., selector switches, controller digital displays, etc.):
    a. Tag type: Type C - Phenolic Name Plates.
    b. Fastener: Screws.
    c. Legend:
        1) Letter height: 1/4 inches minimum.
        2) Component ISA tag number as indicated on the Drawings (e.g., "HS-xx-xx").

D. HVAC Systems:
1. General:
    a. Provide arrows and markers on ducts.
        1) At 20 feet maximum centers along continuous lines.
        2) At changes in direction (route) or obstructions.
        3) At dampers, risers, branches, machinery or equipment.
        4) Where ducts pass through floors, walls, ceilings, cladding assemblies and like obstructions provide markers on both sides.
    b. Position markers on both sides of duct with arrow markers pointing in flow direction.
        1) If flow is in both directions use double headed arrow markers.
    c. Apply tapes and stenciling in uniform manner parallel to ducts.
2. HVAC Equipment (e.g., unit heaters, exhaust fans, air handlers, etc.):
    a. Tag type:
        1) Type B2 - Nonmetallic Signs.
        2) Type C - Phenolic Name Plates.
    b. Fastener: Screws.
    c. Legend:
        1) Letter height: 1 inch minimum.
        2) Equipment designation as indicated on the Drawings (e.g., "EF-xx-xx").
3. Ductwork:
    a. Tag type:
        1) Type D - Self-Adhesive Tape Tags and Signs.
        2) Type G - Stenciling System.
    b. Fastener: Self.
    c. Legend:
        1) Letter height: 1 inch minimum.
        2) Description of ductwork, (e.g., "AIR SUPPLY").
        3) Arrows: Single arrow.
4. Enclosure for instrumentation and control equipment, (e.g., fan control panels, etc.):
    a. Tag type: Type C - Phenolic Name Plates.
    b. Fastener: Screws.
    c. Legend:

1) Letter height: 1/2 inches minimum.
2) Equipment designation as indicated on the Drawings (e.g., "FAN CONTROL PANEL FCP-xx-xx").

5. Wall mounted thermostats:
   a. Tag type: Type D - Self-Adhesive Tape Tags and Signs.
   b. Fastener: Self.
   c. Legend:
      1) Letter height: 3/16 inches minimum.
      2) Description of equipment controlled (e.g., "UH-xx-xx" or AHU-xx-xx").
6. Components inside equipment enclosure, (e.g., controller's, control relays, contactors, and timers):
   a. Tag type: Type D - Self-Adhesive Tape Tags and Signs.
   b. Fastener: Self.
   c. Legend:
      1) Letter height: 3/16 inches minimum.
      2) Description or function of component (e.g., "CR-xx-xx").
7. Through enclosure door mounted equipment (e.g., selector switches, controller digital displays, etc.):
   a. Tag type: Type C - Phenolic Name Plates.
   b. Fastener: Screws.
   c. Legend:
      1) Letter height: 1/4 inches minimum.
      2) Component tag number as indicated on the Drawings or as defined by contractor (e.g., "HS-xx-xx").

E. Electrical Systems:
1. Trenches with ductbanks, direct-buried conduit, or direct-buried wire and cable.
   a. Tag type: Type F - Underground Warning Tape.
   b. Letter height: 1-1/4 inches minimum.
   c. Location:
      1) Where trench is 12 inches or more below finished grade: In trench 6 inches below finished grade.
      2) Where trench is less than 12 inches below finished grade: In trench 3 inches below finished grade.
   d. Electrical power (e.g., low and medium voltage):
      1) Color: Red with black letters.
      2) Legend:
         a) First line: "CAUTION CAUTION CAUTION".
         b) Second line: "BURIED ELECTRIC LINE BELOW".
   e. Communications (e.g., telephone, instrumentation, LAN, SCADA):
      1) Color: Orange with black letters.
      2) Legend:
         a) First line: "CAUTION CAUTION CAUTION".
         b) Second line: "BURIED COMMUNICATION LINE BELOW".
2. Switchgear, switchboards and motor control centers:
   a. Tag type: Type C - Phenolic Name Plates.
   b. Fastener: Screws.
   c. Main equipment legend:

1) Letter height:
a) First line: 1 inch minimum.
b) Subsequent lines: 3/8 inches minimum.
2) First line: Equipment name (e.g., "MAIN SWITCHBOARD MSB-xx-xx").
3) Second line:
a) Source of power (e.g., "FED FROM MCC-xx-xx LOCATED IN ROOM xxx").
b) Include the building name or number if the source is in another building.
4) Third line: System voltage and phase (e.g., “480/277 V, 3PH”).
5) Fourth line: Date installed (e.g., “INSTALLED JULY 20xx”).

d. Main and feeder device legend:
1) Letter height: 3/8 inches minimum.
2) Description of load (e.g., “MAIN DISCONNECT”, "PUMP P-xx-xx" or "PANELBOARD HP-xx-xx").

3. Panelboards and transformers:
a. Tag type: Type C - Phenolic Name Plates.
b. Fastener: Screws.
c. Legend:
1) Letter height:
a) First line: 3/8 inches minimum.
b) Subsequent lines: 3/16 inches minimum.
2) First line: Equipment name (e.g., "PANELBOARD LP-xx-xx" or "TRANSFORMER T-xx-xx").
3) Second line (panelboards only): System voltage and phase (e.g., “208/120V, 3PH”).
4) Third line:
a) Source of power (e.g., "FED FROM MCC-xx-xx LOCATED IN ROOM xxx").
b) Include the building name or number if the source is in another building.
5) Fourth line: Date installed (e.g., “INSTALLED JULY 20xx”).

4. Transfer switches:
a. Tag type: Type C - Phenolic Name Plates.
b. Fastener: Screws.
c. Legend:
1) Letter height:
a) First line: 3/8 inches minimum.
b) Subsequent lines: 3/16 inches minimum.
2) First line: Equipment name (e.g., "AUTOMATIC TRANSFER SWITCH ATS-xx-xx").
3) Second line: Normal source of power (e.g., "NORMAL SOURCE FED FROM MCC-xx-xx").
4) Third line: Emergency source of power (e.g., "EMERGENCY SOURCE FED FROM SGEN-xx-xx").
5) Fourth line: Date installed (e.g., “INSTALLED JULY 20xx”).

5. Safety switches, separately mounted circuit breakers and motor starters, VFD’s, etc.:
a. Tag type: Type C - Phenolic Name Plates.
b. Fastener: Screws.
c. Legend:
1) Letter height: 1/4 inches minimum.
2) First line: Description of load equipment is connected to (e.g., "PUMP P-xx-xx").

3) Second line:
   a) Source of power (e.g., "FED FROM MCC-xx-xx LOCATED IN ROOM xxx").
   b) The source of power room number is only required when there are multiple electrical rooms, if the source is in another building, the building name or number shall be used.

6. Enclosure for instrumentation and control equipment, (e.g., lighting control panels, etc.):
   a. Tag type: Type C - Phenolic Name Plates.
   b. Fastener: Screws.
   c. Legend:
      1) Letter height: 1/2 inches minimum.
      2) Equipment name (e.g., "LIGHTING CONTROL PANEL LCP-xx-xx").
7. Components inside equipment enclosures (e.g., circuit breakers, fuses, control power transformers, control relays, contactors, timers, etc.):
   a. Tag type: Type D - Self-Adhesive Tape Tags and Signs.
   b. Fastener: Self.
   c. Legend:
      1) Letter height: 3/16 inches minimum.
      2) Description or function of component (e.g., "M-xx-xx", “CR-xx-xx” or “TR-xx-xx").
8. Through enclosure door mounted equipment (e.g., selector switches, controller digital displays, etc.):
   a. Tag type: Type C - Phenolic Name Plates.
   b. Fastener: Screws.
   c. Legend:
      1) Letter height: 1/4 inches minimum.
      2) Component tag number as indicated on the Drawings or as defined by contractor (e.g., “HS-xx-xx”).
9. Conductors in control panels and in pull or junction boxes where multiple circuits exist.
   a. Tag type: Type D - Self-Adhesive Tape Tags.
   b. Fastener: Self.
   c. Tag conductor at both ends.
   d. Legend:
      1) Letter height: 1/8 inches minimum.
      2) Circuit number or wire number as scheduled on the Drawings or as furnished with the equipment.
10. Conductors in cable trays.
   a. Tag type: Type D - Self-Adhesive Tape Tags.
   b. Fastener: Self.
   c. Tag all conductors at the same location in the tray at 50 feet maximum intervals.
   d. Legend:
      1) Letter height: 1/8 inches minimum.
      2) Circuit number or wire number as scheduled on the Drawings.
11. Conductors in handholes and manholes.
   a. Tag type: Type A3 - Metal Tape Tags.
   b. Fastener: Nylon strap.
   c. Tag conductor at both ends.
   d. Legend:
      1) Letter height: 1/8 inches minimum.

2) Circuit number or wire number as scheduled on the Drawings.

12. Grounding conductors associated with grounding electrode system in accordance with the following:
    a. Tag type: Type D - Self-Adhesive Tape Tags.
    b. Fastener: Self.
    c. Legend:
        1) Letter height: 1/8 inches minimum.
        2) Function of conductor (e.g., "MAIN BONDING JUMPER", "TO GROUND RING", "TO MAIN WATER PIPE").
13. Flash protection for switchboards, panelboards, industrial control panels and motor control centers:
    a. Tag type: Type D - Self-Adhesive Tape Signs.
    b. Fastener: Self.
    c. Legend: Per NFPA 70.
14. Entrances to electrical rooms:
    a. Tag type: Type B2 - Nonmetallic Signs.
    b. Fastener: Screw or adhesive.
    c. Size: 5 inches x 7 inches.
    d. Location: Each door to room.
    e. Legend:
        1) OSHA Danger Sign.
        2) Description of Danger: “HIGH VOLTAGE, AUTHORIZED PERSONNEL ONLY”.
15. Equipment where more than one voltage source is present:
    a. Tag type:
        1) Type B2 - Nonmetallic Signs.
        2) Type D - Self-Adhesive Tape Signs.
    b. Fastener:
        1) Screw or adhesive.
        2) Self.
    c. Size: 1-3/4 inches x 2-1/2 inches.
    d. Location: Exterior face of enclosure or cubical.
    e. Legend:
        1) OSHA Danger Sign.
        2) Description of Danger: “MULTIPLE VOLTAGE SOURCES”.

END OF SECTION

SECTION 10 14 23
SIGNAGE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Room identification signs.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 10 14 00 - Identification Devices.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. Americans with Disabilities Act (ADA):
   a. Accessibility Guidelines for Buildings and Facilities (ADAAG).
2. ASTM International (ASTM):
   a. B26, Standard Specification for Aluminum-Alloy Sand Castings.

1.3 DEFINITIONS

A. Authority Having Jurisdiction (AHJ): Building official, fire chief, fire marshal or other individual having statutory authority.

B. Wet and/or Corrosive Areas: For the purposes of this Specification Section, the following rooms or areas are considered wet and/or corrosive:

1. Pump rooms.
2. Process equipment rooms.
3. Rooms containing open basins of water or wastewater.

1.4 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Manufacturer's installation instructions.
   c. Color charts for Engineer's color selection.
      1) Color selection shall be made from manufacturer's complete color line including all premium and special colors.
2. Schedule of all signs indicating text and graphics.
3. Layout drawings of all signage showing size, letter style, text, border, finish, and installation detail.
   a. Provide drawings for:
      1) Room, exit, and stair identification signs.

B. Samples:

1. Room, exit, and stair identification signs.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Room, exit and stair identification signs:
    a. ASE - Architectural Signs and Engraving.
    b. ASI Signage Innovations.
    c. Best Sign Systems.
    d. Mohawk Sign Systems.
    e. Nelson-Harkins.
    f. Southwell Co.
    g. Stamprite Supersine Identification Specialists.

2.2 MATERIALS

A. Room, Exit, and Stair Identification Signs:

1. Interior:
    a. Dry, non-corrosive areas: Melamine plastic suitable for raised lettering and Braille.
    b. Wet and/or corrosive areas: Aluminum or fiberglass suitable for raised lettering and Braille.
2. Exterior: Aluminum or fiberglass suitable for raised lettering and Braille.

2.3 FABRICATION

A. Room and Exit Identification Signs:

1. General:
    a. Raised text, border and graphics.
        1) Minimum 1/32 inches height.
        2) Provide international graphic symbology for all toilet, locker and shower rooms or combinations thereof, and for unisex toilet rooms and stairs.
        3) Provide handicap symbol on all signs for rooms meeting handicap requirements.
    b. Grade 2 Braille.
    c. Finish: Eggshell.
        1) Color: To be selected.
    d. Text:
        1) Typeface: Sans Serif.
        2) Size: Minimum 3/4 inches high.
    e. Text as indicated in the SCHEDULES Article in PART 3 of this Specification Section.
    f. Exterior signs shall be rated for exterior use.
    g. All signs shall comply with requirements of ADA.
2. Typeface: Helvetica Medium.
3. Text Size:
    a. Height: 3 inches minimum.
    b. Stroke: 3/8 inches minimum.
    c. Text: As indicated in the SCHEDULES Article in PART 3Fabrication:

B. Hazard Communication Signage (NFPA and OSHA signage): See Specification Section 10 14 00.

2.4 MAINTENANCE MATERIALS

A. Where stenciled markers are provided, clean and retain stencils after completion and include in extra stock, along with required stock of paints and applicators.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Room Identification Signs:

1. Install signs using foam tape for interior signs and stainless steel screws (minimum of two) for exterior signs.
   a. Stainless steel screws shall be painted to match sign color.
2. Mounting Locations:
   a. Tactile characters on signs shall be located 48 inches minimum above the finished floor or ground surface, measured from the baseline of the lowest tactile character and 60 inches maximum above the finish floor or ground surface, measured from the baseline of the highest tactile character.
   b. Where a tactile sign is provided at a door, the sign shall be located alongside the door at the latch side. Where a tactile sign is provided at double doors with one active leaf, the sign shall be located on the inactive leaf. Where a tactile sign is provided at double doors with two active leafs, the sign shall be located to the right side of the right hand door. Where there is no wall space at the latch side of a single door or at the right side of double doors, signs shall be located on the nearest adjacent wall.
   c. Signs containing tactile characters shall be located so that a clear floor space of 18 inches minimum by 18 inches minimum, centered on the tactile characters, is provided beyond the arc of any door swing between the closed position and 45 degree open position.
3. Interior and exterior signs identifying permanent rooms and spaces shall comply with ADA.

3.2 SCHEDULES

A. Room and Exit Identification Signs:

BUILDING LOCATION	MOUNTING	VERBIAGE	REMARKS
HEADWORKS BUILDING			
DOOR D-01	EXTERIOR	ELECTRICAL ROOM	1, 2
DOOR D-03	EXTERIOR	SCREEN ROOM	1, 2
DOOR D-05	EXTERIOR	SCREEN ROOM	1, 2
DOOR D-07	EXTERIOR	SCREEN ROOM	1, 2

REMARKS:
1. Provide exit signage above door.
2. Mount adjacent to pull side of door.

END OF SECTION

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SECTION 10 44 33
FIRE PROTECTION SPECIALTIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Portable fire extinguishers.
2. Fire extinguisher cabinets.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 05 50 00 - Metal Fabrications.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. Americans with Disabilities Act (ADA):
   a. 2010 ADA Standards for Accessible Design.
2. National Fire Protection Association (NFPA):
   a. 10, Standard for Portable Fire Extinguishers.
3. Underwriters Laboratories, Inc. (UL):
   a. 8, Water Based Agent Fire Extinguishers.
   b. 154, Carbon Dioxide Fire Extinguishers.
   c. 299, Dry Chemical Fire Extinguishers.
   d. 626, Water Fire Extinguishers.
   e. 711, Rating and Fire Testing of Fire Extinguishers.
   f. 2129, Halocarbon Clean Agent Fire Extinguishers.

1.3 DEFINITIONS

A. Authority Having Jurisdiction (AHJ): Building official, fire chief, fire marshal or other individual having statutory authority.

1.4 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Manufacturer's installation instructions.
   c. Ratings and classification of extinguishers.

B. Samples:

C. Contract Closeout Information:

1. Operation and Maintenance Data:
   a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver and install filled and charged extinguishers just prior to building occupancy.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Fire extinguishers:
    a. Amerex Corporation.
    b. Ansul – Tyco Fire Protection Products.
    c. Badger Fire Protection.
    d. United Technologies - Kidde.
    e. Buckeye Fire Equipment.
2. Fire extinguisher cabinets:
    a. J. L. Industries.
    b. Larsen's Manufacturing Co.
    c. Nystrom Building Products.
    d. Modern Metal Products.
    e. Potter - Roemer Inc.
3. Fire extinguisher signs:
    a. Seton.
    b. Compliance Signs.
    c. Safety Sign.

2.2 MANUFACTURED UNITS

A. Fire Extinguisher Cabinet (FEC-4):

1. Surface mounting.
2. 22 GA epoxy coated steel box.
3. Epoxy-coated steel door and trim.
    a. Clear 1/4 inches frameless, backless, unlettered smooth acrylic door.
    b. Door to have full, vertical, 1/4 inches clear glass panel.
4. Provide FIRE EXTINGUISHER decal for face of each cabinet.
5. Provide locking closure and break away locking mechanism.
6. Provide 10 pound 4A:60BC extinguisher.

B. Fire Extinguisher (FEXT):

1. Steel bodied, all metal top (head) and valves.
2. Multi-purpose dry chemical extinguisher with hose and nozzle.
3. Provide one listed 10 pound 4A-60BC extinguisher for each fire extinguisher location (FEXT) indicated on Drawings.
4. Finish: Red with epoxy finish coat.

C. Wall Brackets:

1. Bracket type to fit specified extinguisher.
2. Furnish bracket for each extinguisher not in cabinet.
3. Bracket to be finished in red or black enamel.

D. Fire Extinguisher Signage:

1. Single faced: SETON #21999.
2. Double faced: SETON #16551D.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions and NFPA 10.

1. Install units with extinguisher top not over 48 inches above floor.
2. Install wall brackets to concrete or masonry substrate with self-tapping concrete anchors.
    a. See Specification Section 03 15 19.

B. Install FEC with top of unit at 60 inches above floor.

C. Fire extinguisher locations shown on Drawings are approximate locations.

1. Verify all extinguisher mounting locations with the AHJ.

D. Provide "FIRE EXTINGUISHER" sign for each extinguisher location.

1. Provide single or double faced sign to provide optimum visibility for extinguisher location.

END OF SECTION

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DIVISION 22

PLUMBING

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SECTION 22 20 00
PLUMBING FIXTURES AND EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Plumbing fixtures, trim, and equipment.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 01 61 03 - Equipment - Basic Requirements.
2. Section 40 05 00 - Pipe and Pipe Fittings - Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. Americans with Disabilities Act (ADA):
   a. Accessibility Guidelines for Buildings and Facilities (ADAAG).
2. American National Standards Institute (ANSI):
   a. Z358.1, Emergency Eyewash and Shower Equipment.
3. American Society of Heating, Refrigerating and Air Conditioning Engineers/Illuminating Engineering Society of North America (ASHRAE/IESNA):
   a. 90.1 IP, Energy Standard for Buildings Except Low-Rise Residential Buildings.
4. American Society of Mechanical Engineers (ASME):
   a. A112.19.3, Stainless Steel Plumbing Fixtures (Designed for Residential Use).
5. American Society of Sanitation Engineers (ASSE):
   a. 1011, Performance Requirements for Hose Connection Vacuum Breaker.
6. Canadian Standards Association (CSA).
7. NSF International (NSF).
8. Underwriters Laboratories, Inc. (UL).

1.3 SUBMITTALS

A. Shop Drawings:

1. See Specification Section 01 61 03 and Specification Section 40 05 00.
2. Color selection charts for Owner color selection.
3. Fabrication and/or layout drawings:
   a. Layout plan(s) showing dimensions, elevations, etc.
   b. Details showing connections, installation, rough-in locations, etc.
4. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Manufacturer's installation instructions.
   c. Chemical-resistance data.

B. Contract Closeout Information:

1. Operation and Maintenance Data:
   a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Drains, roof drains, carriers, and shock absorbers:
   a. Wade.
   b. Josam.
   c. Zurn.
   d. Smith.
2. Hose bibs:
   a. Nibco.
   b. Woodford.
3. Reduced pressure backflow preventer:
   a. Watts.
   b. Febco.
   c. Clayton.
4. Hose racks:
   a. Strahman Valves, Inc., Model HR-100.

2.2 MANUFACTURED UNITS

A. Drains, Roof Drains and Downspout Nozzle:

1. Floor drain (FD):
   a. Bottom outlet.
   b. Clamping seepage flange.
   c. Seepage openings.
   d. Size as shown on Drawings.
   e. Type: stainless steel body.
      1) FD-1 (unfinished area) sediment bucket, bucket shall support grate: Wade W-1200-TD.
      2) FD-2 (finished area) adjustable satin nickel bronze strainer: Wade W-1100.
      3) FD-3 (finished area with tile floor) adjustable satin nickel bronze square strainer: Wade W-1100-G.
2. Equipment drain (ED):
   a. Pipe material: Refer to Section 40 05 00, Piping System 21.
   b. Type:
      1) ED-1: Refer to Contract Drawings.
      2) ED-2: Refer to Contract Drawings.
3. Roof drain (RD):
   a. Bottom outlet cast iron drain with flashing clamp, removable cast iron mushroom-type dome and cast iron deck clamp.
   b. Provide cast iron extension flange (-DF) where insulation thickness exceeds 2 inches.
   c. Type:
      1) RD-1: Wade W-3000.
4. Downspout nozzle:
   a. Cast bronze downspout.
   b. Wade W-3940 with stainless steel bird screen.

B. Traps:

1. Floor and equipment drains:
    a. Same material and coating as the piping system.
    b. 3 inches minimum seal.
2. Fixture drains:
    a. 2 inches minimum seal.
    b. PVC.
    c. Size as required.
3. Ventilation housing drains: Extra-deep seal sufficient to maintain seal against static pressure maintained in fan housing.

C. Cleanouts (CO):

1. Cleanouts for PVC:
    a. Tapped PVC ferrule.
    b. PVC screw plug with solid hexagonal nut.
2. Access housing with adjustable anchor flange and secured scoriated cast: Wade W-3800-MF.
3. Cleanouts turning out through walls and up through floor shall be made by long sweep ells or "y" and 1/8 bends with plugs and face or deck plates to conform to architectural finish in room.
    a. Where definite finish is not indicated, and floor plates shall be stainless steel.
4. Code:
    a. Provide cleanouts of same size as pipe up to 4 inches and not less than 4 inches for larger pipes.
    b. Close access openings for concealed cleanouts with flush floor or flush wall cover plates or flush ceiling access panels.
    c. Provide wall plates with stainless steel round cleanout cover with flanged ring.
    d. Provide screws which match cover plate material.
5. Cleanouts installed in floor with ceramic tile, concrete, or Terrazzo finish: Wade W-6000-U.
6. Cleanouts installed in finished rooms flush with wall: Wade W-8480-S stainless steel.
7. Cleanouts installed in completely accessible pipe chases or where piping is exposed do not require special covers.
8. Cleanouts in floating floors: Wade 8300-MF housing and cover with 8550 cleanout body and closure plug or Smith 4250 or 4260 Series housing and cover with 4280 or 4290 Series cleanout body and closure plug.

D. Hose Bibb (HB-1):

1. 3/4 inches boiler drain with attached vacuum breaker-backflow preventer.
2. Hose bibb shall be constructed of stainless steel or PVC for corrosion resistance to hydrogen sulfide environment.
3. Vacuum breaker: Non-removable, manual draining, meeting the requirements of the ASSE 1011.

E. Hose Racks:

1. Stainless steel.
2. 3/4 inches hose capacity: 50 feet.

F. Reduced Pressure Backflow Preventer:

1. RPBP-1:
    a. Backflow preventers consist of two check valves, test cocks and relief valve, all assembled as an integral unit.

b. Reduced pressure backflow preventers Watts 957-FS.
    1) All stainless steel construction for corrosion resistance to hydrogen sulfide environment.
    2) Include non-rising stem gate valves on each end.
    3) Z-pattern installation.
    4) 3-inch size with flanged connections.
c. Pressure loss through backflow preventer not exceeding 14 psi at design flow.
d. Provide air gap and pipe discharge to within 6 inches of finished floor.

G. Water Meter:

1. As indicated of a type approved by Water Department.
    a. Coordinate meters furnished by Water Department as to type and size.
    b. Obtain and pay necessary permits and approvals required to complete installation of water service.
    c. Provide valve on each side of meter and 3/4 inches drain valve spilling over floor drain.
2. Install full sized bypass line around meter with a sealed valve approved by Water Department.
    a. Meters 2 inches and less: Threaded fittings.
    b. Meters 2-1/2 inches and larger: Flanged connections.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Cross Connection: Do not install any plumbing components that will provide a cross connection between potable and non-potable or drainage systems.

B. Fixtures:

1. Install fixtures at locations indicated on Drawings and in compliance with local Codes.
2. Connect plumbing supply, drain and vent line sizes as shown on Drawings.
3. Set proper grounds to form secure base for each fixture and rigid setting.
4. Install fixtures except water closets with water supply above rim and with Code approved backflow preventers.
5. Seal fixture joints abutting walls and floors with silicone sealant.
6. Connect exposed traps and supply pipes for fixtures and equipment to rough piping systems at wall, unless otherwise specified.
7. Install emergency fixtures in accordance with ANSI Z358.1.

C. Drains:

1. Install drains at locations indicated on Drawings and in compliance with local Codes.
2. In quarry tile floors:
    a. 24 x 24 inches 6 pound lead sheet clamped to drain.
    b. Set 1-1/2 inches above structural slab for mortar set and 1/2 inches for thin set.
3. In uncovered concrete slabs:
    a. Install at the low points of surface areas to be drained or as indicated.
    b. Set tops of drains flush with the finished floor.
    c. Install drain flashing collar or a flange so that no leakage occurs between the drain and the adjoining surfaces.
    d. Maintain the integrity of waterproof membranes, where penetrated.
4. Trench drains:
    a. Install in accordance with manufacturer's instructions and approved Shop Drawings.

b. Install trench sections with the top edges level and straight at elevations indicated.
    1) Support channel sections in place while concrete is placed under and around sections as indicated.

D. Hose Racks:
1. Adjacent to hose bibbs, top of rack 36 inches above finished floor or grade.
2. Concrete or masonry walls: Mount with 5/8 inches x 2-1/2 inches stainless steel expansion anchors.
3. Handrail:
    a. Bolt hose rack to 24 inches x 24 inches x 1/4 inches aluminum plate with 5/8 inches stainless steel bolts.
    b. Attach to handrail with 3/8 inches stainless steel through bolt at each corner of the plate.
4. Pedestal:
    a. Bolt hose rack to 24 inches to 24 inches x 1/4 inches aluminum plate with 5/8 inches stainless steel bolts.
    b. Attach to pedestal with two, 1/2 inches stainless steel bolts through handrail.

E. Hose Bibbs:
1. Install 36 inches above finished floor.
2. In exterior locations, provide interior isolation valve.

F. Shock Absorbers:
1. Install on hot and cold water lines adjacent to each battery of fixtures or other equipment where indicated on Drawings.
2. Size as recommended by manufacturer for length of pipe served.
3. Locations having two fixtures or less, install capped air chamber 12 inches long on hot and cold water runouts to each fixture, same size as runout.
4. Runouts to hose bibbs and wall hydrants do not require air chambers.
5. Install units vertically on top of pipe or as detailed on the Drawings.

G. Cleanouts:
1. Install cleanouts:
    a. Above floor in each vertical riser that connects to horizontal branch below floor.
    b. At test tee to receive proper test plugs in each vertical riser at least every other floor.
    c. As required by local Code.

H. Wall Plates and Escutcheons: Install as specified in Specification Section 40 05 00 or this Specification Section.

I. Reduce Pressure Backflow Preventer: Install on water lines as required by Code.

3.2 FIELD QUALITY CONTROL

A. Test piping and fixtures for leaks per Specification Section 40 05 00.

END OF SECTION

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DIVISION 23

HEATING, VENTILATING, AND AIR CONDITIONING (HVAC)

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SECTION 23 05 93

HVAC SYSTEMS - BALANCING AND TESTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Adjusting, balancing, and testing of all heating, ventilating and air conditioning (HVAC) systems, including the following systems:
   a. Air distribution and exhaust systems.
   b. Heating system.

B. Related Sections include but are not necessarily limited to:

1. Section 23 09 00 - Instrumentation and Control for HVAC Systems.
2. Section 23 31 00 - HVAC - Ductwork.
3. Section 23 34 00 - HVAC - Fans.
4. Section 23 80 00 - HVAC - Equipment.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. Associated Air Balance Council (AABC):
   a. National Standards for Total System Balance.
2. American Industrial Hygiene Association (AIHA):
   a. Z9.5, Laboratory Ventilation.
3. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE):
   a. HVAC Systems and Equipment Handbook, Chapter entitled "Testing, Adjusting, and Balancing".
4. National Environmental Balancing Bureau (NEBB):
   a. Procedural Standards for Testing Adjusting Balancing of Environmental Systems.

B. Qualifications:

1. Work of this Section to be accomplished by an independent testing and balancing firm certified by one (1) of the following:
   a. Associated Air Balance Council (AABC).
   b. National Environmental Balancing Bureau (NEBB).
   c. Other certification entity approved by Engineer.
2. The independent firm shall not be the same firm as the firm installing the HVAC equipment, nor under contract to the firm installing the equipment.

1.3 SUBMITTALS

A. Shop Drawings:

1. Certifications:
   a. Letter stating the name and qualifications of the firm proposed.
   b. Evidence that relevant subcontractors have been notified of the requirement to coordinate balance and test elements in the work with the testing and balancing firm.
2. Report forms:
   a. Procedures and forms to be used in calibrating of test instruments, balancing systems, and recording and reporting test data.

B. Informational Submittals:

1. Completed test reports and data forms upon completion of installation, balance and testing of HVAC systems.
    a. Insert recorded information on report forms required by specifications and approved for use on project.
    b. Additional written verification and other related information clearly identifying project, date and specifics of verification.
    c. Utilize report forms similar to those shown in Section V of AABC Standard.
    d. Provide forms typed and signed by the testing and balancing firm.

PART 2 - PRODUCTS - (NOT USED)

PART 3 - EXECUTION

3.1 PREPARATION

A. Secure approved Shop Drawings of all HVAC equipment.

B. Procedures and Forms:

1. Submit procedures and forms to be used in calibration of test instruments, balancing systems, and recording and reporting test data.
2. Obtain approval before beginning balancing and testing.

C. Do not begin balancing and testing until HVAC systems are complete and in full working order.

1. Place HVAC systems into full operation and continue their operation during each working day of balancing and testing.

D. Provide qualified heating and ventilating Engineer(s) to supervise and perform balancing and testing.

E. Review design Drawings, specifications, approved Shop Drawings and other related items to become thoroughly acquainted with the design of HVAC systems.

F. Check all installed systems against Contract Drawings, Specifications and Shop Drawings to see that system is installed as required.

1. Report deficiencies to the Engineer.
2. Report deficiencies to Contractor for remedial action including providing corrective measures required in the function of any part of system to complete balancing.

G. Make necessary adjustments as required to balance the systems.

3.2 FIELD QUALITY CONTROL

A. Balance and Test Air Systems:

1. Adjust equipment RPM to design requirements.
2. Report motor full load amperes.
3. Obtain design CFM at fans.
    a. Make pitot tube traverse of main supply and exhaust ducts within 5%.
4. Test and record system static pressures, suction and discharge.
5. Obtain design CFM for recirculated air.
6. Obtain design CFM outside air.
7. Test and record entering air temperatures, (DB, heating and cooling).
8. Test and record leaving air temperatures, (DB, heating and cooling).
9. Test and record leaving air temperatures, (WB, cooling).
10. Adjust dampers in supply, exhaust and return air ducts to design CFM.
11. Test diffusers, grilles, and registers as follows:
    a. Adjust to comply with design requirements within 10%.

b. Identify location and area of each.
c. Adjust face velocity to establish required CFM.
    1) Retest after initial adjustments.
d. Adjust to minimize drafts and to ensure uniform air distribution in all areas.

12. Identify and list size, type and manufacturer of diffusers, grilles, registers, and HVAC equipment.
    a. Use manufacturer's ratings on equipment to make required calculations.
13. Adjust and assure that the operation of automatically operated dampers are as specified.
    a. Check and calibrate controls.
14. Prepare and submit reports.

END OF SECTION

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SECTION 23 31 00
HVAC - DUCTWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. HVAC ductwork and accessories.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 08 90 00 - Louvers and Vents.
2. Section 01 61 03 - Equipment - Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE):
   a. 52, Method of Testing Air Conditioning Devices Used in General Ventilation for Removing Particulate Matter.
2. National Fire Protection Association (NFPA).
3. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
   a. Ducted Electric Heat Guide for Air Handling Systems.
   b. HVAC Duct Construction Standards - Metal and Flexible.
4. Underwriters Laboratory, Inc. (UL):
   a. 555, Standard for Safety Fire Damper and Ceiling Fire Damper.
   b. 555S, Standard for Safety Leakage Rated Dampers for Use in Smoke Control Systems.
   c. Building Materials Directory.

B. Qualifications:

1. Fabricator: Firms regularly engaged in the manufacture of the specific product, of type, size required, whose products have been in use in similar service for not less than three years.
2. Installers: Firm with at least five years installation experience on products similar to that required for this Project.

1.3 DEFINITIONS

A. Installer or Applicator:

1. Installer or applicator is the person actually installing or applying the product in the field at the Project site.
2. Installer and applicator are synonymous.

1.4 SUBMITTALS

A. Shop Drawings:

1. See Specification Section 01 61 03.
2. Efficiency ratings per ASHRAE 52 for factory built and assembled filter units.
3. Scaled ductwork drawings (1/4 inches equals 1 foot) showing duct and accessory layout and support.

B. Contract Closeout Information:

1. Operation and Maintenance Data:
   a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

C. Miscellaneous Submittal:

1. Documentation of qualifications for fabricators and installers.

D. Refer to Section 01 81 33 – Cyber Security Requirements for required cyber security related submittals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Transverse joints (factory fabricated aluminum):
   a. Ductmate Industries, Inc.
2. Turning vanes:
   a. Ductmate Industries, Inc.
   b. Duro Dyne.
   c. SEMCO Incorporated.
   d. Ward Industries, Inc.
3. Flexible duct connections:
   a. Vent Fabrics.
   b. Duro Dyne.
4. Flexible connector thrust restraint:
   a. Mason WB.
5. Access doors in ductwork:
   a. Vent Fabrics.
   b. American Warming.
6. Backdraft dampers:
   a. Air Balance.
   b. Ruskin.
   c. American Warming.
7. Grilles and registers:
   a. Anemostat.
   b. Carnes.
   c. Titus.
8. Air filters:
   a. American Air Filter.
   b. Farr.
   c. Continental.
9. Manual (volume) dampers:
   a. Air Balance.
   b. Ruskin.
   c. American Warming.
10. Duct sealers:
    a. Durkee-Atwood.
    b. Unitec McGill.
    c. Benjamin Foster.
    d. Design Polymerics.
11. Temperature control and automatic dampers:

a. Air Balance.
b. Ruskin.
c. American Warming.

12. Louvers:
    a. Ruskin.
    b. Air Balance.
    c. American Warming.

2.2 COMPONENTS

A. Duct and Fittings (Metallic):

1. Materials:
    a. 3003 H-14 aluminum alloy:
        1) Comply with ASTM B209.
2. Fabrication (aluminum):
    a. Minimum sheet material thickness:
        1) Ducts with largest side or diameter to 30 inches: 0.05 inches thick.
        2) Ducts with largest side or diameter greater than 30 inches: 0.08 inches thick.
    b. Utilize SMACNA HVAC Duct Construction Standards for minimum of 2 inches water gage static pressure for the minimum sheet material thickness specified herein.
        1) Heavier gage sheet material may be used with associated reinforcement as an alternate to minimum thickness specified.
        2) Lighter gage sheet material with associated reinforcement shall not be used as an alternate to minimum thickness specified.
    c. Longitudinal seams:
        1) 0.050 material:
            a) Pittsburgh seam.
            b) Continuously welded.
        2) 0.080 material: Continuously welded.
    d. Continuously weld seams on factory assembled units.
    e. Transverse joints (Alternate A):
        1) SMACNA T-22 companion flange.
        2) Gasketed.
        3) Rigidity class:
            a) Ducts with largest side or diameter to 30 inches: SMACNA Class D (1-1/2 x 1-1/2 x 1/8 inches angles).
            b) Ducts with largest side or diameter greater than 30 to 54 inches: SMACNA Class H (2-1/2 x 2-1/2 x 3/16 inches angles).
    f. Transverse joints (Alternate B):
        1) Materials and fabrication:
            a) Angles: Aluminum.
                (1) Ductmate 35.
            b) Corners: Aluminum.
                (1) Ductmate DC 35.
            c) Snap cleats: Aluminized or stainless steel.
            d) Gaskets: Closed cell neoprene.
            e) Bolts: Stainless steel.
            f) Sheet metal screws: Self-drilling stainless steel with unthreaded section under head.

2) Fabrication:
a) Rigidity class: SMACNA Class H.
b) 3/8 inches diameter x 1 inch bolts.

B. Supports and Hangers:

1. Materials (for aluminum duct):
a. Support angles: Aluminum or stainless steel, minimum 1-1/2 by 1-1/2 by 1/4 angle.
b. Hanger rods: Stainless steel.
c. Anchors: Stainless steel wedge type.
2. Fabrication: Trapeze type units.
3. Strap hangers are not allowed.

C. Turning Vanes:

1. Materials: Same as duct.
2. Fabrication:
a. Fabricate double vane units.
b. Pressure drop through elbows: Maximum 20% of velocity pressure.

D. Flexible Connections:

1. Materials: Hypalon, double coated closely woven glass fabric.
2. Fabrication: Withstand 4.5 inches water column, positive and negative pressure.

E. Access Doors:

1. Materials:
a. Inner panel, out panel and frame: Same as duct.
b. Gaskets: Closed cell neoprene.
c. Insulation: 1 pound density fiberglass.
d. Hinges: Stainless steel.
e. Latches:
1) Aluminum-zinc alloy.
2) Outside lever handle.
3) Adjustable spacer.
4) Beveled inside flange.
5) Studs:
a) Minimum 3/8 inches diameter stud for doors up to 24 inches wide x 48 inches high.
b) Minimum 1/2 inches diameter stud for doors larger than 24 x 48 inches.
2. Fabrication:
a. Provide four-side continuous gaskets.
b. Utilize continuous piano hinges.
c. Latches required:
1) 12 inches in any direction: One.
2) Up to 18 x 18 inches: Two.
3) Up to 24 x 48 inches: Two with inside handles.
4) Up to 24 x 72 inches: Three with inside handles.
5) Minimum door size: 12 x 12 inches.

F. Volume Extractors:

1. Materials (for aluminum duct):

a. Mounting bracket: 0.071 inches aluminum.
b. Movement bar: 0.080 inches aluminum.
c. Blades: 0.050 inches aluminum.

2. Fabrication:
a. Gang operated parallel blade, fully adjustable.
b. Minimum two manually operated adjustment arms.
c. Rotating shaft: Minimum 3/8 inches SQ.

G. Backdraft Dampers:

1. Material:
a. 6063 T5 aluminum.
b. Blade edge seals: Extruded vinyl.

2. Fabrication:
a. Frame thickness: 0.125 inches minimum.
b. Blade thickness: 0.070 inches minimum.
c. Linkage: 1/2 inches tie bars.
d. Bearings: Synthetic.

H. Volume Dampers and Flow Equalizers for Round Neck Diffusers:

1. Material: Aluminum.
2. Fabrication:
a. Design for neck velocity: 2500 feet/MIN.
b. Center rod operator accessible through diffuser without removing diffuser.
c. Furnish with screws, duct collars, transitions and air pattern deflectors as required.

I. Air Grille and Register Assembly:

1. Materials:
a. Assembly: Extruded aluminum.
b. Gaskets: Sponge rubber.

2. Fabrication:
a. Supply registers: Two sets individually adjustable louvers.
b. Exhaust and return registers: 45 degrees deflection front blades.
c. Dampers: Key-operated opposed blade.
d. Screws, duct collars, and transitions as required.
e. Finish:
1) Manufacturer's standard factory applied finish.
2) Color: White.

J. Air Filters:

1. Materials:
a. Holding frame: Aluminum.

2. Fabrication:
a. Factory built and assembled unit.
b. Efficiency rating as per ASHRAE 52.
c. 2 inches thickness minimum.
d. Efficiency: 20%.
e. Air velocity: 450 fpm maximum.
f. Clean pressure drop: 0.2 inches WG maximum.

g. Size, capacity, and type: As indicated on Drawings.

K. Temperature Control, Automatic and Manually (Volume) Operated Dampers:

1. Material:
   a. Body: 6063 T5 aluminum.
   b. Seal blade edge: Extruded vinyl.
2. Fabrication:
   a. Frame thickness: 0.125 inches minimum.
   b. Provide flanged connections.
   c. Blades:
      1) Two-position damper: Parallel blade.
      2) Mixing and volume damper: Opposed blade.
      3) Airfoil shape.
      4) Maximum 6 inches width.
   d. Linkage: Concealed in frame.
   e. Axles: 1/2 inches plated steel hex.
   f. Bearings: Molded synthetic.
   g. Seals:
      1) Jamb: Flexible compression type.
   h. Control shaft: Removable, 1/2 inches diameter.
   i. Air leakage (4 feet SQ damper) at 4 inches WG pressure: 99 cfm maximum.
   j. Motors for motor operated damper: See Specification Section 23 09 00.
   k. Provide outboard support for operator linkage where damper motor is to be installed outside of duct.
   l. Provide stainless steel locking quadrants for manual (volume) dampers.
   m. Provide fold out operator mounting bracket where damper motor is to be installed on face of damper or inside duct.
   n. Finish: 215 R1 anodized.

L. Duct sealer:

1. NFPA rating of "Non-Combustible".
2. Flame spread rating: 25 or lower, in dry condition.
3. Smoke developed rating: 50 or lower, in dry condition.
4. Resistant to water and water vapors.
5. Comply with UL 181.
6. Pressure rupture rating: 16 inches WG, minimum.

M. Louvers:

1. Stormproof.
2. Continuous blade appearance.
3. ASTM B221 extruded aluminum, alloy 6063T5, minimum 0.081 inches thick.
4. Minimum free area: As scheduled.
5. Maximum pressure drop: 0.10 inches of water at 900 fpm at zero water penetration.
6. Bird screen:
   a. 1/2 inches SQ mesh.
   b. 16 GA aluminum.
   c. Install in standard, folded frame.
7. Anchors, fasteners, reinforcing: Aluminum or stainless steel.

8. Finish:
    a. Meet requirements of AAMA 2605.
        1) PVDF coating with minimum 70% resin content.
        2) Color: To be selected by Engineer.

2.3 MAINTENANCE MATERIALS

A. Extra Materials:

1. Furnish Owner with the following extra materials:
    a. 2 complete filter media change(s) for each filter unit.
    b. Filter media used during construction is in addition to this requirement.

PART 3 - EXECUTION

3.1 INSTALLATION

A. See Specification Section 01 61 03.

B. Metal Ductwork:

1. Install with longitudinal seams sealed for zero leakage.
    a. For welded seams, submit sample for approval by Engineer.
2. Install gaskets at each transverse joint and fasten sections together with bolts.
    a. Tighten for zero leakage.
3. Install supports and hangers with anchors in accordance with SMACNA HVAC Duct Construction Standards.
4. Install turning vanes in square elbows:
    a. Unsupported vane length not to exceed 48 inches.
    b. Position vanes at proper angle to meet specified pressure drop.
5. Install flexible connections at fans:
    a. Locate as close as possible to fan.
    b. Allow 1 inch of slack to prevent vibration transmission.
    c. Install thrust restraints across connectors.
6. Install access doors where indicated on Drawings and at smoke and fire damper in accordance with NFPA requirements.
7. Volume extractors:
    a. Install at supply registers, grilles, diffusers and supply branch connections from ducts.
    b. Provide branch duct extensions into main duct above and below extractor when branch duct is narrower than main duct.

C. Dampers:

1. Install where indicated on Drawings of sizes shown.
2. Install fire and smoke dampers in ductwork passing through 1 hour or higher fire-rated construction.
    a. Install in wall and floor openings utilizing steel sleeves, angles and other materials following practices required to provide installation in accordance with local building codes.

D. Air Grille and Register Assemblies:

1. Install where shown on Drawings of size and capacities scheduled on Drawings.
2. Install prime painted grilles and registers in areas where duct work is concealed.
    a. Field paint to match adjacent surface finish.

E. Air Filters:

1. Install where shown on Drawings of size and capacity scheduled on Drawings.
2. Do not operate equipment during construction without filters.

3.2 CLOSEOUT ACTIVITIES

A. Refer to Section 01 81 33 – Cyber-Security Requirements for cyber security related closeout requirements.

END OF SECTION

SECTION 23 34 00
HVAC - FANS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Heating, ventilating, and cooling equipment.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 01 61 03 - Equipment - Basic Requirements.
2. Section 23 05 93 - HVAC Systems - Balancing and Testing.
3. Section 23 31 00 - HVAC - Ductwork.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. Air Movement and Control Association (AMCA).
   a. AMCA Publication 203 "Field Performance Measurement of Fan Systems".
   b. ANSI/AMCA 210 "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating".
2. Air Conditioning and Refrigeration Institute (ARI).
3. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE):
   a. HVAC Applications Handbook, Chapter entitled "Sound and Vibration Control."
   b. 20, Methods of Testing for Rating Remote Mechanical-Draft Air-Cooled Refrigerant Condensers.
   c. 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
4. Canadian Standards Association (CSA).
5. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
6. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
7. National Roofing Contractors Association (NRCA).
8. Underwriters Laboratories, Inc. (UL):
   a. 507, Standard for Electric Fans.

B. Miscellaneous:

1. Gage thickness specified herein shall be manufacturer's standard gage for steel and Brown and Sharpe gage for non-ferrous metals.
2. Corrosion protection of equipment to be as specified herein.

1.3 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Manufacturer's installation instructions.
   c. Wiring diagrams.
   d. Control diagrams.
   e. Manufacturer's catalog cuts and technical data.

f. Corrosion-protection information.
g. Fan curves.
h. Sound data.
i. Vibration isolation.
j. Performance data on all equipment.

2. Certifications:
a. Provide certification of thickness of corrosion-protection coating.
b. Fan systems have been tested in accordance with AMCA Standard 210 or 260, and are licensed to bear the AMCA Certified Ratings Seal.

B. Factory Performance test for any fan having a flow rate greater than 1,000 cfm and/or a total static pressure rating equal to or greater than 1.5 inches WC.

1. Pursuant to AMCA Publication 203 or 210 with no plus tolerances on Power and no minus tolerances on flow or pressure.

C. Contract Closeout Information:

1. Operation and Maintenance Data:
a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Vibration isolation assemblies:
a. Mason.
b. Vibration Mounting and Controls Co.
c. Vibro-Acoustics.
2. Corrosion-protective coatings:
a. Heresite and Chemical Co.; "Heresite."
b. Aero-Marine Engineering, Inc.
3. In-line centrifugal fans:
a. Loren cook.
b. New York Blower.
c. Aerovent.

2.2 GENERAL

A. All Manufactured Units:

1. Comply with Specification Section 01 61 03.
2. Factory wired and assembled.
3. Use fasteners made of same material as unit.
4. Fabricate motor assemblies and unit housings with vibration isolation assemblies:
a. Type: As per [Table 47, Chapter 48], ASHRAE HVAC Applications Handbook.

B. All manufactured units shall be constructed with corrosion-resistant materials or have corrosion-resistant coating.

1. Type:
a. Corrosion-resistant materials:
1) Aluminum.

2) Stainless steel.
3) FRP.

b. Corrosion-resistant coating:
1) Phenolic-based coating.
2) 3 mil minimum dry thickness, air-dried coating, for surfaces exposed to temperatures less than 150 degrees F.
3) 5 mil baked-on coating for heat transfer surfaces and surfaces exposed to temperatures greater than 150 degrees F.
4) Factory applied.
5) Provide factory certification of application.

2.3 MANUFACTURED UNITS

A. In-Line Centrifugal Fans - Square inline centrifugal:

1. AMCA certified Class I, II, or III.
2. Non-overloading horsepower capability.
3. Materials:
   a. Wheel, impeller hub and blades: Aluminum or stainless steel.
   b. Housing, innertube and belt well: Aluminum or stainless steel.
   c. Inlet cone: Aluminum or stainless steel.
   d. Driver shaft: Solid stainless steel.
4. Airfoil design blades.
   a. All welded construction.
5. All welded housing, innertube and belt well.
6. Innertube construction:
   a. Isolates bearings and drive from airstream.
   b. Removable end covers.
7. Bearings:
   a. Cast iron pillow blocks.
   b. Concentric bearing locking collar for drive shafts 1 inch and larger.
      1) SKF "ConCentra."
      2) Dodge "D Lock."
   c. Regreaseable.
   d. 200,000 hour average life.
8. Motor:
   a. See Specification Section 01 61 03.
   b. Belt Drive Units:
      1) Driver and driven sheaves:
         a) Keyed hub type.
         b) Drive sheaves: Fixed pitch diameter.
         c) Driver:
            (1) Shipped with variable pitch diameter sheave.
            (2) Fixed pitch diameter size based on approved test and balance reports.
         d) V-belt drives sized for 150% motor horsepower.
      2) Automatic drive belt tensioner.
   c. Direct Drive Units:
      1) Keyed hub type.
   d. Adjustable motor base.

9. Flanged inlet and outlet.
10. Accessories:
    a. Weatherproof, louvered motor enclosure for exterior installation.
    b. Internal inlet damper with external control linkage.
    c. Cam type access door.
    d. Ceramic felt shaft seal.
    e. Extended grease links and fittings.
    f. Explosion proof motor, rated for Class I, Division 2, Group D environment.
    g. Spark-resistant construction:
        1) Type A: All parts in air stream are aluminum or non-ferrous construction.
        2) Type B: Aluminum wheel and an aluminum rub ring where the fan shaft passes through the housing.
11. Size and capacity as scheduled on Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with Specification Section 01 61 03.

B. Install fixed pitched drive sheave after sheave has been sized based on accepted test and balance report.

C. Do not operate fans for any purpose until ductwork is clean, filters are in place, bearings lubricated and fan has been test run under observation.

3.2 FIELD QUALITY CONTROL

A. Comply with Specification Section 23 05 93.

3.3 ADJUSTING

A. Install new filters on units which have been running prior to acceptance of Project.

END OF SECTION

SECTION 23 80 00
HVAC - EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Heating, ventilating, and cooling equipment.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 01 61 03 - Equipment - Basic Requirements.
2. Section 23 05 93 - HVAC Systems - Balancing and Testing.
3. Section 23 31 00 - HVAC - Ductwork.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. Air Movement and Control Association (AMCA).
2. Air Conditioning and Refrigeration Institute (ARI).
3. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE):
   a. HVAC Applications Handbook, Chapter entitled "Sound and Vibration Control."
   b. 20, Methods of Testing for Rating Remote Mechanical-Draft Air-Cooled Refrigerant Condensers.
   c. 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
4. Canadian Standards Association (CSA).
5. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
6. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
7. National Roofing Contractors Association (NRCA).
8. Underwriters Laboratories, Inc. (UL):
   a. 507, Standard for Electric Fans.

B. Miscellaneous:

1. Gage thickness specified herein shall be manufacturer's standard gage for steel and Brown and Sharpe gage for non-ferrous metals.
2. Corrosion protection of equipment to be as specified herein.

1.3 SUBMITTALS

A. Shop Drawings:

1. Fabrication and/or layout drawings.
2. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Manufacturer's installation instructions.
   c. Wiring diagrams.
   d. Control diagrams.
   e. Manufacturer's catalog cuts and technical data.
   f. Corrosion-protection information.

g. Fan curves.
h. Sound data.
i. Vibration isolation.
j. Control description.
k. Performance data on all equipment.

3. Certifications:
   a. Provide certification of thickness of corrosion-protection coating.

B. Contract Closeout Information:

1. Operation and Maintenance Data:
   a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

C. Refer to Section 01 81 33 – Cyber Security Requirements for required cyber security related submittals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Vibration isolation assemblies:
   a. Mason.
   b. Vibration Mounting and Controls Co.
   c. Vibro-Acoustics.
2. Corrosion-protective coatings:
   a. Heresite and Chemical Co.; "Heresite."
   b. Aero-Marine Engineering, Inc.
   c. Luvata ElectroFin.
3. Cooling coils - direct expansion:
   a. Carrier.
   b. Daikin Applied.
   c. AAON.
4. Make-up air units, direct fired, gas:
   a. Hastings.
   b. Titan.
   c. AAON.
5. Unitary split system heat pump:
   a. Daikin.
   b. Carrier.
   c. Lennox.
   d. Bryant.
6. Positive pressurization unit:
   a. Purafil.

2.2 GENERAL

A. All Manufactured Units:

1. Comply with Specification Section 01 61 03.
2. Factory wired and assembled.

3. Use fasteners made of same material as unit.
4. Fabricate motor assemblies and unit housings with vibration isolation assemblies:
    a. Type: As per Table 47, Chapter 48, ASHRAE HVAC Applications Handbook.

B. All manufactured units shall be constructed with corrosion-resistant materials or have corrosion-resistant coating.

1. Type:
    a. Corrosion-resistant materials:
        1) Aluminum.
        2) Stainless steel.
        3) FRP.
    b. Corrosion-resistant coating:
        1) Phenolic-based coating:
            a) 3 mil minimum dry thickness, air-dried coating, for surfaces exposed to temperatures less than 150 degrees F.
            b) 5 mil baked-on coating for heat transfer surfaces and surfaces exposed to temperatures greater than 150 degrees F.
            c) Factory applied.
            d) Provide factory certification of application.

2.3 MANUFACTURED UNITS

A. Make-Up Air Units, Direct Fired, Gas:

1. CSA design certified heating section.
2. Materials:
    a. Cabinet: Aluminum double-wall construction with 1 IN thick, 1.5 lb density insulation.
    b. Base channels: 12 GA stainless steel.
    c. Burner: Cast aluminum or stainless steel.
    d. Combustion baffles: Perforated stainless steel.
    e. Fan: Aluminum, AMCA type A or B spark resistant construction.
3. Blower section:
    a. Blower wheels:
        1) Statically and dynamically balanced.
        2) Forwardly curved double-width, double-inlet.
        3) Mounted on solid turned ground shaft with keyway.
    b. Bearings: Ball-bearing, self-aligning, permanently lubricated, pillow block-type.
    c. Blower scrolls, bearings, and adjustable base to be mounted on reinforced angle iron frame.
    d. Driver and driven sheaves:
        1) Keyed hub type.
        2) Drive sheaves: Fixed pitch diameter.
        3) Driver:
            a) Shipped with variable pitch diameter sheave.
            b) Fixed pitch diameter size based on approved test and balance reports.
        4) V-belt drives sized for 150% motor horsepower.
    e. Insulated cabinet.
    f. Motors: See Specification Section 01 61 03.
4. Burner section:
    a. Combustion efficiency:

1) Maximum 5 PPM carbon monoxide.
2) Maximum 0.5 PPM nitrogen dioxide.

b. 25:1 turndown ratio.
c. Spark-ignited intermittent pilot.
d. Flame safeguard system.
e. Observation port.
f. Profile plates.
g. Airflow switch.
h. High limit control.

5. Main gas hand shut-off valve.
6. Main and pilot gas pressure regulators.
7. Pilot controls.
8. Electronic safety shut-off valve.
9. Gas modulating valve:
   a. 500 MBH or less burner capacity: Self-contained.
   b. Above 500 MBH: Motorized.
10. Ignition transformer.
11. Low outlet temperature shut-off:
    a. Adjustable.
    b. Shuts off blower on discharge below setpoint.
    c. Adjustable time delay for shut-off.
12. Automatic mild weather lockout.
13. Variable frequency drive for two-speed operation.
    a. Operator adjustable set points at HMI.
    b. VFD enclosure with ventilation fan.
14. Control transformer.
15. Weatherproof Control box.
16. NEMA 4X remote control station with system switches and indicating lights.
    a. Interior: Maxitrol discharge temperature control.
    b. Face:
       1) Summer/winter switch.
       2) "Blower On" light.
       3) "Heating On" light.
       4) "Lockout" light.
       5) "Blocked Filter" light.
17. NEMA 4 fused disconnect switch.
18. Control:
    a. Maxitrol Series 14.
19. Accessories:
    a. Prefabricated insulated roof curb and curb adaptor.
    b. Inlet hood with birdscreen.
    c. "V" bank filter section.
       1) 2 inch, MERV 8 filters.
    d. Filters: See Specification Section 23 31 00.
    e. Outlet shut-off damper.
       1) NEMA 4x actuator.

2) Aluminum, low leakage construction.

f. Auxiliary dry contacts:

1) Closed when blower is "ON".

2) Speed control, high/low speed input from PLC.

3) 120 V rated contacts.

g. Weatherproof construction:

1) Hinged and latched control enclosure.

20. Size and capacity as scheduled on Drawings.

B. Unitary Split System Heat Pump:

1. Outdoor Unit:

a. General: the condenser unit shall be completely factory assembled, piped, wired and tested. The condenser unit shall be designed specifically for use with the indoor unit. The unit shall be equipped with a circuit board that interface with the indoor unit and perform all functions necessary for operation.

b. Unit cabinet: the casing shall be fabricated with 18 gauge galvanized steel, and coated with a powder coated baked enamel.

c. Fan: the condenser unit shall be horizontal air flow and shall be furnished with either one or two direct drive propeller type fans. The fan shall be provided with raised guard to prevent contact with moving parts. The fan motor shall be mounted for quiet operation.

d. Coil: the condenser coil shall be nonferrous construction with corrugated plate fins and copper piping. The coil shall be protected with integral metal guard. The refrigerant flow from the condenser shall be controlled by means of a metering orifice.

e. Compressor: the compressors shall be high performance rotary type. Crankcase heater shall be factory mounted on the outside of the compressors. The condenser unit shall be equipped with accumulator, internal thermal overload, and high pressure safety switch. The compressors shall be mounted to avoid vibration. The condenser unit shall be able to operate at -22°F ambient temperature without additional low ambient controls. The condenser unit shall be able to operate with a maximum height difference of 164 feet and have refrigerant tubing length of 164 feet between indoor and condenser unit without the need for line size changes, traps or additional oil.

f. Electrical: the condenser unit's electric power shall be as shown on the drawings. The electric motor shall meet the requirements of the mechanical schedule. The condenser unit shall be operated and controlled by the microprocessor located in the indoor unit. All control wiring interconnections between indoor and condenser units shall be with single non-polar cable with no splice.

2. Indoor unit:

a. General: the indoor unit shall be factory assembled, wired and run tested. The unit shall contain all factory wiring, piping, control circuit boards and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be charged with dry air instead of refrigerant before shipping from the factory.

b. Unit cabinet: the casing shall be fabricated with 18 gauge galvanized steel and shall have white finish. The unit casing shall be fabricated for multi directional drain and refrigerant piping and electrical connections. The unit cabinet shall be provided with galvanized back plate which should secure the unit firmly to the wall.

c. Fan: the evaporator fan shall be inline type with direct drive three speed motor. The fan shall be statically and dynamically balanced with permanently lubricated bearings. The fan discharge shall be provided with adjustable guide vanes to change air flow direction from side to side. The fan discharge shall be provided with motorized damper to change direction of airflow from up and down.

d. Filter: the indoor unit shall be equipped with return air washable filter.

e. Indoor coil: the evaporator coil shall be constructed with nonferrous material with smooth plate fins and copper tubing with silver alloy brazed joints connection. The tubing shall have inner grooves for high efficiency heat exchange. The coil shall be pressure tested at the factory. Provide with factory installed electronic expansion valve. The cooling coil shall be provided with a stainless steel condensate drain pan with minimum 1" drain pipe connection.

f. Electrical: the electric motor shall meet the requirements of the mechanical schedule.

g. Control: the mini-split system heat pump unit shall have a complete factory wired control system to perform operation of the system. The control system should consist of two microprocessors, with one in the indoor wall mounted unit and second in the wall mounted remote controller interconnected with single non-polar two wire cable with no splice. The wall mounted controller shall consist of on/off switch, cool/dry fan selector, thermostat setting, timer mode, high/low fan speed, auto vane selector, test run switch and check mode switch. The thermostat shall have 2ºF temperature increments with a range of 65 to 85ºF. The microprocessor located in the indoor unit shall have the capability of sensing return air temperature and indoor coil temperature, receiving and processing commands from the wired wall mounted controller, providing emergency operation, and controlling the condenser unit operation. The control system shall be capable of automatic restart of the airconditioning unit when power is restored after interruption. The control system electric power voltage shall be 12 volts dc and provided by the indoor unit. The microprocessor within the wall mounted remote controller shall provide automatic cooling, display set point and room temperature, and check mode for memory of most recent problems. The wall mounted controller shall control the indoor unit air sweep louvers, and shall provide on/off switch.

3. Manufacturer shall provide a pre-charged and insulated lineset when providing the heat pump units.

4. Size and capacity as scheduled on Drawings.

C. Positive Pressurization Unit:

1. Self contained.

2. Pressurization air as scheduled.

3. Total delivered air with recirculation as scheduled.

4. Vertical configuration.

5. Four (4) stages of air purification.

a. First stage: ASHRAE 20, 20-25% removal filter.

b. Second stage: Media modules filled with 50 pounds of media.

c. Third stage: Same as second.

d. Fourth stage: JFL-90, 90% removal.

6. Materials:

a. Unit: 14 GA cold rolled steel.

b. Modules: Perforated aluminum sheets.

c. Stage supports: Aluminum track with sealing material.

7. Blower:

a. Location: Between second and third stage.

b. Wheel: Backward curved, aluminum.

c. VFD drive.

d. Motor: See Specification Section 01 61 03.

8. Module media:

a. Pelletized.

b. Activated alumina impregnated with a minimum of 12% sodium permanganate.

c. 100 pound of media shall remove 14 pound hydrogen sulfide; 14% minimum by weight.

d. Inorganic.
e. Non-toxic.
f. Non-flammable.
g. Shall not support bacterial or fungal growth.

9. Media performance certification (manufacturer's responsibility):
   a. Performed by laboratory of Owner's (Engineer's) choice.
   b. Test procedure: Pass moist (85% RH) air containing 10 (±1) ppm hydrogen sulfide gas at a rate of 2900 ml per minute through a 1.0 inches diameter by 6.0 inches deep uniformly packed bed.
   c. Test shall run continuous for 48 hours.
   d. During test down stream concentration of hydrogen sulfide shall never exceed 0.05 PPM.
10. Gages:
   a. Outside air flow.
   b. Room pressure.
   c. Pressure differential across first stage.
   d. Pressure differential across final stage.
11. Size and capacity as scheduled on Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with Specification Section 01 61 03.

B. Install fixed pitched drive sheave after sheave has been sized based on accepted test and balance report.

3.2 FIELD QUALITY CONTROL

A. Comply with Specification Section 23 05 93.

3.3 ADJUSTING

A. Install new filters on units which have been running prior to acceptance of Project.

3.4 CLOSEOUT ACTIVITIES

A. Refer to Section 01 81 33 – Cyber-Security Requirements for cyber security related closeout requirements.

END OF SECTION

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DIVISION 26

ELECTRICAL

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SECTION 26 05 00

GENERAL REQUIREMENTS FOR ELECTRICAL WORK

PART 1 - GENERAL

1.1 REFERENCES

A. Division 26 incorporates by reference the latest revisions of the following standards. They are part of Division 26 insofar as specified and modified herein. In the event of conflict between the requirements of Division 26 and those of the listed documents, the requirements of Division 26 shall prevail.

B. Unless otherwise specified, references to documents shall mean the documents in effect on the effective date of the Agreement. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.

C. The following is a list of standards which may be referenced in this section:

1. National Electrical Contractors Association (NECA): National Electrical Installation Standards.
2. National Electrical Manufacturers Association (NEMA):
3. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
4. Z535.4, Product Safety Signs and Labels.
5. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
6. Underwriters Laboratories, Inc. (UL).

1.2 DESIGN REQUIREMENTS

A. All equipment anchoring and mounting shall be in accordance with manufacturer's requirements for the seismic zone criteria.

1.3 SHIPMENT AND STORAGE:

A. Materials and equipment shall be stored in a manner to keep them dry and clean. Equipment and materials to be located indoors shall be stored indoors and sealed with plastic film wrap. Electrical and electronic equipment found stored or staged outdoors over night or in inclement weather shall be considered grounds for equipment rejection and shall be replaced at no cost to the Owner.

1.4 SUBMITTALS

A. Action Submittals:

1. Electrical service components.
2. Nameplates, signs, and labels.

1.5 ELECTRIC AND TELECOMMUNICATIONS SERVICE DIVISION OF RESPONSIBILITY

A. Idaho Power supplies the Hailey WRF with 480V, 3-phase electrical power via 1,000-kVA transformer located adjacent to the existing electrical building, and the electric utility metering is located at the transformer. All infrastructure located downstream of the electric utility metering is owned, operated, and maintained by Hailey WRF. All work associate with the Headworks improvements including, but not limited to, trench and backfill and secondary facilities (<600V) shall be scheduled and coordinated with Hailey WRF.

B. SCADA and fire alarm related telecommunications (fiber terminations, Ethernet switches, Cat. 6A cabling, etc. is work provided under this contract. Provide raceways, fiber optic cable, outlet and junction boxes, cover plates, pull wired, as indicated.

1.6 QUALITY ASSURANCE

A. Provide the Work in accordance with NFPA 70. Where required by Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ, in order to provide a basis for approval under the NEC.

B. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. shall conform to those standards and shall have an applied UL listing mark or label.

C. Provide materials and equipment acceptable to AHJ for Class, Division, and Group of hazardous area indicated.

1.7 ENVIRONMENTAL CONDITIONS

A. Unless otherwise specified, equipment and materials shall be sized and de-rated for the ambient conditions but not less than an ambient temperature of 40 degrees C at an elevation of 5,400 feet without exceeding the manufacturer's stated tolerances.

B. Plant area electrical work requirements:

1. NEC area classifications per NFPA 820 are shown on the Drawings.
2. The design intent is that all conduits shall be embedded in concrete walls, ceilings, floors for aboveground installations; direct earth buried, or concrete encased for underground installations; or concealed (not embedded in concrete) for building interior installations unless prevented by existing construction or noted otherwise on the Drawings.
3. All other electrical work shall be in accordance with the following table:

Plant Area	NEMA Enclosure Type	Exposed Conduit Type	Environment	Support Material
Electrical Rooms	1	RGS or IMC up to 6 feet above grade. EMT above 6 feet.	Clean/Dry	Carbon Steel
Outdoor Areas or Areas Open to Atmosphere	4X Stainless Steel	PVC coated RGS	Wet/Corrosive	Type 316 Stainless Steel or PVC-Coated Steel

C. Areas not covered above: Use dust-tight and oil-tight NEMA 12 materials and methods.

1.8 BASIS OF DESIGN

A. Basis of design includes the following:

1. Equipment and motors as shown in the electrical one-line drawing(s) and load/panel schedules.
2. Digital control systems and associated network protocols based on a specific technology platform. Such digital control systems are often proprietary in nature and include, but are not limited to, lighting control systems, generator control systems, fire alarm systems, Process Instrumentation and Control System PICS (i.e., SCADA) systems, and motor control systems.
3. Unless otherwise noted:
    a. All new local control panels with integral programmable controllers shall have a Rockwell Automation Studio 5000 based controller interface, and the data shall be compatible with produce and consume tag formatting to interface with the PICS.

b. All electrical equipment components connected to the PICS via Ethernet shall utilize native Ethernet IP protocol. The term “native” used in this context means that the protocol is integral to the equipment—a converter, gateway or card used to convert from one protocol to another (e.g., Modbus Plus to Ethernet IP) is not required. The use of these devices is not acceptable.

B. If different equipment or sizes are provided in order for the vendor’s equipment to meet mechanical performance requirements, the contractor shall coordinate various suppliers, vendors, and subcontractors to change the required electrical conduit, circuits, breakers, motor control center sections, motor controllers, and accessories, etc. as necessary to meet the vendor’s equipment installation requirements. The traits and characteristics of all provided materials, equipment, and devices shall meet the specifications. These changes to materials, equipment, and devices shall be at no cost to the Owner. Electrical submittal information shall be coordinated with the equipment and motors provided.

C. The contract for the work will be based on materials and equipment included in the Contract Documents, and those “or-equal” and substitute products subsequently approved as outlined in Bidding Requirements, Conditions of the Contract, and Division 1. The burden of proof regarding proposed product merit and the associated cost by the Engineer/Owner to evaluate the product merit is upon the Bidder. Any assumptions regarding the possibility of post-bid approvals of or-equal or substitution requests are made at Bidder’s sole risk.

D. “Or-Equal” or Substitute Digital Control System Materials and Software:

1. Technology platform standardization is required to maximize performance, efficiency, and effectiveness and to minimize technology platform total cost of ownership (TCO). Therefore, the determination of associated “or-equal” or substitute materials and equipment will be based on these elements in addition to those specified in the Contract Documents.
2. TCO includes initial engineering/design costs, construction administration costs, equipment acquisition and installation costs, and ongoing operating costs and personnel/resource costs associated with management and support after construction is completed.
    a. Design costs include digital control system design documents including, but not limited to, network diagrams, riser diagrams, I/O matrixes, schematics, wiring diagrams, equipment layouts, and bill of materials based on the specified product.
    b. Construction administration costs include anticipated submittal reviews, RFI’s, construction changes, and record drawing development based on the specified product.
    c. Acquisition and installation costs include software, hardware, implementation, customization, user licenses, data migration, user training, integrating third-party systems, and physical equipment installation.
    d. Operating costs include replacement parts, additional user licenses, ongoing personnel training, software and firmware maintenance and support, additional integrations, downtime, associated third party service contracts, and electronic security.
    e. Personnel/resource costs include personnel required to manage the system, keeping the system secure, and keeping up with technology obsolescence and maintenance.
3. All associated written requests for approval shall include as a minimum:
    a. Assurance that the proposed system is compatible with any existing digital control system software and hardware system elements proposed to remain in place. Depending on the Owner’s familiarity, a workshop with the Engineer and Owner may also be required to demonstrate compatibility.
    b. TCO breakdown comparison for both the substitute product and that specified. Include actual and verifiable data from similar recent projects to validate.
    c. Net present value (NPV) analysis for both the substitute product TCO and that specified to present to the Owner for evaluation. If elements of the existing digital control systems are proposed to remain in place, the NPV analysis shall also include ongoing operating costs and personnel/resource costs associated with managing both technology types. All Owner related ongoing operating costs and personnel/resource costs forecasted after construction shall be validated and agreed upon by the Owner.

d. Modified design documents showing updated network diagrams, schematics, wiring diagrams, bill of materials, and any other design related changes to accommodate the substitute equipment.

4. Contractor represents the proposals for “or-equal” and substitute products also include:
   a. 8 hours of training (in addition to that specified herein) for Owner operations personnel.
   b. Spare parts (one for each type/size) including control and power boards or modules, operator interface units, and communication and input/output modules.
   c. Engineering design and construction administration costs that may result or are required to accommodate the proposed substitute. Engineer will define these costs during evaluation of substitute.

1.9 EQUIPMENT COORDINATION AND SYSTEM RESPONSIBILITY

A. The Contractor is responsible to review and coordinate the equipment supplied from various manufacturers and vendors. This includes but is not limited to the following:

1. Obtaining specific information on equipment ratings and sizes and verifying the electrical components supplied meet the requirements such as voltage, phase, frequency, starter types, etc.
2. Selecting and providing all components of approved substitute or “or-equal” materials and equipment, updating the design (as required), and provide all associated components such that they are compatible, operate reliably, and comprise a functional and listed system suitable for the required performance.
3. Providing equipment that will fit within the space allocated and meet OSHA and N.E.C. clearances.
4. Coordinating supplied equipment’s electrical power and control requirements.
5. Providing power and control equipment, wiring, and raceways to meet the requirements of the mechanical equipment supplied.
6. Providing all necessary control wiring and components for any special requirements from an equipment manufacturer.
7. Providing single source coordination responsibility and ensure all system elements are products for which the manufacturer has accepted system responsibility. Agents, representatives, or entities not a direct division of the manufacturing corporation will not be accepted as a substitute for the system manufacturer.
8. Confirming the equipment manufacturer does not condition or void any warranty for the performance of Division 26 products due to incompatibility of any components covered in other Divisions. This requirement does not obligate the manufacturer to warranty the workmanship or quality of components not manufactured by them.

B. The Contractor shall verify as a minimum:

1. Correct voltage, phase, and frequency
2. Size and space requirements
3. Mounting requirements
4. Correct motor starter type and size.
5. Proper coordination with the controls and control system integrator.

C. Bring any discrepancies between the electrical equipment and other equipment to the immediate attention of the Owner.

D. The Contractor shall assure that no instrumentation or control interferences are created by the variable frequency drives (VFDs) or load wiring. The Contractor shall coordinate with the VFD manufacturer to provide necessary separation of conductors or shielding and/or filtering equipment as required by the VFD manufacturer. If interferences do occur, the Contractor shall be responsible to take corrective action at no additional cost to the Owner.

1.10 WIRING FOR VENDOR PACKAGES

A. Equipment specifications indicate when the Vendor is responsible for providing interconnection wiring between components of a Vendor package installed on separate skids or assemblies. In this circumstance, interconnection wiring between skids or assemblies in a Vendor package shall be by Vendor.

B. Where equipment specifications do not specify Vendor furnished wiring between skids or assemblies in a Vendor package, the Contractor shall provide and install interconnection wiring between skids or assemblies per the Vendor's interconnection wiring requirements. Interconnection wiring between skids or assemblies in a Vendor package is not shown on the drawings.

C. Determination of circuit requirements.

1. Coordinate cable/conductor requirements with the selected Vendors to determine the correct wiring required to interconnect the package system components/skids.
2. Wiring between Vendor furnished components shipped on separate skids or assemblies shall conform to requirements specified in Division 26 and other Divisions.
3. Wiring between the plant control system and Packages system components/skids are as shown on the drawings.
4. Wiring between external power supplies and the packaged system components/skids are as shown on the drawings.

D. Assign numbers and tagging for unscheduled circuit and raceway between Vendor-furnished components on separate skids or assemblies. Coordinate this information in submittals, record drawings, and O&M manuals.

E. Update contract documents in the record drawing set to include the work provided for wiring the vendor packages.

1.11 CIRCUIT AND RACEWAY SCHEDULE

A. Because the Contractor is allowed to combine circuits as allowed under paragraph COMBINING CIRCUITS INTO COMMON RACEWAY paragraph below, Contractor shall develop circuit and raceway tagging as describe herein and as approved by the Engineer and Owner. All circuits, raceways and cables shall be tagged at all terminations, switchgear, switchboards, panels, MCCs, handholes, terminal junction boxes, and equipment.

B. Prefix Modifiers: The following prefix modifiers shall be used when scheduling/tagging circuits and raceways:

Prefix	Type of Function
H	Power above 600V
P	Power 120V to 600V
C	Control
A	Analog signals (i.e., 4-20ma)
D	Data
PC	Composite of power and control
F	Optical Fiber
PSP, CSP	Spare power, spare control

C. The Woodside WRF equipment tagging standard is as follows:

1. All equipment is identified by an equipment tag according to the following format:
   a. AAA-XXX-YN
2. Abbreviations are defined as follows:

a. AAA represents the equipment type
b. XXX represents the process area
c. Y represents the process subarea
d. N is a suffix when more than one of the same device in the same process area.

D. Circuit Tagging:

1. Tag shall include assigned circuit designation, from (equipment or terminal junction box tag number), to (equipment or terminal junction box tag number).
2. Circuit Designation: Prefixes shall be followed by the end device equipment/instrument tag number shown on the Drawings:
3. Circuit number = P-AAA-XXX-YN
   a. P = Power wiring
   b. - = Delimiter
   c. AAA-XXX-YN = Equipment tag number

E. Raceway Schedule:

1. Tag shall include assigned raceway designation, from (equipment, terminal junction box, or handhole tag number), to (equipment, terminal junction box, or handhole tag number).
2. Raceway Designation: Prefixes shall be followed by a process area code and sequential raceway number per the following example:
3. Raceway number = P-XXX001
   a. P = Raceway contains power wiring
   b. - = Delimiter
   c. XXX = Process area
   d. 001 = Contractor assigned raceway number

1.12 ARC FLASH MITIGATION METHODS

A. The following mitigation method requirements shall apply to all power distribution and utilization equipment supplied for any products supplied on the project and applies to all equipment divisions in the Contract Documents. Refer to the NFPA-70 (NEC), and NFPA-70E (Electrical Safety in the Workplace) for equipment labeling requirements.

B. Equipment Labels: Equipment labels shall be installed on the outside of the electrical equipment enclosure, cabinet, and panels to avoid opening the equipment to access the manufacturer's data or the equipment ratings.

C. Hinged Doors: Power distribution equipment shall have hinged rear doors where back access is shown.

D. Insulated Power Bus and Insulated Cable Boots:

1. Provide insulated power bus in power distribution equipment where accessible to installers or maintenance workers.
2. Provide cable boots for power conductor connections to insulate the exposed power conductor connections.

E. Power and Control Equipment Separation:

1. Provide separation between power equipment within an enclosure, cabinet, or panel by the use of barriers, separate access doors, or by other means.
2. Provide separation barriers between main breaker feeders coming into equipment and other termination points or bussing on the load side of the main breaker.

F. Automatic Shutters: Provide automatic shutters, where possible, to close the access to the power bus when a power device is not engaged.

G. Arc flash maintenance system for circuit breakers in other Division 26 specifications.

PART 2 - PRODUCTS

2.1 GENERAL

A. Where two or more units of the same class of material or equipment are required, provide products of a single manufacturer. Component parts of materials or equipment need not be products of the same manufacturer.

B. Material and equipment installed in heated and ventilated areas shall be capable of continuous operation at their specified ratings within an ambient temperature range of 40 degrees F to 104 degrees F.

C. Materials and equipment installed outdoors shall be capable of continuous operation at their specified rating within the ambient temperature range specified.

2.2 EQUIPMENT FINISH

A. Manufacturer's standard finish color, except where specific color is indicated. If manufacturer has no standard color, finish equipment in accordance with light gray color finish as approved by Engineer.

2.3 NAMEPLATES

A. Nameplates shall be provided on all electrical devices, including but not limited to motor control equipment, MCC cubicles/cells/buckets, switchgear, panelboards. control stations, junction boxes, panels, harmonic filters, instruments, disconnect switches, indicating lights, meters, fire alarm panels/devices, and all electrical equipment enclosures.

B. Nameplates shall also be provided on all electrical panel interior equipment, including but not limited to relays, circuit breakers, power supplies, terminals, contactors, and other devices.

C. Equipment nameplates shall have both the equipment name and number.

D. Unless noted otherwise, nameplates shall be made of 1/16" thick machine engraved laminated phenolic having black letters (not less than 1/8" high for pushbuttons/selector switches, and 3/16" high for other electrical equipment) on white background or as shown on the drawings or other sections of the specifications.

E. Nameplates on the interior of panels and fire alarm notification/detection devices shall be White Polyester with printed thermal transfer lettering and permanent pressure sensitive acrylic; TYTON 822 or equal. All nameplates shall include the equipment name and number (and function, if applicable).

F. Provide warning nameplates on all panels and equipment which contain multiple power sources. Lettering shall be white on red background.

G. Nameplates shall be secured to equipment with stainless steel screws/fasteners.

H. Nameplates for disconnect switches shall contain name and number, source tag number, as well as voltage, phases and colors of conductors.

2.4 SIGNS AND LABELS

A. Provide NFPA 820 ventilation system failure warning signs as shown on the drawings and in accordance with NEMA Z535.4.

PART 3 - EXECUTION

3.1 GENERAL

A. Electrical Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned. Contractor shall be responsible for actual location of equipment and devices and for proper routing and support of raceways, subject to approval of Engineer.

B. Check approximate locations of light fixtures, switches, electrical outlets, equipment, and other electrical system components shown on Drawings for conflicts with openings, structural

members, and components of other systems and equipment having fixed locations. In the event of conflicts, notify Engineer in writing.

C. Install work in accordance with NECA Standard of Installation, unless otherwise specified.

D. Keep openings in boxes and equipment closed during construction.

E. Lay out work carefully in advance. Do not cut or notch any structural member or building surface without specific approval of Engineer. Carefully perform cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, paving, or other surfaces required for the installation, support, or anchorage of conduit, raceways, or other electrical materials and equipment. Following such work, restore surfaces to original condition.

F. Unless otherwise detailed or dimensioned, electrical layout drawings are diagrammatic. The Contractor shall coordinate the field location of electrical material or equipment with the work of other disciplines and subcontractors. Minor changes in location of electrical material or equipment made prior to installation shall be made at no cost to the Owner.

3.2 ANCHORING AND MOUNTING

A. Equipment anchoring and mounting shall be in accordance with manufacturer's requirements for seismic zone criteria given in Section 01 81 10, Wind and Seismic Design Criteria.

3.3 COMBINING CIRCUITS INTO COMMON RACEWAY

A. Drawings show each homerun circuit to be provided. Do not combine power or control circuits into common raceways without authorization of Engineer.

B. Homerun circuits shown on Drawings indicate functional wiring requirements for power and control circuits. Circuits may be combined into common raceways in accordance with the following requirements:

1. Analog control circuits from devices in same general area to same destination.
    a. No power or AC discrete control circuits shall be combined in same conduit with analog circuits.
    b. No Class 2 or Class 3 circuits including, but not limited to, HVAC control circuits, fire alarm circuits, paging system circuits shall be combined with power or Class 1 circuits.
    c. Analog circuits shall be continuous from source to destination. Do not add terminal junction box (TJB), splice, or combine into a multi-pair cable without authorization of Engineer.
    d. Raceways: Do not exceed 40 percent fill.
    e. Changes shall be documented on record drawings.
2. Discrete control circuits from devices in the same general area to the same destination.
    a. No power or analog control circuits shall be combined in same conduit with discrete circuits.
    b. No Class 2 or Class 3 circuits including, but not limited to, HVAC control circuits, fire alarm circuits, and paging system circuits shall be combined with power or Class 1 circuits.
    c. Raceways: Do not exceed 40 percent fill.
    d. Changes shall be documented on record drawings.
3. Power circuits from loads in same general area to same source location (such as: panelboard, switchboard, low voltage motor control center).
    a. Lighting Circuits: Combine no more than three circuits to a single raceway. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.
    b. Receptacle Circuits, 120-Volt Only: Combine no more than three circuits to a single raceway. Provide a separate neutral conductor for each circuit. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.

c. Motor Branch Circuits and Associated Motor Controller Circuits Sourced from Low-Voltage Motor Control Center: Combine no more than the circuits sourced from one full voltage motor starter unit. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.

d. No VFD branch circuits shall be combined in the same conduit with the associated motor controller circuits.

e. All Other Power Circuits: Do not combine power circuits without authorization of Engineer.

3.4 NAMEPLATES, SIGNS, AND LABELS

A. Arc Flash Protection Warning Signs:

1. Field mark switchboards, motor control centers, and panelboards to warn qualified persons of potential arc-flash hazards. Locate marking so to be clearly visible to persons before working on energized equipment.
2. Use arc flash hazard boundary, energy level, PPE level and description, shock hazard, bolted fault current, and equipment name from Engineer as basis for warning signs.
3. Engineer to provide arc flash warning signs. Contractor shall coordinate with Engineer.

B. Equipment Nameplates:

1. Provide a nameplate to label electrical equipment including switchgear, switchboards, motor control centers, panelboards, motor starters, transformers, terminal junction boxes, disconnect switches, switches and control stations.
2. Switchgear, motor control center, transformer, and terminal junction box nameplates shall include equipment designation.
3. Disconnect switch, starter, and control station nameplates shall include name and number of equipment powered or controlled by that device.
4. Switchboard and panelboard nameplates shall include equipment designation, service voltage, and phases.

C. Equipment Labels:

1. Equipment labels shall be installed on the outside of the electrical equipment enclosure, cabinet, and panels to avoid opening the equipment to access the manufacturer’s data or the equipment ratings.

3.5 MOTOR CONNECTIONS

A. Verify that the motors are purchased with the correct size motor termination boxes for the circuit content specified or submit custom fabrication drawing indicating proposed motor termination box material, size, gasket, termination kit, grounding terminal, boot type insulated motor lead connection (T&B type MSC, or equal), and motor terminal box connection/support system. Verify the motor termination box location prior to raceway rough-in.

3.6 CONDUCTOR INSTALLATION

A. An enclosure containing disconnecting means, overcurrent devices, or electrical equipment shall not be used as a wireway or raceway for conductors not terminating within the enclosure. Provide wireways, raceways, termination boxes, or junction boxes external to the enclosure for the other conductors.

3.7 LOAD BALANCE

A. Drawings and Specifications indicate circuiting to electrical loads and distribution equipment.

B. Balance electrical load between phases as nearly as possible on switchgear, panelboards, motor control centers, and other equipment where balancing is required.

C. When loads must be reconnected to different circuits to balance phase loads, maintain accurate record of changes made, and provide circuit directory that lists final circuit arrangement.

3.8 CLEANING AND TOUCHUP PAINTING

A. Cleaning: Throughout the Work, clean interior and exterior of devices and equipment by removing debris and vacuuming.

B. Touchup Paint:

1. Touchup scratches, scrapes and chips on exterior and interior surfaces of devices and equipment with finish matching type, color, and consistency and type of surface of original finish.

C. If extensive damage is done to equipment paint surfaces, refinish entire equipment in a manner that provides a finish equal to or better than factory finish, that meets requirements of Specification, and is acceptable to Engineer.

3.9 PROTECTION FOLLOWING INSTALLATION

A. Protect materials and equipment from corrosion, physical damage, and effects of moisture on insulation and contact surfaces.

B. When equipment intended for indoor installation is installed at Contractor's convenience in areas where subject to dampness, moisture, dirt or other adverse atmosphere until completion of construction, ensure adequate protection from these atmospheres is provided and acceptable to Engineer.

END OF SECTION

SECTION 26 05 04
BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 REFEREMCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   b. A1011/A1011M, Standard Specification for Steel, Sheet, and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low Alloy and High-Strength Low Alloy Formability.
   c. E814, Method of Fire Tests of Through-Penetration Fire Stops.
2. Canadian Standards Association (CSA).
3. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 18, Standard for Shunt Power Capacitors.
4. International Society of Automation (ISA): RP12.06.01, Wiring Practices for Hazardous (Classified) Locations Instrumentation–Part 1: Intrinsic Safety.
5. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. AB 1, Molded Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures.
   c. C12.1 Code for Electricity Metering
   d. C12.6 Phase-Shifting Devices Used in Metering, Marking and Arrangement of, Terminals for
   e. CP 1, Shunt Capacitors.
   f. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts.
   g. ICS 5, Industrial Control and Systems: Control Circuit and Pilot Devices.
   h. KS 1, Enclosed and Miscellaneous Distribution Switches (600 Volts Maximum).
6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
7. Underwriters Laboratories Inc. (UL):
   a. 98, Standard for Enclosed and Dead-Front Switches.
   b. 248, Standard for Low Voltage Fuses.
   c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   d. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   e. 508, Standard for Industrial Control Equipment.
   f. 810, Standard for Capacitors.
   g. 943, Standard for Ground-Fault Circuit-Interrupters.
   h. 1059, Standard for Terminal Blocks.
   i. 1479, Fire Tests of Through-Penetration Fire Stops.

1.2 SUBMITTALS

A. Action Submittals:

1. Provide manufacturers' data for the following:
   a. Control devices.

b. Control relays.
c. Circuit breakers.
d. Fused switches.
e. Nonfused switches.
f. Timers.
g. Fuses.
h. Terminal blocks.
i. Magnetic control relays.
j. Intrinsic safety barriers
k. Time delay relays.
l. Magnetic contactors.
m. Support and framing channel.
n. Firestopping.
o. Enclosures: Include enclosure data for products having enclosures.

1.3 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts and special tools:

1. Fuses, 0 to 600 Volts: Six of each type and each current rating installed.

PART 2 - PRODUCTS

2.1 MOLDED CASE CIRCUIT BREAKER THERMAL MAGNETIC, LOW VOLTAGE

A. General:

1. Type: Molded case.
2. Trip Ratings: 15-800 amps.
3. Voltage Ratings: 120, 240, 277, 480, and 600V ac.
4. Suitable for mounting and operating in any position.
5. NEMA AB 1 and UL 489.

B. Operating Mechanism:

1. Overcenter, trip-free, toggle type handle.
2. Quick-make, quick-break action.
3. Locking provisions for padlocking breaker in open position.
4. ON/OFF and TRIPPED indicating positions of operating handle.
5. Operating handle to assume a center position when tripped.

C. Trip Mechanism:

1. Individual permanent thermal and magnetic trip elements in each pole.
2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
3. Two and three pole, common trip.
4. Automatically opens all poles when overcurrent occurs on one pole.
5. Test button on cover.
6. Calibrated for 40 degrees C ambient, unless shown otherwise.
7. Do not provide single-pole circuit breakers with handle ties where multi-pole circuit breakers are shown.

D. Short Circuit Interrupting Ratings:

1. Equal to, or greater than, available fault current or interrupting rating shown.

E. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker as specified above with ground fault sensor and rated to trip on 5 mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel).

1. Ground fault sensor shall be rated same as circuit breaker.
2. Push-to-test button.

F. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker specified above with ground fault sensor and rated to trip on 30 mA ground fault (UL-listed for equipment ground fault protection).

G. Magnetic Only Type Breakers: Where shown; instantaneous trip adjustment which simultaneously sets magnetic trip level of each individual pole continuously through a 3X to 10X trip range.

H. Accessories: Shunt trip, auxiliary switches, handle lock ON devices, mechanical interlocks, key interlocks, unit mounting bases, double lugs as shown or otherwise required. Shunt trip operators shall be continuous duty rated or have coil-clearing contacts.

I. Connections:

1. Supply (line side) at either end.
2. Mechanical wire lugs, except crimp compression lugs where shown.
3. Lugs removable/replaceable for breaker frames greater than 100 amperes.
4. Suitable for 75 degrees C rated conductors without derating breaker or conductor ampacity.

J. Enclosures for Independent Mounting:

1. See Article Enclosures.
2. Service Entrance Use: Breakers in required enclosure and required accessories shall be UL 489 listed.
3. Interlock: Enclosure and switch shall interlock to prevent opening cover with switch in the ON position. Provide bypass feature for use by qualified personnel.

2.2 FUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

A. UL 98 listed for use and location of installation.

B. NEMA KS 1.

C. Short Circuit Rating: 200,000 amps RMS symmetrical with Class R, Class J, or Class L fuses installed.

D. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

E. Connections:

1. Mechanical lugs, except crimp compression lugs where shown.
2. Lugs removable/replaceable.
3. Suitable for 75 degrees C rated conductors at NEC 75 degrees C ampacity.

F. Fuse Provisions:

1. 30 amp to 600 amp rated shall incorporate rejection feature to reject all fuses except Class R.
2. 601 amp rated and greater shall accept Class L fuses, unless otherwise shown.

G. Enclosures: See Article Enclosures.

H. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.3 NONFUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

A. UL 98 listed for use and location of installation.

B. NEMA KS 1.

C. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type, single throw or double throw as required by Drawings, with external markings clearly indicating ON/OFF positions.

D. Lugs: Suitable for use with 75 degrees C wire at NEC 75 degrees C ampacity.

E. Auxiliary Contact:

1. As required to disconnect adjustable frequency drive control power or other auxiliary controls.
2. Operation: Make before power contacts make and break before power contacts break.
3. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.

F. Enclosures: See Article Enclosures.

G. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.4 FUSE, 250-VOLT AND 600-VOLT

A. Power Distribution, General:

1. Current-limiting, with 200,000 ampere rms interrupting rating.
2. Provide to fit mountings specified with switches.
3. UL 248.

B. Power Distribution, Ampere Ratings 1 Amp to 600 Amps:

1. Class: RK 1.
2. Type: Dual element, with time delay.
3. Manufacturers and Products:
   a. Bussmann; Types LPS RK (600 volts) and LPN RK (250 volts).
   b. Littelfuse; Types LLS RK (600 volts) and LLN-RK (250 volts).

C. Power Distribution, Ampere Ratings 601 Amps to 6,000 Amps:

1. Class: L.
2. Double O rings and silver links.
3. Manufacturers and Products:
   a. Bussmann; Type KRP C.
   b. Littelfuse, Inc.; Type KLPC.

D. Cable Limiters:

1. 600V or less; crimp to copper cable, bolt to bus or terminal pad.
2. Manufacturer and Product: Bussmann; K Series.

E. Ferrule:

1. 600V or less, rated for applied voltage, small dimension.
2. Ampere Ratings: 1/10 amp to 30 amps.
3. Dual-element time-delay, time-delay, or nontime-delay as required.
4. Provide with blocks or holders as indicated and suitable for location and use.
5. Manufacturers:
   a. Bussmann.
   b. Littlefuse, Inc.

2.5 CONTROL DEVICES

A. HOA Padlocking Cover: Provide padlocking cover on all HOA switches. Cover shall be clear plastic. AB 800T or approved equal.

B. Potentiometer Units: Provide ohm value for the application. Provide with back plate marked with 0-100% in 10% increments.

1. Legend Plate Label: SPEED.

C. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600. Provide bifurcated contacts for 24Vdc switching.

D. Selector Switch Operating Lever: Standard.

E. Emergency stop/close buttons shall be 2-position, push-pull/twist release type with red jumbo mushroom head.

F. Indicating Light: press-to-test LED, full voltage.

G. Pushbutton Color:

1. ON or START: Black.
2. OFF or STOP: Red.

H. Pushbutton and selector switch lockable in OFF position where indicated.

I. Legend Plate:

1. Material: Aluminum.
2. Engraving: Enamel filled in high contrasting color.
3. Text Arrangement: 11 character/spaces on one line, 14 character/spaces on each of two lines, as required, indicating specific function.
4. Letter Height: 7/64 inch.

J. Manufacturers and Products:

1. Allen Bradley 800H or 800T, or equivalent.

2.6 INDICATING LAMP COLORS

A. All indicating lamps shall have an integrated lamp-test function or a common lamp test switch for all lamps on a single line-up of equipment.

B. Unless otherwise specified, indicating lights shall be equipped with colored lenses in accordance with the following schedule:

Color	Function	Example
Green	Run, open valve	Equipment operating, motor running
Red	Stopped, closed valve	Alarm, end of cycle, motor stopped
White or Clear	Normal condition, Ready	Control power on, status OK
Amber (yellow)	Abnormal condition	Failure of equipment or status abnormal, fault condition

2.7 TERMINAL BLOCK, 600 VOLTS

A. UL 486E and UL 1059.

B. Size components to allow insertion of necessary wire sizes.

C. Capable of termination of control circuits entering or leaving equipment, panels, or boxes.

D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between compression screw and yoke.

E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.

F. Yoke shall guide all strands of wire into terminal.

G. Current bar shall ensure vibration-proof connection.

H. Terminals:

1. Capable of wire connections without special preparation other than stripping.
2. Capable of jumper installation with no loss of terminal or rail space.
3. Individual, rail mounted.

I. Marking system, allowing use of preprinted or field-marked tags.

J. Manufacturers:

1. Weidmuller, Inc.
2. Ideal.
3. Electrovert USA Corp.

2.8 MAGNETIC CONTROL RELAY

A. Industrial control with field convertible contacts rated 10 amps continuous, 7,200VA make, 720VA break.

B. NEMA ICS 2, Designation: A600 (600 volts).

C. Time Delay Relay Attachment:

1. Pneumatic type, timer adjustable from 0.2 second to 60 seconds (minimum).
2. Field convertible from ON delay to OFF delay and vice versa.

D. Latching Attachment: Mechanical latch, having unlatching coil and coil clearing contacts.

E. Manufacturers and Products:

1. Eaton/Cutler-Hammer; Type M 600.
2. General Electric Co.; Type CR120B.

2.9 TIME DELAY RELAY

A. Industrial relay with contacts rated 5 amps continuous, 3,600VA make, 360VA break.

B. NEMA ICS 2 Designation: B150 (150 volts).

C. Solid-state electronic, field convertible ON/OFF delay.

D. One normally open and one normally closed contact (minimum).

E. Repeat accuracy plus or minus 2 percent.

F. Timer adjustment from 1 second to 60 seconds, unless otherwise indicated on Drawings.

G. Manufacturers and Products:

1. Square D Co.; Type F.
2. Eaton/Cutler-Hammer.
3. General Electric Co.

2.10 INTRINSIC SAFETY BARRIER

A. Provides a safe energy level for exposed wiring in a Class I, Division 1 or Division 2 hazardous area when circuit is connected to power source in nonhazardous area.

B. Rating: Power source shall be rated 24 volts dc, nominal, with not more than 250 volts available under fault conditions.

C. Contact Rating: 5 amps, 250 volts ac.

D. Mounting: Rail or surface.

E. Manufacturers and Products:

1. MTL, Inc.
2. R. Stahl, Inc.

2.11 SUPPORT AND FRAMING CHANNELS

A. Carbon Steel Framing Channel:

1. Material: Rolled, mild strip steel, 12 gauge minimum, ASTM A1011/A1011M, Grade 33.
2. Finish: Hot-dip galvanized after fabrication.

B. Paint Coated Framing Channel: Carbon steel framing channel with electro-deposited rust inhibiting acrylic or epoxy paint.

C. PVC Coated Framing Channel: Carbon steel framing channel with 40 mil polyvinyl chloride coating.

D. Stainless Steel Framing Channel: Rolled, ASTM A167, Type 316 stainless steel, 12 gauge minimum.

E. Manufacturers:

1. B Line Systems, Inc.
2. Unistrut Corp.
3. Aickinstrut.

2.12 FIRESTOPS

A. General:

1. Provide UL 1479 classified hourly fire-rating equal to, or greater than, the assembly penetrated.
2. Prevent the passage of cold smoke, toxic fumes, and water before and after exposure to flame.
3. Sealants and accessories shall have fire-resistance ratings as established by testing identical assemblies in accordance with ASTM E814, by Underwriters Laboratories Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.

B. Firestop System:

1. Formulated for use in through-penetration firestopping around cables, conduit, pipes, and duct penetrations through fire-rated walls and floors.
2. Fill, Void, or Cavity Material: 3M Brand Fire Barrier Caulk CP25, Putty 303, Wrap/Strip FS195, Composite Sheet CS195 and Penetration Sealing Systems 7902 and 7904 Series.
3. Two-Part, Foamed-In-Place, Silicone Sealant: Dow Corning Corp. Fire Stop Foam, General Electric Co. Pensil 851.

2.13 ENCLOSURES

A. Finish: Sheet metal structural and enclosure parts shall be completely painted using an electrodeposition process so interior and exterior surfaces as well as bolted structural joints have a complete finish coat on and between them.

B. Color: Manufacturer’s standard color (gray) baked-on enamel, unless otherwise shown.

C. Barriers: Provide metal barriers within enclosures to separate wiring of different systems and voltage.

D. Enclosure Selections: Except as shown otherwise, provide electrical enclosures according to the following table:

ENCLOSURES			
Location	**Finish**	**Environment**	**NEMA 250 Type**
Indoor	Finished	Dry	1
Indoor	Unfinished	Industrial Use	12
Outdoor	Any	Denoted “WP”	3R
Indoor and Outdoor	Any	Wet and/or Corrosive	4X: 304 Stainless Steel
Indoor and Outdoor	Any	Wet, Dust, or Oil	13
Indoor	Any	Hazardous Gas	7
Outdoor	Any	Hazardous Gas	8

PART 3 - EXECUTION

3.1 GENERAL

A. Install equipment in accordance with manufacturer’s recommendations.

3.2 CONTROL DEVICES

A. Unless otherwise shown, install heavy-duty, oil-tight type in nonhazardous, indoor, dry locations, including motor control centers, control panels, and individual stations.

B. Unless otherwise shown, install heavy-duty, watertight and corrosion-resistant type in nonhazardous, outdoor, or normally wet areas.

3.3 SUPPORT AND FRAMING CHANNEL

A. Install where required for mounting and supporting electrical equipment, raceway, and cable tray systems.

B. Channel Type:

1. Interior, Dry (Noncorrosive) Locations:
   a. Steel Raceway: Carbon steel or paint coated.
2. Interior, Corrosive (Wet or Dry) Locations:
   a. PVC-Coated Steel Conduit and Other Systems Not Covered: Type 316 stainless steel or PVC-coated steel.
3. Outdoor Locations:
   a. PVC-Coated Steel Conduit and Other Systems Not Covered: Type 316 stainless steel or PVC coated steel.

C. Paint cut ends prior to installation with the following:

1. Carbon Steel Channel: Zinc-rich primer.
2. Painted Channel: Rust-inhibiting epoxy or acrylic paint.
3. Nonmetallic Channel: Epoxy resin sealer.
4. PVC-Coated Channel: PVC patch.

3.4 INTRINSIC SAFETY BARRIERS

A. Install in compliance with ISA RP12.06.01.

B. Arrange conductors such that wiring from hazardous areas cannot short to wiring from nonhazardous area.

C. Stencil “INTRINSICALLY SAFE CIRCUIT” on all boxes enclosing barriers.

3.5 FIRESTOPS

A. Install in strict conformance with manufacturer’s instructions. Comply with installation requirements established by testing and inspecting agency.

B. Sealant: Install sealant, including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide firestops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs.

END OF SECTION

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SECTION 26 05 19
CONDUCTORS AND COMMUNICATIONS CABLING

PART 1 - GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   b. B3, Standard Specification for Soft or Annealed Copper Wire.
   c. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   d. B496, Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors.
2. Insulated Cable Engineer's Association, Inc. (ICEA):
   a. S-58-679, Standard for Control Cable Conductor Identification.
   b. S-73-532, Standard for Control Thermocouple Extensions and Instrumentation Cables.
   c. T-29-520, Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input of 210,000 Btu/hour.
3. National Electrical Manufacturers' Association (NEMA):
   a. CC 1, Electric Power Connectors for Substations.
   b. WC 57, Standard for Control, Thermocouple Extension, and Instrumentation Cables.
   c. WC 70, Standard for Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
4. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
5. Telecommunications Industry Association (TIA): TIA-568-C, Commercial Building Telecommunications Cabling Standard.
6. American National Standards Institute (ANSI)
   a. ANSI X3.166, Information Systems--Fiber Data Distributed Interface (FDDI)--Token Ring Physical Layer Medium Dependent (PMD)
7. Underwriters Laboratories Inc. (UL):
   a. 13, Standard for Safety for Power-Limited Circuit Cables.
   b. 44, Standard for Safety for Thermoset-Insulated Wires and Cables.
   c. 62, Standard for Safety for Flexible Cord and Cables.
   d. 486A-486B, Standard for Safety for Wire Connectors.
   e. 486C, Standard for Safety for Splicing Wire Connectors.
   f. 510, Standard for Safety for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
   g. 854, Standard for Safety for Service-Entrance Cables.
   h. 1277, Standard for Safety for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
   i. 1569, Standard for Safety for Metal-Clad Cables.
   j. 1581, Standard for Safety for Reference Standard for Electrical Wires, Cables, and Flexible Cords.

1.2 SUBMITTALS

A. Action Submittals:

1. Product Data:
   a. Wire and cable.
   b. Wire and cable accessories.
   c. Fiber optic data cable and accessories.
2. Cable Pulling Calculations:
   a. Ensure submitted and reviewed before cable installation.
   b. Provide for the following cable installations:
      1) Multiconductor 600-volt cable sizes larger than 2 AWG that cannot be hand pulled.
      2) Power and control conductor, and control and instrumentation cable installations in ductbanks.
      3) Feeder circuits; single conductors #4/0 and larger.
3. Fiber Optic Cable light budget calculations:
   a. Describe design parameters used in calculation including light attenuation (dB per km), cable construction details, and connector characteristics and losses.
   b. Use spreadsheet format that calculates total power loss, received power, receiver overload margin, and receiver power margin.
4. Testing Related Submittals:
   a. Optical Time Domain Reflectometer (OTDR) certification, current within last 6 months.
   b. Pre-installation and post installation test documentation as specified herein.

B. Informational Submittals:

1. Factory Test Report for conductors 600 volts and below.

1.3 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70. Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. shall conform to those standards and shall have an applied UL listing mark.

PART 2 - PRODUCTS

2.1 CONDUCTORS 600 VOLTS AND BELOW

A. Conform to applicable requirements of NEMA WC 70.

B. Conductor Type: Stranded copper.

C. Insulation: Type THHN/THWN-2, except for sizes No. 6 and larger, with XHHW-2 insulation.

D. Flexible Cords and Cables:

1. Type SOW-A/50 with ethylene propylene rubber insulation in accordance with UL 62.
2. Conform to physical and minimum thickness requirements of NEMA WC 70.

2.2 600-VOLT RATED CABLE

A. General:

1. Type TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 70,000 Btu per hour, and NFPA 70, Article 340, or UL 13 meeting requirements of NFPA 70, Article 725.

2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
3. Suitable for installation in open air, in cable trays, or conduit.
4. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
5. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil resistant.

B. Multiconductor Control Cable:

1. Conductors:
   a. 14 AWG, seven-strand copper.
   b. Insulation: 15-mil PVC with 4-mil nylon.
   c. UL 1581 listed as Type THHN/THWN rated VW-1.
   d. Conductor group bound with spiral wrap of barrier tape.
   e. Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.
2. Cable: Passes the ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
3. Cable Sizes:

No. of Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
3	0.41	45
5	0.48	45
7	0.52	45
12	0.72	60
19	0.83	60
25	1.00	60
37	1.15	80

4. Manufacturers:
   a. Okonite Co.
   b. Southwire.

C. 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal thickness.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
3. Dimension: 0.31-inch nominal OD.
4. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
   b. 20 AWG, seven-strand tinned copper drain wire.
   c. Insulation: 15-mil nominal PVC.
   d. Jacket: 4-mil nominal nylon.
   e. Color Code: Pair conductors, black and red.
5. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Belden.

D. 16 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
3. Dimension: 0.32-inch nominal OD.
4. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
    b. 20 AWG, seven-strand, tinned copper drain wire.
    c. Insulation: 15-mil nominal PVC.
    d. Jacket: 4-mil nylon.
    e. Color Code: Triad conductors black, red, and blue.
5. Manufacturers:
    a. Okonite Co.
    b. Alpha Wire Corp.
    c. Belden.

E. 18 AWG, Multitwisted Shielded Pairs, with a Common Overall Shield, Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable, meeting NEMA WC 57 requirements.

1. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
    b. Tinned copper drain wires.
    c. Pair drain wire size AWG 20, group drain wire size AWG 18.
    d. Insulation: 15-mil PVC.
    e. Jacket: 4-mil nylon.
    f. Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.
    g. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer.
2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.
3. Cable Sizes:

Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.50	45
8	0.68	60
12	0.82	60
16	0.95	80
24	1.16	80
36	1.33	80
50	1.56	80

4. Manufacturers:
    a. Okonite Co.

b. Alpha Wire Corp.
c. Belden.

F. Multiconductor Adjustable Frequency Drive Power Cable:

1. Conductors:
   a. Class B, stranded coated copper.
   b. Insulation: 600-volt cross-linked polyethylene, UL Type XHHW-2.
2. Conductors #2AWG and smaller: Utilize 300% ground foil/braid design.
   a. Grounding Conductor: Insulated stranded copper.
   b. Sheath:
      1) UL 1277 Type TC, 90 degrees C.
      2) Continuous shield, A1/polyester foil, tinned copper drain wires, overall tinned copper braid.
3. Conductors larger than #2AWG: Utilize 100% ground symmetrical design.
   a. Grounding Conductors: Three symmetrical bare copper 100% ground.
   b. Outer Shield:
      1) 100% coverage
      2) Two spiral copper tape shields.
4. Outer Jacket: Polyvinyl chloride (PVC) per UL 1569.
5. Cable Sizes:

Conductor Size	Minimum Ground Wire Size (AWG)	No. of Insulated Conductors	Max. Outside Diameter (Inches)	Minimum Jacket Thickness (Mils)
12 AWG	12	4	0.655	50
10 AWG	10	4	0.769	50
8 AWG	8	4	0.940	50
6 AWG	6	4	1.038	50
4 AWG	4	4	1.180	50
2 AWG	2	4	1.351	50

6. Manufacturers and Products:
   a. Belden; Series 29500.
   b. Alpha Wire; Series V.
   c. LAPP USA; OLFLEX VFD Slim.

2.3 300-VOLT RATED CABLE

A. General:

1. Type PLTC, meeting requirements of UL 13 and NFPA 70, Article 725.
2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
3. Suitable for installation in open air, in cable trays, or conduit.
4. Minimum Temperature Rating: 105 degrees C.
5. Passes Vertical Tray Flame Test.
6. Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.

B. Twisted Pair Fire Alarm Cable, Shielded: Power limited fire protective signaling circuit cable meeting requirements of NFPA 70, Article 760.

1. Cable: Pass NFPA 262, 70,000 Btu flame test and listed by State Fire Marshall.
2. Outer Jacket: Red in color, identified along its entire length as fire protective signaling circuit cable.
3. Conductors:
   a. Solid, tinned, or bare copper shielded, with stranded tinned copper drain wire.
   b. Insulation: 15-mil PVC.
4. Cable Sizes:

Wire Size	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Inches)
12	0.36	0.042
14	0.32	0.042
16	0.26	0.037
18	0.23	0.037

5. Manufacturers:
   a. West Penn Wire.
   b. Coleman Cable, Inc.

2.4 SPECIAL CABLES

A. Foil Shielded/Unshielded Twisted Pair (F/UTP) Telephone and Data Cable, 300V:

1. Category 6A, UL listed, and third party verified to comply with TIA/EIA 568-C.2 Category 6A requirements.
2. Suitable for high-speed network applications including gigabit ethernet and video. Cable shall be interoperable with other standards compliant products and shall be backward compatible with Category 5 and Category 5e.
3. Four each individually twisted pair, 23 AWG conductors, with polyolefin insulation and blue PVC jacket.
4. Outer foil screen with 26 AWG tinned copper shield drain wire.
5. NEC/UL Riser (CMR) rated.
6. Cable shall withstand a bend radius of 1.2-inch minimum at a temperature of minus 10 degrees C maximum without jacket or insulation cracking.
7. Manufacturer and Product: Belden; 10GX62F.

B. Fiber Optic Cables:

1. Unless noted otherwise on the Drawings, fiber optic cables shall be as follows:
   a. Single Mode Fiber-Optic Cable:
      1) 24-count fiber cable.
      2) Outdoor/Indoor; Riser Rated (OFNR).
      3) Tight buffered.
      4) Fibers and buffer tubes shall be color coded with distinct and recognizable colors in accordance with EIA/TIA-598.
      5) Jacket: Flame retardant, UV resistant, black.
      6) Type:
         a) Approvals and Listings: NEC OFNR, CSA FT-4, ICEA S104-696.
         b) Fiber Type: Single mode

c) Nominal Cable Outer Diameter: 0.31 in.
d) Fiber Category: OS2
e) Wavelengths: 1310 nm/1383 nm/1550 nm
f) Maximum Attenuation: 0.4 dB/km/0.4 dB/km/0.4 dB/km.
g) Operating Temperature Range: -40 to +70 Deg C
h) Max Tensile Loading: 300/90 lbf (Installation/Operation)
i) Minimum Cable Bending Radius: 4.7/3.1 inches (Installation/Operation).

7) Manufacturers:
a) Corning Cable Systems, Corning FREEDM One (024E8F-31131-29) or equivalent.

b. Multimode Fiber-Optic Cable:
1) 24-count fiber cable.
2) Outdoor/indoor; Riser Rated (OFNR).
3) Tight buffered.
4) Fibers and buffer tubes shall be color coded with distinct and recognizable colors in accordance with EIA/TIA-598.
5) Jacket: Flame retardant, UV resistant, black.
6) Type:
a) Approvals and Listings: NEC OFNR, CSA FT-4, ICEA S104-696.
b) Fiber Type: Multimode
c) Nominal Cable Outer Diameter: 0.31 in.
d) Core Diameter: 50 µm
e) Fiber Category: OM3
f) Wavelengths: 850 nm/1300 nm
g) Maximum Attenuation: 2.8 dB/km/1.0 dB/km
h) Operating Temperature Range: -40 to +70 Deg C
i) Max Tensile Loading: 300/90 lbf (Installation/Operation)
j) Minimum Cable Bending Radius: 4.7/3.1 inches (Installation/Operation).
7) Manufacturers:
a) Corning Cable Systems, Corning FREEDM One (024T8F-31180-29) or equivalent.

2.5 GROUNDING CONDUCTORS

A. Equipment: Stranded copper with green, Type USE/RHH/RHW-XLPE or THHN/THWN, insulation.

B. Direct Buried: Bare stranded copper.

2.6 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW AND FIBER OPTICS

A. Tape:

1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33+, rated for 90 degrees C minimum, meeting requirements of UL 510.
2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.
3. Arc and Fireproofing:
a. 30-mil, elastomer.
b. Manufacturers and Products:
1) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.
2) Plymouth; 53 Plyarc, with 77 Plyglas glass cloth tapebinder.

B. Identification Devices:

1. Sleeve:
    a. Permanent, PVC, yellow or white, with legible machine-printed black markings.
    b. Manufacturers and Products:
        1) Raychem; Type D-SCE or ZH-SCE.
        2) Brady, Type 3PS.
2. Heat Bond Marker:
    a. Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive.
    b. Self-laminating protective shield over text.
    c. Machine printed black text.
    d. Manufacturer and Product: 3M Co.; Type SCS-HB.
3. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.
4. Tie-On Cable Marker Tags:
    a. Chemical-resistant white tag.
    b. Size: 1/2 inch by 2 inches.
    c. Manufacturer and Product: Raychem; Type CM-SCE.
5. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum.

C. Connectors and Terminations:

1. Nylon, Self-Insulated Crimp Connectors:
    a. Manufacturers and Products:
        1) Thomas & Betts; Sta-Kon.
        2) Burndy; Insulug.
        3) ILSCO.
2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
    a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
    b. Seamless.
    c. Manufacturers and Products:
        1) Thomas & Betts; Sta-Kon.
        2) Burndy; Insulink.
        3) ILSCO; ILSCONS.
3. Self-Insulated, Freespring Wire Connector (Wire Nuts):
    a. UL 486C.
    b. Plated steel, square wire springs.
    c. Manufacturers and Products:
        1) Thomas & Betts.
        2) Ideal; Twister.
4. Self-Insulated, Set Screw Wire Connector:
    a. Two-piece compression type with set screw in brass barrel.
    b. Insulated by insulator cap screwed over brass barrel.
    c. Manufacturers:
        1) 3M Co.
        2) Thomas & Betts.
        3) Marrette.

D. Cable Lugs:

1. In accordance with NEMA CC 1.
2. Rated 600 volts of same material as conductor metal.

3. Uninsulated Crimp Connectors and Terminators:
    a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
    b. Manufacturers and Products:
        1) Thomas & Betts; Color-Keyed.
        2) Burndy; Hydent.
        3) ILSCO.
4. Uninsulated, Bolted, Two-Way Connectors and Terminators:
    a. Manufacturers and Products:
        1) Thomas & Betts; Locktite.
        2) Burndy; Quiklug.
        3) ILSCO.

E. Cable Ties:
1. Nylon, adjustable, self-locking, and reusable.
2. Manufacturer and Product: Thomas & Betts; TY-RAP.

F. Heat Shrinkable Insulation:
1. Thermally stabilized cross-linked polyolefin.
2. Single wall for insulation and strain relief.
3. Dual Wall, adhesive sealant lined, for sealing and corrosion resistance.
4. Manufacturers and Products:
    a. Thomas & Betts; SHRINK-KON.
    b. Raychem; RNF-100 and ES-2000.

G. F/UTP cable:
1. Connector type: RJ-45.
2. Provide terminators, connectors, and junctions necessary for a complete Ethernet/IP system.

H. Fiber optics:
1. Connector type: LC or as required by equipment transceiver form factor.
2. Provide markers for labeling each end of a fiber optic cable.
3. Provide markers for individual fiber optic strands, jumpers, and patch cables. Attach to fiber using tie wrap or other approved method of securing the marker.
4. Markers must have space for typed or machine printed text.
5. Innerduct:
    a. Smooth walled polyethylene tube to protect fiber optic cable.
    b. Install innerduct in conduit.
    c. Install fiber optic cable in innerduct.
    d. Manufacturers: Carlon, or equal.
6. Split Duct:
    a. At patch panels and pull boxes provide smooth walled polyethylene split innerduct to bridge gap between panel and end of conduit.

2.7 PULLING COMPOUND

A. Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant; UL listed.

B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.

C. Approved for intended use by cable manufacturer.

D. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.

E. Manufacturers:

1. Ideal Co.
2. Polywater, Inc.
3. Cable Grip Co.

2.8 WARNING TAPE

A. As specified in Section 26 05 33, Raceway and Boxes.

2.9 SOURCE QUALITY CONTROL

A. Conductors 600 Volts and Below: Test in accordance with UL 44 and UL 854.

PART 3 - EXECUTION

3.1 GENERAL

A. Conductor installation shall be in accordance with manufacturer's recommendations.

B. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.

C. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii.

D. Terminate conductors and cables, unless otherwise indicated.

E. Tighten screws and terminal bolts in accordance with UL 486A-486B for copper conductors.

F. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.

G. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 12 inches on center.

H. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.

I. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrel approximately 1/4 inch smaller than raceway inside diameter.

J. VFD Wiring: Shielded power cables shall be used for load-side circuits between VFD's and motors.

3.2 POWER CONDUCTOR COLOR CODING

A. Conductors 600 Volts and Below:

1. 6 AWG and Larger: Apply general-purpose, flame-retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering area 1-1/2 inches to 2 inches wide.
2. 8 AWG and Smaller: Provide colored conductors.
3. Colors:

System	Conductor	Color
All Systems	Equipment Grounding	Green
240/120 Volts, Single-Phase, Three-Wire	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red
208Y/120 Volts, Three-Phase, Four-Wire	Grounded Neutral Phase A	White Black

	Phase B Phase C	Red Blue
240/120 Volts, Three-Phase, Four-Wire, Delta, Center Tap, Ground on Single-Phase	Grounded Neutral Phase A High (wild) Leg Phase C	White Black Orange Blue
480Y/277 Volts, Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Brown Orange Yellow

Note: Phase A, B, C implies direction of positive phase rotation.

4. Tracer: Outer covering of white with identifiable colored strip, other than green, in accordance with NFPA 70.

3.3 CIRCUIT IDENTIFICATION

A. Identify power, instrumentation, control conductor circuits, and fiber optic cables at each termination, and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.

B. Circuit Schedules: Identify using circuit schedule designations as specified in Section 26 05 00, General Requirements for Electrical Work.

C. Method:

1. Conductors 3 AWG and Smaller: Identify with sleeves or heat bond markers.
2. Cables and Conductors 2 AWG and Larger:
   a. Identify with marker plates or tie-on cable marker tags.
   b. Attach with nylon tie cord.
3. Taped-on markers or tags relying on adhesives not permitted.

3.4 CONDUCTORS 600 VOLTS AND BELOW

A. Install 10 AWG or 12 AWG conductors for branch circuit power wiring in lighting and receptacle circuits.

B. Do not splice incoming service conductors and branch power distribution conductors 6 AWG and larger, unless specifically indicated or approved by Engineer.

C. Connections and Terminations:

1. Install wire nuts only on solid conductors. Wire nuts are not allowed on stranded conductors.
2. Install nylon self-insulated crimp connectors and terminators for instrumentation and control, circuit conductors.
3. Install self-insulated, set screw wire connectors for two-way connection of power circuit conductors 12 AWG and smaller.
4. Install uninsulated crimp connectors and terminators for instrumentation, control, and power circuit conductors 4 AWG through 2/0 AWG.
5. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors 3/0 AWG and larger.
6. Install uninsulated terminators bolted together on motor circuit conductors 10 AWG and larger.
7. Place no more than one conductor in any single-barrel pressure connection.
8. Install crimp connectors with tools approved by connector manufacturer.
9. Install terminals and connectors acceptable for type of material used.
10. Compression Lugs:

a. Attach with a tool specifically designed for purpose. Tool shall provide complete, controlled crimp and shall not release until crimp is complete.
b. Do not use plier type crimpers.

D. Do not use soldered mechanical joints.

E. Splices and Terminations:

1. Insulate uninsulated connections.
2. Indoors: Use general-purpose, flame-retardant tape or single wall heat shrink.
3. Outdoors, Dry Locations: Use flame retardant, cold- and weather-resistant tape or single wall heat shrink.
4. Below Grade and Wet or Damp Locations: Use dual wall heat shrink.

F. Cap spare conductors with UL listed end caps.

G. Cabinets, Panels, and Motor Control Centers:

1. Remove surplus wire, bridle and secure.
2. Where conductors pass through openings or over edges in sheet metal, remove burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.

H. Control and Instrumentation Wiring:

1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions.
3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.
4. Where connections of cables installed under this section are to be made under Section 40 90 00, Instrumentation and Control for Process Systems leave pigtails of adequate length for bundled connections.
5. Cable Protection:
   a. Under Infinite Access Floors: May install without bundling.
   b. All Other Areas: Install individual wires, pairs, or triads in flex conduit under floor or grouped into bundles at least 1/2 inch in diameter.
   c. Maintain integrity of shielding of instrumentation cables.
   d. Ensure grounds do not occur because of damage to jacket over shield.

I. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

3.5 FIBER OPTIC CABLE

A. Application:

1. Single Mode Fiber Optic Cable: Provide for mission critical data backhaul communications links between core network hub SCADA PLC's and SCADA Remote I/O equipment, and between mission critical protection and monitoring Remote I/O equipment as shown on the Drawings.
2. Multi-Mode Fiber Optic Cable: Provide for radial communications circuits between core network hub elements and individual nodes at the edge of the network such as between SCADA PLC's and instrumentation as shown on the Drawings.

B. Innerduct:

1. Install in accordance with manufacturer's recommendation.
2. Use single unjoined lengths from one handhole or pull point to the next.
3. End innerduct at manholes or pull points.

4. One fiber optic cable per innerduct, maximum.

C. Fiber Optic Cable:

1. Install cables in innerduct.
2. Provide lengths required to perform installations as indicated on Drawings.
3. Install cable directly from shipping reels. Ensure cable is not:
    a. Dented, nicked, or kinked.
    b. Subjected to pull stress greater than or bend radius less than manufacturers specification.
    c. Otherwise subjected to treatment which may damage fiber strands during installation.
4. Splices: None. Install cables in unspliced lengths between fiber patch panels.
5. Terminate at fiber patch panel:
    a. Fan out fiber cable to allow direct connectorization of fiber optic cable.
    b. Sleeve over individual fiber with Kevlar reinforced furcation tubes.
    c. At point of convergence of furcation tubes, provide strain relief with high density plastic fan-out collar.
    d. Terminate all fibers.

D. Provide No. 12 stranded copper tracer wire for each underground conduit containing fiber optic cable.

E. Contractor shall use zip-cord jumper cables between patch/breakout panels and communications equipment.

F. Test with optical time domain reflectometer (OTDR) prior to installation and after installation. Test Polarization Mode Dispersion (PMD) and Fiber Distributed Data Interface (FDDI) requirements for the following:

1. Transmit power levels
2. AC extinction ratio
3. Optical wave shape
4. Duty cycle distortion
5. Data dependent jitter
6. Random jitter
7. Transmit frequency
8. Minimum optical input
9. Receiver jitter tolerance

G. Pre-installation tests:

1. Perform acceptance tests on the cable prior to installation to verify that the cable conforms to the manufacturer's specifications, and is free of defects, breaks and damages by transportation and manufacturing processes. Perform tests on all reels of cable. Cable shall not be installed until the Engineer has reviewed the test report.
2. Verify continuity and attenuation or loss for each fiber on each reel and document results of physical inspections to identify any cable and reel damage conditions, and any deviations from the manufacturer's specifications.
3. Document test results and submit the report to the Engineer for review.

H. Post-Installation Tests:

1. Conduct the following tests on each fiber in the cable segment. Tests shall be conducted at both 850 and 1300 nm. No splice loss shall have a loss of 0.15 dB or greater with fiber attenuation measured in dB/km.
2. Measure the attenuation of each optical fiber in both directions using a with an Optical Loss Test Set (OLTS) at both 850 nm and 1300 nm. Test shall be conducted per TIA/EIA 526-7.

Provide a reference power level measured with a patch cord and connectors of the same types used on the fiber cable. Measure and record the reference power level of the Laser Light Source. Measure and record the received power level of each optical. Repeat the same measurements in the other direction.

3. Pigtail splices shall have a loss no greater than 0.15 dB, as determined by either a Profile Alignment System (PAS) or Light Injection (LID) splice loss estimate, at the time the splice is made. Splices with an optical loss of greater than 0.15 dB shall be redone. OTDR traces at both 1310 nm and 1550 nm wavelengths display no unexplained losses, reflectance events, or other discontinuities.
4. Test Documentation:
    a. Hard copy of OTDR plots.
    b. Results of bi-directional test with power meter and light source.
    c. Provide an updated version of the light budget spreadsheet including actual cable lengths used, and actual losses measured by tests.

I. The Owner shall be notified a minimum of 5 days prior to tests and reserve the right to witness field tests.

3.6 CONDUCTOR ARC AND FIREPROOFING

A. Install arc and fireproofing tape on 600-volt single conductors and cables, except those rated Type TC, throughout entire exposed length in manholes, handholes, and vaults.

B. Wrap conductors of same circuit entering from separate conduit together as single cable.

C. Follow tape manufacturer’s installation instructions.

D. Secure tape at intervals of 5 feet with bands of tapebinder. Each band to consist of a minimum of two wraps directly over each other.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers (IEEE): C2, National Electrical Safety Code (NESC).
2. National Fire Protection Association (NFPA): 70, National Electrical Code. (NEC).

1.2 SUBMITTALS

A. Action Submittals: Product data for all specified products.

1.3 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

PART 2 - PRODUCTS

2.1 GROUNDING BUSBAR

A. Material: Copper.

B. Minimum Dimensions:

1. Thickness: 1/4 inch.
2. Width: 2 inches.
3. Length: 12 inches.

C. Hole pattern: As required.

D. Include busbar mounting hardware, fasteners, insulators and brackets.

2.2 GROUND ROD

A. Material: Copper-clad.

B. Diameter: Minimum 5/8 inch.

C. Length: 10 feet.

2.3 GROUND CONDUCTORS

A. As specified in Section 26 05 19.

2.4 CONNECTORS

A. Exothermic Weld Type:

1. Outdoor Weld: Suitable for exposure to elements or direct burial.
2. Indoor Weld: Utilize low-smoke, low-emission process.
3. Manufacturers:
   a. Erico Products, Inc. Cadweld and Cadweld Exolon.

b. Thermoweld.

B. Compression Type:

1. Compress-deforming type; wrought copper extrusion material.
2. Single indentation for conductors 6 AWG and smaller.
3. Double indentation with extended barrel for conductors 4 AWG and larger.
4. Barrels prefilled with oxide-inhibiting and antiseizing compound and sealed.
5. Manufacturers:
   a. Burndy Corp.; Hyground Irreversible Compression.
   b. Thomas and Betts Co.
   c. ILSCO.

C. Mechanical Type: Split-bolt, saddle, or cone screw type; copper alloy material.

1. Manufacturers:
   a. Burndy Corp.
   b. Thomas and Betts Co.

2.5 ADJUSTABLE FREQUENCY DRIVE POWER CABLE SHIELD GROUND:

A. Cold-shrinkable seal with copper braid and full diameter constant force spring.

B. Size range as required for jacket diameter.

C. Manufacturer: Southwire, Spec 85451 or equivalent.

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with NFPA 70 and IEEE C2.

B. The ground system resistance of the completed installation shall be determined by tests as specified in Section 26 08 00 – Commissioning of Electrical Systems.

C. Ground electrical service neutral at service entrance equipment with grounding electrode conductor to grounding electrode system.

D. Ground each separately derived system neutral with common grounding electrode conductor to grounding electrode system.

E. Bond together all grounding electrodes that are present at each building or structure served to form one common grounding electrode system.

F. Bond together system neutrals, service equipment enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.

G. Shielded Power Cables: Ground shields at each splice or termination in accordance with recommendations of splice or termination manufacturer.

H. Multiconductor Adjustable Frequency Drive Power Cables:

1. Comply with VFD manufacturer grounding requirements.
2. Provide shield termination and grounding.
3. Ground shield at VFD ground bus and at motor.

I. Shielded Instrumentation Cables:

1. Ground shield to ground bus at power supply for analog signal.
2. Expose shield minimum 1 inch at termination to field instrument and apply heat shrink tube.
3. Do not ground instrumentation cable shield at more than one point.

3.2 WIRE CONNECTIONS

A. Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.

B. Nonmetallic Raceways and Flexible Tubing: Install equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.

C. Connect ground conductors to raceway grounding bushings.

D. Extend and connect ground conductors to ground bus in all equipment containing a ground bus.

E. Connect enclosure of equipment containing ground bus to that bus.

F. Bolt connections to equipment ground bus.

G. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.

H. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding clips mounted directly on box, or with 3/8-inch machine screws.

I. Metallic Equipment Enclosures: Use furnished ground lug; if none furnished, tap equipment housing and install solderless terminal connected to box with machine screw. For circuits greater than 20 amps use minimum 5/16-inch diameter bolt.

3.3 MOTOR GROUNDING

A. Extend equipment ground bus via grounding conductor installed in motor feeder raceway; connect to motor frame.

B. Nonmetallic Raceways and Flexible Tubing: Install an equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.

C. Motors Less Than 10 hp: Use furnished ground lug in motor connection box; if none furnished, provide compression, spade-type terminal connected to conduit box mounting screw.

D. Motors 10 hp and Above: Use furnished ground lug in motor connection box; if none furnished, tap motor frame or equipment housing; furnish compression, one-hole, lug type terminal connected with minimum 5/16-inch brass threaded stud with bolt and washer.

E. Circuits 20 Amps or Above: Tap motor frame or equipment housing; install solderless terminal with minimum 5/16-inch diameter bolt.

3.4 GROUND RODS

A. Install full length with conductor connection at upper end.

B. Install with connection point below finished grade, unless otherwise shown.

C. Space multiple ground rods by one rod length.

D. Install to 8 feet below local frost depth.

3.5 CONNECTIONS

A. General:

1. Abovegrade Connections: Install exothermic weld, mechanical, or compression-type connectors; or brazing.
2. Belowgrade Connections: Install exothermic weld or compression type connectors.
3. Remove paint, dirt, or other surface coverings at connection points to allow good metal-to-metal contact.
4. Notify Engineer prior to backfilling ground connections.

B. Exothermic Weld Type:

1. Wire brush or file contact point to bare metal surface.
2. Use welding cartridges and molds in accordance with manufacturer’s recommendations.

3. Avoid using badly worn molds.
4. Mold to be completely filled with metal when making welds.
5. After completed welds have cooled, brush slag from weld area and thoroughly clean joint.

C. Compression Type:

1. Install in accordance with connector manufacturer's recommendations.
2. Install connectors of proper size for grounding conductors and ground rods specified.
3. Install using connector manufacturer's compression tool having proper sized dies and operate per manufacturer's instructions.

D. Mechanical Type:

1. Apply homogeneous blend of colloidal copper and rust and corrosion inhibitor before making connection.
2. Install in accordance with connector manufacturer's recommendations.
3. Do not conceal mechanical connections.

3.6 METAL STRUCTURE GROUNDING

A. Bond metal sheathing and exposed metal vertical structural elements to grounding system.

B. Bond electrical equipment supported by metal platforms to the platforms.

C. Provide electrical contact between metal frames and railings supporting pushbutton stations, receptacles, and instrument cabinets, and raceways carrying circuits to these devices.

3.7 HANDHOLE GROUNDING

A. Install one ground rod inside each manhole and handhole larger than 24-inch by 24-inch inside dimensions.

B. Ground Rod Floor Protrusion: 4 inches to 6 inches above floor.

C. Make connections of grounding conductors fully visible and accessible.

D. Connect all noncurrent-carrying metal parts, and any metallic raceway grounding bushings to ground rod with 6 AWG copper conductor.

3.8 TRANSFORMER GROUNDING

A. Bond neutrals of transformers within buildings to system ground network, and to any additional indicated grounding electrodes.

B. Bond neutrals of medium-voltage pad-mounted transformers and other medium-voltage pad-mounted equipment to four locally driven ground rods and buried ground wire encircling equipment and system ground network.

3.9 SURGE PROTECTION EQUIPMENT GROUNDING

A. Connect surge arrestor ground terminals to equipment ground bus.

END OF SECTION

SECTION 26 05 33
RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO): HB, Standard Specifications for Highway Bridges.
2. ASTM International (ASTM):
    a. A123/123M, Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products.
    b. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
    c. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
    d. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
    e. D149, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
3. Telecommunications Industry Association (TIA): 569B, Commercial Building Standard for Telecommunications Pathways and Spaces.
4. National Electrical Contractor's Association, Inc. (NECA): Installation standards.
5. National Electrical Manufacturers Association (NEMA):
    a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
    b. C80.1, Electrical Rigid Steel Conduit (ERSC).
    c. C80.3, Steel Electrical Metallic Tubing (EMT).
    d. C80.6, Electrical Intermediate Metal Conduit (EIMC).
    e. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
    f. TC 2, Electrical Polyvinyl Chloride (PVC) Conduit.
    g. TC 6, Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation.
6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
7. Underwriters Laboratories Inc. (UL):
    a. 1, Standard for Safety for Flexible Metal Conduit.
    b. 6, Standard for Safety for Electrical Rigid Metal Conduit – Steel.
    c. 360, Standard for Safety for Liquid-Tight Flexible Steel Conduit.
    d. 514B, Standard for Safety for Conduit, Tubing, and Cable Fittings.
    e. 651, Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit and Fittings.
    f. 651A, Standard for Safety for Type EB and A Rigid PVC Conduit and HDPE Conduit.
    g. 797, Standard for Safety for Electrical Metallic Tubing – Steel.
    h. 870, Standard for Safety for Wireways, Auxiliary Gutters, and Associated Fittings.
    i. 1242, Standard for Safety for Electrical Intermediate Metal Conduit – Steel.
    j. 1660, Standard for Safety for Liquid-Tight Flexible Nonmetallic Conduit.
    k. 1684, Standard for Safety for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
    l. 2024, Standard for Safety for Optical Fiber and Communication Cable Raceway.

1.2 SUBMITTALS

A. Action Submittals: Manufacturer's Literature:

1. Rigid galvanized steel conduit.
2. Intermediate metal conduit.
3. Electric metallic tubing
4. PVC Schedule 40 conduit.
5. PVC-coated rigid galvanized steel conduit, submittal to include copy of manufacturer's warranty.
6. Flexible metal, liquid-tight conduit.
7. Conduit fittings.
8. Wireways.
9. Device boxes for use in hazardous areas.
10. Junction and pull boxes used at or below grade.
11. Large junction and pull boxes.
12. Terminal junction boxes.
13. Precast Handholes and Manholes:
    a. Dimensional drawings and descriptive literature.
    b. Traffic loading calculations.
    c. Accessory information.
14. Equipment and machinery proposed for bending metal conduit.
15. Method for bending PVC conduit less than 30 degrees.
16. Seismic anchorage and bracing drawings and cut sheets.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by 01 73 24, Design Requirements for Non-Structural Components and Non-Building Structures.
2. Manufacturer's certification of training for PVC-coated rigid galvanized steel conduit installer.

1.3 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

B. PVC-Coated, Rigid Galvanized Steel Conduit Installer: Certified by conduit manufacturer as having received training on installation procedures.

PART 2 - PRODUCTS

2.1 CONDUIT AND TUBING

A. Rigid Galvanized Steel Conduit (RGS):

1. Meet requirements of NEMA C80.1 and UL 6.
2. Material: Hot-dip galvanized with chromated protective layer.

B. Intermediate Metal Conduit (IMC):

1. Meet requirements of NEMA C80.6 and UL 1242.

2. Material: Hot-dip galvanized with chromated and lacquered protective layer.

C. Electric Metallic Tubing (EMT):

1. Meet requirements of NEMA C80.3 and UL 797.
2. Material: Hot-dip galvanized with chromated and lacquered protective layer.

D. PVC Schedule 40 Conduit:

1. Meet requirements of NEMA TC 2 and UL 651.
2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors.

E. PVC-Coated Rigid Galvanized Steel Conduit:

1. Meet requirements of NEMA RN 1 and ETL.
2. Material:
   a. Meet requirements of NEMA C80.1 and UL 6.
   b. Exterior Finish: PVC coating, 40-mil nominal thickness; bond to metal shall have tensile strength greater than PVC.
   c. Interior finish: Urethane coating, 2-mil nominal thickness.
3. Threads: Hot-dipped galvanized and factory coated with urethane.
4. Bendable without damage to interior or exterior coating.

F. Flexible Metal, Liquid-Tight Conduit:

1. UL 360 listed for 105 degrees C insulated conductors.
2. Material: Galvanized steel with extruded PVC jacket.

G. Flexible, Nonmetallic, Liquid-Tight Conduit:

1. Material: PVC core with fused flexible PVC jacket.
2. UL 1660 listed for:
   a. Dry Conditions: 80 degrees C insulated conductors.
   b. Wet Conditions: 60 degrees C insulated conductors.
3. Manufacturers and Products:
   a. Carlon; Carflex or X-Flex.
   b. T & B; Xtraflex LTC or EFC.

H. Innerduct:

1. Resistant to spread of fire, per requirements of UL 2024.
2. Smooth or corrugated HDPE.
3. Textile Manufacturer: Maxcell.

2.2 FITTINGS

A. Rigid Galvanized Steel and Intermediate Metal Conduit:

1. General:
   a. Meet requirements of UL 514B.
   b. Type: Threaded, galvanized. Set screw and threadless compression fittings not permitted.
2. Bushing:
   a. Material: Malleable iron with integral insulated throat, rated for 150 degrees C.
   b. Manufacturers and Products:
      1) Appleton; Series BU-I.
      2) O-Z/Gedney; Type HB.
3. Grounding Bushing:

a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs.
b. Manufacturers and Products:
1) Appleton; Series GIB.
2) O-Z/Gedney; Type HBLG.

4. Conduit Hub:
a. Material: Malleable iron with insulated throat with bonding screw.
b. UL listed for use in wet locations.
c. Manufacturers and Products:
1) Appleton, Series HUB-B.
2) O-Z/Gedney; Series CH.
3) Meyers; ST Series.

5. Conduit Bodies:
a. Sized as required by NFPA 70.
b. Manufacturers and Products (For Normal Conditions):
1) Appleton; Form 35 threaded unilets.
2) Crouse-Hinds; Form 7 or Form 8 threaded condulets.
3) Killark; Series O electrolets.
4) Thomas & Betts; Form 7 or Form 8.
c. Manufacturers (For Hazardous Locations):
1) Appleton.
2) Crouse-Hinds.
3) Killark.

6. Couplings: As supplied by conduit manufacturer.
7. Unions:
a. Concrete tight, hot-dip galvanized malleable iron.
b. Manufacturers and Products:
1) Appleton; Series SCC bolt-on coupling or Series EC three-piece union.
2) O-Z/Gedney; Type SSP split coupling or Type 4 Series, three-piece coupling.

8. Conduit Sealing Fitting:
a. Manufacturers and Products:
1) Appleton; Type EYF, EYM, or ESU.
2) Crouse-Hinds; Type EYS or EZS.
3) Killark; Type EY or Type EYS.

9. Drain Seal:
a. Manufacturers and Products:
1) Appleton; Type EYD.
2) Crouse-Hinds; Type EYD or Type EZD.

10. Drain/Breather Fitting:
a. Manufacturers and Products:
1) Appleton; Type ECDB.
2) Crouse-Hinds; ECD.

11. Expansion Fitting:
a. Manufacturers and Products:
1) Deflection/Expansion Movement:
a) Appleton; Type DF.

b) Crouse-Hinds; Type XD.

2) Expansion Movement Only:

a) Appleton; Type XJ.

b) Crouse-Hinds; Type XJ.

c) Thomas & Betts; XJG-TP.

12. Cable Sealing Fitting:
    a. To form watertight nonslip cord or cable connection to conduit.
    b. For Conductors with OD of 1/2 inch or Less: Neoprene bushing at connector entry.
    c. Manufacturers and Products:
        1) Appleton; CG-S.
        2) Crouse-Hinds; CGBS.

B. Electric Metallic Tubing:
    1. Meet requirements of UL 514B.
    2. Type: Steel body and locknuts with steel or malleable iron compression nuts. Set screw and drive-on fittings not permitted.
    3. Electro zinc-plated inside and out.
    4. Raintight.
    5. Coupling Manufacturers and Products:
        a. Appleton; Type 95T.
        b. Crouse-Hinds.
        c. Thomas & Betts.
    6. Connector Manufacturers and Products:
        a. Appleton; Type ETP.
        b. Crouse-Hinds.
        c. Thomas & Betts.

C. PVC Conduit:
    1. Meet requirements of NEMA TC 3.
    2. Type: PVC, slip-on.

D. PVC-Coated Rigid Galvanized Steel Conduit:
    1. Meet requirements of UL 514B.
    2. Fittings: Rigid galvanized steel type, PVC coated by conduit manufacturer.
    3. Conduit Bodies: Cast metal hot-dipped galvanized or urethane finish. Cover shall be of same material as conduit body. PVC coated by conduit manufacturer.
    4. Finish: 40-mil PVC exterior, 2-mil urethane interior.
    5. Overlapping pressure-sealing sleeves.
    6. Conduit Hangers, Attachments, and Accessories: PVC-coated.
    7. Manufacturers:
        a. Robroy Industries.
        b. Ocal.
        c. Plasti-Bond.
    8. Expansion Fitting:
        a. Manufacturer and Product: Ocal; OCAL-BLUE XJG.

E. Flexible Metal, Liquid-Tight Conduit:
    1. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C.

2. Insulated throat and sealing O-rings.
3. Manufacturers and Products:
    a. Thomas & Betts; Series 5331.
    b. O-Z/Gedney; Series 4Q.

F. Flexible, Nonmetallic, Liquid-Tight Conduit:

1. Meet requirements of UL 514B.
2. Type: High strength plastic body, complete with lock nut, O-ring, threaded ferrule, sealing ring, and compression nut.
3. Body/compression nut (gland) design to ensure high mechanical pullout strength and watertight seal.
4. Manufacturers and Products:
    a. Carlon; Type LT.
    b. O-Z/Gedney; Type 4Q-P.
    c. Thomas & Betts; Series 6300.

G. Flexible Coupling, Hazardous Locations:

1. Approved for use in atmosphere involved.
2. Rating: Watertight and UL listed for use in Class I, Division 1 and 2 areas.
3. Outer bronze braid and an insulating liner.
4. Conductivity equal to a similar length of rigid metal conduit.
5. Manufacturers and Products:
    a. Crouse-Hinds; Type ECGJH or Type ECLK.
    b. Appleton; EXGJH or EXLK.

H. Watertight Entrance Seal Device:

1. New Construction:
    a. Material: Oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp.
    b. Manufacturer and Product: O-Z/Gedney; Type FSK or Type WSK, as required.
2. Cored-Hole Application:
    a. Material: Assembled dual pressure disks, neoprene sealing ring, and membrane clamp.
    b. Manufacturer and Product: O-Z/Gedney; Series CSM.

2.3 OUTLET AND DEVICE BOXES

A. Sheet Steel: One-piece drawn type, zinc-plated or cadmium-plated.

B. Cast Metal:

1. Box: Malleable iron or cast ferrous metal.
2. Cover: Gasketed, weatherproof, malleable iron, or cast ferrous metal, with stainless steel screws.
3. Hubs: Threaded.
4. Lugs: Cast Mounting.
5. Manufacturers and Products, Nonhazardous Locations:
    a. Crouse-Hinds; Type FS or Type FD.
    b. Appleton; Type FS or Type FD.
    c. Killark.
6. Manufacturers and Products, Hazardous Locations:
    a. Crouse-Hinds; Type GUA or Type EAJ.
    b. Appleton; Type GR.

C. PVC-Coated Cast Metal:

1. Type: One-piece.
2. Material: Malleable iron or cast ferrous metal.
3. Coating:
    a. Exterior Surfaces: 40-mil PVC.
    b. Interior Surfaces: 2-mil urethane.
4. Manufacturers:
    a. Robroy Industries.
    b. Ocal.

D. Nonmetallic:

1. Box: PVC.
2. Cover: PVC, weatherproof, with stainless steel screws.
3. Manufacturer and Product: Carlon; Type FS or Type FD, with Type E98 or Type E96 covers.

2.4 JUNCTION AND PULL BOXES

A. Outlet Box Used as Junction or Pull Box: As specified under Article Outlet and Device Boxes.

B. Conduit Bodies Used as Junction Boxes: As specified under Article Fittings.

C. Large Sheet Steel Box:

1. NEMA 250, Type 1.
2. Box: Code-gauge, galvanized steel.
3. Cover: Hinged with clamps.
4. Machine Screws: Corrosion-resistant.

D. Large Cast Metal Box:

1. NEMA 250, Type 4.
2. Box: Cast malleable iron or electrogalvanized finished, with drilled and tapped conduit entrances and exterior mounting lugs.
3. Cover: Hinged with clamps.
4. Gasket: Neoprene.
5. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
6. Manufacturer and Product, Surface Mounted, Hinged Type: O-Z/Gedney; Series YW.
7. Manufacturers and Products, Recessed Type:
    a. Crouse-Hinds; Type WJBF.
    b. O-Z/Gedney; Series YR.

E. Large Cast Metal Box, Hazardous Locations:

1. NEMA 250 Type 7 or Type 9 as required for Class, Division, and Group involved.
2. Box: Cast ferrous metal, electro-galvanize finished with drilled and tapped conduit entrances.
3. Cover: Hinged with screws.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers and Products:
    a. Crouse-Hinds; Type EJB.
    b. O-Z/Gedney; Series AJBEW.

F. Large Stainless-Steel Box:

1. NEMA 250 Type: 4X

2. Box: 14-gauge, ASTM A240/A240M, Type: 316 stainless steel, with white enamel painted interior mounting panel.
3. Cover: Hinged with clamps.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers:
    a. Hoffman Engineering Co.
    b. Robroy Industries.
    c. Wiegman.

G. Large Steel Box:

1. NEMA 250 Type 3R
2. Box: 14-gauge steel, with white enamel painted interior and gray primed exterior, over phosphated surfaces. Provide gray finish as approved by Engineer.
3. Cover: Hinged with clamps.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers:
    a. Hoffman Engineering Co.
    b. Robroy Industries.
    c. Wiegman.

H. Concrete Box:

1. Box: Reinforced, cast concrete with extension and bottom slab.
2. Cover: Steel checked plate; H/20 loading.
3. Cover Marking: ELECTRICAL, CONTROL, SIGNAL, TELEPHONE, or as shown.
4. Manufacturers and Products:
    a. Oldcastle Precast; Model 3030-LA (3030-SB with No. 3030-P Cover).
    b. Christy, Concrete Products, Inc.; B1017.

2.5 TERMINAL JUNCTION BOX

A. Cover: Hinged, unless otherwise shown.

B. Interior Finish: Paint with white enamel or lacquer.

C. Terminal Blocks:

1. Separate connection point for each conductor entering or leaving box.
2. Spare Terminal Points: 25 percent, minimum.

2.6 METAL WIREWAYS

A. Meet requirements of UL 870.

B. Type: Steel-enclosed, lay-in type.

C. Cover: Removable, screw type.

D. Rating: Outdoor raintight.

E. Finish: Rust inhibiting phosphatizing primer and gray baked enamel.

F. Hardware: Plated to prevent corrosion; screws installed toward the inside protected by spring nuts or otherwise guarded to prevent wire insulation damage.

G. Knockouts: Without knockouts, unless otherwise indicated.

H. Manufacturers:

1. Circle AW.
2. Hoffman.

3. Square D.

2.7 NONMETALLIC WIREWAY

A. Rating: Outdoor, corrosion resistant, raintight, NEMA Type 12 and Type 3R.

B. Type: Fiberglass-enclosed, with removable cover.

C. Captivated, corrosion-resistant cover screws.

D. Oil-resistant gaskets.

E. Meet UL cold impact test to minus 35 degrees C.

F. Manufacturer: Hoffman.

2.8 PRECAST MANHOLES

A. Concrete Strength: Minimum, 3,000 psi compressive, in 28 days.

B. Loading: AASHTO, H-20 in accordance with ASTM C857.

C. Drainage:

1. Slope floors toward drain points, leaving no pockets or other nondraining areas.
2. Provide drainage outlet or sump at low point of floor constructed with a heavy, cast iron, slotted or perforated hinged cover, and a minimum 4-inch outlet and outlet pipe.

D. Raceway Entrances:

1. Provide on all four sides.
2. Provide knockout panels or precast individual raceway openings.
3. At entrances where raceways are to be installed by others, provide minimum 12-inch-high by 24-inch-wide knockout panels for future raceway installation.

E. Embedded Pulling Iron:

1. Material: 3/4-inch-diameter stock, fastened to overall steel reinforcement before concrete is placed.
2. Location:
   a. Wall: Opposite each raceway entrance and knockout panel for future raceway entrance.
   b. Floor: Centered below handhole cover.

F. Manhole Frames and Covers:

1. Material: Steel, hot-dipped galvanized.
2. Cover Type: Solid, bolt-on, torsion spring, of diamond design.
3. Cover Loading: AASHTO H-20.
4. Cover Designation: Burn by welder, on upper side in integral letters, minimum 2 inches in height, appropriate titles:
   a. 600 Volts and Below: ELECTRIC LV, CONTROL, SIGNAL, TELEPHONE.

G. Hardware: Steel, hot-dip galvanized.

H. Furnish knockout for ground rod in each manhole.

I. Manufacturers:

1. Oldcastle Precast.
2. Penn-Cast Products, Inc.
3. Concrete Conduit Co.
4. Associated Concrete Products, Inc.
5. Pipe, Inc.

2.9 ACCESSORIES

A. Duct Bank Spacers:

1. Modular Type:
    a. Nonmetallic, interlocking, for multiple conduit sizes.
    b. Suitable for all types of conduit.
    c. Manufacturers:
        1) Underground Device, Inc.
        2) Carlon.
2. Template Type:
    a. Nonmetallic, custom made one-piece spacers.
    b. Suitable for all types of conduit.
    c. Material: HDPE or polypropylene, 1/2-inch minimum thickness.
    d. Conduit openings cut 1 inch larger than conduit outside diameter.
    e. Additional openings for stake-down, rebar, and concrete flow through as required.
    f. Manufacturer and Product: SP Products; Quik Duct.

B. Identification Devices:

1. Raceway Tags:
    a. Material: Laminated phenolic.
    b. Raceway Designation: Pressure stamped, embossed, or engraved.
    c. Tags relying on adhesives or taped-on markers not permitted.
2. Warning Tape:
    a. Material: Polyethylene, 4-mil gauge with detectable strip.
    b. Color: Red.
    c. Width: Minimum 3 inches.
    d. Designation: Warning on tape that electric circuit is located below tape.
    e. Identifying Letters: Minimum 1-inch-high permanent black lettering imprinted continuously over entire length.
    f. Manufacturers and Products:
        1) Panduit; Type HTDU.
        2) Reef Industries; Terra Tape.
3. Buried Raceway Marker:
    a. Material: Sheet bronze, consisting of double-ended arrows, straight for straight runs and bent at locations where runs change direction.
    b. Designation: Engrave to depth of 3/32 inch; ELECTRIC CABLES, in letters 1/4-inch high.
    c. Minimum Dimension: 1/4-inch-thick, 10 inches long, and 3/4 inch wide.

C. Raceway Coating: Clean and paint.

D. Heat Shrinkable Tubing:

1. Material: Heat-shrinkable, cross-linked polyolefin.
2. Semi-flexible with meltable adhesive inner liner.
3. Color: Black.
4. Manufacturers:
    a. Raychem.
    b. 3M.

E. Wraparound Duct Band:

1. Material: Heat-shrinkable, cross-linked polyolefin, precoated with hot-melt adhesive.
2. Width: 50 mm minimum.
3. Manufacturer and Product:
    a. Raychem; Type TWDB.
    b. Kable Kontrol Heat Shrink Tape.

PART 3 - EXECUTION

3.1 GENERAL

A. Conduit and tubing sizes shown are based on use of copper conductors.

B. Comply with NECA Installation Standards.

C. Crushed or deformed raceways not permitted.

D. Maintain raceway entirely free of obstructions and moisture.

E. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.

F. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.

G. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.

H. Group raceways installed in same area.

I. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.

J. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.

K. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.

L. Block Walls: Do not install raceways in same horizontal course or vertical cell with reinforcing steel.

M. Install watertight fittings in outdoor, underground, or wet locations.

N. Paint threads and cut ends, before assembly of fittings, galvanized conduit, PVC-coated galvanized conduit, or IMC installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.

O. Metal conduit shall be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.

P. Do not install raceways in concrete equipment pads, foundations, or beams without Engineer approval.

Q. Do not run conduits beneath a structural column.

R. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.

S. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.

T. Install conduits for fiber optic cables, telephone cables, and Category 6 data cables in strict conformance with the requirements of TIA 569B.

3.2 REUSE OF EXISTING CONDUITS

A. Where Drawings indicate existing conduits may be reused, they may be reused only where they meet the following criteria.

1. Conduit is in useable condition with no deformation, corrosion, or damage to exterior surface.
2. Conduit is sized per the NEC.
3. Conduit is of the type specified in Contract Documents.
4. Conduit is supported as specified in Contract Documents.

B. Conduit shall be reamed with wire brush, then with a mandrel approximately 1/4 inch smaller than raceway inside diameter then cleaned prior to pulling new conductors.

3.3 INSTALLATION IN CAST-IN-PLACE STRUCTURAL CONCRETE

A. Minimum Cover: 2 inches, including fittings.

B. Conduit placement shall not require changes in reinforcing steel location or configuration. Spacing and size limitations shall conform to ACI 318. Minimum distance between conduit and reinforcing steel shall be 2-inches minimum.

C. Provide nonmetallic support during placement of concrete to ensure raceways remain in position.

D. Conduit larger than 1 inch shall not be embedded in concrete slabs, walls, foundations, columns, or beams unless approved by Engineer.

E. Slabs and Walls (Requires Engineer Approval):

1. Trade size of conduit not to exceed one-fourth of slab or wall thickness.
2. Install within middle two-fourths of slab or wall.
3. Separate conduit less than 2-inch trade size by a minimum ten times conduit trade size, center-to-center, unless otherwise allowed by Engineer.
4. Separate conduit 2-inch and greater trade size by a minimum eight times conduit trade size, center-to-center, unless otherwise allowed by Engineer.
5. Cross conduit at an angle greater than 45 degrees, with minimum separation of 1.5 inch.
6. Separate conduit by a minimum six times the outside dimension of expansion/deflection fittings at expansion joints.
7. Conduit shall not be installed below the maximum water surface elevation in walls of water holding structures.

F. Columns and Beams (Requires Engineer Approval):

1. Trade size of conduit not to exceed one-fourth of beam thickness.
2. Conduit cross-sectional area not to exceed 4 percent of beam or column cross section.

3.4 CONDUIT APPLICATION

A. Diameter:

1. Exposed or aboveground concealed: Minimum ¾ inch.
2. Direct buried or concrete-encased duct bank: Minimum 1 inch.

B. Exterior, Exposed: PVC-coated rigid galvanized steel.

C. Interior, Exposed:

1. Dry areas: Rigid galvanized steel or intermediate metal conduit up to 6 feet above grade. Electric metallic tubing above 6 feet.
2. Process areas and wet areas: PVC-coated rigid galvanized steel.

D. Interior, Concealed (Not Embedded in Concrete): Rigid galvanized steel, intermediate metal conduit, or electric metallic tubing.

E. Aboveground, Embedded in Concrete Walls, Ceilings, or Floors: PVC Schedule 40.

F. Direct Earth Burial: PVC Schedule 40.

1. 90-Degree Bends: PVC-coated rigid steel.

G. Concrete-Encased Raceways: PVC Schedule 40, except where rigid galvanized steel is indicated.

H. Under Slabs-On-Grade: PVC Schedule 40.

I. Transition from Underground or Concrete Embedded to Exposed: PVC-coated rigid steel conduit.

J. Under Equipment Mounting Pads: Rigid galvanized steel conduit.

K. Exterior Light Pole Foundations: PVC Schedule 40.

L. Corrosive Areas: PVC-coated rigid galvanized steel.

M. Hazardous Gas Areas: PVC-coated rigid galvanized steel.

3.5 FLEXIBLE CONNECTIONS

A. For motors, wall or ceiling mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other locations approved by Engineer where flexible connection is required to minimize vibration:

1. Conduit Size 4 Inches or Less: Flexible, liquid-tight conduit.
2. Conduit Size Over 4 Inches: Nonflexible.
3. Wet or Corrosive Areas: Flexible, nonmetallic or flexible metal liquid-tight.
4. Dry Areas: Flexible, nonmetallic liquid-tight.
5. Hazardous Areas: Flexible coupling suitable for Class I, Division 1 and 2 areas.

B. Suspended Lighting Fixtures in Dry Areas: Flexible steel, liquid-tight conduit.

C. Outdoor Areas, Process Areas Exposed to Moisture, and Areas Required to be Oiltight and Dust-Tight: Flexible metal, liquid-tight conduit.

D. Flexible Conduit Length: 18 inches minimum, 60 inches maximum; sufficient to allow movement or adjustment of equipment.

3.6 PENETRATIONS

A. Make at right angles, unless otherwise shown.

B. Notching or penetration of structural members, including footings and beams, not permitted.

C. Fire-Rated Walls, Floors, or Ceilings: Firestop openings around penetrations to maintain fire-resistance rating as specified in Section 26 05 04, Basic Electrical Materials and Methods.

D. Apply a single layer of wraparound duct band to metallic conduit protruding through concrete floor slabs to a point 2 inches above and 2 inches below concrete surface.

E. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack or use watertight seal device.

F. Entering Structures:

1. General: Seal raceway at first box or outlet with oakum or expandable plastic compound to prevent entrance of gases or liquids from one area to another.
2. Concrete Roof or Membrane Waterproofed Wall or Floor:
   a. Provide a watertight seal.
   b. Without Concrete Encasement: Install watertight entrance seal device on each side.
   c. With Concrete Encasement: Install watertight entrance seal device on accessible side.
   d. Securely anchor malleable iron body of watertight entrance seal device into construction with one or more integral flanges.
   e. Secure membrane waterproofing to watertight entrance seal device in a permanent, watertight manner.

3. Heating, Ventilating, and Air Conditioning Equipment:
    a. Penetrate equipment in area established by manufacturer.
    b. Terminate conduit with flexible metal conduit at junction box or condulet attached to exterior surface of equipment prior to penetrating equipment.
    c. Seal penetration with sealant, as specified in Section 07 92 00, Joint Sealants.
4. Corrosive-Sensitive Areas:
    a. Seal conduit passing through corrosive room walls.
    b. Seal conduit entering equipment panel boards and field panels containing electronic equipment.
    c. Seal penetration with sealant, as specified in Section 07 92 00, Joint Sealants.
5. Existing or Precast Wall (Underground): Core drill wall and install watertight entrance seal device.
6. Nonwaterproofed Wall or Floor (Underground, without Concrete Encasement):
    a. Provide Schedule 40 galvanized pipe sleeve, or watertight entrance seal device.
    b. Fill space between raceway and sleeve with expandable plastic compound or oakum and lead joint, on each side.
7. Handholes:
    a. Metallic Raceways: Provide insulated grounding bushings.
    b. Nonmetallic Raceways: Provide bell ends flush with wall.
    c. Install such that raceways enter as near as possible to one end of wall, unless otherwise shown.

3.7 SUPPORT

A. Support from structural members only, at intervals not exceeding NFPA 70 requirements. Do not exceed 8 feet in any application. Do not support from piping, pipe supports, or other raceways.

B. Multiple Adjacent Raceways: Provide ceiling trapeze. For trapeze-supported conduit, allow 20 percent extra space for future conduit.

C. Application/Type of Conduit Strap:
    1. Rigid Steel or EMT Conduit: Zinc coated steel, pregalvanized steel or malleable iron.
    2. PVC-Coated Rigid Steel Conduit: PVC-coated metal.
    3. Nonmetallic Conduit: Nonmetallic or PVC-coated metal.

D. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:
    1. Wood: Wood screws.
    2. Hollow Masonry Units: Toggle bolts.
    3. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.
    4. Steelwork: Machine screws.
    5. Location/Type of Hardware:
        a. Dry, Noncorrosive Areas: Galvanized.
        b. Wet, Noncorrosive Areas: Stainless steel.
        c. Corrosive Areas: Stainless steel.

E. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.

3.8 BENDS

A. Install concealed raceways with a minimum of bends in the shortest practical distance.

B. Make bends and offsets of longest practical radius. Bends in conduits and ducts being installed for fiber optic cables shall be not less than 20 times cable diameter, 15 inches minimum.

C. Install with symmetrical bends or cast metal fittings.

D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.

E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.

F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.

G. PVC Conduit:

1. Bends 30 Degrees and Larger: Provide factory-made elbows.
2. 90-Degree Bends: Provide rigid steel elbows, PVC-coated where direct buried.
3. Use manufacturer's recommended method for forming smaller bends.

H. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

3.9 EXPANSION/DEFLECTION FITTINGS

A. Provide on raceways at structural expansion joints and in long tangential runs.

B. Provide expansion/deflection joints for 25 degrees F maximum temperature variation.

C. Install in accordance with manufacturer's instructions.

3.10 PVC CONDUIT

A. Solvent Welding:

1. Apply manufacturer recommended solvent to joints.
2. Install in order that joint is watertight.

B. Adapters:

1. PVC to Metallic Fittings: PVC terminal type.
2. PVC to Rigid Metal Conduit or IMC: PVC female adapter.

C. Belled-End Conduit: Bevel unbelled end of joint prior to joining.

3.11 PVC-COATED RIGID STEEL CONDUIT

A. Install in accordance with manufacturer's instructions.

B. Tools and equipment used in cutting, bending, threading and installation of PVC-coated rigid conduit shall be designed to limit damage to PVC coating.

C. Provide PVC boot to cover exposed threading.

3.12 WIREWAYS

A. Install in accordance with manufacturer's instructions.

B. Locate with cover on accessible vertical face of wireway, unless otherwise shown.

C. Applications:

1. Metal wireway in indoor dry locations.
2. Nonmetallic wireway in indoor process/wet, outdoor, and corrosive locations.

3.13 TERMINATION AT ENCLOSURES

A. Cast Metal Enclosure: Install manufacturer's premolded insulating sleeve inside metallic conduit terminating in threaded hubs.

B. Nonmetallic, Cabinets, and Enclosures:

1. Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.
2. Metallic Conduit: Provide ground terminal for connection to maintain continuity of ground system.

C. Sheet Metal Boxes, Cabinets, and Enclosures:

1. General:
   a. Install insulated bushing on ends of conduit where grounding is not required.
   b. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.
   c. Utilize sealing locknuts or threaded hubs on sides and bottom of NEMA 3R and NEMA 12 enclosures.
   d. Terminate conduits at threaded hubs at the tops of NEMA 3R and NEMA 12 boxes and enclosures.
   e. Terminate conduits at threaded conduit hubs at NEMA 4 and NEMA 4X boxes and enclosures.
2. Rigid Galvanized Steel and Intermediate Metal Conduit:
   a. Provide one lock nut each on inside and outside of enclosure.
   b. Install grounding bushing at source enclosure.
   c. Provide bonding jumper from grounding bushing to equipment ground bus or ground pad.
3. Flexible Metal Conduit: Provide two screw type, insulated, malleable iron connectors.
4. Flexible, Nonmetallic Conduit: Provide nonmetallic, liquid-tight strain relief connectors.
5. PVC-Coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector.
6. PVC Schedule 40 Conduit: Provide PVC terminal adapter with lock nut, except where threaded hubs required above.

D. Motor Control Center, Switchgear, and Free-Standing Enclosures:

1. Terminate metal conduit entering bottom with grounding bushing; provide grounding jumper extending to equipment ground bus or grounding pad.
2. Terminate PVC conduit entering bottom with bell end fittings.

E. Medium-Voltage Transformer and Switchgear Enclosures:

1. Terminate metal conduit entering bottom with grounding bushing; provide grounding jumper extending to equipment ground bus or grounding pad.
2. Terminate PVC conduit entering bottom with bell end fittings.

3.14 UNDERGROUND RACEWAYS

A. Grade: Maintain minimum grade of 4 inches in 100 feet, either from one handhole, or pull box to the next, or from a high point between them, depending on surface contour.

B. Cover: Maintain minimum 2-foot cover above conduit and concrete encasement, unless otherwise shown.

C. Make routing changes as necessary to avoid obstructions or conflicts.

D. Couplings: In multiple conduit runs, stagger so couplings in adjacent runs are not in same transverse line.

E. Union type fittings not permitted.

F. Spacers:

1. Provide preformed, nonmetallic spacers designed for such purpose, to secure and separate parallel conduit runs in a trench or concrete encasement.

2. Install at intervals not greater than that specified in NFPA 70 for support of the type conduit used, but in no case greater than 10 feet.

G. Support conduit to prevent bending or displacement during backfilling or concrete placement.

H. Transition from Underground to Exposed: PVC-coated rigid steel conduit.

I. Installation with Other Piping Systems:

1. Crossings: Maintain minimum 12-inch vertical separation.
2. Parallel Runs: Maintain minimum 12-inch separation.
3. Installation over valves or couplings not permitted.

J. Metallic Raceway Coating: Apply wherever rigid galvanized or intermediate metal conduit raceways are specified in direct burial installation. Along entire length, coat with raceway coating or apply tape with one-half tape width overlap to obtain two complete layers.

K. Provide expansion fittings that allow minimum of 4 inches of movement in vertical conduit runs from underground where exposed conduit will be fastened to or will enter building or structure.

L. Provide expansion/deflection fittings in conduit runs that exit building or structure belowgrade. Conduit from building wall to fitting shall be PVC-coated rigid steel.

M. Backfill:

1. As specified in Section 31 23 33. Controlled low strength fill is an acceptable bedding and pipe zone material. Backfill material to within 12 inches of surface.
2. Do not backfill until inspected by Engineer and Owner.

3.15 UNDER SLAB RACEWAYS

A. Make routing changes as necessary to avoid obstructions or conflicts.

B. Support raceways to prevent bending or displacement during backfilling or concrete placement.

C. Install raceways with no part embedded within slab and with no interference with slab on grade construction.

D. Raceway spacing, in a single layer or multiple layers:

1. 3 inches clear between adjacent 2-inch or larger raceway.
2. 2 inches clear between adjacent 1-1/2-inch or smaller raceway.

E. Multiple Layers of Raceways: Install under slab on grade in trench below backfill zone.

F. Individual Raceways and Single Layer Multiple Raceways: Install at lowest elevation of backfill zone with spacing as specified herein. Where conduits cross at perpendicular orientation, installation of conduits shall not interfere with placement of under slab fill that meets compaction and void limitations of earthwork specifications.

G. Under slab raceways that emerge from below slab to top of slab as exposed, shall be located to avoid conflicts with structural slab rebar. Coordinate raceway stub ups with location of structural rebar.

H. Fittings:

1. Union type fittings are not permitted.
2. Provide expansion/deflection fittings in raceway runs that exit building or structure below slab. Locate fittings 18 inches, maximum, beyond exterior wall. Raceway type between building exterior wall to fitting shall be PVC-coated rigid steel.
3. Couplings: In multiple raceway runs, stagger so couplings in adjacent runs are not in same traverse line.

3.16 OUTLET AND DEVICE BOXES

A. General:

1. Install plumb and level.
2. Install suitable for conditions encountered at each outlet or device in wiring or raceway system, sized to meet NFPA 70 requirements.
3. Open no more knockouts in sheet steel device boxes than are required; seal unused openings.
4. Install galvanized mounting hardware in industrial areas.

B. Size:

1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted.
    a. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.
2. Ceiling Outlet: Minimum 4-inch octagonal device box, unless otherwise required for installed fixture.
3. Switch and Receptacle: Minimum 2-inch by 4-inch device box.

C. Locations:

1. Drawing locations are approximate.
2. To avoid interference with mechanical equipment or structural features, relocate outlets as directed by Engineer.
3. Light Fixture: Install in symmetrical pattern according to room layout, unless otherwise shown.

D. Mounting Height:

1. General:
    a. Dimensions given to centerline of box.
    b. Where specified heights do not suit building construction or finish, adjust up or down to avoid interference.
    c. Do not straddle CMU block or other construction joints.
2. Light Switch:
    a. 48 inches above floor.
    b. When located next to door, install on lock side of door.
3. Thermostat: 56 inches above floor.
4. Telephone Outlet:
    a. 18 inches above floor.
    b. 6 inches above counter tops.
    c. Wall Mounted: 48 inches above floor.
5. Convenience Receptacle:
    a. General Interior Areas: 18 inches above floor.
    b. General Interior Areas (Counter Tops): Install device plate bottom or side flush with top of backsplash, or 6 inches above counter tops without backsplash.
    c. Industrial Areas, Workshops: 48 inches above floor.
    d. Outdoor Areas: 24 inches above finished grade.
6. Special-Purpose Receptacle: 48 inches above floor or as shown.
7. Switch, Motor Starting: 48 inches above floor, unless otherwise indicated on Drawings.

E. Flush Mounted:

1. Install with concealed conduit.
2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.

3. Holes in surrounding surface shall be no larger than required to receive box.

F. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.
2. Install bar hangers in frame construction or fasten boxes directly as follows:
   a. Wood: Wood screws.
   b. Concrete or Brick: Bolts and expansion shields.
   c. Hollow Masonry Units: Toggle bolts.
   d. Steelwork: Machine screws.
3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
4. Provide plaster rings where necessary.
5. Boxes embedded in concrete or masonry need not be additionally supported.

G. Install separate junction boxes for flush or recessed lighting fixtures where required by fixture terminal temperature.

H. Boxes Supporting Fixtures: Provide means of attachment with adequate strength to support fixture.

3.17 JUNCTION AND PULL BOXES

A. General:

1. Install plumb and level.
2. Installed boxes shall be accessible.
3. Do not install on finished surfaces.
4. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.
5. Use conduit bodies as junction and pull boxes where no splices are required and allowed by applicable codes.
6. Install pull boxes where necessary in raceway system to facilitate conductor installation.
7. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.
8. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.

B. Flush Mounted:

1. Install with concealed conduit.
2. Holes in surrounding surface shall be no larger than required to receive box.
3. Make edges of boxes flush with final surface.

C. Mounting Hardware:

1. Noncorrosive Dry Areas: Galvanized.
2. Noncorrosive Wet Areas: Stainless steel.
3. Corrosive Areas: Stainless steel.

D. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.
2. Install bar hangers in frame construction or fasten boxes directly as follows:
   a. Wood: Wood screws.
   b. Concrete or Brick: Bolts and expansion shields.

c. Hollow Masonry Units: Toggle bolts.

d. Steelwork: Machine screws.

3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.

4. Boxes embedded in concrete or masonry need not be additionally supported.

E. At or Below Grade:

1. Install boxes for below grade conduit flush with finished grade in locations outside of paved areas, roadways, or walkways.

2. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location.

3. Obtain Engineer's written acceptance prior to installation in paved areas, roadways, or walkways.

4. Use boxes and covers suitable to support anticipated weights.

F. Install Drain/breather fittings in NEMA 250 Type 4 and Type 4X enclosures.

3.18 HANDHOLES AND MANHOLES

A. Excavate, shore, brace, backfill, and final grade.

B. Do not install until final raceway grading has been determined.

C. In paved areas:

1. Provide concrete curb a minimum of 1-foot around handhole frame and cover.

2. Slope concrete curb to grade away from handhole frame and cover leaving no pockets or other nondraining areas.

D. Install such that raceway enters at nearly right angle and as near as possible to end of wall, unless otherwise shown.

E. Grounding: As specified in Section 26 05 26, Grounding

F. Identification: Field stamp covers with handhole number as shown. Stamped numbers to be 1-inch minimum height.

3.19 EMPTY RACEWAYS

A. Provide permanent, removable cap over each end.

B. Provide PVC plug with pull tab for underground raceways with end bells.

C. Provide one No. 12 stranded copper ground wire in each empty conduit for utilization as pull cord and tracer wire.

D. Identify, as specified in Identification Devices, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

3.20 IDENTIFICATION DEVICES

A. Raceway Tags:

1. Identify per Raceway Schedule designation.

2. For exposed raceways, install tags at each terminus, near midpoint, and at minimum intervals of every 50 feet, whether in ceiling space or surface mounted.

3. Install tags at each terminus for concealed raceways.

4. Provide noncorrosive wire for attachment.

B. Warning Tape: Install approximately 12 inches above underground or concrete-encased raceways. Align parallel to, and within 12 inches of, centerline of run.

C. Buried Raceway Marker:

1. Install at grade to indicate direction of underground raceway.

2. Install at bends and at intervals not exceeding 100 feet in straight runs.
3. Embed and secure to top of concrete base, sized 14 inches long, 6 inches wide, and 8 inches deep; top set flush with finished grade.

3.21 PROTECTION OF INSTALLED WORK

A. Protect products from effects of moisture, corrosion, and physical damage during construction.

B. Provide and maintain manufactured watertight and dust-tight seals over conduit openings during construction.

C. Touch up painted conduit threads after assembly to cover nicks or scars.

D. Touch up coating damage to PVC-coated conduit with patching compound approved by manufacturer. Compound shall be kept refrigerated according to manufacturers' instructions until time of use.

END OF SECTION

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SECTION 26 05 73
ELECTRICAL SYSTEMS ANALYSIS

PART 1 - GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI).
2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. C57.12.00, Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.
   b. 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.
   c. 399, Recommended Practice for Industrial and Commercial Power System Analysis.
   d. 1584, Guide for Performing Arc Flash Hazard Calculations.
3. National Electrical Manufacturers Association (NEMA): Z535.4, Product Safety Signs and Labels.
4. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 70E, Standard for Electrical Safety in the Workplace.
5. Occupational Safety and Health Standards (OSHA): 29 CFR, Part 1910 Subpart S, Electrical.

1.2 SCOPE

A. The Contractor shall perform the following:

1. Data collection required for Engineer to complete the Power System Study requirements specified herein for arc flash, short circuit, and coordination studies.
2. Provide information on data collection forms included herein, and additional information as required for Engineer to complete the Power System Study. Data collection form information includes, but is not limited to, equipment types and nameplate data; all services and feeders including size and type of conductors, conduit types, and lengths; overcurrent protection device information including actual catalog numbers, ratings, and available trip settings; transformer information including type, connections, power ratings, and impedance; load nameplate data.
3. Deliver completed data collection forms as specified herein to the Engineer 120 days prior to Project Substantial Completion to be utilized by the Engineer to develop a Power System Study Report.
4. Initially set protective devices to maximum settings during equipment installation, or as recommended by manufacturer.
5. Adjust protective device settings based on Engineer-furnished Power System Study Report results prior to Project Substantial Completion.
6. Install Engineer-furnished arc flash warning labels on switchboards, motor control centers, panel boards, VFD’s, disconnect switches, and other applicable new power system elements prior to Project Substantial Completion.

B. The Engineer shall perform the following:

1. Prepare a Power System Study Report that includes arc flash, short circuit, and coordination studies for switchboards, motor control centers, panel boards, and other applicable new power system elements. The studies and report will be based on as-installed equipment, circuit, and raceway data collection form information provided by the Contractor to the Engineer.

2. Deliver final protective device settings and arc flash labels to the Contractor 14 days prior to Project Substantial Completion.

1.3 POWER SYSTEM STUDY PERFORMED BY ENGINEER

A. General:

1. Perform studies using SKM Power Tools for Windows.
2. Perform complete fault calculations for each source combination, which may include present and future power company supply circuits, large motors, or generators.
3. Utilize data for study obtained from Contractor's field investigation of system configuration, wiring information, and equipment.
4. Existing System and Equipment:
    a. Extent of existing system to be included in study is limited to system elements that affect new system and equipment.
    b. Include fault contribution of existing motors and equipment in study.
    c. Include impedance elements that affect new system and equipment.
    d. Include protective devices in series with new equipment.
5. Device coordination time-current curves for low voltage distribution system; include individual protective device time-current characteristics.

B. Power System Study includes:

1. Short Circuit Study
2. Protective Device Coordination Study
3. Arc Flash Study

PART 2 - PRODUCTS

2.1 ARC FLASH WARNING LABELS

A. The Engineer will provide the Contractor adhesive backed labels for installation by Contractor.

2.2 DATA COLLECTION FORMS

A. Examples of data collection forms are located at the end of section. Contractor shall coordinate with the Engineer if collection form modifications are required to accommodate differing circumstances or unlisted equipment.

PART 3 - EXECUTION

3.1 GENERAL

A. Adjust relay and protective device settings according to values established by coordination study.

B. Make modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

C. Notify Engineer in writing of required major equipment modifications.

D. Install Engineer-provided arc flash warning labels on equipment as required by code.

3.2 SUPPLEMENTS

A. The supplement listed below, following "End of Section," is a part of this Specification:

1. Data collection form – Panelboard.
2. Data collection form – Low Voltage MCC (main circuit breaker).
3. Data collection form – Low Voltage MCC (feeder circuit breaker or motor controller unit).
4. Data collection form – Dry Type Transformer.

DATA COLLECTION FORM

PANELBOARD

PANEL ID OR TAG #:

FED FROM:

MANUFACTURER:

PART #:

VOLTAGE:

SHORT CIRCUIT CURRENT RATING (SSCR):

PANELBOARD CONNECTION:

MAIN CIRCUIT BREAKER MANUFACTURER:

MAIN CIRCUIT BREAKER PART #:

MAIN CIRCUIT BREAKER AMPACITY:

MAGNETIC TRIP SETTING (IF APPLICABLE):

ARC FLASH REDUCTION MAINTENANCE SYSTEM MANUFACTURER AND PART NUMBER:

WIRE SIZE FROM SOURCE:

WIRE LENGTH FROM SOURCE:

CONDUIT SIZE:

NOTES:

DATA COLLECTION FORM

LOW-VOLTAGE MCC (MAIN CIRCUIT BREAKER)

MCC ID OR TAG #:

FED FROM (SOURCE):

MCC MANUFACTURER:

MCC PART #:

VOLTAGE:

SHORT CIRCUIT CURRENT RATING (SSCR):

CIRCUIT BREAKER MANUFACTURER AND PART #:

FRAME SIZE:

INTERRUPTING RATING:

ADJUSTABLE MAGNETIC PICKUP:

RATING PLUG:

TRIP UNIT PROTECTIVE PROGRAMMER MANUFACTURER AND PART NUMBER:

ARC FLASH REDUCTION MAINTENANCE SYSTEM MANUFACTURER AND PART NUMBER:

WIRE SIZE FROM SOURCE:

NUMBER OF PARALLEL RUNS:

WIRE LENGTH:

CONDUIT SIZE(S):

DATA COLLECTION FORM

LOW VOLTAGE MCC (FEEDER CIRCUIT BREAKER OR MOTOR CONTROLLER UNITS)

MCC ID OR TAG #:

FEEDER BREAKER MANUFACTURER AND PART #:

FRAME SIZE:

INTERRUPTING RATING:

ADJUSTABLE MAGNETIC PICKUP:

CIRCUIT BREAKER RATING PLUG:

TRIP UNIT PROTECTIVE PROGRAMMER MANUFACTURER AND PART NUMBER:

ARC FLASH REDUCTION MAINTENANCE SYSTEM MANUFACTURER AND PART NUMBER:

MOTOR STARTER UNIT PART #:

MOTOR STARTER SIZE:

OVERLOAD RELAY SETTING (>40HP):

ADDITIONAL MOTOR STARTER INFO:

LOAD SERVED:

LOAD ID OR TAG #:

LOAD NAMEPLATE DATA AND TYPE:

WIRE SIZE TO LOAD:

NUMBER OF PARALLEL RUNS:

WIRE LENGTH:

CONDUIT SIZE(S):

NOTES:

DATA COLLECTION FORM

DRY-TYPE TRANSFORMER

TRANSFORMER ID OR TAG #:

FED FROM:

MANUFACTURER:

NAMEPLATE DATA:

KVA:

PRIMARY VOLTAGE:

PRIMARY CONNECTION (DELTA OR WYE-GND):

SECONDARY VOLTAGE:

SECONDARY CONNECTION (WYE-GND):

IMPEDANCE:

PRIMARY TAP SETTING:

PRIMARY WIRE SIZE:

PRIMARY WIRE LENGTH:

PRIMARY CONDUIT SIZE:

SECONDARY WIRE SIZE:

SECONDARY WIRE LENGTH:

SECONDARY CONDUIT SIZE:

NOTES:

END OF SECTION

SECTION 26 08 00
COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers (IEEE):
   a. 43, Recommended Practice for Testing Insulating Resistance of Rotating Machinery.
   b. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
   c. C2, National Electrical Safety Code.
   d. C37.20.1, Standard for Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear.
   e. C62.33, Standard Test Specifications for Varistor Surge-Protective Devices.
2. National Electrical Manufacturers Association (NEMA):
   a. AB 4, Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
   b. PB 2, Deadfront Distribution Switchboards.
3. InterNational Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
4. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 70B, Recommended Practice for Electrical Equipment Maintenance.
   c. 70E, Standard for Electrical Safety in the Workplace.
   d. 101, Life Safety Code.
5. National Institute for Certification in Engineering Technologies (NICET).
6. Occupational Safety and Health Administration (OSHA): CFR 29, Part 1910, Occupational Safety and Health Standards.

1.2 SUBMITTALS

A. Informational Submittals:

1. Submit 30 days prior to performing inspections or tests:
   a. Schedule for performing inspection and tests.
   b. List of references to be used for each test.
   c. Sample copy of equipment and materials inspection form(s).
   d. Sample copy of individual device test form.
   e. Sample copy of individual system test form.
2. Energization Plan: Prior to initial energization of electrical distribution equipment; include the following:
   a. Owner’s representative sign-off form for complete and accurate arc flash labeling and proper protective device settings for equipment to be energized.
   b. Staged sequence of initial energization of electrical equipment.
   c. Lock-Out-Tag-Out plan for each stage of the progressive energization.
   d. Barricading, signage, and communication plan notifying personnel of newly energized equipment.
3. Submit test or inspection reports and certificates for each electrical item tested within 30 days after completion of test:
4. Operation and Maintenance Data:

a. In accordance with Section 01 78 23, Operation and Maintenance Data.
b. After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in Operation and Maintenance Manual.

5. Programmable Settings: At completion of Performance Demonstration Test, submit final hardcopy printout and electronic files on compact disc of as-left set points, programs, and device configuration files for:
   a. Circuit breakers
   b. Intelligent overload relays.
   c. Variable frequency drives.
   d. Power metering devices.

1.3 QUALITY ASSURANCE

A. Testing Firm Qualifications:
   1. Corporately and financially independent organization functioning as an unbiased testing authority.
   2. Professionally independent of manufacturers, suppliers, and installers of electrical equipment and systems being tested.
   3. Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems.
   4. Supervising engineer accredited as Certified Electrical Test Technologist by NICET or NETA and having a minimum of 5 years' testing experience on similar projects.
   5. Technicians certified by NICET or NETA.
   6. Assistants and apprentices assigned to Project at ratio not to exceed two certified to one noncertified assistant or apprentice.
   7. In compliance with OSHA CFR 29, Part 1910.7 criteria for accreditation of testing laboratories or a full member company of NETA.

B. Test equipment shall have an operating accuracy equal to or greater than requirements established by NETA ATS.

C. Test instrument calibration shall be in accordance with NETA ATS.

1.4 SEQUENCING AND SCHEDULING

A. Perform inspection and electrical tests after equipment listed herein has been installed.

B. Perform tests with apparatus de-energized whenever feasible.

C. Inspection and electrical tests on energized equipment shall be:
   1. Scheduled with Engineer prior to de-energization.
   2. Minimized to avoid extended period of interruption to the operating plant equipment.

D. Notify Engineer at least 24 hours prior to performing tests on energized electrical equipment.

E. Manufacturer's Services: The services of qualified manufacturer's representatives have been specified for testing under certain specification sections. Coordinate and employ those services as required to provide complete testing in accordance with this section and the manufacturer's recommendations.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL

A. Perform tests in accordance with requirements of Section 01 75 00.

B. Tests and inspections shall establish:

1. Electrical equipment is operational within industry and manufacturer's tolerances and standards.
2. Installation operates properly.
3. Equipment is suitable for energization.
4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E, NFPA 101, and IEEE C2.

C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

D. Set, test, and calibrate protective relays, circuit breakers, fuses, power monitoring meters and other applicable devices in accordance with values established by short circuit, coordination, and harmonics studies as specified in Section 26 05 73, Electrical Systems Analysis.

E. Adjust mechanisms and moving parts of equipment for free mechanical movement.

F. Adjust and set electromechanical electronic relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

G. Verify nameplate data for conformance to Contract Documents and approved Submittals.

H. Realign equipment not properly aligned and correct unlevelness.

I. Properly anchor electrical equipment found to be inadequately anchored.

J. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench/screwdriver to manufacturer's recommendations, or as otherwise specified in NETA ATS.

K. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

L. Provide proper lubrication of applicable moving parts.

M. Inform Engineer of working clearances not in accordance with NFPA 70.

N. Investigate and repair or replace:

1. Electrical items that fail tests.
2. Active components not operating in accordance with manufacturer's instructions.
3. Damaged electrical equipment.

O. Electrical Enclosures:

1. Remove foreign material and moisture from enclosure interior.
2. Vacuum and wipe clean enclosure interior.
3. Remove corrosion found on metal surfaces.
4. Repair or replace, as determined by Engineer**,** door and panel sections having dented surfaces.
5. Repair or replace, as determined by Engineer poor fitting doors and panel sections.
6. Repair or replace improperly operating latching, locking, or interlocking devices.
7. Replace missing or damaged hardware.
8. Finish:
    a. Provide matching paint and touch up scratches and mars.
    b. If required because of extensive damage, as determined by Engineer, refinish entire assembly.

P. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents or approved Submittals.

3.2 CHECKOUT AND STARTUP

A. Voltage Field Test:

1. Check voltage at point of termination of power company supply system to Project when installation is essentially complete and is in operation.
2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
3. Unbalance Corrections:
    a. Make written request to power company to correct condition if balance (as defined by NEMA) exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded condition more than plus or minus 4 percent of nominal.
    b. Obtain written certification from responsible power company official that voltage variations and unbalance are within their normal standards if corrections are not made.

B. Equipment Line Current Tests:

1. Check line current in each phase for each piece of equipment.
2. Make line current check after power company has made final adjustments to supply voltage magnitude or balance.
3. If phase current for a piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken.

3.3 PANELBOARDS

A. Visual and Mechanical Inspection: Include the following inspections and related work:

1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.
2. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer's instruction manual.
3. Check panelboard mounting, area clearances, and alignment and fit of components.
4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
5. Perform visual and mechanical inspection for overcurrent protective devices.

B. Electrical Tests: Include the following items performed in accordance with manufacturer's instruction:

1. Ground continuity test ground bus to system ground.

3.4 DRY TYPE TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Physical and insulator damage.
2. Proper winding connections.
3. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
4. Defective wiring.
5. Proper operation of fans, indicators, and auxiliary devices.
6. Removal of shipping brackets, fixtures, or bracing.
7. Free and properly installed resilient mounts.
8. Cleanliness and improper blockage of ventilation passages.
9. Verify tap-changer is set at correct ratio for rated output voltage under normal operating conditions.
10. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

B. Electrical Tests:

1. Insulation Resistance Tests:

a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.5 for each:
    1) Winding-to-winding.
    2) Winding-to-ground.
b. Test Duration: 10 minutes with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
c. Results temperature corrected in accordance with NETA ATS, Table 100.14.
d. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
e. Insulation resistance test results to compare within 1 percent of adjacent windings.

2. Perform tests and adjustments for fans, controls, and alarm functions as suggested by manufacturer.

3.5 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect each individual exposed power cable No. 4 and larger for:
    a. Physical damage.
    b. Proper connections in accordance with single-line diagram.
    c. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.
    d. Color coding conformance with specification.
    e. Proper circuit identification.
2. Mechanical Connections for:
    a. Proper lug type for conductor material.
    b. Proper lug installation.
    c. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
3. Shielded Instrumentation Cables for:
    a. Proper shield grounding.
    b. Proper terminations.
    c. Proper circuit identification.
4. Control Cables for:
    a. Proper termination.
    b. Proper circuit identification.
5. Cables Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests for Conductors No. 4 and Larger:

1. Insulation Resistance Tests:
    a. Utilize 1,000-volt dc megohmmeter for 600-volt insulated conductors.
    b. Test each conductor with respect to ground and to adjacent conductors for 1 minute.
    c. Evaluate ohmic values by comparison with conductors of same length and type.
    d. Investigate values less than 50 megohms.
2. Continuity test by ohmmeter method to ensure proper cable connections.

3.6 FIBER-OPTIC CABLES

A. Visual and mechanical inspection:

1. Compare cable, connector, and splice data with the Contract Documents.
2. Inspect cable and connections for physical and mechanical damage.
3. Verify that all connectors and splices are correctly installed.

B. Electrical tests:

1. Perform cable length measurement, fiber fracture inspection, and construction defect inspection using an optical time domain reflectometer (OTDR):
    a. OTDR test performed on fiber cables less than 100 meters shall be performed with the aid of a launch cable.
    b. Adjust OTDR pulse width settings to a maximum setting of 1/1,000th of the cable length or 10nanoseconds.
2. Perform connector and splice integrity test using an optical time domain reflectometer.
3. Perform cable attenuation loss measurement with an optical power loss test set:
    a. Perform attenuation tests with an Optical Loss Test Set capable and calibrated to show anomalies of 0.1 dB as a minimum.
    b. Test multimode fibers at 850 nanometer and 1,300 nanometer.
    c. Test single mode fibers at 1,310 nanometer and 1,550 nanometers.
4. Perform connector and splice attenuation loss measurement from both ends of the optical cable with an optical power loss test set:
    a. At the conclusion of all outdoor splices at 1 location, and before they are enclosed and sealed, all splices shall be tested with OTDR at the optimal wavelengths (850 and 1,300 for multimode, 1,310 and 1,550 for single mode), in both directions. The splices shall be tested for integrity as well as attenuation.
5. Perform fiber links integrity and attenuation tests using each link shall be an OTDR and an Optical Loss Test Set:
    a. OTDR traces shall be from both directions on each fiber at the 2optimal wavelengths, 850nanometer, and 1,300nanometer for multimode fibers.
    b. Optical loss testing shall be done with handheld test sets in 1direction at the 2 optimal wavelengths for the appropriate fiber type. Test equipment shall equal or exceed the accuracy and resolution of Agilent/HP 8147 high performance OTDR.

C. Test values:

1. Cable and connections shall not have been subjected to physical or mechanical damage.
2. Connectors and splices shall be installed in accordance with industry standards.
3. The optical time domain reflectometer signal should be analyzed for excessive connection, splice, or cable backscatter by viewing the reflected power/distance graph.
4. Attenuation loss measurement shall be expressed in dB/km. Losses shall be within the manufacturer's recommendations when no local site specifications are available.
5. Individual fusion splice losses shall not exceed 0.1 dB. Measurement results shall be recorded, validated by trace, and filed with the records of the respective cable runs.

3.7 NETWORK CABLES

A. Visual and mechanical inspections:

1. Compare cable type and connections with that indicated on the Drawings and specified in the Specifications.
2. Inspect cable and connectors for physical and mechanical damage.
3. Verify that all connectors are correctly installed.

B. Pre-testing:

1. Test individual cables before installation:
    a. Before physical placement of the cable, test each cable while on the spool with a LAN certification test device.
    b. Before the cable is installed, verify that the cable conforms to the manufacturer's attenuation specification and that no damage has been done to the cable during shipping or handling.

c. The test shall be fully documented, and the results submitted to the Engineer, including a hard copy of all traces before placement of the cable.
d. The Engineer shall be notified if a cable fails to meet specification and the cable shall not be installed unless otherwise directed by the Engineer.

C. Electrical tests:

1. Perform cable end-to-end testing on all installed cables after installation of connectors from both ends of the cable.
2. Test shall include cable system performance tests and confirm the absence of wiring errors.

D. Test results:

1. Cables shall meet or exceed TIA standards for a Category 6a installation.

E. Test equipment:

1. LAN certification equipment used for the testing shall be capable of testing Category 6 cable installation to TIA proposed Level III accuracy. Tests performed shall include:
   a. Near end cross talk.
   b. Attenuation.
   c. Equal level far end cross talk.
   d. Return loss.
   e. Ambient noise.
   f. Effective cable length.
   g. Propagation delay.
   h. Continuity/loop resistance.
2. LAN certification test equipment shall be able to store and produce plots of the test results.
3. Acceptable manufacturers: The following or equal:
   a. Agilent Technologies, WireScope 350.

3.8 SAFETY SWITCHES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Proper blade pressure and alignment.
2. Proper operation of switch operating handle.
3. Adequate mechanical support for each fuse.
4. Proper contact-to-contact tightness between fuse clip and fuse.
5. Cable connection bolt torque level in accordance with NETA ATS, Table 100.12.
6. Proper phase barrier material and installation.
7. Verify fuse sizes and types correspond to one-line diagram or approved Submittals.
8. Perform mechanical operational test and verify mechanical interlocking system operation and sequencing.

3.9 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated 100 amperes and larger and to motor circuit protector breakers rated 100 amperes and larger.

B. Visual and Mechanical Inspection:

1. Proper mounting.
2. Proper conductor size.
3. Feeder designation according to nameplate and one-line diagram.
4. Cracked casings.
5. Connection bolt torque level in accordance with NETA ATS, Table 100.12.
6. Operate breaker to verify smooth operation.

7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.
8. Verify that terminals are suitable for 75 degrees C rated insulated conductors.

C. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 1,000-volt dc megohmmeter for 480-volt and 600-volt circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
   c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
   d. Test values to comply with NETA ATS, Table 100.1.
2. Contact Resistance Tests:
   a. Contact resistance in microhms across each pole.
   b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
3. Primary Current Injection Test to Verify:
   a. Long-time minimum pickup and delay.
   b. Short-time pickup and delay.
   c. Ground fault pickup and delay.
   d. Instantaneous pickup by run-up or pulse method.
   e. Trip characteristics of adjustable trip breakers shall be within manufacturer's published time-current characteristic tolerance band, including adjustment factors.
   f. Trip times shall be within limits established by NEMA AB 4, Table 5-3. Alternatively, use NETA ATS, Table 100.7.
   g. Instantaneous pickup value shall be within values established by NEMA AB 4, Table 5-4. Alternatively, use NETA ATS, Table 100.8.

3.10 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Visually check current, potential, and control transformers for:
   a. Cracked insulation.
   b. Broken leads or defective wiring.
   c. Proper connections.
   d. Adequate clearances between primary and secondary circuit wiring.
2. Verify Mechanically:
   a. Grounding and shorting connections have good contact.
   b. Withdrawal mechanism and grounding operation, when applicable, operate properly.
3. Verify proper primary and secondary fuse sizes for potential transformers.

3.11 METERING

A. Visual and Mechanical Inspection:

1. Verify meter connections in accordance with appropriate diagrams.
2. Verify meter multipliers.
3. Verify meter types and scales conform to Contract Documents.
4. Check calibration of meters at cardinal points.
5. Check calibration of electrical transducers.

3.12 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Equipment and circuit grounds in switchboards, motor control centers, and panelboards assemblies for proper connection and tightness.

2. Ground bus connections in switchboards, motor control centers, and panelboards assemblies for proper termination and tightness.
3. Effective transformer core and equipment grounding.
4. Accessible connections to grounding electrodes for proper fit and tightness.
5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

B. Electrical Tests:

1. Fall-of-Potential Test:
   a. In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.
   b. Main ground electrode system resistance to ground to be no greater than 1 ohm.
2. Two-Point Direct Method Test:
   a. In accordance with IEEE 81, Section 8.2.1.1 for measurement of ground resistance between main ground system, equipment frames, and system neutral and derived neutral points.
   b. Equipment ground resistance shall not exceed main ground system resistance by 0.25 ohm.

3.13 AC INDUCTION MOTORS

A. General: Inspection and testing limited to motors rated 5 horsepower and larger.

B. Visual and Mechanical Inspection:

1. Proper electrical and grounding connections.
2. Shaft alignment.
3. Blockage of ventilating air passageways.
4. Operate motor and check for:
   a. Excessive mechanical and electrical noise.
   b. Overheating.
   c. Correct rotation.
   d. Check vibration detectors, resistance temperature detectors, or motor inherent protectors for functionality and proper operation.
   e. Excessive vibration, more than values in NETA ATS, Table 100.10.
5. Check operation of space heaters.

C. Electrical Tests:

1. Insulation Resistance Tests:
   a. In accordance with IEEE 43 at test voltages established by NETA ATS, Table 100.1 for:
      1) Motors above 200 horsepower for 10-minute duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
      2) Motors 200 horsepower and less for 1-minute duration with resistances tabulated at 30 seconds and 60 seconds.
   b. Insulation resistance values equal to, or greater than, ohmic values established by manufacturers.
2. Calculate polarization index ratios for motors above 200 horsepower. Investigate index ratios less than 1.5 for Class A insulation and 2.0 for Class B insulation.
3. Insulation resistance test on insulated bearings in accordance with manufacturer's instructions.
4. Measure running current and voltage and evaluate relative to load conditions and nameplate full-load amperes.

3.14 VARIABLE FREQUENCY DRIVE SYSTEMS

A. Visual and Mechanical Inspection:

1. Proper operation of indicating and monitoring devices.
2. Inspect physical and mechanical condition.
3. Improper blockage of air-cooling passages.
4. Inspect anchorage, alignment, and grounding.
5. Integrity and contamination of bus insulation system.
6. Inspect bolted electrical connections for high resistance.
7. Motor running protection:
    a. Verify drive overcurrent setpoints are correct for their application.
    b. If drive is used to operate multiple motors, verify individual overload element ratings are correct for their application.
    c. Apply minimum and maximum speed setpoints. Verify setpoints are within limitations of the load coupled to the motor.
8. Check nameplates for proper identification of:
    a. Equipment title and tag number with latest one-line diagram.
    b. All devices.
9. Verify fuse and circuit breaker sizes and types conform to Contract Documents.
10. Control Wiring:
    a. Compare wiring to local and remote control, and protective devices with elementary diagrams.
    b. Check for proper conductor lacing and bundling.
    c. Check for proper conductor identification.
    d. Check for proper conductor lugs and connections.
    e. Verify correct connections of circuit boards, wiring, disconnects, and ribbon cables.
11. Exercise active components.

B. Electrical Tests:

1. Measure harmonic distortion for both voltage and current to verify if within specification limits.
2. Measure peak voltage at motor terminations to verify if less than 90 percent of motor insulation dielectric withstand level.
3. Perform resistance measurements through bolted connections with low-resistance ohmmeter, if applicable.
4. Test the motor overload relay elements by injecting primary current through the overload circuit and monitoring trip time of the overload element.
5. Test input circuit breaker by primary injection.
6. Perform insulation resistance tests on all control wiring with respect to ground. Applied potential shall be 500 volts DC for 300-volt rated cable and 1000 volts dc for 600-volt rated cable. Test duration shall be one minute. Follow manufacturer’s recommendations for units with solid-state components.
7. Test for the following parameters in accordance with manufacturer’s recommendations:
    a. Input phase loss protection
    b. Input overvoltage protection
    c. Output phase rotation
    d. Overtemperature protection
    e. DC overvoltage protection
    f. Over frequency protection

g. Drive overload protection
h. Fault alarm outputs

8. Operational test by initiating control devices to affect proper operation.
9. Slowly vary drive speed between minimum and maximum. Observe motor and load for unusual noise or vibration.

3.15 LOW-VOLTAGE MOTOR CONTROL CENTERS

A. Visual and Mechanical Inspection:

1. Proper barrier and shutter installation and operation.
2. Proper operation of indicating and monitoring devices.
3. Proper overload protection for each motor.
4. Improper blockage of air-cooling passages.
5. Proper operation of drawout elements.
6. Integrity and contamination of bus insulation system.
7. Check door and device interlocking system by:
   a. Closure attempt of device when door is in OPEN position.
   b. Opening attempt of door when device is in ON or CLOSED position.
8. Check key interlocking systems for:
   a. Key captivity when device is in ON or CLOSED position.
   b. Key removal when device is in OFF or OPEN position.
   c. Closure attempt of device when key has been removed.
   d. Correct number of keys in relationship to number of lock cylinders.
   e. Existence of other keys capable of operating lock cylinders; destroy duplicate sets of keys.
9. Check nameplates for proper identification of:
   a. Equipment title and tag number with latest one-line diagram.
   b. All devices.
10. Verify fuse and circuit breaker sizes and types conform to Contract Documents.
11. Verify current and potential transformer ratios conform to Contract Documents.
    a. Check bus connections for high resistance by calibrated torque wrench applied to bolted joints: Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
12. Check operation and sequencing of electrical and mechanical interlock systems by:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
    c. Key exchange to operate devices in OFF-NORMAL positions.
13. Verify performance of each control device and feature furnished as part of motor control center.
14. Control Wiring:
    a. Compare wiring to local and remote control, and protective devices with elementary diagrams.
    b. Check for proper conductor lacing and bundling.
    c. Check for proper conductor identification.
    d. Check for proper conductor lugs and connections.
15. Exercise active components.
16. Inspect contactors for:
    a. Correct mechanical operations.
    b. Correct contact gap, wipe, alignment, and pressure.

c. Correct torque of connections.

17. Compare overload rating with full-load current for proper size.
18. Compare motor protector and circuit breaker with motor characteristics for proper size.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
   b. Bus section phase-to-phase and phase-to-ground for 1 minute on each phase.
   c. Contactor phase-to-ground and across open contacts for 1 minute on each phase.
   d. Starter section phase-to-phase and phase-to-ground on each phase with starter contacts closed and protective devices open.
   e. Test values to comply with NETA ATS, Table 100.1.
2. Operational test by initiating control devices to affect proper operation.

3.16 SURGE PROTECTIVE DEVICES

A. Visual and Mechanical Inspection:

1. Adequate clearances between arrestors and enclosures.
2. Ground connections to ground bus.

B. Electrical Tests:

1. Varistor Type Arrestors:
   a. Clamping voltage test.
   b. Rated RMS voltage test.
   c. Rated dc voltage test.
   d. Varistor arrestor test values in accordance with IEEE C62.33, Section 4.4 and Section 4.9.

3.17 ACTIVE HARMONIC CONDITIONERS

A. Visual and Mechanical Inspection:

1. Inspect equipment for signs of damage.
2. Verify installation per drawings.
3. Verify current transformer orientation and wiring to power correction system.
4. Proper connection and grounding.
5. Verify that fuse types and ratings conform to shop Drawings.
6. Verify logic setup corresponds to performance specifications.
7. Check wiring and terminal connections for tightness.

B. Electrical Tests:

1. Electrical and functional tests in accordance with manufacturer’s instructions.
2. Functional test of all control and indication devices.
3. Performance testing: Test shall document specified control of current and voltage harmonic distortion.

END OF SECTION

SECTION 26 09 13
INSTRUMENT TRANSFORMERS AND METERS

PART 1 - GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI)
   a. ANSI C37.20, Switchgear Assemblies Including Metal-Enclosed Bus
   b. ANSI C39.1, Requirements for Electrical Analog Indicating Instruments
   c. ANSI C57.13, Requirements for Instrument Transformers

1.2 SUBMITTALS

A. Action Submittal Items for this Section:

1. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations from Section requirements.
2. Catalog cuts of equipment, devices, and materials installed under this section. Catalog information shall include technical specifications and application information, including electrical ratings, dimensions, weight, etc. Catalog cuts shall be edited to show only the items, model numbers, and information which apply.
3. Operation and maintenance items as specified in Section 01 78 23, Operation and Maintenance Data.
4. Manufacturer's product data with features and dimensions of devices.
5. Burden, accuracy class, and ratio data for instrument transformers.

PART 2 - PRODUCTS

2.1 INSTRUMENT TRANSFORMERS

A. Instrument transformers shall be molded dry type in accordance with ANSI C57.13. Transformer volt-ampere rating shall be suitable for carrying the specified load without overheating or exceeding the permissible accuracy for the transformer.

B. Current transformers shall be furnished with the specified ratios. The accuracies shall conform to ANSI C37.20. Add shorting terminal blocks for all current transformers.

2.2 POWER MONITOR AND DISPLAY (PMD)

A. Power monitor and display unit shall be provided where shown on the one-line diagram. The unit shall monitor all three phases and shall display volts (phase to phase and phase to neutral), amperes, power factor, and hertz. The PMD shall be supplied with native Ethernet IP communications port (no exceptions) for internal networking via Ethernet switch within switchgear and motor control centers, and to the plant control network.

B. Service Entrance Switchboards and Motor Control Centers: Allen Bradley PowerMonitor 5000 model M6 with integral display module, or equivalent.

C. Main Lug Only Motor Control Centers: Allen Bradley PowerMonitor 500, or equivalent.

D. Provide blown fuse indicators on all fuses.

E. Provide current transformers with a minimum of 1% accuracy at 10% of range, and all mounting hardware, including but not limited to, shorting terminal blocks for a complete installation.

F. Mount the power monitor in the unit door between 54” and 66” above the floor when installed on the house keeping pad.

G. Power monitors shall be powered at 120V via separately mounted UPS specified in Section 40 98 00 – Control Panels and Enclosures.

2.3 NAMEPLATES

A. Refer to Section 26 05 00, General Requirements for Electrical Work.

PART 3 - EXECUTION

3.1 GENERAL

A. Accessories and devices shall be installed per the electrical distribution equipment manufacturer's instructions.

B. Confirm PMD’s are properly communicating the required data to SCADA via Ethernet/IP.

END OF SECTION

SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.1 SUMMARY

A. Scope: This section specifies low-voltage dry-type transformers.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers (IEEE): C57.96, Guide for Loading Dry Type Transformers.
2. National Electrical Contractor's Association (NECA): 409, Recommended Practice for Installing and Maintaining Dry-Type Transformers.
3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. ST 20, Dry-Type Transformers for General Applications.
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. Underwriters Laboratories Inc. (UL):
   a. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   b. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   c. 1561, Standard for Dry-Type, General Purpose, and Power Transformers.

1.3 SUBMITTALS

A. Action Submittal Items for this Section:

1. A copy of this Section, addendum updates included, with each paragraph check-marked to indicate compliance or marked to indicate requested deviations from Section requirements.
2. Operation and maintenance items as specified in Section 01 78 23, Operation and Maintenance Data.
3. Descriptive information.
4. Dimensions and weight.
5. Transformer nameplate data.
6. Schematic and connection diagrams.
7. Seismic anchorage and bracing drawings and cut sheets.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations.
2. Test Report: Sound test certification for dry type power transformers (0 to 600 volt, primary).

PART 2 - PRODUCTS

2.1 GENERAL

A. UL 1561, NEMA ST 20, unless otherwise indicated.

B. Dry-type, self-cooled, two-winding, with copper windings.

C. Units larger than 5 kVA suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

D. Efficiency: Transformers Rated 15-kVA and Larger:

1. Comply with 10 CFR 431 (DOE 2016) efficiency levels.
2. Marked as compliant with DOE 2016 efficiency levels by an NRTL

E. Maximum Sound Level per NEMA ST 20:

1. 40 decibels for 0 kVA to 9 kVA.
2. 45 decibels for 10 kVA to 50 kVA.
3. 50 decibels for 51 kVA to 150 kVA.
4. 55 decibels for 151 kVA to 300 kVA.
5. 60 decibels for 301 kVA to 500 kVA.

F. Overload capability: Short-term overload per IEEE C57.96.

G. Wall Bracket: For single-phase units, 15 kVA to 37 1/2 kVA, and for three-phase units, 15 kVA to 30 kVA.

H. Vibration Isolators:

1. Rated for transformer's weight.
2. Isolation Efficiency: 99 percent, at fundamental frequency of sound emitted by transformer.
3. Less Than 30 kVA: Isolate entire unit from structure with external vibration isolators.
4. 30 kVA and Above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator.

I. Manufacturers:

1. Eaton.
2. General Electric Co.
3. Square D Co.

2.2 GENERAL PURPOSE TRANSFORMER

A. Insulation Class and Temperature Rise: Manufacturer's standard.

B. Core and Coil:

1. Encapsulated for single-phase units 1/2 kVA to 25 kVA and for three-phase units 3 kVA to 15 kVA.
2. Thermosetting varnish impregnated for single-phase units 37.5 kVA and above, and for three-phase units 30 kVA and above.

C. Enclosure:

1. Single-Phase, 3 kVA to 25 kVA: NEMA 250, Type 3R, nonventilated.
2. Single-Phase, 37 1/2 kVA and Above: NEMA 250, Type 2, ventilated.
3. Three-Phase, 3 kVA to 15 kVA: NEMA 250, Type 3R, nonventilated.
4. Three-Phase, 30 kVA and Above: NEMA 250, Type 2, ventilated.
5. Outdoor Locations: NEMA 250, Type 3R.
6. Corrosive Locations: NEMA 250, Type 3R stainless steel.

D. Voltage Taps:

1. Single-Phase, 3 kVA to 10 kVA: Two 5 percent, full capacity, normal voltage rating.
2. Single-Phase, 15 kVA and Above: Four 2 1/2 percent, full capacity; two above and two below normal voltage rating.
3. Three-Phase, 3 kVA to 15 kVA: Two 5 percent, full capacity, normal voltage rating.
4. Three-Phase, 30 kVA and Above: Four 2 1/2 percent, full capacity; two above and two below normal voltage rating.

E. Impedance: 4.5 percent minimum on units 75 kVA and larger.

2.3 NAMEPLATES

A. Refer to Section 26 05 00, General Requirements for Electrical Work.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with NECA and manufacturer's instructions.

B. Install equipment plumb and in longitudinal alignment with pad or wall.

C. Load external vibration isolator such that no direct transformer unit metal is in direct contact with mounting surface.

D. Provide moisture-proof, flexible conduit for electrical connections.

E. Connect voltage taps to achieve (approximately) rated output voltage under normal plant load conditions.

F. Provide wall brackets for single-phase units, 15 kVA to 167 1/2 kVA, and three-phase units, 15 kVA to 112 kVA.

END OF SECTION

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SECTION 26 24 16
LOW-VOLTAGE PANELBOARDS

PART 1 - GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers (IEEE):
   a. C62.1, Surge Arresters for Alternating Current Power Circuits.
   b. C62.11, Standards for Metal-Oxide Surge Arrestors for AC Power Circuits.
2. National Electrical Contractors Association (NECA): 407, Recommended Practice for Installing and Maintaining Panelboards.
3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. 289, Application Guide for Ground Fault Circuit Interrupters.
   c. AB 1, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
   d. KS 1, Enclosed Switches.
   e. LA 1, Surge Arrestors.
   f. PB 1, Panelboards.
   g. PB 1.1, General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. Underwriters Laboratories Inc. (UL):
   a. 67, Standard for Panelboards.
   b. 98, Standard for Enclosed and Dead-Front Switches.
   c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   d. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   e. 508, Standard for Industrial Control Equipment.
   f. 870, Wireways, Auxiliary Gutters and Associated Fittings.
   g. 943, Standard for Ground-Fault Circuit-Interrupters.

1.2 SUBMITTALS

A. Action Submittals:

1. Manufacturer’s data sheets for each type of panelboard, protective device, accessory item, and component.
2. Manufacturer’s shop drawings including dimensioned plan, section, and elevation for each panelboard type, enclosure, and general arrangement.
3. Tabulation of features for each panelboard to include the following:
   a. Protective devices with factory settings.
   b. Provisions for future protective devices.
   c. Space for future protective devices.
   d. Voltage, frequency, and phase ratings.
   e. Enclosure type.
   f. Bus and terminal bar configurations and current ratings.
   g. Provisions for circuit terminations with wire range.

h. Short circuit current rating of assembled panelboard at system voltage.
i. Features, characteristics, ratings, and factory settings of auxiliary components.
j. Seismic anchorage and bracing drawings and cut sheets.

B. Informational Submittals:

1. Manufacturer's recommended installation instructions.

1.3 QUALITY ASSURANCE

A. Listing and Labeling: Provide products specified in this Section that are listed and labeled as defined in NEC Article 100.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Eaton/Cutler-Hammer.
2. General Electric Co.
3. Square D Co.
4. Or equivalent.

2.2 GENERAL

A. Provide low voltage panelboards for application at 600V or less in accordance with this Section.

B. Provide equipment in accordance with NEMA PB 1, NFPA 70, and UL 67.

C. Wire Terminations:

1. Panelboard assemblies, including protective devices, shall be suitable for use with 75 degrees C or greater wire insulation systems at NEC 75 degrees C conductor ampacity.
2. In accordance with UL 486E.

D. Load Current Ratings:

1. Unless otherwise indicated, load current ratings for panelboard assemblies, including bus and circuit breakers, are noncontinuous as defined by NEC. Continuous ratings shall be 80 percent of noncontinuous rating.
2. Where indicated "continuous", "100 percent", etc., selected components and protective devices shall be rated for continuous load current at value shown.

E. Short Circuit Current Rating (SCCR): Integrated equipment short circuit rating for each panelboard assembly shall be no less than the following:

1. Minimum SCCR at 208Y/120 or 120/240 volts shall be 18,000 amperes rms symmetrical.
2. Minimum SCCR at 480Y/277 volts shall be 50,000 amperes rms symmetrical.

F. Overcurrent Protective Devices:

1. In accordance with NEMA AB 1, NEMA KS 1, UL 98, and UL 489.
2. Protective devices shall be adapted to panelboard installation.
   a. Capable of device replacement without disturbing adjacent devices and without removing main bus.
   b. Spaces: Cover openings with easily removable cover.
3. Devices shall be fully rated; series-connected ratings unacceptable.

G. Circuit Breakers:

1. General: Thermal-magnetic unless otherwise indicated, quick-make, quick-break, molded case, of indicating type showing ON/OFF and TRIPPED positions of operating handle.
2. Noninterchangeable: In accordance with NEC.

3. Bus Connection: Bolt-on circuit breakers in 480Y/277-volt, and plug-in circuit breakers in 208Y/120 and 240/120-volt branch circuit panelboards.
4. Trip Mechanism:
    a. Individual permanent thermal and magnetic trip elements in each pole.
    b. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
    c. Two and three pole, common trip.
    d. Automatically opens all poles when overcurrent occurs on one pole.
    e. Test button on cover.
    f. Calibrated for 40 degrees C ambient, unless shown otherwise.
5. Unacceptable Substitution:
    a. Do not substitute single-pole circuit breakers with handle ties for multi-pole breakers.
    b. Do not use tandem or dual circuit breakers in normal single-pole spaces.
6. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker as specified above with ground fault sensor and rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel).
    a. Ground fault sensor shall be rated same as circuit breaker.
    b. Push-to-test button.
    c. Reset button.
7. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker specified above with ground fault sensor and rated to trip on 30-mA ground fault (UL listed for equipment ground fault protection).

H. Enclosures:
1. Provide as specified in Section 26 05 04, Basic Electrical Materials and Methods.
2. Material: Type 1, shall be code-gauge, hot-dip galvanized sheet steel with reinforced steel frame.
3. Finish: Rust inhibitor prime followed by manufacturer’s standard gray baked enamel or lacquer.

I. Bus:
1. Material: Tin-plated copper full sized throughout length.
2. Provide for mounting of future protective devices along full length of bus regardless of number of units and spaces shown. Machine, drill, and tap as required for current and future positions.

J. Feeder Lugs: Main, feed-through, and neutral shall be replaceable, bolted mechanical or crimp compression type.

K. Equipment Ground Terminal Bus: Copper with suitably sized provisions for termination of ground conductors and bonded to box.
1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
2. Provide individual termination points for all other grounding conductors such as feeder, grounding electrode, etc.

L. Neutral Terminal Bus: Copper with suitably sized provisions for termination of neutral conductors, and isolated from box.
1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
2. Provide individual termination points for all other neutral conductors.

M. Provision for Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances for future protective device ampere ratings indicated.

N. Special Features:

1. Service Equipment Approval: Listed for use as service equipment for panelboards having service disconnecting means.

2.3 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

A. Protective Device Locking: Furnish provisions for handle padlocking for main and subfeed devices; also provide for branch devices where indicated.

B. NEMA 250 Type 1 Branch Panelboard Enclosure:

1. Front trim shall be secured to box with concealed trim clamps.
2. Surface-mount panelboard front trim shall have same dimensions as box.
3. Flush panelboards front trims shall overlap box nominal 3/4 inch on all sides.
4. Door in panelboard front trim, with concealed hinges, shall provide access to protective device operating handles.
5. Doors over 30 inches in height shall have multi-point latching.
6. Door lock shall be secure with flush catch and tumbler lock; all panelboards keyed alike, with two milled keys each lock.
7. Circuit Directory: Metal frame with transparent plastic face and enclosed card, mounted inside each panel door.
8. Hinged Front Cover (Door in Door): Entire front trim hinged to surface box with standard door within hinged trim cover.

PART 3 - EXECUTION

3.1 GENERAL

A. Install in accordance with NECA 407, NEMA PB 1.1 and manufacturers' written installation instructions.

B. Install securely, plumb, in-line and square with walls.

C. Install top of cabinet trim 78 inches above floor, unless otherwise shown. Install cabinet so tops of protective device operating handles are no more than 78 inches above the floor.

D. Ground Fault Protection: Install panelboard ground fault circuit interrupter devices in accordance with installation guidelines of NEMA 289.

E. Install filler plates in unused spaces.

F. Wiring in Panel Gutters: Train conductors neatly in groups; bundle and wrap with nylon wire ties.

3.2 BRANCH CIRCUIT PANELBOARD

A. Mount flush panels uniformly flush with wall finish.

B. Provide typewritten circuit directory for each panelboard.

END OF SECTION

SECTION 26 24 19
LOW-VOLTAGE MOTOR CONTROL

PART 1 - GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American national Standard Institute (ANSI):
   a. C2, National Electrical Safety Conde (NESC)
   b. C57.12.28, Switchgear and Transformers – Pad-Mounted Equipment – Enclosure Integrity.
   c. Z55, Gray Finishes for Industrial Apparatus and Equipment.
2. National Electrical Manufacturers Association (NEMA)
   a. AB1, Molded Case Circuit Breakers.
   b. ICS 1, General Standards for Industrial Control and Systems.
   c. ICS 2, Standards for Industrial Control Devices, Controllers, and Assemblies.
   d. ICS 2.3, Instructions for Handling, Installation, Operation, and Maintenance of Motor Control Centers.
   e. ICS 2-322, AC General Purpose Motor Control Centers
   f. KS 1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
   g. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
3. National Fire Protection Association (NFPA 70): National Electrical Code (NEC).
4. Underwriters Laboratories, Inc. (UL):
   a. 98, Standard for Safety Enclosed and Dead-Front Switches.
   b. 489, Standard for Safety Molded Case Circuit Breakers and Circuit Breaker Enclosures.
   c. 845, Standard for Safety Motor Control Centers.
   d. Uniform Building Code (UBC):

1.2 DESIGN REQUIREMENTS

A. Provide MCC based upon applicable NEMA and UL standards and in accordance with the detailed contract specifications and drawings.

B. Ethernet IP Protocol: All Ethernet connected terminal equipment specified herein shall be provided with a native Ethernet IP port. Separate protocol converters and gateways used to convert from other protocols will not be accepted.

C. Motor Controller Units: Unit elements shall be of the same manufacturer as the motor control centers. Variance may only be considered to meet Ethernet IP protocol requirements.

D. The contractor shall confirm motor full-load amperage ratings and provide those to the MCC manufacturer to ensure proper sizing of the motor branch circuit and overload protection.

1.3 SUBMITTALS

A. Shop Drawings:

1. Itemized bill of material
2. Nameplate information
3. Descriptive information
4. Dimensional drawings
5. Conduit entrance locations
6. One-line diagrams

7. Schematic (elementary) diagrams for each starter unit and an interconnection diagram for the entire motor control center including all field devices.
8. Outline diagrams
9. Bus data
10. Data sheets and publications on all major components
11. Protective devices, time current curves for all protection devices, and time-current curve diagrams showing coordination between the main circuit breakers and feeder breakers.
12. Anchoring instructions and details.
13. Typed tabulation (provide in O&M Manual):
    a. Motor name; tag (equipment) numbers as shown on Drawings.
    b. Motor horsepower.
    c. Nameplate full load current.
    d. Measured load current and voltage.
    e. Overload settings.
    f. Protective device trip settings.
14. Attach above typed, tabulated data to a copy of starter manufacturer's overload heater selection tables for the starters provided.
15. Control diagrams.
16. Manufacturer's installation instructions
17. Operation and Maintenance Manual
18. Factory test reports
19. Letter of coordination from the MCC manufacturer stating that the Transient Voltage Suppression System selected for the MCC has been coordinated with and will not adversely affect the active harmonic filter.

1.4 UL COMPLIANCE

A. Products manufactured within scope of Underwriters Laboratories shall conform to UL Standards and have an applied UL Listing Mark.

1.5 PACKING AND SHIPPING

A. Shipping splits: Established by Contractor to facilitate ingress of equipment to final installation location within the building.

PART 2 - PRODUCTS

2.1 CANDIDATE MANUFACTURERS/PRODUCTS

A. Candidate manufacturers and models of Low Voltage Motor Control Centers are listed below. To conform with specified requirements, the manufacturer's standard product may require modification.

1. Eaton Freedom 2100
2. Allen Bradley Centerline 2100
3. Approved equivalent.

2.2 GENERAL:

A. In accordance with NEMA ICS 2 and UL 845.

B. Voltage Rating: 600 volts, 60 hertz, 3-phase, 3-wire.

C. Short Circuit Rating: 42,000 amperes rms symmetrical for entire motor control center as a complete assembly.

D. All controllers, main and branch circuit breakers, wire connections, and other devices to be front mounted and accessible unless otherwise noted.

E. NEMA ICS 2, Section 322.08

1. Class: I.
2. Type: B.

F. Adjust as necessary to wiring, conduit, disconnect devices, motor starters, branch circuit protection, and other affected material or equipment to accommodate motors provided under this Contract.

G. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

H. Operating Conditions:

1. Ambient Temperature: Maximum 40 degrees C.
2. Equipment to be fully rated without any derating for operating conditions.
3. Enclosures: In accordance with NEMA 250 and ANSI C57.12.28.

2.3 ENCLOSURE

A. Type: NEMA 250 Type 1, gasketed.

B. Vertical Section Dimensions: 90 inches high, 20 inches (or 30 inches as required) wide, 20 inches deep.

C. Construction:

1. Sheet steel reinforced with channel or angle irons.
2. Butt sections flush, end-to-end against similar section without bolts, nuts, or cover plates causing interference.
3. Removable top cover plates.
4. Removable plates on end panels for future bus extension.

D. Section Mounting: Removable formed-steel channel sills and lifting angles to meet specified seismic requirements.

E. Horizontal Wiring Compartments: Accessible from front, full width, top and bottom.

F. Vertical Wiring Compartments: Full height, isolated from unit starters with separate hinged door.

G. Unit Compartment: Individual compartments separated by steel barriers for each starter, feeder, or other unit capable of being wired from front without unit removal.

H. Compartment Doors: Separate hinged doors for each starter, feeder, or other unit.

I. Door Interlocking: Interlock starter and feeder doors mechanically so doors cannot be opened with unit energized. Provide defeater mechanism to allow intentional access at any time.

J. External disconnect handles, padlockable in OFF position.

K. Cable Entrance: Main leads enter from the bottom; control and feeder circuits enter from top and bottom.

L. Hardware for mounting future starter and feeder tap units shall be provided at compartments specified as "FUTURE” and “SPACE.”

M. Anchor Bolts: Galvanized, sized by equipment manufacturer, 1/2-inch minimum diameter.

N. Equipment Finish:

1. Electroplating process applied over a rust-inhibiting phosphate base coating.
2. Exterior Color: ANSI Z55.1, No. 61, light gray.

2.4 BUS:

A. Horizontal Power Bus:

1. Three-phase tin-plated, copper, entire width of control center, rated as indicated.
2. Construct to allow future extension of additional sections.

3. Pressure type solderless lugs for each incoming line cable.
4. Isolated from top horizontal wireway.

B. Vertical Power Bus:

1. Three-phase tin plated copper, full height of section, rated 300 amperes (min).
2. Sandwich type bus insulation providing dead front construction with starter units removed except for bus stab openings.
3. Insulated and isolated barrier complete with shutters.

C. Neutral Bus: 50 percent of main horizontal bus rating unless otherwise shown on one-line diagram.

D. Ground Bus: Copper, 33 percent minimum of phase bus ampacity, entire width of control center.

E. Bus Bracing: 65,000 amperes rms symmetrical.

2.5 WIRING:

A. Internal wiring and provisions of or external terminations and interfacing shall be provided in strict accordance with the Control Wiring Diagrams.

B. Provide wiring and terminals in MCC buckets in accordance with the wiring diagrams provided with the contract drawings.

C. All starter units shall have terminal blocks for control wiring. Terminal blocks shall be provided for power wiring for starters size 2 and smaller. Motor control centers shall be provided with all necessary interconnecting wiring and interlocking. Provide a drawing pocket in each unit.

D. Power Wire: Power wire shall be copper 90 degrees C "MTW" insulated, sized to suit load; minimum power wire size shall be No. 12 AWG copper stranded.

E. Control Wire: Control wire shall be No. 14 AWG stranded copper wire, rated 90 degrees C and UL listed for panel wiring.

F. Terminals: Provide crimp type terminals made from electrolytic copper, tin-plated. Provide cable termination connectors to match cable size and quantities as indicated on the drawings.

G. Conductor Markers:

1. All internal wiring in MCC buckets shall be numbered with a basic wire numbering scheme. Wires which terminate on a terminal shall have the terminal number. Wires that leave the MCC shall be labeled in accordance with Sections 26 05 00 and 26 24 19.
2. Markers used for identification shall meet the requirements of Section 26 05 00.

2.6 MAIN PROTECTIVE DEVICE AND FEEDER UNITS:

A. Molded Case Circuit Breaker:

1. In accordance with NEMA AB1 and UL 489.
2. Thermal magnetic trip and interrupting capacity required for connection to system with short circuit capacity indicated.
3. The tripped position shall be clearly indicated by breaker handle maintaining a position between "ON" and "OFF." All poles shall open, close, and trip simultaneously.
4. Suitable for use with 75 degrees C wire at full NEC 75 degrees C ampacity.

B. Main protective device shall be 100% rated, with frame size, solid state trip unit, rating plug, and the following fully adjustable (dynamic) trip functions: Long Time delay, Short Time Pick-up, Short Time delay, Instantaneous, Ground Fault Pick-up, and Ground Fault delay.

C. Feeder protective devices 250A and greater shall include solid state trip unit, rating plug, and fully coordinate with the main breaker.

D. Arc Flash: Provide arc flash reduction maintenance system on all main breakers and feeder breakers rated 400A or greater.

1. System shall not compromise breaker phase protection when enabled.
2. Clearing time of 0.04 seconds, adjustable 2.5X to 10X of the sensor value.
3. Enabled via door mounted lockable lockout/tagout selector switch with confirmation via a blue LED indication lamp.
4. All indicating lamps shall have an integrated lamp-test function or a common lamp test switch for all lamps.
5. Provide associated control power transformer as required.

2.7 MOTOR CONTROLLER UNIT:

A. NEMA ICS 2, Class A. Units shall provide integral phase-loss and phase-unbalance protection.

B. Provide indicated individual components and control devices including pushbuttons, selector switches, indicating lights, control relays, time delay relays, and elapsed time meters as specified in 26 05 04 – Basic Electrical Materials and Methods.

C. Construction:

1. Draw-out combination type with stab connections for starters NEMA ICS, Size 4 and smaller.
2. Bolt-on combination type with cable connection to riser for starters NEMA ICS, Size 5 and larger.
3. Readily interchangeable with starters of similar size.
4. Pull-apart unit control wiring terminal boards on all units.

D. Electromechanical Starters:

1. NEMA ICS 2, Section 322.08 standard rating, except none smaller than NEMA ICS, size 1.
2. Rating: HP rated at 600 volts, UL labeled for 65,000 amperes with overload protection.
3. Three-phase, full voltage reversing (FVR) and full voltage non-reversing (FVNR) as shown in Drawings.
4. Disconnect type: Motor circuit protector (MCP) with size based on the specific motor supplied. Trip setting shall be adjustable from 700 to 1300 percent of the motor full load amperes from the front of the breaker.
5. Combination FVNR Magnetic Starter:
   a. NEMA full size rated contactor with overload relay.
   b. Control: As shown.
6. Combination FVR Magnetic Starter:
   a. Two (2) FVNR starters with one (1) overload relay assembled together.
   b. Mechanically and electrically interlocked to prevent line shorts and the energizing of both contactors simultaneously
   c. Control: As shown.
7. Padlockable operating handle when de-energized.
8. Unit door interlocked to prevent opening when disconnect is in CLOSED position.
9. Mechanical interlocked to prevent placing disconnect in ON position when unit door is open.
10. Minimum Dimensions: 12 inches high by full section width, less vertical wireway.

E. Disconnecting Device:

1. As indicated.
2. Padlockable in OPEN position.

F. Overload Protection:

1. All motor starters shall include fully programmable electronic overload relays with I/O as shown in the Drawings.

2. Overload relays shall monitor all three phases individually for current and voltage and provide thermal overload, power measurements, ground fault detection.
3. Provide communications capability via native Ethernet/IP data port.
4. Provide CT's as required for motor load.
5. User interface shall be accessible without opening the cubicle door.
6. Protective functions:
    a. Thermal overload
    b. Jam
    c. Over/under current
    d. Current unbalance
    e. Phase loss
    f. Phase reversal
    g. Over/under voltage
    h. Voltage unbalance
    i. Over/under power (kW)
    j. Power factor
7. Monitoring functions:
    a. Phase currents
    b. Current unbalance
    c. Ground fault current
    d. Over/under current trip
    e. Thermal capacity
    f. Phase voltage
    g. Voltage unbalance
    h. Over/under voltage trip
    i. Over/under power trip
    j. Real power (kW)
    k. Power factor
    l. Frequency
    m. Motor starts count
    n. Motor starts time
    o. Fault history
8. Control functions:
    a. Local with hardwire
    b. Network/remote
    c. Programmable alarms
    d. Programmable trips
    e. Normally open dry contact rated 1 amp (min) at 120 VAC for remote alarming.
9. Provide cables and necessary software to access data via portable computer.

G. Control Transformer:

1. Two winding, 120-volt secondary, primary voltage to suit.
2. Two current-limiting fuses for primary circuit.
3. One fuse in secondary circuit.
4. All fuses shall be provided with blown fuse indicators.
5. Mount within starter unit.
6. Sized for load shown.

H. Variable Frequency Drives (VFD) integral to MCC:

1. Refer to Section 26 29 23 – Low-Voltage Variable Frequency Drives.

2.8 MISCELLANEOUS:

A. Nameplates: In accordance with Section 26 05 00, General Requirements for Electrical Work.

1. Each motor control center compartment shall have a nameplate designating the equipment and its identifying number and size or rating. Data shall be as shown on one-line diagrams.
2. Provide one large nameplate for each motor control center identifying the motor control center name and number with 1" lettering.
3. Equipment titles and numbers shall be completely spelled out on nameplates or as shown on the drawings.
4. Nameplates shall also be provided for identifying all relays and devices that are located inside the panels and shall be of the sandwich phenolic described above or approved equal.
5. Nameplates shall be mounted in a manner or location such that other equipment or devises do not block them so they are easily viewed.

B. Power Monitor and Display (PMD):

1. PMD shall be in accordance with Section 26 09 13, Instrument Transformers and Meters.

C. Ethernet/IP Communications:

1. Each electronic overload relay, VFD, and power monitor (PMD) in the MCC shall be supplied with a means to communicate via Ethernet/IP protocol and shall be networked via an externally mounted Ethernet switch (furnished and installed under Section 40 90 00).
2. MCC shall have provisions for installation of 600 V UL Shielded Category 6A Ethernet cabling incorporated throughout the entire lineup.

D. Uninterruptible Power Supply (UPS):

1. A separately mounted 120VAC UPS furnished and installed under Division 40 will provide power to the MCC mounted PMD.

E. Surge Protective Device (SPD):

1. Provide metal oxide varistor (MOV) surge protective device integral within each motor control center per Section 26 43 13, Surge Protective Devices.
2. Provide protective device as disconnecting means and short circuit protection per manufacturer's recommendation.
3. SPD type selection shall be coordinated with active harmonic filter installation to prevent mis-operation due to SPD capacitors.
4. Mount in dedicated bucket.

F. Spare Parts:

1. In addition to spare parts mentioned elsewhere in this section, the Contractor shall supply the following spare parts for use by the Owner. Spare parts shall be provided in a NEMA 1 storage box with hinged door for wall mounting as directed by Owner:
   a. 100% spare LED lamp type used for indicating lights.
   b. One spare control, time delay phase fail, etc. relay of each type used. or 20% whichever is the greater number.
   c. One spare lens of each color used for indicating lights.
   d. Two spare fuses for each fuse provided under 10 amps and one spare fuse for each fuse provided over 10 amps.
   e. One spare overload relay for each type and size provided.
   f. Spare parts shall be provided with the motor control equipment when shipped to the site.

PART 3 - EXECUTION

3.1 GENERAL

A. It is the Contractors responsibility to verify that the motor starters, protection equipment, and other components, etc. provided are suitable (correct phase, voltage, starter type, correct breakers, and overload relays) for the motors and equipment loads being served.

B. Operator interface devices such as metering and devices with control and displays shall be installed between 5’ and 5’-8” above finished floor. Operator interface devices on full height sections shall be installed between 4’-6”and 6’ above finished floor.

3.2 INSTALLATION

A. Install equipment in accordance with NEMA ICS 2.3, Submittal Drawings, and Manufacturer’s Instructions and Recommendations.

B. Secure equipment to mounting pads with anchor bolts of sufficient size and number for specified seismic conditions.

C. Install equipment plumb and in longitudinal alignment with pad or wall.

D. Coordinate terminal connections with installation of secondary feeders.

E. Grout mounting channels into floor or mounting pads.

F. Retighten current-carrying bolted connections and enclosure support framing and panels to manufacturer’s recommendations.

G. Cables larger than No. 6 AWG which hang from their vertical connections shall be supported within 2 feet of the connection.

3.3 CIRCUIT BREAKERS

A. Field adjust trip settings of motor starter magnetic-trip-only circuit breakers.

B. Adjust to approximately 11 times motor rated current.

C. Determine motor rated current from motor nameplate following installation.

3.4 OVERLOAD RELAYS

A. The setting of the overload relays shall be by the Contractor and adjusted based on the actual full load amperes of the motor connected to the starter.

B. Verify overload relays operate in accordance the control strategy specified in 25 99 15 – Control Sequence.

3.5 POWER MONITORS

A. Power monitors shall be tested for verification of correct amps, volts, hertz, power factor, and harmonics by comparison of the signal into the plant’s power monitoring system with a high accuracy hand held meter.

3.6 MOTOR DATA

A. Provide typed, self-adhesive label attached inside each motor control starter enclosure door displaying the following information:

1. Motor served by tag number and equipment name.
2. Nameplate horsepower.
3. Motor code letter.
4. Full load amperes.
5. Service factor.
6. Overload settings.

3.7 FIELD TESTS

A. Motor control centers shall be tested in accordance with Section 26 08 00, Commissioning of Electrical Systems.

3.8 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative for the following services at site or classroom as designated by Owner for minimum person-days listed below, travel time excluded:

   1. 3 person-days for installation inspection and pre-startup classroom training.

B. Provide Manufacturer Field Service Report in accordance with Section 01 61 03, Equipment Basic Requirements,

C. Furnish startup services and training of Owner's personnel at such times as requested by Owner to accommodate the shift schedules of Owner's operation and maintenance staff.

END OF SECTION

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SECTION 26 27 26
WIRING DEVICES

PART 1 - GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM): A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
2. Federal Specifications (FS):
   a. W-C-596G, General Specification for Connector, Electrical, Power.
   b. W-S-896F, Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).
3. Institute of Electrical and Electronic Engineers, Inc. (IEEE):
   a. C62.41.2, Recommended Practice on Characterization of Surges in Low-Voltage (1000V and less) AC Power Circuits.
   b. C62.45, Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000V and less) AC Power Circuits.
4. National Electrical Contractors Association (NECA): 1, Standard Practice of Good Workmanship in Electrical Contracting.
5. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. FB 11, Plugs, Receptacles, and Connectors of the Pin and Sleeve Type for Hazardous Locations.
   c. WD 1, General Color Requirements for Wiring Devices.
   d. WD 6, Wiring Devices – Dimensional Specifications.
6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
7. Underwriters Laboratories Inc. (UL):
   a. 498, Standard for Safety for Attachment Plugs and Receptacles.
   b. 508, Standard for Safety for Industrial Control Equipment.
   c. 943, Standard for Safety for Ground-Fault Circuit-Interrupters.
   d. 1010, Standard for Safety for Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations.
   e. 1436, Standard for Safety for Outlet Circuit Testers and Similar Indicating Devices.
   f. 1449, Standard for Safety for Surge Protective Devices (SPD).

1.2 SUBMITTALS

A. Action Submittals: Manufacturer’s product data for wiring devices.

PART 2 - PRODUCTS

2.1 SWITCHES

A. Switch, General Purpose:

1. NEMA WD 1 and FS W-S-896F.
2. Totally enclosed, ac type, with quiet tumbler switch and screw terminal.
3. Rivetless one-piece brass or copper alloy contact arm with silver alloy contact.
4. Capable of controlling 100 percent LED lamp loads.
5. Rating: 20 amps, 120/277 volts.

6. Automatic grounding clip and integral grounding terminal on mounting strap.
7. Special Features: Provide the following features in comparable devices where indicated:
    a. Three-way and four-way.
8. Manufacturers and Products, Industrial Grade:
    a. Cooper Arrow Hart; AH1220 Series.
    b. Bryant; 4901 Series.
    c. Hubbell; 1221 Series.
    d. Leviton; 1221 Series.

2.2 SWITCH, MOTOR RATED:

A. UL 508 listed.

B. Rated for fractional horsepower and integral horsepower to maximum of 10HP at 600V.

C. Quick-make, quick-break toggle mechanism that is lockable in the OFF position.

D. Types:

1. Horsepower rated, for ON/OFF control.
2. Horsepower rated, for ON/OFF control and thermal overload protection.
    a. Switch to clearly indicate ON, OFF, and TRIPPED position.

E. Voltage and current ratings and number of poles as required for the connected motor.

2.3 RECEPTACLES

A. Receptacle, General Purpose:

1. NEMA WD 1 and FS W-C-596G.
2. Duplex, two-pole, three-wire grounding type with screw type wire terminals.
3. Impact resistant nylon cover and body, with finder grooves in face, unless otherwise indicated.
4. One-piece mounting strap with integral ground contact (rivetless construction).
5. Contact Arrangement: Contact to be made on two sides of each inserted blade without detent.
6. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps, unless otherwise indicated.
7. Size: For 2-inch by 4-inch outlet box.
8. Industrial Grade Manufacturers and Products:
    a. Cooper Arrow Hart; 5362 Series.
    b. Hubbell Bryant; HBL5362 Series.
    c. Leviton; 5362 Series.

B. Receptacle, Ground Fault Circuit Interrupter:

1. Meet requirements of general-purpose receptacle.
2. Listed Class A to UL 943, tripping at 5 mA.
3. Rectangular smooth face with push-to-test and reset buttons.
4. Listed weather-resistant per NEC 406.8.
5. Feed-through Capability: 20 amps.
6. Manufacturers and Products:
    a. Hubbell Bryant; GFTR20 Series.
    b. Cooper Arrow Hart; WRVGF20 Series.
    c. Leviton; 7899 Series.

C. Receptacle, Corrosion-Resistant:

1. Meet requirements of general-purpose receptacle.

2. Nickel coated metal parts.
3. Manufacturers and Products:
    a. Hubbell Bryant; HBL53CM62 Series.
    b. Leviton; 53CM-62 Series.
    c. Cooper Arrow Hart; 5362CR Series.

D. Receptacle, Special-Purpose:
1. General:
    a. Rating and number of poles as indicated or required for anticipated purpose.
    b. Provide matching plug with cord-grip features for each special-purpose receptacle.
2. Standard Duty Receptacles and Plugs:
    a. Rating: Voltage and ampere ratings as shown.
    b. Provide handles, adapter plates, metal adapters, cord grips, dead front safety shutter, closed lid configuration and accessories as required for the installation.
    c. Provide auxiliary contacts for additional motor controls where applicable.
    d. Manufacturers:
        1) Meltric; DR series, or equivalent.
3. Multipin Compact Control Receptacles and Plugs;
    a. Control plugs and receptacles for influent pump motor moisture and temperature controls,
    b. Rating:
        1) Voltage rating as shown,
        2) 5-amp current interrupting. Suitable for 4-20mA low current applications.
    c. Manufacturers:
        1) Meltric; PN12c, or equivalent.

2.4 HAZARDOUS (CLASSIFIED) LOCATION DEVICES

A. Wiring devices for hazardous (classified) locations shall comply with NEMA FB 11 and UL 1010.

B. Provide enclosures as specified in 26 05 04 - Basic Electrical Materials and Methods.

C. Switches:
1. Manufacturer and Products:
    a. Crouse-Hinds EDS Series
    b. Killark XS Series
    c. Or equivalent

D. Manually Operated Starters, Fractional Horsepower:
1. Manufacturer and Products:
    a. Crouse Hinds EDS Series
    b. Killark XSD Series
    c. Or equivalent

E. Manually Operated Starters, Integral Horsepower:
1. Manufacturer and Products:
    a. Killark XMSW Series
    b. Crouse-Hinds EMN Series
    c. Or equivalent

F. Receptacles, General:
1. Contain integral switch which must be closed to energize circuit.

2. Design shall permit only an approved plug to be energized.
    a. Actuation of switch shall require plug be inserted and rotated approximately 45 degrees.
    b. Plug shall lock into this position preventing unintended disengagement.
    c. To remove, plug shall be turned opposite direction as engagement and pulled straight out.

G. General Purpose Receptacle, Explosion Proof, 125 Volts, 20 Amps:
1. Dead front, interlocked, circuit breaking.
2. Receptacle Cover: Spring loaded closes when plug is removed.
3. Enclosure: Corrosion-resistant, aluminum alloy with less than 0.4 percent copper.
4. Finish: Electrostatically applied and baked powder epoxy/polyester.
5. External Hardware: Type 316 stainless steel.
6. Switch Chamber: Factory sealed to contain switch's arcing components.
7. Hazardous Area Ratings: Suitable for Class I, Division 2, NEMA 7BCD, 9FG.
8. Provide matching plug with each receptacle.
9. Manufacturers and Products:
    a. Cooper Crouse-Hinds; Ark Guard 2, Series ENR.
    b. EGS/Appleton Electric; U-Line.
    c. Killark, a division of Hubbell Inc.; UGR/UGP.

H. Ground Fault Circuit Interrupter (GFCI), Explosion-Proof:
1. Meet requirements of general-purpose receptacle, except as otherwise indicated.
2. Hazardous Area Ratings: NEMA 7D suitable for Class I, Group C and Group D, Class 2, Groups F and G, and Class 3 locations.
3. Provide matching plug with each receptacle.
4. Manufacturers and Products:
    a. Killark; Acceptor series UGFI.
    b. Appleton; EFSXXX-2023GFI.

2.5 DEVICE PLATES

A. Sectional type plate not permitted.

B. Metal:
1. Material: Specification grade, one-piece, 0.040-inch nominal thickness stainless steel.
2. Finish: ASTM A167, Type 302/304, satin.
3. Mounting Screw: Oval-head, finish matched to plate.

C. Cast Metal:
1. Material: Malleable ferrous metal with gaskets.
2. Screw: Oval-head stainless steel.

D. Sheet Steel:
1. Finish: Zinc electroplate.
2. Screws: Oval-head stainless steel.
3. Manufacturers:
    a. Appleton.
    b. Crouse-Hinds.

E. Engraved:
1. Character Height: 3/16-inch.
2. Filler: Black.

F. Weatherproof:

1. Receptacle, Weatherproof Type 1:
    a. Gasketed, cast-aluminum, with individual cap over each receptacle opening.
    b. Mounting Screw and Cap Spring: Stainless steel.
    c. Manufacturers and Products:
        1) Crouse-Hinds; Type WLRD-1.
        2) Appleton; Type FSK-WRD.
2. Switch:
    a. Gasketed, cast-metal or cast-aluminum, incorporating external operator for internal switch.
    b. Mounting Screw: Stainless steel.
    c. Manufacturers and Products:
        1) Crouse-Hinds; DS-181 or DS-185.
        2) Appleton; FSK-1VTS or FSK-1VS.

2.6 FINISHES

A. Wiring device catalog numbers specified in this section do not designate device color. Unless otherwise indicated, or required by code, provide colors as specified below.

B. Wiring Device: Brown.

C. Special purpose and hazardous location devices may be manufacturer's standard color (black).

D. Corrosion-resistant receptacle may be manufacturer's standard color (yellow).

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Comply with NECA 1.

B. Coordination with Other Trades:

1. Ensure device and its box are protected. Do not place wall finish materials over device box and do not cut holes for box with router that is guided by riding against outside of box.
2. Keep outlet box free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate raceway system, conductors, and cables.
3. Install device box in brick or block wall such that cover plate does not cross a joint, unless otherwise indicated. Where indicated or directed to cross joint, trowel joint flush with face of wall.
4. Install wiring device after wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
2. Strip insulation evenly around conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. Length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
    a. Cut back and pigtail, or replace damaged conductors.
    b. Straighten conductors that remain and remove corrosion and foreign matter.
    c. Pigtailing existing conductors is permitted provided outlet box is large enough.

D. Device Installation:

1. Replace devices that have been in temporary use during construction or that show signs they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (150 mm) in length.
5. Use torque screwdriver when a torque is recommended or required by manufacturer.
6. When conductors larger than 12 AWG are installed on 15-amp or 20-amp circuits, splice 12 AWG pigtails for device connections.
7. Tighten unused terminal screws on device.
8. Device Plates:
    a. Do not use oversized or extra deep plate.
    b. Repair wall finishes and remount outlet box when standard device plate does not fit flush or does not cover rough wall opening.

3.2 SWITCH INSTALLATION

A. Switch, General Purpose:

1. Mounting Height: See Section 26 05 33, Raceways and Boxes.
2. Install with switch operation in vertical position.
3. Install single-pole, two-way switch such that toggle is in up position when switch is on.

B. Switch, Motor Rated:

1. Mounting Height: See Section 26 05 33, Raceways and Boxes.
2. Install with switch operation in vertical position such that toggle is in up position when ON.
3. Install within sight of motor when used as disconnect switch.

3.3 RECEPTACLE INSTALLATION

A. Duplex Receptacle:

1. Install with grounding slot down, except where horizontal mounting is shown, in which case install with neutral slot up**.**
2. Ground receptacle to box with grounding wire only.
3. Weatherproof Receptacle:
    a. Install in cast metal box.
    b. Install such that hinge for protective cover is above receptacle opening.
4. Ground Fault Interrupter: Install feed-through model at locations where ground fault protection is specified for “downstream” conventional receptacles.
5. Special-Purpose Receptacle: Install in accordance with manufacturer’s instructions.

3.4 DEVICE PLATE INSTALLATION

A. Securely fasten to wiring device; ensure tight fit to box.

B. Flush Mounted: Install with all four edges in continuous contact with finished wall surface without use of mat or similar material. Plaster fillings will not be acceptable.

C. Surface Mounted: Plate shall not extend beyond sides of box unless plate has no sharp corners or edges.

D. Install with alignment tolerance to box of 1/16 inch.

E. Engrave with designated title.

F. Type (Unless Otherwise Shown): Metal.

1. Exterior:
    a. Switch: Weatherproof.
    b. Receptacle in Damp Location: Weatherproof Type 1.

G. Interior:

1. Flush Mounted Box: Metal**.**
2. Surface Mounted; Cast Metal Box.
3. Surface Mounted, Sheet Steel Box: Raised sheet steel.
4. Surface Mounted, Nonmetallic Box: Manufacturer's standard.
5. Receptacle Shown as Weatherproof on Drawings: Weatherproof Type 1.

3.5 IDENTIFICATION

A. Use tape labels for identification of individual wall switches and receptacles in dry indoor locations.

1. Degrease and clean device plate surface to receive tape labels.
2. Use 3/16-inch Kroy black letters on white background, unless otherwise indicated.
3. Identify panelboard and circuit number from which item is served on face of plate.

B. Identify conductors with durable wire markers or tags inside outlet boxes.

3.6 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Test Instrument for 125-Volt 20-Amp Receptacle: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

C. Using test plug, verify device and its outlet box are securely mounted.

D. Line Voltage Range: 105 volts to 132 volts.

E. Percent Voltage Drop under 15-Amp Load: Less than 6 percent; 6 percent or higher is not acceptable.

F. Ground Impedance: 2 ohms, maximum.

G. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.

H. Tests shall be diagnostic, indicating damaged conductors, high resistance at circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

END OF SECTION

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SECTION 26 29 23
LOW-VOLTAGE ADJUSTABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SUMMARY

A. This section includes adjustable frequency drive systems installed in a motor control center as specified in Section 26 24 19 – Low Voltage Motor Control, consisting of solid state VFD, HIM, line and load conditioning, control power transformer, bucket temperature control, and associated control components as required.

B. For the purposes of this contract, the terms “adjustable frequency drive (AFD)” and “variable frequency drive (VFD)” are used interchangeably and refer to the same motor drives.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. National Electrical Manufacturers’ Association (NEMA):
    a. NEMA ICS 1, General Standards for Industrial Controls and Systems.
    b. NEMA ICS 2, Standards for Industrial Control Devices, Controllers and Assemblies
    c. NEMA ICS 3, Industrial Systems
    d. NEMA ICS 3.1, Safety Standards for Construction and Guide for Selection, Installation and Operation of Variable-speed Drive Systems
    e. NEMA ICS 4, Terminal Blocks for Industrial Control Equipment and Systems
    f. NEMA ICS 6, Enclosures for Industrial Controls and Systems.
2. American National Standards Institute (ANSI)
    a. ANSI C37.90, Relays and Relay Systems Associated with Electric Power Apparatus
    b. ANSI C37.30A (1984), Definitions and Requirements for High- Voltage Air Switches, Insulators, and Bus Supports, Supplement to C37.30-1971
    c. ANSI C37.32, Schedules of Preferred Ratings, Manufacturing Specifications and Application Guide for High-Voltage Air Switches, Bus Supports, and Switch Accessories.
3. Institute of Electrical and Electronics Engineers (IEEE)
    a. IEEE 519, Harmonic Control and Reactive Compensation of Static Power Converters

1.3 DESIGN REQUIREMENTS

A. Design requirements:

1. Each VFD system shall consist of all components required to meet the performance, protection, safety, testing and certification criteria of this Section.
2. The VFD system shall be a fully integrated package and includes all material necessary to interconnect VFD system elements, even if shipped separately.
3. Any modifications to a standard product necessary to meet this Section shall be made only by the VFD manufacturer.
4. Each VFD shall be completely factory pre-wired, assembled and then tested as a complete package by the VFD manufacturer to ensure a properly coordinated, fully integrated drive system.
5. The VFD shall be capable of operating standard NEMA Design B motors. It is the responsibility of the VFD manufacturer to ensure that the drive will not damage motor insulation due to high carrier frequency, reflected wave, dv/dt or other drive electrical characteristics:
    a. The VFD manufacturer shall furnish equipment necessary to mitigate potential damage to motor insulation.

b. Coordinate bearing protection methods with the supplier of the driven equipment.

1.4 SOURCE QUALITY CONTROL

A. Listed and labeled by Underwriter's Laboratories, Inc. (UL), ETL, or Canadian Standards Association.

B. All upgrades to specified requirements per UL 508 or ETL.

C. Quality Assurance: The Owner reserves the right to observe factory tests on the VFD controller at the Owner's option and expense.

D. Compatibility: VFD controller's performance shall be compatible and tolerant of disturbances produced by other VFD controllers and not interfere with each other.

E. Programming: Provide VFD controller configuration and MACRO or sub-routine programming to meet specified driven equipment requirements.

F. Maintainability: VFD controller's parts shall be interchangeable and modular for all controllers.

G. Factory Test: Subject VFD to a complete simulated operational test. Drive a calibrated load at various speeds over the specified speed range to determine VFD efficiency.

1.5 SUBMITTALS

A. Action Submittals:

1. Catalog and technical data indicating the equipment complies with the Construction Documents.
2. External connection diagram showing function and identification of all terminals requiring field connections.
3. Schematics and wiring diagrams.
4. Design data:
   a. Efficiency and power factor values.
   b. Certification that the drive is sized for the full nameplate motor horsepower and current (at rated RPM) of the driven load at the installed altitude.
   c. Certification that based upon VFD design, cable length to motor, and motor dielectric insulation level that the VFD will not damage motor insulation due to carrier frequency, reflected wave, dv/dt, or other VFD produced characteristics.
   d. Certification that all electronic circuits and printed circuit boards are conformally coated.
5. Efficiency and power factor calculations:
   a. Calculate efficiencies of the VFD controller, ventilation fans, control power and all VFD losses.
   b. Calculate displacement and total power factor including filter.
   c. Perform calculations at 100, 75, and 50 percent speed.
   d. Include first 36 harmonics.
6. Calculations of cooling and ventilation requirements.
7. Location and description of service center and spare parts stock.
8. Spare parts list.
9. Factory and field test documentation.
10. Training schedule and materials.
11. Written descriptions explaining ladder diagram operation, system operation, and analog signal processing.
12. Comprehensive interconnection diagrams for VFD and motor.
13. Certification that VFD, motor, and driven load are compatible throughout the specified speed range.
14. Certified statement from the manufacturer accepting responsibility for providing a fully functioning installation as specified herein.

15. Manufacturer's installation instructions, outline dimensions and equipment weights.
16. Operation and Maintenance Manual
17. Certified final factory test procedure and reports for each drive.

1.6 COORDINATION

A. Obtain and review the appropriate data for the driven motor and load over the required speed range, for a complete system analysis.

B. Confirm VFD is rated for the applicable variable torque or constant torque applications.

C. Verify that equipment is mutually compatible and free of resonance over the complete operating range. Coordinate the assignment of any critical frequencies with the motor supplier.

D. Prepare the certificate required under Submittals paragraph in this Section; the certificate shall specifically state whether the VFD equipment is rated for variable torque or constant torque applications.

PART 2 - PRODUCTS

2.1 MANUFACTURERS/PRODUCTS

A. Rockwell Automation PowerFlex 750 series

B. Or equivalent.

2.2 VARIABLE FREQUENCY DRIVES

A. General:

1. Provide integrated, all solid-state VFD complete with power and signal conditioning.
2. System shall comply with NEMA ICS 1, 3, 4, 3.1, 4, and 6.
3. System includes:
    a. Incoming line lockable thermal magnetic circuit breaker. Lockable in the OFF position.
    b. Input line reactors where shown on Drawings. Provide 5 percent nominal reactance unless noted otherwise.
    c. Sinusoidal pulse width modulated, (PWM), voltage source type drive.
        1) Diode rectifier section.
        2) Direct current link with capacitors.
        3) Insulated gate bipolar transistor (IGBT), inverter section.
        4) Microprocessor based controls.
    d. Load reactors where shown on Drawings. Provide 3 percent nominal reactance unless noted otherwise.
4. VFDs that have an active input section for either harmonic or voltage control are not acceptable.

B. Operation: Accomplish speed control by adjusting the output frequency according to the desired reference speed. Adjust ac voltage and frequency simultaneously to provide the constant Volts/Hertz necessary to operate the motor at the desired speed. The VFD must use pulse width modulation technology.

C. Rating:

1. Line Voltage: 480 volts, -5 percent continuous, -10 percent momentary, +10 percent, 3-phase.
2. Line Frequency: 60 Hz, ±2 Hz
3. Ambient Temperature: 5°C to 40°C
4. Altitude: Up to 5,400 feet above sea level.
5. Power Factor: Above 0.95 at full speed and rated load.

D. Performance:

1. Provide 100 percent of rated output current on a continuous basis.
2. Variable torque VFD:
    a. Minimum 110 percent current overload for 1 minute.
3. Constant torque VFD:
    a. Minimum 150 percent current overload for 1 minute.
4. Efficiency: Above 95 percent at 100 percent full speed, above 93 percent at 70 percent full speed.
5. VFD Inrush Current: Limited to less than 100 percent of motor full load
6. Duty Cycle: 6 starts per hour.

E. Features:

1. Communications: Native Ethernet/IP connectivity.
2. Inputs and Outputs:
    a. Potentiometer 3-wire input for manual speed control. Motor speed indicator calibrated in percent of full speed.
    b. Analog inputs: Configurable as either 0-10 volts or 4-20 mA dc signal. Input impedance shall be 250 ohms resistive.
    c. Analog outputs: Programmable 4-20 mA dc signal for remote indication to a local PLC. Input impedance shall be 250 ohms resistive.
    d. Discrete inputs: Programmable.
    e. Discrete outputs: Programmable, form C relay contacts.
3. Diagnostics:
    a. Minimum of 4 fault conditions in memory on a first in - first out basis.
    b. Operating frequency, drive status and power mode shall also be stored at the time of the fault.
    c. Fault memory shall be maintained in the event of a power outage.
    d. The fault memory shall be accessible via RS-232, RS-422 or RS-485.
4. Automatic restart:
    a. User selectable, automatic restart feature allowing the VFD to restart following a momentary power failure or other VFD fault:
        1) Programmable for up to 9 automatic restart attempts with an adjustable time delay between restart attempts.
5. Control Power Transformers (CPT):
    a. Two winding, 120-volt secondary, primary voltage to suit.
    b. Two current-limiting fuses for primary circuit.
    c. One fuse in secondary circuit.
    d. All fuses shall be provided with blown fuse indicators.
    e. Size for load shown on motor control schematics.
6. Variable time delay for delaying motor drive restart after power failure; timer range shall be 0 to 120 seconds, with initial settings differing by 10 seconds for each drive; provide module which causes multiple attempts to restart.
7. Provision for automatic emergency shutdown in any mode, activated by the following:
    a. Motor thermal protection.
    b. Any additional abnormal conditions as shown on the Drawings. Provide for manual restart.
8. VFD able to withstand harmonic distortion and notching as defined in IEEE-519 for dedicated system (10 percent voltage distortion factor and 36,500-volt microseconds commutation notch area).
9. VFD operable with motor disconnected, to test VFD.

10. Linearity and repeatability accuracy of 3 phase output of 1 percent of analog input control signal regardless of input power voltage fluctuations between 437 and 505 volts.
11. Independent acceleration and deceleration controls, adjustable from 2 to 30 Hz per second.
12. Label with fault current rating and arc flash warning per NEC and Section 26 05 73, Electrical Systems Analysis.
13. Label denoting overload setting and date it was set.

F. Protection: Protect VFD against the following conditions:

1. Reverse phase sequence and single phasing of input power.
2. Input power failure.
3. Input transient voltages, including peak suppression and snubbers, in accordance with ANSI C37.90.
4. Transmission signal interference.
5. Output overcurrent.
6. Input overcurrent.
7. Motor over temperature.
8. Cabinet over temperature.
9. Under voltage: VFD shall automatically shut down if input voltage falls below preset limit with automatic restart upon return to a stable supply.

G. Conformal coating:

1. Provide conformal coating material applied to electronic circuitry and printed circuit boards to act as protection against moisture, dust, temperature extremes, and chemicals such as H_2S and chlorine.

H. Door-mounted HIM

1. Furnished with a keypad for programming and control.
2. Password security to protect drive parameters.
3. Mounted on the door of the VFD or as indicated on the Drawings.
4. Back-lit LCD with a minimum of 2 lines of a minimum of 16 characters each.
5. Programming and display features language: English.
6. Capable of displaying the following parameters:
    a. Speed (percent).
    b. Input current (Amperes).
    c. Output current (Amperes).
    d. Output frequency (Hertz).
    e. Input voltage.
    f. Output voltage.
    g. Total 3-phase kilowatt.
    h. Kilowatt hour meter.
    i. Elapsed run time meter.
    j. Revolutions per minute.
    k. Direct current bus voltage.
7. In addition to all keys required for programming, the keypad shall have the following:
    a. Automatic/Manual selector.
    b. Start pushbutton.
    c. Stop pushbutton.
    d. Jog pushbutton.
    e. Speed increment.

f. Speed decrement.
g. Forward/Reverse selector.
h. RUN indicator.
i. PROGRAM indicator.
j. FAULT indicator.
k. DRIVE READY indicator.
l. Diagnostics.

I. Door-mounted hardwired controls indicated on the Drawings.

J. External operating handle for the incoming disconnect/overcurrent protection.

K. Control components shall be in accordance Section 26 05 04, Basic Electrical Materials and Methods.

L. Configuration and components shall be as shown on the drawings.

M. Mount components on circuit cards or modules, which can be adjusted or replaced in the field without the use of special tools.

N. Air filters:

1. Mounted on the outside enclosure:
2. Replaceable without requiring that the VFD be turned off or the door opened.

O. Spare Parts:

1. Furnish two sets of spare power fuses for each size and type of fuse used.
2. Furnish a minimum of five fuses of each size and type of control circuit fuse.
3. 1 spare enclosure fan for each VFD unit.
4. 2 sets of ventilation filters for each VFD unit (if applicable in VFD cabinet louvers).
5. 1 set of thyristors or power electronics for each type and rated size of VFD.
6. Any special dedicated tools for emergency service and troubleshooting.
7. All hardware and software required for configuration, maintenance, troubleshooting and inquiry of all drive parameters.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

B. Enclosure shall be fully wired to all field devices as indicated by the Drawings.

C. Protect the internal panel components from metal shavings, liquids and construction debris at all times.

D. Confirm doors will open and close freely and are in longitudinal alignment with pad or wall.

E. Clean and repair scratched or damaged surfaces to "new" condition.

F. Secure enclosure hardware of sufficient size and number for specified seismic conditions.

G. Per manufacturer's instructions, lace power conductors to resist short circuit forces.

H. Operate each drive from no load to full load and perform a spectrum analysis to verify line side waveform complies with IEEE 519 for general systems.

I. Provide and install batteries in factory I/O cards as required to maintain time and date settings.

J. Label denoting overload setting and date it was set.

K. Provide the services of a factory trained service technician to inspect and check out each system before energizing.

1. Protective device settings provided by the VFD manufacturer in accordance with the manufacturer of the driven equipment requirements.
2. Provide documentation of VFD settings included but not limited to:
    a. Minimum speed.
    b. Maximum speed.
    c. Skip speeds.
    d. Current limit.
    e. Acceleration time.
    f. Deceleration time.
    g. Carrier frequency.

3.2 IDENTIFICATION

A. Install unique nameplate that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual on each enclosure.

3.3 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative for the following services at site or classroom as designated by Owner for minimum person-days listed below, travel time excluded:

    1. 3 person-days for installation inspection, and prestart-up classroom training

B. Furnish startup services and training of Owner's personnel at such times as requested by Owner to accommodate the shift schedules of Owner's operation and maintenance staff.

C. Provide Manufacturer Field Service Report in accordance with Section 01 61 03, Equipment Basic Requirements

END OF SECTION

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SECTION 26 35 26
ACTIVE HARMONIC FILTERS

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies requirements necessary to provide:

1. Active harmonic filter power correction systems to reduce current harmonics and correct power factor on 480-volt power distribution systems.
2. Manufacturer's services.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. IEEE C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
2. IEEE 519, Recommended Practices and Requirements for Harmonic Control in Electric Power Systems.
3. CSA 22.2: No. 14 & 66, Industrial Control Equipment & Specialty Transformers, Industrial Products
4. UL 508, Industrial Control Equipment
5. IEC 60529, IP20, Degrees of Protection Provided by Enclosures (IP Code)
6. ICC IBC, International Building Code

1.3 FACTORY TESTS:

A. The manufacturer shall test the system performance at rated current and voltage while functioning as a harmonic correction device prior to shipment. A certified report shall be submitted at the successful completion of factory performance tests.

1.4 SUBMITTALS

A. Action Submittal:

1. Electrical single line, schematic diagrams, and conductor connection diagram.
2. Layout drawings indicating arrangement, dimensions, cable entries, and weights.
3. Manufacturer's product and catalog data indicating equipment specifications and features.
4. Provide size and weights of shipping units to be handled by installer. Detailed layouts of customer power and control connections. Detailed installation drawings including all terminal locations.
5. Operation and maintenance information as specified in Section 01 78 23, Operation and Maintenance Data including:
    a. As-built drawings.
    b. Final, complete reviewed submittal information.
6. Factory test report and field test reports.

1.5 QUALIFICATIONS

A. Manufacturer providing harmonic correction equipment of the type specified, with minimum 5 years documented experience.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Schneider Electric Accusine

B. Eaton HCU2

C. TCI Harmonic Guard

2.2 GENERAL

A. System description: System Voltage: 480 volts, 3-Phase, 3-Wire plus ground conductor.

B. Output load capacity: Rated capacity shall be the specified current capacity at the voltage required as indicated within this specification and shown on the respective electrical drawings included within this document.

C. Current transformers:

1. Two split core type current transformers rated for 50 to 400-Hertz shall be installed on phases A & B at locations shown. 1% or better (metering class) accuracy shall be provided.
2. Current transformer current ratings based on based on full load current rating of the installed circuit/bus or as shown.
3. Current transformer output shall be 5 amperes full scale.
4. Current transformers shall be dedicated for AHF operation and not shared with other system components.
5. When active filters are shown to be connected for future parallel operation, CT burden rating shall be appropriate for the number of units shown.

D. Modes of operation:

1. The power correction system shall inject harmonic current to cancel load produced harmonic current so the upstream power harmonic current and voltage are reduced to below 5% TDD and 5% THD(V), respectfully. The system shall correct all types of nonlinear loads.
2. The applied circuit may be a single nonlinear load, a distribution-bus with multiple loads, or the facility load at the point-of-common coupling (PCC) with the power source.
3. The displacement power factor correction of the reactive current shall be activated or deactivated via a door-mounted human machine interface (HMI) with touch screen control.

E. Performance requirements:

1. Input Power:
   a. Voltage: Automatically adapted to 480V, 3 phase, 3-wire plus ground conductor.
   b. Voltage Tolerance: +/- 10% of nominal.
   c. Frequency: automatically adapted to 60 Hertz, +/- 3 Hertz.
   d. Surge Withstand Capability: ANSI/IEEE C62.41-1991 without damage.
   e. Input circuit breaker or fuses: Short circuit current rating as shown on the Drawings.
2. Output Performance: Performance of the power correction system shall be independent of the impedance of the power source.
3. Harmonic Correction:
   a. Limit the 3rd through 49th order harmonic current to <5% TDD at the main bus. Harmonic levels for individual harmonic orders shall comply with respective levels established in ANSI/IEEE std 519-1992, Table 10.3.
   b. Limit the THD(V) added to the electrical system immediately upstream of the power correction system location(s) to less than or equal to 5%.
   c. The power correction system shall not correct for power utility supplied voltage distortion levels.
4. Reactive Current Compensation: Maintain a set point of .99 lagging displacement power factor under all load conditions. Power factor shall not go “leading” at any point.
5. Filters shown to operate in tandem (tie closed) or independently shall have all necessary wiring to achieve this requirement.

F. System Features:

1. Each unit provided with a current limiting function to protect the semiconductors.
2. Non-critical level faults (AC line over/under voltage, power loss, and phase imbalance) shall provide automatic restart and return to normal operation upon automatic fault clearance.
3. Critical level faults shall stop the function of the unit and await Operator action to restart the power correction system.
4. The ratio of the two CTs shall be entered into the logic via the digital keypad/display to calibrate the operation of the power correction system.

G. Indicators and Controls:

1. Features:
   a. Door-mounted color touchscreen display.
   b. Configurable network-based run/stop control.
   c. Manual and auto run/stop control.
   d. Power quality information
   e. Configuration parameters
   f. Operational measurements, status, and alarms/fault.
   g. Display trend history for line voltage, line current, filter current, filter voltage, THD, and filter heatsink temperature.
2. Control modes:
   a. Harmonic correction only
   b. Power factor correction only
   c. Combination harmonic and power factor
3. Ethernet/IP interface for remote communications.
4. Two form C, 2-amp, 120VAC, dry relay output contacts for remote indication of system run, fault, and maximum load status contacts.
5. Remote enable input.

H. Enclosure:

1. Each unit shall be provided in a wall mounted NEMA 1 gasketed enclosure with bottom entry. Provide floor stand from manufacturer as required.
2. Disconnects:
   a. The switchgear or MCC feeder circuit breaker shall be utilized as the local disconnecting means. A mechanism shall be provided that locks the AHC door when the unit is energized.
3. Lifting Provisions:
   a. Freestanding units shall include lifting provisions by lifting lugs.
   b. Wall mount units weighing more than 80 pounds shall have lifting lugs.
4. Features:
   a. Incoming circuit breaker or fuses rated for available fault current as shown on the Drawings.
   b. Grounding lug.

I. Nameplates:

1. In addition to the manufacturer's identification, an external nameplate conforming to the requirements of Section 26 05 00 shall be provided with equipment tag number and name as shown.

2.3 SPECIAL WARRANTY

A. Manufacturer shall warrant against defects in materials and workmanship for two (2) years.

PART 3 - EXECUTION

3.1 DELIVERY

A. Active harmonic conditioners shall be factory assembled.

B. Factory test results shall be reviewed and accepted by Seller before active harmonic conditioner shipment.

3.2 INSTALLATION

A. Take all necessary precautions to always exclude moisture and foreign material from the equipment during storage and installation. Care shall be taken to prevent corrosion of silver-plated contact surfaces and damage to relays and control devices.

B. Secure equipment to mounting pads with anchor bolts of sufficient size and number for specified seismic conditions.

C. Install equipment plumb and in longitudinal alignment with pad or wall.

D. Install in accordance with the manufacturer’s written instructions.

3.3 FIELD QUALITY CONTROL

A. Provide field quality control as part of manufacturer’s services.

B. Inspect completed installation for any physical damage, proper alignment, anchorage, and grounding.

3.4 STARTUP AND SITE TESTING

A. Installation, Start up and Testing Services:

1. Provide complete manufacturer' s installation and startup services. Coordinate all manufacturer' s recommended testing services with those provided under Section 26 08 00, Commissioning of Electrical Systems.
2. Provide Manufacturer's Certificate of Proper Installation.

B. Training Services:

1. Provide training of OWNER's personnel in accordance with Section 01 79 23.
2. Provide 0.5-person days of installation inspection and prestart up training, which shall be provided in one session.

END OF SECTION

SECTION 26 43 13

SURGE PROTECTIVE DEVICES (SPDs) 1000V OR LESS

PART 1 - GENERAL

1.1 SUMMARY

A. Provide SPD with electrical characteristics and ratings for service entrance equipment, switchboards, switchgear, motor control centers, and panelboards specified in the Division 26 electrical distribution equipment specification sections or indicated on the Drawings. Provide SPD with the same voltage, phase, 3 or 4 wire system as the host electrical equipment.

1.2 REFERENCES

A. Institute of Electrical and Electronics Engineers (IEEE):

1. C62.41 - Recommended Practice on Surge Voltages in Low Voltage AC Power Circuits.
2. C62.45 - Guide on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits.
3. C62.62 - Standard Test Specifications for Surge Protective Devices for Low Voltage AC Power Circuits.

B. Underwriters Laboratory: 1449, Standard for Surge Protective Devices.

C. National Fire Protection Association (NFPA): 70, Electrical Code (NEC).

1.3 SUBMITTALS

A. Action Submittals:

1. Provide verification that the SPD complies with the required ANSI/UL 1449 3rd Edition listing by Underwriters Laboratories (UL) or other Nationally Recognized Testing Laboratory (NRTL).
2. Compliance: File number verified on UL's website or other NRTL's website, with the following information:
    a. Model number
    b. SPD Type
    c. System voltage, phases
    d. Protection modes
    e. Voltage Protection Rating (VPR)
    f. Nominal Discharge Current (In).
    g. Name of nationally recognized testing lab that performed the test.
3. For side mount mounting applications (SPD mounted external to electrical assembly), electrical/mechanical drawings showing unit dimensions, weights, installation instruction details, and wiring configuration.
4. Final Record as-built drawings and information.
5. Operation and maintenance manuals shall be provided with each SPD shipped.

1.4 SPECIAL WARRANTY

A. Manufacturer shall warrant against defects in materials and workmanship for ten years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly unless noted otherwise.

B. The manufacturer shall be ISO 9001 or ISO 9002 certified for the equipment specified herein.

C. The manufacturer shall have produced similar electrical equipment for a minimum period of five years.

D. The listing of manufacturers does not imply acceptance of products that do not meet the specified ratings, features, and functions. Manufacturers listed shall meet the specifications in their entirety.

E. Manufacturers:

1. Square D, Surelogic
2. Eaton, SPD Series
3. General Electric, Tranquell
4. Or approved equivalent

2.2 SURGE PROTECTIVE DEVICES

A. Electrical requirements:

1. SPD ratings are to be consistent with the nominal system operating voltage, phase, and configuration as indicated on the Drawings.
2. MCOV:
   a. For the SPD and all components in the suppression path (including all MOVs, SADs, and selenium cells): Greater than 115 percent of the nominal system operating voltage.
3. Operating frequency:
   a. 47 to 63 hertz.
4. SCCR:
   a. Not less than the equipment it is connected to as indicated on the Drawings.
   b. The SCCR shall be marked on the SPD in accordance with UL 1449 and the NEC.
5. Power Filter: Include a high-frequency extended range power filter for each SPD complimentary listed to UL 1283 as an electromagnetic interference filter.
6. Provide UL type 2 SPD's.
7. Maximum VPR:

Modes	240/120	208Y/120	480Y/277
L-N, L-G, N-G	800	800	1,200
L-L	1,200	1,200	2000

B. Protection modes:

1. Provide SPD protection modes as follows:
   a. Line to Neutral (L-N) where applicable.
   b. Line to Ground (L-G).
   c. Neutral to Ground (N-G), where applicable.

C. Environmental requirements:

1. Storage temperature:
   a. -40 degrees to +50 degrees Celsius.
2. Operating temperature:
   a. -0 degrees to +60 Celsius.
3. Relative humidity:
   a. 5 percent to 95 percent.
4. Audible noise:
   a. Less than 45 dBa at 5 feet (1.5 m).
5. Operating altitude:
   a. Zero to 12,000 feet above sea level.

D. Enclosure:

1. Located in electrical equipment as indicated on the Drawings.

E. Internal connections:

1. Provide low impedance copper plates for intra-unit connections:
    a. Attach surge modules using bolted connections to the plates for low impedance connections.
2. Size all connections, conductors, and terminals for the specified surge current capacity.

F. Surge diversion modules:

1. MOV:
    a. Where multiple MOVs are used in parallel, utilize computer matched MOVs to within 1-volt variance and tested for manufacturer's defects.

G. Overcurrent protection:

1. Individually fuse all components, including suppression, filtering, and monitoring components:
    a. Rated to allow maximum specified nominal discharge current capacity.
    b. Overcurrent protection that limits specified surge currents is not acceptable.

H. Connections:

1. Provide terminals to accommodate wire sizes up to #2 AWG.

I. Unit status indicators:

1. Provide red and green solid-state indicators, with printed labels, on the front cover to redundantly indicate on-line unit status:
    a. The absence of the green light and the presence of the red light indicate that surge protection is reduced, and service is needed to restore full operation.
    b. Indicates the status of protection on each mode or phase.

J. Dry contacts for remote monitoring:

1. Electrically isolated Form C dry contacts (1 A/125 VAC) for remote monitoring of system integrity, and indication of under voltage, phase and/or power loss.

K. Provide transient counter to count transient voltage surges:

1. LCD readout located on the unit’s front cover.
2. Counter to utilize batteries with a 10-year nominal life or non-volitile memory to maintain accurate counts in the event of power loss.

L. Provide surge protective devices that are suitable for application in IEEE C62.41 Category A, B and C3 environments, as tested to IEEE C62.45.

M. Verify SPD’s are compatible with active harmonic filters.

2.3 PANELBOARDS

A. Provide SPD meeting IEEE C62.41.1 and IEEE C62.41.2 location in accordance with Category B.

B. Surge Current Capacity:

1. Distribution: 120 kA per phase, minimum; 60 kA per mode.
2. Branch: 80kA per phase; 40kA per mode

C. Nominal discharge current I_n: 10 kA.

D. SPD shall not limit the use of through-feed lugs, sub-feed lugs, and sub-feed breaker options.

E. SPD's installed following the load side of the main breaker and in main lug only panelboards installed following the incoming main lugs.

F. SPD interfaced to the panelboard via a manufacturer sized circuit breaker for disconnecting purposes shall be installed using short lengths of conductors integrally to the SPD and located directly adjacent to the circuit breaker.

G. SPD shall be mounted within the panelboard by the manufacturer.

H. Panelboard including the SPD shall be UL67 listed.

2.4 SERVICE ENTRANCE SWITCHGEAR, SWITCHBOARD, AND MCC

A. Provide SPD meeting IEEE C62.41.1 and IEEE C62.41.2 location in accordance with Category C.

B. Surge Current Capacity: 200 kA per phase; 100 kA per mode.

C. Nominal discharge current I_n: 20 kA.

D. SPD shall be factory installed inside or adjacent to the switchgear, switchboard, MCC, and/or bus plug at the assembly point by the original equipment manufacturer. Location of SPD shall be such that it does not require de-energization of switchgear, switchboard, MCC or panelboard for replacement.

E. Locate SPD on the load side of the main disconnect device, close to the phase conductors and the ground/neutral bar.

F. SPD connected through a circuit breaker or fused disconnect with current limiting fuses located in immediate proximity to SPD. Connection shall be made via bus, conductors, or other connections originating in the SPD shall be as short as possible per the factory specifications.

G. Monitoring and diagnostic features shall be visible on the front of equipment.

PART 3 - EXECUTION

3.1 GENERAL

A. Host equipment Manufacturer's representative shall visit the site, verify installation and testing, and verify that the SPD equipment and SPD installation meets intent of the Contract Documents and manufacturer's warranties and that the guarantees are in effect.

3.2 INSTALLATION

A. Install according to manufacturer's recommendations.

B. Lead lengths shall not exceed manufacturer's recommendation.

C. Electrical equipment manufacturer shall authorize and perform bus taps connections, as necessary.

END OF SECTION

SECTION 26 50 00
LIGHTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Solid-state luminaires that use LED technology.
2. Lighting fixture supports.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Canadian Standards Association (CSA).
2. Certified Ballast Manufacturer (CBM).
3. Federal Communications Commission (FCC).
4. Illuminating Engineering Society of North America (IESNA).
5. Institute of Electrical and Electronics Engineers (IEEE): C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
6. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
7. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC) – Softbound Version.
8. Underwriters Laboratories, Inc. (UL):
    a. 1598, Luminaires.
    b. 595, Marine-Type Electric Lighting Fixtures.
    c. 844, Electric Lighting Fixtures for Use in Hazardous (Classified) Locations.
    d. 924, Emergency Lighting and Power Equipment.
    e. 8750, Light Emitting Diode (LED) Equipment For Use in Lighting Products.

1.3 SUBMITTALS

A. Action Submittals:

1. General:
    a. Mounting and suspension details.
    b. Arrange in order of luminaire designation.
    c. Include data on features, accessories, and finishes.
    d. Include physical description and dimensions of luminaires.
    e. Include emergency lighting units, including batteries and chargers.
    f. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
    g. Photometric data and adjustment factors based on laboratory tests.
2. Shop Drawings:
    a. Interior Luminaires:
        1) Catalog data sheets and pictures.
        2) Luminaire finish and metal gauge.
        3) Lens material, pattern, and thickness.
        4) Candle power distribution curves in two or more planes.
        5) Candle power chart 0 degrees to 90 degrees.
        6) Lumen output chart.

7) Average brightness data in foot lamberts.
8) Coefficient of utilization for zonal cavity calculations.

b. Exterior Luminaires:
1) Catalog data sheets and pictures.
2) Luminaire finish and metal gauge.
3) Lens material, pattern, and thickness.
4) IESNA lighting classification and isolux diagram.
5) Distribution data according to classification type as defined in IESNA HB-9.
6) Fastening details to wall or pole.
7) Light pole catalog data sheets including wind loading, complete dimensions, and finish.

c. Lighting Contactors:

d. Photocells:
1) Voltage, and power consumption.
2) Capacity.
3) Contacts and time delay.
4) Operating levels.
5) Enclosure type and dimensions.
6) Temperature range.

e. Occupancy Sensors:
1) Type.
2) Switching capacity.
3) Coverage.
4) Time delay AUTO/OFF adjustment.

3. Samples: Submit Samples of each substituted luminaire if requested by Engineer**.**

B. Informational Submittals:

1. Seismic anchorage and bracing calculations.
2. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.
a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Sample warranty.

C. Closeout Submittals:

1. Operation and maintenance data. For luminaires and lighting systems to include in operation and maintenance manuals.
a. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.
b. Provide a list of all photoelectric relay types used on Project; use manufacturer’s codes.

1.4 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.

2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

B. Preinstallation Meeting:

1. Occupancy Sensors: Arrange preinstallation meeting with manufacturer's factory authorized representative at Owner's facility, to verify placement of sensors and installation criteria.

1.5 DELIVERY, STORAGE, AND HANDLING

A. General:

1. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

B. Poles:

1. Manufacturer's standard provision shall be made for protecting the finish during shipment and installation. Minimum protection shall consist of spirally wrapping each pole shaft with protective paper secured with tape and shipping small parts in boxes.
2. Do not store poles on ground.
3. Support poles so they are at least 1 foot above ground level and growing vegetation.
4. Do not remove factory-applied pole wrappings until just before installing pole.
5. Ship poles with bolt circle template, base cover, handhold cover, and shaft cap or tenon.

1.6 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Structural failures, including luminaire support components.
   b. Faulty operation of luminaires and accessories.
   c. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires and lamps shall be labeled vibration and shock resistant.

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified and the luminaire will be fully operational during and after the seismic event."

2.2 LUMINAIRES REQUIREMENTS

A. Specific performance requirements relative to execution of the Work are in Luminaire Schedule on Drawings. All luminaires shall be LED, unless noted otherwise.

B. Component Access: Accessible and replaceable without removing luminaire from its mounting.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

E. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

F. Recessed Fixtures: Comply with NEMA LE 4.

G. Bulb shape complying with ANSI C79.1.

H. Lamp base complying with ANSI C81.61 or IEC 60061-1.

I. CRI, CCT, and rated lamp life shall meet or exceed those listed in the Luminaire Schedule.

J. L70 lamp life of 50,000 hours.

K. Lamps dimmable from 100 percent to 0 percent of maximum light output.

L. Internal driver.

M. Nominal Operating Voltage: As shown on Drawings.

N. Feed-through type, or separate junction box.

O. Wire Leads: Minimum 18 AWG.

P. Component Access: Accessible and replaceable without removing luminaire from ceiling.

Q. Hazardous Classified Areas:

1. UL labeled: CLASS 1, DIVISION 1, GROUPS C AND D.
2. Fixture Enclosure and Fittings: Copper-free, cast aluminum in accordance with UL 844.

R. Soffit Installations: UL labeled SUITABLE FOR WET LOCATIONS

S. Exterior Installations: UL Labeled: SUITABLE FOR WET LOCATIONS. When factory-installed photocells are provided, entire assembly shall have UL label.

T. Emergency Lighting:

1. Power Pack: Self-contained, 120/277-volt dual voltage transformer, inverter/charger, sealed battery, and indicator switch in accordance with UL 924.
2. Lighted, push-to-test indicator.
3. Capable of providing full illumination for 1-1/2 hours in emergency mode.
4. Capable of full recharge in 24 hours, automatically upon resumption of normal line voltage.
5. Capable of protecting against excess charging and discharging.
6. Emergency Self-Diagnostic System:
    a. Solid state device with LED display and audible alarm.
    b. Automatic and manual test unit.
    c. Test for malfunction of lamps, battery, and charger board.
    d. Manufacturer: Lithonia.

2.3 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.
4. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.
5. Housings:
    a. Rigidly formed, weather and light-tight enclosure that will not warp, sag, or deform in use.
    b. Provide filter/breather for enclosed outdoor luminaires.
6. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

a. Label shall include the following lamp characteristics:
    1) "USE ONLY" and include specific lamp type.
    2) Lamp diameter, shape, size, wattage, and coating.
    3) CCT and CRI for all luminaires.

2.4 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Match finish process and color of pole or support materials.

2.5 LUMINAIRE FIXTURE SUPPORT COMPONENTS

A. Comply with requirements in Section 26 05 04 for supports. Use materials appropriate for the area as specified in Section 26 05 00.

B. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

C. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.

D. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

2.6 IN-LINE FUSE HOLDER AND FUSE

A. Fuse Holder:

1. General: Waterproof, of corrosion-resistant material.
2. Rating: 600 volts.

B. Fuse:

1. General: Midget, dual element.
2. Rating: 5-amp, voltage as required by application.

C. Manufacturer: Methods Electronics Inc. Network, Buss Div.

2.7 EQUIPMENT IDENTIFICATION

A. Manufacturer’s Nameplate: Each item of equipment shall have a nameplate bearing manufacturer’s name, address, model number, and serial number securely affixed in a conspicuous place; nameplate of distributing agent will not be acceptable.

B. Markings shall be clear and located to be readily visible to service personnel.

2.8 FACTORY FINISH

A. Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

2.9 SPARE PARTS

A. The Contractor shall supply the following spare parts for use by the Owner. These are to be boxed and labeled with the applicable fixture type on them and delivered to the Owner upon the completion of the project.

1. One spare LED driver for each fixture type.
2. One spare emergency driver for each fixture type.

PART 3 - EXECUTION

3.1 LUMINAIRES

A. General:

1. Install in accordance with manufacturer's recommendations.
2. Provide proper hangers, pendants, and canopies as necessary for complete installation and meeting specified seismic requirements.
3. Provide additional ceiling bracing, hanger supports, and other structural reinforcements to building and to pole concrete bases required to safely mount.
4. Install plumb and level.
5. Install each luminaire outlet box with galvanized stud.

B. Mounting:

1. General:
    a. Mounting, fastening, and environmental conditions shall be coordinated.
2. Wall Mounted: Measure mounting heights from center of mounting plate to finished floor or finished grade, whichever is applicable.
3. Pendant Mounted:
    a. Provide swivel type hangers and canopies to match luminaires, unless otherwise noted.
    b. Space single-stem hangers on continuous-row fluorescent luminaires nominally 48 inches apart.
    c. Provide twin-stem hangers on single luminaires.
    d. Measure mounting heights from bottom of luminaire to finished floor or finished grade, whichever is applicable.
4. Pole Mounted:
    a. Provide cast-in-place concrete base.
    b. Poles in straight runs shall be in a straight line.
    c. Provide branch circuit in-line fuses in pole base handhole.

C. Swinging Type: Provide, at each support, safety cable capable of supporting four times vertical load from structure to luminaire.

D. Unfinished Areas: Locate luminaires to avoid conflict with other building systems or blockage of luminaire light output.

1. Fixture Suspension: Provide 1/4-inch threaded steel hanger rods. Scissor type hangers not permitted.
2. Attachment to Steel Beams: Provide flanged beam clips and straight or angled hangers.

E. Building Exterior: Flush-mounted back box and concealed conduit, unless otherwise indicated.

F. Grounding: Ground noncurrent-carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures as specified in Section 26 05 26, Grounding and Bonding for Electrical Systems. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

3.2 EMERGENCY LIGHTING UNIT

A. Install in accordance with manufacturer's recommendations.

B. Provide permanent circuit connections with conduit and wire.

C. Connect to branch circuit feeding normal lighting in area ahead of all local switches.

D. Provide separate circuit wiring to luminaire.

3.3 FIELD QUALITY CONTROL

A. Upon completion of installation, verify equipment is properly installed, connected, and adjusted. Conduct an operating test to show equipment operates in accordance with the requirements of this section.

B. Coordinate lighting and controls installation and testing with commissioning.

3.4 CLEANING

A. Remove labels and markings, except UL listing mark.

B. Wipe luminaires inside and out to remove construction dust.

C. Clean luminaire plastic lenses with antistatic cleaners only.

D. Touch up painted surfaces of luminaires and poles with matching paint ordered from manufacturer.

E. Replace defective lamps at time of Substantial Completion.

END OF SECTION

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DIVISION 31

EARTHWORK

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SECTION 31 10 00
SITE CLEARING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Site clearing Work, including:
    a. General provisions for site clearing Work.
    b. Preparation for site clearing Work.
    c. Clearing and grubbing.
    d. Tree protection, selective removals, and selective trimming.
    e. Disposal and cleaning.
    f. Stripping and stockpiling of topsoil.

B. Related Requirements: Include but are not necessarily limited to:

1. Section 02 41 00 - Demolition.
2. Section 31 23 00 - Earthwork.
3. Section 31 23 33 - Trenching, Backfilling, and Compacting for Utilities.

1.2 REFERENCES

A. Terminology:

1. Terms indicated below are not defined terms indicated with initial capital letters but, when used in this Section, have the meanings indicated below:
    a. “Arborist” means Subcontractor retained to perform Work requiring a specialist in trees, shrubs, brush, other vegetation of the types existing at the Site, and possessing not less than the required qualifications indicated in this Section.
    b. “Clearing and grubbing” means removing and disposing of all: (1) trees, brush, and other vegetation, logs, and similar items (“clearing”); and (2) stumps, roots, logs, rubbish, and debris on or in the soil (“grubbing”) after Clearing. Clearing and grubbing includes grinding and removing of stumps. When clearing and grubbing, topsoil stripping and stockpiling, and required demolition Work is complete, the Site will be ready for grading and other new construction.
    c. “Demolition” means removal, whether in whole or in part, of existing human-made construction, such as removal of buildings, structures, and building systems; site work (such as pavement, curbs, sidewalks, gutters) and the like; Underground Facilities; and other existing construction.
    d. “Selective removal” means removal of specific trees, shrubs, brush, and other vegetation, whether as shown or indicated in the Contract Documents or as directed at the Site by Engineer.
    e. “Selective trimming” means removal of selected parts of trees, shrubs, brush, and other vegetation, performed by arborist, for the purpose of either: (1) allowing installation of new construction adjacent to or through the tree, shrub, brush, or vegetation, or)2) removing damaged or unhealthy growth, to allow balance of the subject tree, shrub, brush, or vegetation to continue normal, healthy growth.
    f. “Site clearing” means all the Work required by this Section and related Drawings.
    g. “Topsoil” means existing material at the Site, visible after clearing and grubbing, to be stripped, when such material is friable, clay loam, surface soil present in depth of not less than four inches. Topsoil shall be free of subsoil, clay lumps, stones, and other objects over two-inch diameter and other objectionable material. Topsoil required for

planting and landscaping Work in the Specifications of Division 32 may differ from the meaning indicated in this Section.

B. Reference Standards:

1. ASTM International (ASTM):
   a. C700, Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated.
   b. D448, Standard Classification for Sizes of Aggregate for Road and Bridge Construction.
2. American National Standards Institute (ANSI):.
   a. A300, Standard for Tree Care Operations – Tree, Shrub, and Other Woody Plant Maintenance – Standard Practices.
3. International Society of Arboriculture (ISA):
   a. Container Rootball Shaving.
   b. Crown Correction.
   c. Balled and Burlapped Root Correction.
   d. Container Root Correction.
   e. High Branched Crown Observation.
   f. Low Branched Crown Observation.
   g. Multiple Low Branches Crown Observation.
   h. Balled and Burlapped Root Observation.
   i. Container Root Observation - Tree.
   j. Protection Maintenance.

1.3 QUALITY ASSURANCE

A. Qualifications:

1. Arborist:
   a. Where selective removal, selective trimming, or both are required or necessary, retain the services of, and employ in the Work, accredited arborist, possessing qualifications acceptable to Engineer.
   b. Arborist shall be skilled, trained, and possess documented experience in successfully protecting, trimming, and restorative care of trees and shrubs of the types necessary for the Work.
   c. Certification: Arborist shall be certified by either International Society of Arboriculture (ISA) or American Society of Consulting Arborists (ASCA).
   d. Arborist shall use in selective removal and selective trimming Work only workers with specific skill and successful experience in this type of Work required. Such workers shall work under the direct, personal supervision of arborist.
   e. Submit to Engineer names, employer(s), certifications, other relevant qualifications and record of relevant experience, as indicated below, for not less than three successful projects involving same species of trees, shrubs, and vegetation as involved in the site clearing Work:
      1) Names and telephone numbers of site owners, architects or engineers responsible for projects.
      2) Approximate contract price of the selective removal and selective trimming of trees, shrubs, and vegetation.
      3) Approximate time of year work was performed on each referenced project.
      4) Approximate quantity and types of selective removal and selective trimming of performed.
      5) General indication of species of trees, shrubs, and vegetation involved.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:
    a. Limits of Site Clearing Work: When limits of site clearing Work are not expressly shown on the Drawings, or where Contractor proposes alternative limits of site clearing Work, submit drawings, developed from the Drawings, clearly indicating proposed limits of site clearing Work, with dimensions indicated where appropriate.
    b. Where proposed limits of clearing and grubbing, selective removals, and topsoil stripping are not identical with each other, clearly and expressly indicate limits of each on the Shop Drawings.

B. Informational Submittals: Submit the following:

1. Permits and Approvals:
    a. Submit copy of each permit required and obtained for site clearing Work, issued by authority having jurisdiction.
    b. Where Owner's permission or approval is required for selected site clearing activities, submit copy of Owner's written permission or approval for such activity.
    c. When approval of owner of property (other than Owner) is required for selected site clearing activity, submit to Engineer written copy of such approval.
2. Certificates:
    a. Arborist's certification that trees and shrubs shown or indicated to remain were protected during the site clearing Work in accordance with the Contract Documents.
    b. Where trees or shrubs (shown or indicated to remain) were damaged during site clearing Work, submit arborist's certification that such trees and shrubs were promptly and properly treated or, where successful treatment was not feasible, were replaced.
3. Qualifications Statements:
    a. Arborist qualifications.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Filter Fabric:

1. In accordance with requirements for temporary erosion and sediment controls indicated in Section 01 57 05 - Temporary Controls.

B. Drainage Fill:

1. Selected crushed stone, or crushed or uncrushed gravel, washed.
2. Size 24 (in accordance with ASTM D448), with 90 to 100 percent passing 2.5-inch sieve and not more than 10 percent passing 3/4-inch sieve.

C. Burlap:

1. Jute, not less than 7.2 ounces per square yard.

D. For other materials needed for site clearing Work, such as stone, topsoil, or other, comply with requirements of the Contract Documents.

PART 3 - EXECUTION

3.1 SITE CLEARING – GENERAL

A. Limits of Site Clearing Work:

1. Perform site clearing Work for all Work areas unless otherwise shown or indicated in the Contract Documents. Do not perform site clearing Work outside the limits of the areas required for new construction.

B. General Provisions for Site Clearing:

1. Contractor shall provide all labor, materials, equipment, tools, services, and incidentals necessary and required to perform site clearing Work in accordance with the Contract Documents.
2. Perform site clearing Work to avoid creating nuisances, pollution, and preventable adverse effects on the environment.
3. Comply with this Section's Article, "Tree Protection, Selective Removals, and Selective Trimming".
4. Excavation required for site clearing shall comply with Section 31 23 00 - Earthwork.
5. Requirements of Authorities Having Jurisdiction:
    a. Perform site clearing Work in accordance with Laws and Regulations.
    b. Obtain, pay for, and comply with permits required for site clearing Work. Obtain from authorities having jurisdiction and furnish copy of each permit as a Submittal.
6. Site clearing Work shall comply with ANSI A300 and applicable ISA standards indicated in this Section's "References" Article, unless the Contract Documents indicate more-stringent requirements.
7. Demolition Work is indicated in Section 02 41 00 - Demolition, including removal of site improvements and Underground Facilities.

3.2 PREPARATION

A. Permits and Approvals:

1. Do not commence site clearing Work until necessary permits and approvals are obtained and copies furnished to Engineer as Submittals.

B. Delineation of Limits of Site Clearing Work Areas:

1. Locate and clearly flag at the Site:
    a. Limits of site clearing Work.
    b. Trees, shrubs, vegetation, and other materials to remain within limits of site clearing Work.
    c. Trees, shrubs, and other vegetation to be selectively trimmed.
    d. Trees, shrubs, and vegetation to be selectively removed.
    e. Salvageable trees, shrubs, and vegetation (to be relocated) within limits of site clearing Work.
2. Flagging:
    a. Flagging shall be high-visibility type. Where necessary, provide lath or stakes driven into the ground, with flagging, to clearly delineate limits.
    b. Provide different-colored flagging for each type of delineation required by this Article.
    c. Promptly replace lost, moved, or destroyed flagging until Engineer concurs that flagging is no longer needed.
3. Review with Engineer:
    a. Before starting site clearing Work, other than flagging, review at the Site with Engineer.
    b. Make corrections as necessary.
    c. Review all trees, 12-inch diameter (measured one foot above ground) and larger, to be removed or selectively trimmed.
    d. Review with Engineer at the Site trees and shrubs to be selectively trimmed, to reach mutual agreement on extent of selective trimming required.

C. Protection: Establish protection of trees, shrubs, and vegetation to remain, in accordance with this Section's Article, "Tree Protection, Selective Removals, and Selective Trimming", and other applicable provisions of the Contract Documents.

D. Temporary Erosion and Sediment Controls:

1. Provide applicable temporary erosion and sediment controls before commencing clearing and grubbing and topsoil stripping Work.
2. Comply with temporary erosion and sediment control requirements of Section 01 57 05 - Temporary Controls.
3. Continue providing temporary erosion and sediment controls as clearing and grubbing and topsoil stripping and stockpiling Work progresses into previously uncleared, ungrubbed areas of the Site.

3.3 CLEARING AND GRUBBING

A. Clearing and Grubbing – General:

1. Remove and dispose of all materials constituting clearing and grubbing Work within limits shown and indicated in the Contract Documents.
2. After grubbing Work is complete, properly fill holes resulting from grubbing before commencing site grading Work.

B. Trees and Shrubs Improperly Destroyed or Damaged:

1. Refer to this Section's Article, "Tree Protection, Selective Removals, and Selective Trimming".

C. Trees and Shrubs to Remain:

1. Trees and shrubs to remain shall be protected, and trimmed where necessary or required, in accordance with this Section's Article, "Tree Protection, Selective Removals, and Selective Trimming".

3.4 TREE PROTECTION, SELECTIVE REMOVALS, AND SELECTIVE TRIMMING

A. General Provisions for Tree Protection, Selective Removals, and Selective Trimming:

1. Provide temporary fencing, barricades, or guarding measures, as recommended by arborist, outside drip line of trees and shrubs to remain.
2. Protect root systems from damage caused by noxious materials, storm water runoff, site clearing, planting and landscaping, other Work, and storage of materials and equipment. Protect root systems from flooding, erosion, and excessive wetting resulting from dewatering of excavations, drainage of tanks, and other construction activities.
3. Fires are not allowed under or adjacent to trees, shrubs, and other vegetation to remain.
4. Do not store matter resulting from site clearing or demolition, topsoil, or other excavated material within drip line of trees and shrubs to remain. Vehicles are not allowed within drip line. Restrict foot, vehicle and equipment traffic to prevent compaction of soil over root systems. Where such activities are unavoidable, and only as acceptable to Engineer, provide temporary, continuous, heavy-duty wood planking effectively fastened together and capable of distributing loads from such activities. Temporary planking shall be underlaid by layer of filter fabric covered with two-inch layer of gravel.
5. Cut branches and roots, when necessary, with sharp pruning instruments; do not break or chop. Fully paint cuts 1/2-inch and larger in size with tree wound dressing.

B. Excavation and Protection of Trees and Shrubs:

1. Excavate within drip line of trees only where shown.
2. Where trenching for utilities is required within drip line, tunnel under or around main lateral feeder roots by drilling, auger boring, pipe jacking, or digging by hand under supervision of arborist. Do not cut main lateral roots or tap roots; cut smaller roots, which interfere with installation of the Work.
3. Where excavation for the Work is required within drip line of trees or shrubs, hand excavate to minimize damage to root systems. Perform excavation under supervision of arborist. Provide temporary shoring or other protective support systems at excavations, to minimize sloping and benching of excavations. Use narrow tine spading forks and comb excavated material to expose roots.

4. Relocate roots in backfill areas wherever possible. If large, main lateral roots are encountered, expose beyond excavation limits as required to bend and relocate without breaking. If encountered immediately adjacent to location of construction and relocation is not practical, cut roots approximately three inches back from construction.
5. Do not allow exposed roots to dry out before permanent backfill is provided; provide temporary earth cover. Water and maintain in moist condition and temporarily support and protect from damage until permanently relocated and covered with earth.

C. Grade Adjustments and Tree Protection:

1. Maintain existing grade within drip line of trees, unless otherwise shown or indicated.
2. Lowering of Preconstruction Grade:
   a. Where proposed finish grade is required below preconstruction grade around trees and shrubs to remain, slope the grade away from trees and shrubs as recommended by arborist.
   b. Prune tree and shrub roots exposed during grade lowering, or provide permanent protections as recommended by arborist. Do not cut main or lateral roots or tap-roots; cut only smaller roots.
   c. Compensate for loss of roots and prune branches to stimulate root growth.
   d. Provide extended service through completion of the Contract correction period as recommended by arborist.
3. Minor Fills:
   a. Where preconstruction grade is six inches or less below elevation of finish grade shown, fill with topsoil complying with quality requirements of Specifications for finish grading and landscaping.
   b. Place in single layer and do not compact.
   c. Hand-grade to required finish elevations.
4. Moderate Fills:
   a. Where preconstruction grade is more than six inches, but less than 16 inches, below finish grade elevation, provide layer of drainage fill and filter fabric on preconstruction grade prior to placing topsoil that complies with quality requirements of Specifications on finish grading and landscaping.
   b. Carefully place drainage fill against trunk of tree or shrub approximately two inches above elevation of finish grade and extend not less than 1.5 feet from tree or shrub trunk on all sides.
   c. Provide filter fabric with edges overlapping by 6 inches, minimum.
   d. Place fill layer of topsoil to finish grade elevation.
   e. Do not compact stone, gravel or topsoil layers. Hand-grade to required finish elevations.
5. Deep Fills:
   a. Provide an open dry circular well of durable, unmortared stone, located not less than two feet from trunk of associated tree or shrub.
   b. To facilitate proper drainage, provide eight to 10 continuous runs of four-inch drain tiles horizontally on the preconstruction ground surface under the complete spread of branches in radial pattern around the tree or shrub.
   c. Slope drain tiles away from tree or shrub.
   d. Provide drainage fill on preconstruction ground surface in depth of two inches under and six inches over drain tiles.
   e. Provide filter fabric over entire top surface of drainage fill.
   f. Provide eight to 10 drainage tiles, each four-inch diameter, vertically in radial pattern around tree or shrub, located five feet from trunk of tree or shrub. Extend vertical drainage tiles from the filter fabric layer above the horizontal drainage tiles to postconstruction finished grade.

g. Hold drainage tiles in place with drainage fill.
h. Hand-grade to required finish grade elevation.

D. Tree and Shrub Pruning (Selective Trimming):

1. Perform pruning and selective trimming under the supervision of arborist.
2. Remove branches from trees and shrubs to remain only after Engineer's concurrence, only to extent necessary to clear location of permanent construction, using branch removal methods in accordance with ANSI A300 and applicable ISA standards indicated in this Section's "References" Article.
3. Extend pruning operation to restore natural shape of entire tree or shrub where pruning is approved by Engineer and as recommended by arborist.
4. Prune branches to balance loss to root system caused by damage or cutting of root system.
5. Chip branches removed from trees and shrubs. Stockpile and spread chips as directed by Engineer, with arborist's recommendation.

E. Selective Trimming:

1. In addition to pruning (as required above), perform other selective trimming under direction of arborist.
2. Comply with ANSI A300 and applicable ISA standards indicated in this Section's "References" Article.
3. Where shown or indicated, and as directed by Engineer with arborist's recommendation, carefully remove larger branches, when necessary, using appropriate methods.
4. Repair cut branches in accordance with this Section.
5. During selective trimming, avoid damaging healthy (to remain) elements of trees and shrubs.
6. Dispose of trimmings as indicated in this Section's "Disposal and Cleaning" Article.

F. Selective Removals:

1. Perform selective removals under direction of arborist.
2. Comply with ANSI A300 and applicable ISA standards indicated in this Section's "References" Article.
3. Fully remove trees and shrubs shown or indicated for selective removal.
4. Remove stumps to not less than one feet below preconstruction ground surface.
5. During selective removals, avoid damaging adjacent trees and shrubs to remain, and other property.
6. Remove larger branches before cutting the trunk of tree or shrub being selectively removed.
7. Dispose of trees and shrubs selectively removed as indicated in this Section's "Disposal and Cleaning" Article.

G. Repair and Replacement of Trees and Shrubs:

1. Perform tree and shrub repair under direction of arborist.
2. Cavity Repair:
   a. Remove decayed areas to depth that exposes healthy tissue.
   b. Shape cavities to provide drainage.
   c. Paint inside of cavity with antiseptic tree wound dressing material.
   d. Do not fill cavities.
   e. When cavity's cross-section exceeds 60 percent of cross-section of tree or shrub branch, selectively trim subject branch. When cavity's cross-section exceeds 60 percent of cross-section of trunk of tree or shrub, remove tree or shrub upon Engineer's authorization. Engineer will consider arborist's recommendation. Comply with this Section's requirements for selective trimming and selective removals.

3. Repair trees and shrubs damaged by construction operations, or selectively trimmed, within 24 hours of occurrence of such damage or selective trimming. Treat damaged trunks, branches, and roots according to written instructions of arborist, in accordance with ANSI A300 and applicable ISA standards indicated in this Section's "References" Article.
4. Remove and replace trees and shrubs that are (1) dead or destroyed due to construction operations, or (2) damaged beyond reasonable hope of recovery (as determined by arborist) following repairs, or (3) damaged and determined by arborist to be incapable of resuming normal growth pattern after repairs.,
5. Obtain opinion from arborist regarding whether damaged trees, shrubs, and other vegetation is repairable with reasonable chance of success. Submit arborist's certification required in this Section's "Submittals" Article.
6. For each tree or shrub to remain but is destroyed or damaged (beyond repair) by Contractor:
    a. For trees 8 inches or more in diameter (measured one foot above preconstruction ground surface), provide two replacements of the same species. Each replacement shall be four inches diameter (measured one foot above top of root ball).
    b. For trees smaller than 8 inches diameter, and for shrubs, provide one replacement for each, of same species. Replacements shall be equal in size to original, up to maximum oof four inches (measured one foot above root ball).
    c. Provide replacement at locations at the Site as directed by Engineer.
    d. Provide replacements in accordance with the Contract Documents, including Specifications on planting and landscaping.

3.5 DISPOSAL AND CLEANING

A. Disposal – General:

1. Dispose of matter resulting from clearing and grubbing, selective removals, and selective trimming, at appropriate offsite location, unless otherwise expressly allowed by the Contract Documents or mutual agreement of Owner and Contractor.
2. Do not use cleared, grubbed, or trimmed material as fill, backfill, or in embankments.
3. Dispose of cleared, grubbed, and trimmed material, and other materials, rubbish, and debris, in accordance with Laws and Regulations.
4. Pay all costs associated with transporting and disposing of materials and debris resulting from site clearing Work.
5. Cleared lumber and trimmings from trees are Contractor's property and, at Contractor's option, may be sold or salvaged offsite.

B. Cleaning:

1. Perform progress cleaning and other cleaning Work, and disposal of resulting materials and debris, in accordance with Section 01 74 00 - Cleaning.

C. Burning:

1. Burning of trees, shrubs, brush, other vegetation, and other materials at, or adjacent to, the Site, whether in-place or cut, is prohibited unless: (a) burning is not prohibited by Laws or Regulations, and (b) required permits, if any, are obtained by Contractor from authorities having jurisdiction and are furnished to Engineer as Submittals; and (c) written approval of Owner is obtained and furnished to Engineer as a Submittal; and (d) when burning will be performed on lands at the Site not owned by Owner, obtain and submit to Engineer as Submittals written approval of owners of such properties.
2. Before burning, alert local fire department (both orally and in writing) not less than 72 hours before burning, and provide at location of burning appropriate emergency materials, tools, and equipment to contain and extinguish fires. Use such items and furnish necessary labor to prevent fire from burning other than intended trees, shrubs, brush, and vegetation.

3. If burning is allowed, exercise appropriate care and judgement. Do not perform burning in high wind conditions. Do not perform burning when areas adjacent to burning are of dryness that will foster wildfires.
4. Promptly and fully extinguish fires before they burn unintended areas or materials, and when burning is completed.
5. Dispose of ashes and burned materials off-site at appropriate location.

3.6 TOPSOIL STRIPPING AND STOCKPILING

A. Stripping:

1. Before commencing topsoil stripping:
   a. Perform clearing and grubbing and selective removals.
   b. Remove grass and other vegetation that may remain following clearing and grubbing.
   c. Provide necessary and required temporary erosion and sediment controls.
2. Strip topsoil to depths encountered, in manner that prevents intermingling of topsoil with underlying subsoil and other objectionable material. Remove heavy growths of grass and vegetation and material below topsoil.
3. Before stockpiling, separate objectionable material from topsoil.
4. Do not strip topsoil from within drip line of trees and shrubs to remain as part of the completed Project.

B. Stockpiling:

1. Construct and maintain topsoil stockpiles in accordance with Section 01 66 00 - Product Storage and Handling Requirements, at locations in accordance with Section 01 14 19 - Use of Site.

C. Reuse of Stripped Topsoil:

1. Reuse in the finish grading and landscaping Work topsoil that complies with the Contract Documents for such Work.
2. Where topsoil stripped from the Site does not comply with the Contract Documents relative to quality required for use in finish grading and landscaping Work, provide appropriate soil amendment material, properly and fully mixed into topsoil stripped from the Site, so that amended material complies with quality requirements for topsoil required for finish grading and landscaping Work.

D. Disposal of Excess Topsoil:

1. Topsoil in excess of quantity required for the finished Project is Owner's property and shall be stockpiled onsite at location designated by Owner, in accordance with stockpiling requirements of Section 01 66 00 - Product Storage and Handling Requirements.

END OF SECTION

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SECTION 31 22 19
FINISH GRADING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Topsoil quality and placing.
2. Finish grading.

B. Related Requirements: Include, but are not necessarily limited to, the following:

1. Section 31 10 00 - Site Clearing.
2. Section 31 23 33 - Trenching, Backfilling and Compacting for Utilities.
3. Section 32 92 00 - Seeding, Sodding and Landscaping.

1.2 PRICE AND PAYMENT PROCEDURES

A. Measurement and Payment:

1. Perform the Work of this Section for all areas within limits of grading and all areas outside limits of grading disturbed during construction.
2. Perform the Work of this Section as part of the Lump Sum bid/pay item(s) indicated in the Contract.

1.3 REFERENCES

A. Reference Standards:

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. T194, Standard Method of Test for Determination of Organic Content of Soils by Loss on Ignition.
2. ASTM International (ASTM):
   a. D2974, Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils.
   b. D4221, Standard Test Method for Dispersive Characteristics of Clay Soil by Double Hydrometer.
   c. D4972, Standard Test Methods for pH of Soils.
   d. D5268, Standard Specification for Topsoil Used for Landscaping and Construction Purposes.
   e. D6913, Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis.
   f. D7928, Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis.
   g. E329, Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection.

1.4 QUALITY ASSURANCE

A. Qualifications:

1. Contractor's Testing Laboratory:
   a. Retain the services of independent testing laboratory to perform testing and determine compliance with the Contract Documents of materials specified in this Section.
   b. When Contractor is expressly required, by this Section's "Quality Assurance" Article, "Source Quality Control" Article or elsewhere in the Contract Documents, to retain testing laboratory for tests required under this Section's "Quality Assurance" Article or

"Source Quality Control" Article, retain one testing laboratory for quality assurance testing and field quality control testing.

c. Testing laboratory shall comply with ASTM E329.

d. Testing laboratory shall be experienced in the types of testing required.

e. Selection of testing laboratory is subject to Engineer's acceptance. Upon Engineer's request, submit qualifications statement for testing laboratory, including name of entity, location, copies of applicable certifications, summary of entity's experience, and names and qualifications of personnel who will perform the subject sampling and testing.

B. Quality Assurance Testing:

1. Quality assurance testing, which may also be regarded as source quality control testing when topsoil to be installed will be topsoil originally stripped from the Site, is in addition to field quality control activities required by this Section's "Field Quality Control" Article.
2. Allow free access to material stockpiles and borrow areas at all times. Tests shall be at Contractor's cost.
3. Contractor's Testing Laboratory Scope:
   a. Obtain samples and perform testing of proposed topsoil materials, whether obtained from offsite borrow sources or stockpiled topsoil originally stripped from the Site, to provide assurance that the Work will comply with the Contract Documents.
4. Required Quality Assurance Material Testing by Contractor's Testing Laboratory:
   a. Perform the following quality assurance tests for every 1,000 cubic yards of topsoil, or part thereof, to be incorporated into the Work. Submit results of such tests to Engineer and obtain Engineer's acceptance thereof prior to incorporating the subject topsoil into the Work.
      1) Gradation in accordance with ASTM D6913 and D7928.
      2) Clay content in accordance with ASTM D4221.
      3) pH in accordance with ASTM D4972.
      4) Organic content in accordance with ASTM D2974 or AASHTO T194.

1.5 SUBMITTALS

A. Action Submittals: Submit the following:

1. Product Data:
   a. Borrow Soil Materials: Name and address of Supplier of borrow soil materials, gradation, and Supplier's certification that materials are sufficiently free of Constituents of Concern so that a Hazardous Environmental Condition will not be created or exacerbated.
   b. If no soil materials will be obtained from any borrow location, expressly so indicate to Engineer in writing.
2. Samples:
   a. Submit Sample of topsoil material required by this Section. Furnish Samples in durable, tightly-sealed containers; plastic bags are unacceptable. Samples shall be of sufficient quantity and material size to demonstrate the array of gradation and material types expected in the Work.

B. Informational Submittals: Submit the following:

1. Quality Assurance Test Results Submittals:
   a. Submit results of quality assurance testing performed in accordance with this Section's "Quality Assurance" Article, unless included as part of another submittal under this Section.
      1) Tests on materials from onsite and borrow sources.
2. Qualifications Statements:
   a. Quality assurance testing laboratory, when requested by Engineer.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Topsoil:

1. All soil accepted as topsoil, whether obtained from onsite or offsite sources, shall comply with requirements of this Section.
2. Topsoil Source: Reuse surface soil stockpiled on Site, where possible. Verify suitability of stockpiled surface soil to produce topsoil, as specified. Clean surface soil of roots, plants, sod, stones, clay lumps, and other extraneous materials harmful to plant growth.
    a. Supplement acceptable onsite soil with manufactured topsoil from offsite sources, when quantities available on-Site are insufficient to complete the Work.
    b. When existing soil material stripped from the Site and stockpiled does not comply with requirements of this Section, such soil may be provided as topsoil when addition of amendments and fertilizers will bring such soil material into compliance with this Section's topsoil requirements. Furnish to Engineer written advisory of Contractor's intent to amend existing soil materials to be compliant with topsoil requirements.
3. Provide fertile, friable, natural loam, surface soil, capable of sustaining vigorous plant growth; free of any admixture of subsoil, clods of hard earth, plants or roots, sticks, stones larger than 3/8 inch diameter, or other extraneous material harmful to plant growth, in compliance with ASTM D 5268.
4. Provide topsoil of the following characteristics:
    a. Required gradation:

Sieve Size	Percent Passing
3/4 inch mesh	100
No. 4-sieve	90 to 100
No. 200-sieve	0 to 10

    b. Clay content of material passing No. 200-sieve shall be not greater than 60 percent, as determined by hydrometer tests.
    c. pH-adjusted with ferrous sulphate or ground limestone to provide pH 5.5 to 7.0 at time of installation of lawns and meadow areas, unless particular species of planting requires a different pH for optimal growth.
    d. Electrical conductivity of a 1:2 soil-water suspension shall not exceed 1.0 milliohm per centimeter and with less than 200 parts per million of extractable aluminum.
    e. Cation Exchange Capacity: 5, minimum.
    f. Organic content not less than five percent, as determined by ignition loss of oven-dried samples passing No. 10-sieve (Muffle Furnace Temperature: 110 plus or minus five degrees C for eight hours).
    g. Free of pests and pest larvae.
    h. Relative to Constituents of Concern, topsoil shall be in accordance with Laws and Regulations. Constituents of Concern, if any, in topsoil furnished shall not constitute or result in a Hazardous Environmental Condition.

B. Topsoil Amendments and Fertilizer

1. Requirements for topsoil amendments and fertilizer, together with other planting materials, are in Section 32 92 00 - Seeding, Sodding, and Landscaping.
2. Provide planting soil by adding amendments, fertilizer, and other materials to topsoil and other suitable soil materials in accordance with Section 32 92 00 - Seeding, Sodding, and Landscaping, as necessary to support vigorous growth of required plantings.

2.2 SOURCE QUALITY CONTROL

A. Tests and Inspections at Source of Supply:

1. Perform quality assurance testing, and submit results to Engineer, in accordance with the "Quality Assurance" Article in Part 1 of this Section.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protection of In-place Conditions:

1. Protect structures, utilities, sidewalks, pavements, and other facilities, and lawns and existing plants from damage caused by finish grading.

B. Preparation – General:

1. In accordance with Section 01 57 05 - Temporary Controls, provide temporary measures for controlling erosion and sedimentation, airborne dust, and fugitive dust emissions from the Site.
2. Topsoil stripping and stockpiling requirements are indicated in Section 31 10 00 - Site Clearing.
3. Adjust rough grading to within 0.1 foot of required elevations. Properly compact sub-grades. Rough grading shall provide for appropriate drainage in accordance with the Contract Documents.
4. Before applying topsoil:
   a. Remove from exposed subgrade all stones and debris over two inches in any dimension and properly dispose of such items at an appropriate, offsite location.
   b. Apply superphosphate fertilizer directly to subgrade before loosening.
   c. Loosen sub-grade surface to depth of not less than two inches.

3.2 INSTALLATION

A. Installation Requirements:

1. Required Depth of Topsoil:
   a. For areas of gardens, shrubs and similar plantings, provide finished, lightly compacted, topsoil depth of not less than 6 inches.
   b. For all other areas requiring topsoil, including lawns and meadows, provide finished, lightly compacted, topsoil depth of not less than 4 inches.
2. Do not place topsoil when subgrade is muddy, wet or frozen enough to cause clodding.
3. Provide finished surface smooth and true to required grades, in accordance with this Article's "Installation Tolerances" provision. Provide finished surface of topsoil equal to required finished elevations after light rolling and natural settlement.
4. Grade topsoil to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to provide required finish grades.
5. Restore topsoil if eroded or otherwise disturbed after finish grading and before planting.
6. Topsoil Quantity Differentials:
   a. If quantity of required topsoil exceeds the quantity, if any, of topsoil stockpiled at the Site and available for use by Contractor, provide the additional required quantity from appropriate offsite borrow sources at no additional cost to Owner.
   b. When quantity of topsoil obtained from offsite borrow sources exceeds the required quantity of topsoil, remove excess from the Site, unless Owner allows such excess to be stockpiled at an appropriate location at the Site.
   c. When quantity of required topsoil is less than quantity of onsite stockpiles, following installation of topsoil, properly grade remaining stockpile for appropriate drainage

without undue erosion and seed stockpile as required for other areas of lawn restoration in accordance with the Contract Documents.

B. Installation Tolerances:

1. Finish Grading Tolerance: ±0.1 foot from finish elevation required by the Contract Documents. Ensure adequate drainage.

3.3 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Upon completion of topsoil installation, obtain Engineer's concurrence regarding grades and drainage.
2. Where directed by Engineer, provide test holes to demonstrate that required depth of topsoil was provided. After observation and measurement by Engineer, properly refill test holes.
3. Where insufficient depth of topsoil is revealed, remedy by providing required depth and quantity in accordance with the Contract Documents. When additional topsoil is added after initial establishment of plant growth, re-establish required plantings to provide compliance with the Contract Documents.

3.4 PROTECTION

A. Commencing immediately after topsoil installation, protect installed topsoil from erosion and damage from other causes, including personnel, vehicles, and equipment. Promptly perform seeding, sodding (as applicable), mulching, and other measures to permanently stabilize soils and prevent erosion, in accordance with Section 32 92 00 - Seeding, Sodding, and Landscaping.

END OF SECTION

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SECTION 31 23 00
EARTHWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Earthwork - excavation, backfilling, grading, compaction, disposal of waste and surplus materials, placing crushed stone, construction of berms, sheeting, bracing, dewatering and other Earthwork related work.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 01 57 05 – Temporary Controls.
2. Section 07 26 00 - Under Slab Vapor Retarder.
3. Section 31 23 33 - Trenching, Backfilling and Compacting for Utilities.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. ASTM International (ASTM):
   a. C33/C33M, Standard Specification for Concrete Aggregates.
   b. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 feet-LBF/FT^3).
   c. D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 feet-LBF/FT^3(2,700 kN-M/M^3)).
   d. D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
   e. D3786, Standard Test Method for Bursting Strength of Textile Fabrics--Diaphragm Bursting Strength Tester Method.
   f. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   g. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
   h. D4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
2. Occupational Safety and Health Administration (OSHA):
   a. 29 CFR Part 1926.650, Safety and Health Regulations for Construction - Excavations, referred to herein as OSHA Standards.

1.3 DEFINITIONS

A. Excavation:

1. Consists of removal of material encountered to subgrade elevations required or indicated.
2. Includes excavation of soils; pavements and other obstructions visible on surface; underground structures, utilities, and other items indicated to be demolished and removed; boulders; and rock.

B. Foundations: Footings, base slabs, foundation walls, mat foundations, grade beams, piers and any other support placed directly on soil or rock.

C. Geotechnical Engineer: Independent geotechnical specialist providing field quality control for the project.

D. Non-Structural Fill/Backfill: Soil materials placed and compacted to achieve finish grade elevations that do NOT support foundations, slabs, paving, or other flatwork.

E. Structure: Buildings, foundations, slabs, tanks, curbs, or other man-made stationary features occurring above or below ground surface.

F. Subgrade: The earth or soil layer immediately below foundation bearing elevation, subbase material, fill material, backfill material, or topsoil materials.

G. Unauthorized Excavation:

1. Consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of Engineer.
    a. Unauthorized excavation, as well as associated remedial work as directed by Engineer or Geotechnical Engineer, shall be at Contractor's expense.
2. Unsuitable Soil Materials: Soil materials encountered at or below subgrade elevation of insufficient strength and stiffness to support construction as determined by the Geotechnical Engineer.

1.4 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
    a. Acknowledgement that products submitted meet requirements of standards referenced.
    b. Manufacturer's installation instructions.
2. Certifications.

B. Samples:

1. Coordinate samples and testing for approval of off-site materials with the Geotechnical Engineer.
2. Test reports.
    a. Report and certification of aggregate fill and drainage fill.
    b. Test reports on borrow material.
    c. Verification of suitability of each footing subgrade material, in accordance with specified requirements.
    d. Field reports; in-place soil density and moisture tests.
    e. One optimum moisture-maximum density curve for each type of soil encountered.
    f. Report of actual unconfined compressive strength and/or results of bearing tests of each strata tested.

1.5 PROJECT CONDITIONS

A. .Salvageable Items: Carefully remove items to be salvaged, and store on Owner's premises unless otherwise directed.

B. Dispose of waste materials, legally, off site.

1. Burning, as a means of waste disposal, is not permitted.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Fill and Backfill:

1. Selected material approved by Geotechnical Engineer from site excavation or from off site borrow.
2. Structural Fill:
    a. May be low volume change cohesive or granular soil at Contractor's option.
    b. Free of organic matter, frozen material and debris.
    c. Low volume change cohesive soil:
        1) ASTM D2487 classification: CL-ML or CL.

2) Liquid limit: Less than 45.
3) Maximum plasticity index: 20.

d. Granular soil:
1) ASTM D2487 classification: GW, GP, GM, GC, SW, SP, SM or SC.

3. Non-Structural Fill:
a. ASTM D2487 classification: GW, GP, GM, GC, SC, SW, SP, SM, CL-ML or CL.
b. Liquid limit: Less than 45.
c. Maximum plasticity index: 20.

4. Capillary Layer Fill:
a. ASTM D2487 classification: SW.
b. Liquid limit: Less than 45.
c. Maximum plasticity index: 20.

B. Granular Fill Under Building Floor Slabs-On-Grade, Electrical Equipment Pads, Manholes and Handholes :

1. Clean, granular material.
2. Less than 5% fines passing the No. 200 sieve.
3. ASTM C33/C33M gradation size No. 67, 3/4 inches to No. 4 or other material acceptable to Geotechnical Engineer.

C. Granular Fill Under Base Slabs with Pressure Relief Valves:

1. Drainage material: Conform to ASTM C33/C33M, Size No. 67.
2. Filter material: Conform to ASTM C33/C33M requirements for fine aggregate.

D. Granular Fill Under Electrical Equipment Pads, Manholes and Handholes: Clean, crushed, nonporous rock, crushed or uncrushed gravel complying with ASTM C33/C33M gradation size No. 67, 3/4 inches to No. 4.

E. Geotextile Filter Fabric:

1. Nonwoven type.
2. Equivalent opening size: 50 - 100 (U.S. Standard Sieve).
3. Permeability coefficient (cm/second): 0.07 minimum, 0.30 maximum.
4. Grab strength: 90 pounds minimum in either direction in accordance with ASTM D4632 requirements.
5. Mullen burst strength: 125 psi minimum in accordance with ASTM D3786 requirements.

F. Vapor Retarder: Refer to Specification Section 07 26 00.

G. Flowable Fill: See Section 03 31 30.

PART 3 - EXECUTION

3.1 PROTECTION

A. Erosion Control:

1. See Specification Section 01 57 05.
2. Clean paved roadways daily of any spillage of dirt, rocks or debris from vehicles and equipment entering or leaving site.
3. Conduct work to minimize erosion of site. Remove eroded material washed off site.
a. If necessary or requested by Engineer, construct stilling areas to settle and detain eroded material.

B. Protect existing surface and subsurface features on-site and adjacent to site as follows:

1. Provide barricades, coverings, or other types of protection necessary to prevent damage to existing items indicated to remain in place.
2. Protect and maintain benchmarks, monuments or other established reference points and property corners.
    a. If disturbed or destroyed, replace at own expense to full satisfaction of Owner and controlling agency.
3. Verify location of utilities.
    a. Omission or inclusion of utility items does not constitute nonexistence or definite location.
    b. Secure and examine local utility records for location data.
    c. Take necessary precautions to protect existing utilities from damage due to any construction activity.
        1) If utilities are indicated to remain in place, provide adequate means of support and protection during earthwork operations.
        2) Do not interrupt existing utilities serving facilities occupied by Owner or others, during occupied hours, except when permitted in writing by Owner and then only after acceptable temporary utility services have been provided.
        3) Obtain Owner's approval prior to disconnecting any utility service.
    d. Repair damages to utility items at own expense.
    e. In case of damage, notify Engineer at once so required protective measures may be taken.
4. Maintain free of damage, existing sidewalks, structures, and pavement, not indicated to be removed.
    a. Protect new and existing structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.
    b. Any item known or unknown or not properly located that is inadvertently damaged shall be repaired to original condition.
    c. All repairs to be made and paid for by Contractor.
5. Provide full access to public and private premises, fire hydrants, street crossings, sidewalks and other points as designated by Owner to prevent serious interruption of travel.
6. Maintain stockpiles and excavations in such a manner to prevent inconvenience or damage to structures on-site or on adjoining property.
7. Avoid surcharge or excavation procedures which can result in heaving, caving, or slides.

3.2 SITE EXCAVATION AND GRADING

A. The site excavation and grading work includes the offsite disposition of all material:
    1. That exceed quantities required for earthwork on the project.
    2. That the Geotechnical engineer classifies as unclassified excavation.
    3. That the Geotechnical engineer classifies as unacceptable.
    4. That the Geotechnical engineer classifies as potentially contaminated.

B. Excavation and Grading:
    1. Perform as required by the Contract Drawings.
    2. Contract Drawings may indicate both existing grade and finished grade required for construction of Project.
        a. Stake all units, structures, piping, roads, parking areas and walks and establish their elevations.
        b. Perform other layout work required.
        c. Replace property corner markers to original location if disturbed or destroyed.
    3. Preparation of ground surface for embankments or fills:

a. Before fill is started, scarify to a minimum depth of 6 inches in all proposed embankment and fill areas.
b. Where ground surface is steeper than one vertical to four horizontal, plow surface in a manner to bench and break up surface so that fill material will bind with existing surface.

4. Protection of finish grade:
   a. During construction, shape and drain embankment and excavations.
   b. Maintain ditches and drains to provide drainage at all times.
   c. Protect graded areas against action of elements prior to acceptance of work.
   d. Reestablish grade where settlement or erosion occurs.

C. Borrow:

1. Provide necessary amount of approved fill compacted to density equal to that indicated in this Specification.
2. Include cost of all borrow material in original proposal.
3. Fill material to be approved by Geotechnical Engineer prior to placement.

D. Construct embankments and fills as required by the Contract Drawings:

1. Construct embankments and fills at locations and to lines of grade indicated.
   a. Completed fill shall correspond to shape of typical cross section or contour indicated regardless of method used to show shape, size, and extent of line and grade of completed work.
2. Provide approved fill material which is free from roots, organic matter, trash, frozen material, and stones having maximum dimension greater than 6 inches.
   a. Ensure that stones larger than 4 inches are not placed in upper 6 inches of fill or embankment.
   b. Do not place material in layers greater than 8 inches loose thickness.
   c. Place layers horizontally and compact each layer prior to placing additional fill.
3. Compact soils as required to obtain specified density. Selection of appropriate equipment is the Contractor's responsibility.
   a. In general, compact cohesive soils by sheepsfoot, and granular soils by pneumatic rollers, vibrators, or by other equipment as required to obtain specified density.
   b. Control moisture for each layer necessary to meet requirements of compaction.

E. Grading Tolerances: As shown on Drawings.

3.3 USE OF EXPLOSIVES

A. Blasting with any type of explosive is prohibited.

3.4 COMPACTION DENSITY REQUIREMENTS

A. Obtain approval from Geotechnical Engineer with regard to suitability of soils and acceptable subgrade prior to subsequent operations.

B. Provide dewatering system necessary to successfully complete compaction and construction requirements.

C. Remove frozen, loose, wet, or soft material and replace with approved material as directed by Geotechnical Engineer.

D. Stabilize subgrade with well graded granular materials as directed by Geotechnical Engineer.

E. Assure by results of testing that compaction densities comply with the following requirements:

1. Sitework:

LOCATION	COMPACTION DENSITY	MOISTURE CONTENT
Under Paved Areas, Sidewalks and Piping:		
Cohesive soils	95% per ASTM D698	-2 to +3% of optimum
Cohesionless soils	75% relative density per ASTM D4253 and ASTM D4254	
Unpaved Areas:		
Cohesive soils	90% of ASTM D698	-2 to +3% of optimum
Cohesionless soils	65% relative density per ASTM D4253 and ASTM D4254	

2. Structures:

LOCATION	COMPACTION DENSITY	MOISTURE CONTENT
Inside of structures under foundations, under equipment support pads, under slabs-on-grade and scarified existing subgrade under fill material	98% per ASTM D698	-2 to +3% of optimum
Outside structures next to walls, piers, columns and any other structure exterior member	92% per ASTM D698	-2 to +3% of optimum

3. Specific areas:

LOCATION	COMPACTION DENSITY	MOISTURE CONTENT
Outside structures under equipment support foundations	98% per ASTM D698	-2 to +3% of optimum
Under void	85% per ASTM D1557	-2 to +3% of optimum
Granular fill under base slabs with pressure relief valves	75% relative density per ASTM D4253 and ASTM D4254 or 98% of ASTM D698	
Granular fill under building floor slabs-on-grade	60% relative density per ASTM D4253 and ASTM D4254	

3.5 EXCAVATION, FILLING, AND BACKFILLING FOR STRUCTURES

A. General:

1. In general, work includes, but is not necessarily limited to, excavation for structures and retaining walls, removal of underground obstructions and undesirable material, backfilling, filling, and fill, backfill, and subgrade compaction.
2. Obtain fill and backfill material necessary to produce grades required.
   a. Materials and source to be approved by Geotechnical Engineer.
   b. Excavated material approved by Geotechnical Engineer may also be used for fill and backfill.
3. In the paragraphs of this Specification Section, the word "soil" also includes any type of rock subgrade that may be present at or below existing subgrade levels.

B. Excavation Requirements for Structures:

1. General:

a. Do not commence excavation for foundations for structures until Geotechnical Engineer approves:
    1) The removal of topsoil and other unsuitable and undesirable material from existing subgrade.
    2) Density and moisture content of site area compacted fill material meets requirements of specifications.
    3) Site surcharge or mass fill material can be removed from entire construction site or portion thereof.
    4) Surcharge or mass fill material has been removed from construction area or portions thereof.
b. Engineer grants approval to begin excavations.

2. Dimensions:
    a. Excavate to elevations and dimensions indicated or specified.
    b. Allow additional space as required for construction operations and inspection of foundations.
    c. Slope sides of excavations to comply with local codes, ordinances, and requirements of agencies having jurisdiction.
    d. Maintain sides and slopes of excavations in safe condition until completion of backfilling.
3. Removal of obstructions and undesirable materials in excavation includes, but is not necessarily limited to, removal of old foundations, existing construction, unsuitable subgrade soils, expansive type soils, and any other materials which may be concealed beneath present grade, as required to execute work indicated on Contract Drawings.
    a. If undesirable material and obstructions are encountered during excavation, remove material and replace as directed by Geotechnical Engineer.
    b. Remove unsuitable subgrade soils located below foundations. The bottom of the overexcavation shall be located outside the exterior limits of foundations around the perimeter of structure the following horizontal distance, whichever is greater:
        1) Distance equal to depth of overexcavation below bottom of foundations.
        2) 5 feet.
        3) As directed by Geotechnical Engineer.
    c. When excavation has reached required subgrade elevations, notify Geotechnical Engineer, who will make an inspection of conditions.
        1) If Geotechnical Engineer determines that bearing materials at required subgrade elevations are unsuitable, provide Subgrade Stabilization as specified herein.
4. Proof-roll all subgrades to receive fill or concrete placement after subgrade has been scarified and compacted.
    a. Proof-roll in the presence of Geotechnical Engineer with a fully-loaded tandem axle dump truck or other equipment with a minimum gross weight of 25 tons.
5. Install working surface over approved subgrade.
    a. Minimum thickness: 12 inches.
6. Level off bottoms of excavations to receive foundations, floor slabs, equipment support pads, or compacted fill.
    a. Remove loose materials and bring excavations into approved condition to receive concrete or fill material.
    b. Where compacted fill material must be placed to bring subgrade elevation up to underside of construction, scarify existing subgrade upon which fill material is to be placed to a depth of 6 inches and then compact to density stated in this Specification Section before fill material can be placed thereon.
    c. Do not carry excavations lower than shown for foundations except as directed by Geotechnical Engineer or Engineer.

d. If any part of excavations is carried below required depth without authorization, notify Engineer and correct unauthorized excavation as directed. Corrections may include:
    1) Under soil supported footings, foundation bases, or retaining walls, fill unauthorized excavation by extending indicated bottom elevation of footing or base to excavation bottom, without altering required top elevation.
        a) Concrete fill may be used to bring elevations to proper position.
    2) In locations other than those above, including slabs on grade and pile supported foundations, backfill and compact unauthorized excavations as specified for authorized excavations of same classification, unless otherwise directed by Geotechnical Engineer.
    3) No extra compensation will be made to Contractor for correcting unauthorized excavations.

7. Make excavations large enough for working space, forms, damp proofing, waterproofing, and inspection.
8. Notify Geotechnical Engineer and Engineer as soon as excavation is completed in order that subgrades may be inspected.
    a. Do not commence further construction until subgrade under compacted fill material, under foundations, under floor slabs-on-grade, under equipment support pads, and under retaining wall footings has been inspected and approved by the Geotechnical Engineer as being free of undesirable material, being of compaction density required by this specification, and being capable of supporting the allowable foundation design bearing pressures and superimposed foundation, fill, and building loads to be placed thereon.
    b. Geotechnical Engineer shall be given the opportunity to inspect subgrade below fill material both prior to and after subgrade compaction.
    c. Place fill material, foundations, retaining wall footings, floor slabs-on-grade, and equipment support pads as soon as weather conditions permit after excavation is completed, inspected, and approved and after forms and reinforcing are inspected and approved.
    d. Before concrete or fill material is placed, protect approved subgrade from becoming loose, wet, frozen, or soft due to weather, construction operations, or other reasons.
9. Dewatering:
    a. Where groundwater is or is expected to be encountered during excavation, install a dewatering system to prevent softening and disturbance of subgrade below foundations and fill material, to allow foundations and fill material to be placed in the dry, and to maintain a stable excavation side slope.
    b. Groundwater shall be maintained at least 3 feet below the bottom of any excavation.
    c. Review Geotechnical investigation before beginning excavation and determine where groundwater is likely to be encountered during excavation.
    d. Employ dewatering specialist for selecting and operating dewatering system.
    e. Keep dewatering system in operation until dead load of structure exceeds possible buoyant uplift force on structure.
    f. Dispose of groundwater to an area which will not interfere with construction operations or damage existing construction.
        1) Install groundwater monitoring wells as necessary.
    g. Shut off dewatering system at such a rate to prevent a quick upsurge of water that might weaken the subgrade.
10. Subgrade stabilization:
    a. If subgrade under foundations, fill material, floor slabs-on-grade, or equipment support pads is in a frozen, loose, wet, or soft condition before construction is placed thereon, remove frozen, loose, wet, or soft material and replace with approved compacted material as directed by Geotechnical Engineer.

b. Provide compaction density of replacement material as stated in this Specification Section.

c. Loose, wet, or soft materials, when approved by Geotechnical Engineer, may be stabilized by a compacted working mat of well graded crushed stone.

d. Compact stone mat thoroughly into subgrade to avoid future migration of fines into the stone voids.

e. Remove and replace frozen materials as directed by Geotechnical Engineer.

f. Method of stabilization shall be performed as directed by Geotechnical Engineer.

g. Do not place further construction on the repaired subgrades, until the subgrades have been approved by the Geotechnical Engineer.

11. Do not place floor slabs-on-grade including equipment support pads until subgrade below has been approved, piping has been tested and approved, reinforcement placement has been approved, and Contractor receives approval to commence slab construction.
    a. Do not place building floor slabs-on-grade including equipment support pads when temperature of air surrounding the slab and pads is or is expected to be below 40 degrees F before structure is completed and heated to a temperature of at least 50 degrees F.
12. Protection of structures:
    a. Prevent new and existing structures from becoming damaged due to construction operations or other reasons.
    b. Prevent subgrade under new and existing foundations from becoming wet and undermined during construction due to presence of surface or subsurface water or due to construction operations.
13. Shoring:
    a. Shore, slope, or brace excavations as required to prevent them from collapsing.
    b. Remove shoring as backfilling progresses but only when banks are stable and safe from caving or collapse.
    c. Construct shoring that is required to retain water as part of the dewatering system, using non-permeable details such as interlock sealant for sheet piles.
14. Drainage:
    a. Control grading around structures so that ground is pitched to prevent water from running into excavated areas or damaging structures.
    b. Maintain excavations where foundations, floor slabs, equipment support pads or fill material are to be placed free of water.
    c. Provide pumping required to keep excavated spaces clear of water during construction.
    d. Should any water be encountered in the excavation, notify Engineer and Geotechnical Engineer.
    e. Provide free discharge of water by trenches, pumps, wells, well points, or other means as necessary and drain to point of disposal that will not damage existing or new construction or interfere with construction operations.
15. Frost protection:
    a. Do not place foundations, slabs-on-grade, equipment support pads, or fill material on frozen ground.
    b. When freezing temperatures may be expected, do not excavate to full depth indicated, unless foundations, floor slabs, equipment support pads, or fill material can be placed immediately after excavation has been completed and approved.
    c. Protect excavation from frost if placing of concrete or fill is delayed.
    d. Where a concrete slab is a base slab-on-grade located under and within a structure that will not be heated, protect subgrade under the slab from becoming frozen until final acceptance of the Project by the Owner.

e. Protect subgrade under foundations of a structure from becoming frozen until structure is completed and heated to a temperature of at least 50 degrees F.

C. Fill and Backfill Inside of Structure and Below Foundations, Base Slabs, Floor Slabs, Equipment Support Pads and Piping:

1. General:
   a. Subgrade to receive fill or backfill shall be free of undesirable material as determined by Geotechnical Engineer and scarified to a depth of 6 inches and compacted to density specified herein.
   b. Surface may be stepped by at not more than 12 inches per step or may be sloped at not more than 2%.
   c. Do not place any fill or backfill material until subgrade under fill or backfill has been inspected and approved by Geotechnical Engineer as being free of undesirable material and compacted to specified density.
2. Obtain approval of fill and backfill material and source from Geotechnical Engineer prior to placing the material.
3. Granular fill under floor slabs-on-grade: Place all floor slabs-on-grade on a minimum of 6 IN of granular fill unless otherwise indicated.
4. Capillary layer between Granular fill and slab on grade: Place a 2 inch (minimum) layer of clean sand directly above granular fill and below concrete slab layer.
5. Vapor barrier: Install a continuous vapor barrier under floor slabs-on-grade as required by Specification Section 07 62 00 and shown on Contract Drawings.
6. Fill and backfill placement:
   a. Prior to placing fill and backfill material, optimum moisture and maximum density properties for proposed material shall be obtained from Geotechnical Engineer.
   b. Place fill and backfill material in 8 inches lifts.
   c. Compact material by means of equipment of sufficient size and proper type to obtain specified density.
   d. Use hand operated equipment for filling and backfilling within 5 feet of walls and less than 3 feet above pipes.
      1) Compaction equipment exceeding 3000 pounds dead weight shall not be used within 5 feet of the wall as a minimum.
      2) Contractor is responsible for method of compaction so as not to damage wall.
   e. Use hand operated equipment for filling and backfilling next to walls.
   f. Do not place fill and backfill when the temperature is less than 40 degrees F and when subgrade to receive fill and backfill material is frozen, wet, loose, or soft.
   g. Use vibratory equipment to compact granular material; do not use water.
7. Where fill material is required below foundations, place fill material, conforming to the required density and moisture content as required to fill the specified overexcavation to bottom of foundation.

D. Filling and Backfilling Outside of Structures:

1. This paragraph of this Specification applies to fill and backfill placed outside of structures above bottom level of both foundations and piping but not under paving.
2. Provide material as approved by Geotechnical Engineer for filling and backfilling outside of structures.
3. Fill and backfill placement:
   a. Prior to placing fill and backfill material, obtain optimum moisture and maximum density properties for proposed material from Geotechnical Engineer.
   b. Place fill and backfill material to maximum allowable lift thickness indicated in Paragraph 3.5, C, 5, b of this Section.
   c. Compact material with equipment of proper type and size to obtain density specified.

d. Use hand operated equipment for filling and backfilling within 5 feet of walls and less than 3 feet above pipes.
    1) Compaction equipment exceeding 3,000 pounds dead weight shall not be used within 5 feet of the wall as a minimum.
    2) Contractor is responsible for method of compaction so as not to damage wall.
e. Use only hand operated equipment for filling and backfilling next to walls and retaining walls.
f. Do not place fill or backfill material when temperature is less than 40 degrees F and when subgrade to receive material is frozen, wet, loose, or soft.
g. Use vibratory equipment for compacting granular material; do not use water.

4. Backfilling against walls:
    a. Do not backfill around any part of structures until each part has reached specified 28-day compressive strength and backfill material has been approved.
    b. Do not start backfilling until concrete forms have been removed, trash removed from excavations, pointing of masonry work, concrete finishing, dampproofing and waterproofing have been completed.
    c. Do not place fills against walls until floor slabs at top, bottom, and at intermediate levels of walls are in place and have reached 28-day required compressive strength to prevent wall movement.
        1) See Contract Drawings for specific exceptions.
    d. Bring backfill and fill up uniformly around the structures and individual walls, piers, or columns.

E. Backfilling Outside of Structures Under Piping or Paving:

1. When backfilling outside of structures requires placing backfill material under piping or paving, the material shall be placed from bottom of excavation to underside of piping or paving at the density required for fill under piping or paving as indicated in this Specification Section.
2. This compacted material shall extend transversely to the centerline of piping or paving a horizontal distance each side of the exterior edges of piping or paving equal to the depth of backfill measured from bottom of excavation to underside of piping or paving.
3. Provide special compacted bedding or compacted subgrade material under piping or paving as required by other Specification Sections for the Project.

3.6 FIELD QUALITY CONTROL

A. All excavation, trenching, and related sheeting, bracing, etc. shall comply with the requirements of OSHA Standards, and state requirements. Where conflict between OSHA and state regulations exists, the more stringent requirements shall apply.

B. Special Inspection and Testing:

1. See Section 01 45 33.

C. Responsibilities of Special Inspector:

1. Review proposed materials for fill and backfill around structures.
2. All testing, observation and work indicated as being performed by the Geotechnical Engineer in Article 3.5 of this Specification Section.
3. Services will include verification and documentation of satisfactory soil materials, subgrade quality, sampling, placement, moisture conditioning, compaction and testing of proposed soil materials, and field testing for quality control.
4. Moisture density relations, to be established by the Geotechnical Engineer required for all materials to be compacted.
5. Extent of compaction testing will be as necessary to assure compliance with specifications.
6. Prepare and submit inspection and test reports to Engineer.

a. Coordinate such work with other Special Inspectors.

7. Test reports to include the following:
   a. Report and certification of aggregate fill and drainage fill.
   b. Test reports on borrow material.
   c. Verification of suitability of each footing subgrade material, in accordance with specified requirements.
   d. Field reports; in-place soil density and moisture tests.
   e. One optimum moisture-maximum density curve for each type of soil encountered.
   f. Report of actual unconfined compressive strength and/or results of bearing tests of each strata tested.
   g. Other documentation necessary for Geotechnical Engineer to approve earthwork.
   h. Assist Engineer to determine corrective measures necessary for defective work.

D. Responsibilities of Testing Agency for Site Excavation and Grading:

1. All testing, observation and work indicated as being performed by the Geotechnical Engineer in other than Article 3.5 of this Specification Section.
2. Services will include verification and documentation of satisfactory soil materials, subgrade quality, sampling, placement, moisture conditioning, compaction and testing of proposed soil materials, and field testing for quality control.
3. Moisture density relations, to be established by the Geotechnical Engineer required for all materials to be compacted.
4. Extent of compaction testing will be as necessary to assure compliance with specifications.

END OF SECTION

SECTION 31 23 16.43
TEMPORARY SUPPORT OF EXCAVATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Requirements for temporary (during construction) support of excavations including:
   a. Qualifications of Contractor's professional engineer (if any) retained for designing temporary support of excavations.
   b. Contractor's additional investigations and evaluations necessary for designing temporary support of excavations.
   c. Performance criteria and general provisions for temporary support of excavations.
   d. General provisions for temporary support of excavations, including supports Contractor proposes remain in place following construction.
   e. Trench boxes.
   f. Maintenance and removal of temporary support of excavations.

B. Related Requirements: Include, but are not necessarily limited to:

1. Section 31 23 33 – Trenching, Backfilling, and Compacting for Utilities.

1.2 PRICE AND PAYMENT PROCEDURES

A. Measurement and Payment:

1. Temporary support of excavations is part of the Work associated with excavating and filling. Include costs for temporary support of excavations under the Lump Sum bid/pay item. No separate payment will be made for temporary support of excavations.

1.3 REFERENCES

A. Terminology:

1. Terminology indicated below are not defined terms and are not indicated with initial capital letters, but when used in this section have the meaning indicated below:
   a. "Sheeting" means: Long, structural sections of steel with a vertical interlocking system that create a continuous wall, often used for retaining soil or water. The terms "sheet piling", "sheeting", and "piling" (and derivative terms, such as "piles") have the same meaning. Certain types of soldier piles may qualify as sheeting.
   b. "Shoring" means: Temporary means of supporting the walls of an excavation or existing structure, that does not qualify as sheeting. Two basic types of shoring for excavations are timber shoring and aluminum hydraulic shoring; the latter is a lightweight system and equipment used for supporting trench excavations.
   c. "Subgrade" means: The uppermost surface of native soil material unmoved from cuts; the bottom of excavation.
   d. "Tie-backs" means: A method of laterally supporting sheeting or shoring when congestion within the limits of the excavation need to be minimized. Tiebacks generally consist of a central steel bar (or strand tendon), embedded in the soil, surrounded by an annulus of grout.
   e. "Trench box" means: A one- or two-sided shield, placed temporarily in an excavation, typically a trench, which protects workers inside the trench box in the event of collapse of the excavation wall. Trench boxes may be relocated within the excavation as the Work progresses. Trench boxes also shield workers from falling or dislodged materials. Trench boxes are not intended to shore up excavation walls or prevent collapse. The terms "trench box", "trench shield", and "shore shield" have the same meaning.

f. “Wales” means: Beams that span across the face of sheeting or shoring distributing the earth and water pressures to either a raker or cross-strut. Struts, as used in this Section, are structural elements that transfer the load from a temporary excavation support wall to an adjacent, parallel structure. Rakers are struts that are positioned at an angle extending from a temporary excavation support wall to a foundation block or supporting substructure. In this Section, the words “wales” and “walers” have the same meaning.

B. Reference Standards: Standards referenced in this section include, but are not necessarily limited to, the following:

1. American Institute of Steel Construction (AISC):
   a. ANSI/AISC 360 - Specification for Structural Steel Buildings.
2. American Welding Society (AWS):
   a. D1.1/D1.1M - Structural Welding Code – Steel.
3. United States Army Corps of Engineers (USACE) :
   a. Engineer Manual 1110-2-2504 - Design of Sheet Pile Walls.
4. United States Department of Transportation, Federal Highway Administration (FHWA):
   a. FHWA-IF-99-015 Geotechnical Engineering Circular No . 4 - Ground Anchors and Anchored Systems.

1.4 QUALITY ASSURANCE

A. Qualifications:

1. Contractor’s Professional Engineer:
   a. Where necessary for performing the Work in accordance with this Section and when required by Laws or Regulations governing the practice of the associated design discipline or Laws or Regulations governing excavation safety and trench safety in construction, retain the services of a professional engineer, licensed and registered in the same jurisdiction as the Site, to evaluate subsurface conditions and design systems for temporary support of excavations.
   b. Professional engineer shall be appropriately licensed and registered for the professional services required by this Section, and shall be appropriately experienced in evaluating subsurface conditions and excavation conditions affecting health and safety of personnel and protection of property similar to those at the Site, and in designing and evaluating systems for temporary support of excavations.
   c. Responsibilities shall include:
      1) Evaluating existing subsurface data and information for the Site and adjacent areas, available to Contractor.
      2) Advising Contractor regarding additional subsurface investigations necessary to provide temporary support of excavations as required by this Section.
      3) Evaluating the potential effect on existing facilities, at and adjacent to the Site, of installing and removing temporary systems for supporting excavations.
      4) Personally designing or supervising the design of temporary supports for excavations, including preparing drawings, performance requirements, and specifications for temporary support of excavations, such as temporary sheeting, shoring, bracing, wales, tie-backs, and similar systems.
      5) Sealing and signing instruments of service developed for the Work, including calculations, evaluation reports, recommendations of a technical nature, drawings, specifications, and similar documents.
      6) Assisting Contractor with obtaining permits and approvals necessary for temporary support of excavations.
      7) Consulting with Contractor, including visiting the Site during construction as required by Contractor, during installation, use, and removal of temporary supports of excavations.

1.5 SUBMITTALS

A. Informational Submittals: Submit the following:

1. Advisory on Approach for Temporary Support of Excavations:
    a. Furnish document regarding Contractor's proposed approach for temporary support of excavations, indicating the following:
        1) General indication of Contractor's overall, intended approach for temporary support of excavations; for example, indicate whether excavations will be supported by a trench box, temporary sheeting, shoring, wales, tie-backs, or other method. Indicate where different approach will be used for different excavations or portions of excavations.
        2) Indication of whether Contractor or Subcontractor intends to retain services of a professional engineer relative to temporary support of excavations. When such individual or entity will be so retained, indicate name of entity and specific, individual design professional-in-responsible-charge, together with indication of type of license and registration and associated license and registration number and jurisdiction. If not previously furnished with Contractor's insurance documentation, furnish evidence that such professional engineer possesses professional liability insurance in accordance with the Contract Documents, including indication of whether required coverage limits have been eroded during the current policy by prior claims.
        3) Contractor-proposed modifications to the permanent Work requested to accommodate temporary support of excavations. In the event such changes are proposed, approval, if any, of such changes will be only via an appropriate Contract modification. If no such request is submitted prior to start of the Work of this Section, Engineer will proceed on the premise that Contractor-proposed modifications are not intended.
        4) Where temporary steel sheeting will be used for temporary support of excavations, indicate anticipated dates for installing such items and anticipated dates for removing such items.
        5) Description of how temporary support of excavations and operations will, or may, affect Owner, facility manager (if other than Owner), and other property owners and occupants.
        6) Indication of locations, if any, where temporary support of excavations are proposed to remain in place following construction and backfilling, and extent of Contractor's proposed modifications or partial removals of such systems.
        7) Indicate Project-specific sequence of installation and removal of temporary supports of excavations, including: installation and removal of wales, struts, and other supports; and locations and approximate elevations of interim (partial) backfilling against foundations, when interim (partial) backfilling is proposed.
        8) Where applicable, indicate intended monitoring including monitoring of deflection of permanent construction and settlement outside of excavations.
    b. Engineer's (or Owner's) review, comments upon, acceptance, or other appropriate action on such Submittal does not, in any way, reduce or mitigate Contractor's sole responsibility for construction means, methods, techniques, procedures, sequences, and associated safety and protection measures.
    c. Do not include in such Submittal: calculations, evaluation reports, recommendations, drawings, or specifications developed, sealed, and signed by Contractor or Subcontractor or by professional engineer retained by Contractor or Subcontractor. However, in the event of alleged or potential effect of temporary support of excavations on facilities or property, or in the event of disagreement between the parties concerning allegedly differing subsurface or physical conditions, promptly furnish such documents to Engineer and Owner upon request. Should such request be received by Contractor, furnishing such documents to Engineer and Owner will not, in any way, reduce or

mitigate Contractor's sole responsibility for construction means, methods, techniques, procedures, sequences, or associated safety and protection measures.

1.6 FIELD CONDITIONS

A. Existing Conditions:

1. Refer to Section 31 23 33 – Trenching, Backfilling, and Compacting for Utilities].

PART 2 - PRODUCTS

2.1 MATERIALS

A. Description:

1. Provide temporary support of excavations comprised of materials and systems suitable for the intended purpose, excavation depth, subsurface conditions, other environmental factors, installation and removal methods, and duration of use.
2. Contractor shall determine necessary elements for temporary support of excavations for compliance with Laws and Regulations and the Contract Documents, while considering subsurface conditions, construction means, methods, techniques, procedures, and sequences, and associated safety and protection measures.
3. Previously-used materials, where used for temporary support of excavations, shall be in good condition and be neither damaged nor excessively pitted.
4. Steel materials and fabrications for temporary support of excavations shall be in accordance with ANSI/AISC 360 and welding shall be in accordance with AWS D1.1/D1.1M.
5. Steel sheeting that Contractor proposes remain in place following construction shall consist of rolled sections of continuous interlocking type. Type and design of the sheeting and bracing shall comply with this Article's requirements, above, for steel work for all temporary support of excavations.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification, Evaluation, and Assessment of Existing Conditions:

1. Evaluate information and data available to Contractor regarding subsurface and physical conditions at the Site and adjacent areas relative to temporary support of excavations. Perform additional investigations as necessary to enable Contractor to provide appropriate temporary support of excavations required to comply with Laws and Regulations and the Contract Documents.
2. Such investigations and evaluations by Contractor may include excavating (and subsequently backfilling), test pits to visually observe subsurface conditions and groundwater, test borings, sampling, and laboratory analyses. Obtain and record data and perform evaluations necessary for Contractor to provide temporary support of excavations as required.
3. As the Work progresses, evaluate performance of temporary support of excavations as necessary and modify temporary support of excavations as appropriate to comply with Laws and Regulations and the Contract Documents.

B. Installing the Work constitutes Contractor's approval of field conditions prevailing at the time of the Work and materials and design of temporary support of excavations used by Contractor.

3.2 GENERAL PROVISIONS FOR TEMPORARY SUPPORT OF EXCAVATIONS

A. Excavations in stable rock may be made with vertical sides without temporary support of the excavation. Under all other conditions, excavations shall be sloped and benched as appropriate for the subsurface conditions, or provided with temporary support of excavations.

B. Temporary Support of Excavations - General:

1. Provide temporary sheeting, shoring, wales, tie-backs, trench boxes, cofferdams, and other excavation supports as necessary and required for the Work, in accordance with Laws and Regulations and the Contract Documents.
2. Clearances and types of temporary sheeting, shoring, wales, tie-backs, and other excavation supports, insofar as they may affect the finished character of the Work and the design of sheeting to be left in place, will be subject to Engineer's approval; but Contractor is solely responsible for adequacy of all temporary sheeting, shoring, wales, tie-backs, cofferdams, and other excavation supports, Contractor proposes remain in place following construction.
3. Performance and Design: Design and provide temporary supports of excavations and excavation supports Contractor proposes to remain in place in conformance with USACOE Engineer Manual 1110-2-2504 and FHWA-IF-99-015 Geotechnical Engineering Circular No. 4, unless more-stringent requirements are expressly indicated in the Contract Documents or by Laws or Regulations.
4. Installation:
    a. Steel work for temporary support of excavations shall be in accordance with ANSI/AISC 360 and AWS D1.1/D1.1M.
5. As excavation progresses, carry down temporary supports of excavation to required elevation at or below subgrade.

C. Sheeting Left in Place:

1. Temporary Excavation Supports Contractor Proposes to Remain in Place Following Construction:
    a. Installation:
        1) Steel sheeting proposed by Contractor to remain in place shall be driven straight to lines and grades as shown, indicated, or directed. Sheeting shall penetrate into firm materials below subgrade with secure interlocking throughout pile's entire length. Remove sheeting that is damaged or that has defective alignment and replace with acceptable sheeting.
        2) Type of guide structure used and method of driving steel sheeting to remain in-place shall be determined by Contractor's professional engineer. Line jetting is unacceptable.
    b. Cut off at elevation directed by Engineer, sheeting proposed by Contractor to remain in place and remove cut off pilings from the Site for proper disposal. When cut-off elevation is not otherwise directed by Engineer, remove tops of sheeting down to three feet below finished grade.
    c. Clean wales, braces, and all other items to be embedded in the permanent structure, and ensure that concrete surrounding the embedded element is sound and free of air pockets and harmful inclusions. Provisions shall include the cutting of holes in the webs and flanges of wales and bracing members, and welding of steel diaphragm waterstops perpendicular to the centerline of brace-ends that are to be embedded. Wales or bracing proposed to be left in place shall be coordinated and require Engineer's express, written approval.
    d. Subsequent to removing the inside face forms, and when removal of bracing is allowed, cut back steel not less than two inches inside the wall face, coat with a corrosion inhibitor (in accordance with Specifications of Division 03 - Concrete), and patch opening with concrete patch mortar in accordance with Section 03 35 00 - Concrete Finishing and Repair of Surface Defects. Comply with details on the Drawings. Concrete shall be thoroughly worked beneath wales and braces, around stiffeners, and at other place where voids may be formed.
    e. Portions of sheeting or soldier piles and breast boards that are in contact with structure foundations concrete shall be left in place, together with wales and bracing members that are cast into foundation or superstructure concrete.

3.3 TRENCH BOXES

A. Installing and Using Trench Boxes:

1. Excavation of unclassified and other materials below bottom of trench box shall not exceed limits established in Laws and Regulations.
2. When using trench box for installing piping:
    a. Portions of trench box extending below the mid-diameter of an installed, rigid pipe, such as prestressed concrete pipe and other types of rigid pipe, shall be raised above the pipe's mid-diameter elevation prior to relocating the trench box within the excavation for further construction.
    b. Bottom of trench box shall not at any time extend below mid-diameter of installed pipe that is flexible or has flexing capability, such as steel, ductile iron, PVC, CPVC, polyethylene, and other pipe that has flexing capability.
3. When using trench box for installing structures, bottom of trench box shall not extend below elevation of top of granular base material of structure.

B. Removal or Relocation of Trench Boxes:

1. When removing trench box or relocating trench box within the excavation, exercise extreme care to prevent moving piping, structures, and other Underground Facilities, and prevent disturbance of bedding material for piping, structures, and other Underground Facilities.
2. When piping, structures, or other Underground Facilities are disturbed, remove and reinstall the disturbed items in accordance with the Contract Documents.

3.4 MAINTENANCE AND REMOVAL OF TEMPORARY SUPPORT OF EXCAVATIONS

A. Maintenance of Temporary Support for Excavations:

1. During construction, maintain temporary support of excavations as long as necessary until removal or Engineer's concurrence that such temporary support of excavations may remain in place following construction.
2. As necessary, promptly remedy deficiencies in temporary support of excavations.

B. Removal of Temporary Support of Excavations:

1. When temporary support of excavations are no longer necessary, remove from the Site all elements of temporary systems supporting excavations unless Owner (through Engineer) approves temporary support of excavations, or part thereof, continuing existence at the Site after final payment.
2. Perform such removal in manner not injurious to buildings, structures, Underground Facilities, and other facilities, their appearance, and adjacent construction.
3. Removal of Temporary Sheeting and Bracing:
    a. Remove from excavations sheeting, shoring, wales, and other elements of temporary supports, unless otherwise directed by Engineer in writing. Perform removal to avoid damaging the Work and adjacent construction. Removal shall be equal on both sides of excavation to ensure no unequal loads on buildings, structures, Underground Facilities, and other facilities.
    b. Defer removal of sheeting, shoring, wales, and other elements, where removal may cause soil to come into contact with concrete, until the following conditions are satisfied:
        1) Concrete has cured for not less than seven days, and reached full design strength as indicated in the Contract Documents.
        2) Wall and floor framing, up to and including grade level floors, is in place.
    c. When temporary support of excavations is allowed to remain in-place following construction, accurately record locations on the record drawings, in accordance with Section 01 78 39 - Project Record Documents.
4. Requirements for removing and relocating trench boxes are indicated in the "Trench Boxes" Article of this Section.

5. Restore disturbed areas in accordance with the Contract Documents. Where the Contract Documents do not indicate requirements for restoration, restore such areas to existing condition prior to disturbance.

END OF SECTION

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SECTION 31 23 33

TRENCHING, BACKFILLING, AND COMPACTING FOR UTILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Excavation, trenching, backfilling and compacting for all underground utilities.
2. Wastewater piping.
3. Sewers, channel, and drain piping.
4. Water piping (potable, plant, process and non-potable).
5. Natural gas, propane, fuel oil piping.
6. Relocation of existing piping.
7. Electrical ductbanks, conduits, and direct burial cables.
8. All related utility and process appurtenances.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 03 31 31 - Concrete Mixing, Placing, Jointing, and Curing.
2. Division 26 - Electrical.
3. Section 31 23 00 - Earthwork.
4. Section 33 05 15 - Precast Concrete Utility Structures.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. ASTM International (ASTM):
   a. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 feet-LBF/FT^3 (600 kN-M/M^3)).
   b. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   c. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.

B. Qualifications: Hire an independent soils laboratory to conduct in-place moisture-density tests for backfilling to assure that all work complies with this Specification Section.

1.3 DEFINITIONS

A. Excavation: All excavation will be defined as unclassified.

1.4 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Manufacturer's installation instructions.
2. Submit respective pipe or conduit manufacturer's data regarding bedding methods of installation and general recommendations.
3. Submit sieve analysis reports on all granular materials.

B. Informational Submittals:

1. Trench shield (trench box) certification if employed:
   a. Specific to Project conditions.

b. Re-certified if members become distressed.

c. Certification by registered professional structural engineer, registered in the state where the Project is located.

d. Engineer is not responsible to, and will not, review and approve.

1.5 SITE CONDITIONS

A. Avoid overloading or surcharge a sufficient distance back from edge of excavation to prevent slides or caving.

1. Maintain and trim excavated materials in such manner to be as little inconvenience as possible to public and adjoining property owners.

B. Provide full access to public and private premises and fire hydrants, at street crossings, sidewalks and other points as designated by Owner to prevent serious interruption of travel.

C. Protect and maintain bench marks, monuments or other established points and reference points and if disturbed or destroyed, replace items to full satisfaction of Owner and controlling agency.

D. Verify location of existing underground utilities

PART 2 - PRODUCTS

2.1 MATERIALS

A. Backfill Material:

1. Per ISPWC Section 306 – Trench Backfill.
2. As approved by Engineer.
   a. Trench backfill material shall be 6-inch minus and less than 10% passing #200 sieve.
      1) Soil Classification: GW, GP, GP-GM, SP, and SP-SM.
      2) Native backfill material may be used if it meets requirements listed.
   b. Free of rock cobbles, roots, sod or other organic matter, and frozen material.
   c. Moisture content at time of placement: ±3% of optimum moisture content as specified in accordance with ASTM D698.

B. Subgrade Stabilization Materials: Provide subgrade stabilization material consisting of one inch minus.

C. Bedding Materials:

1. As approved by the Geotechnical Engineer.
2. Trench bedding materials percent passing per ISPWC Section 305 – Pipe Bedding:

Sieve Size	3 inches	1 inches	3/4 inches	3/8 inches	No. 4	No. 20	No. 200
Type 1 (3/4-inch 60% crushed or fractured gravel and sand)	-	100	80 – 100	20 – 70	0 – 5	0 – 3	-
Type II (Foundation Stabilization in accordance with ISPWC Section 801)	100	-	-	-	25 – 60	-	0 – 12
Type III (Sand)	-	-	-	-	100	-	< 3
Type IV (Class 3000 PSI concrete)	-	-	-	-	-	-	-

3. Flowable fill: See Section 03 31 30.

PART 3 - EXECUTION

3.1 GENERAL

A. Remove and dispose of unsuitable materials as directed by Geotechnical Engineer to site provided by Owner.

3.2 EXCAVATION

A. Unclassified Excavation: Remove rock excavation, clay, silt, gravel, hard pan, loose shale, and loose stone as directed by Geotechnical Engineer.

B. Excavation for Appurtenances:

1. 12 inches (minimum) clear distance between outer surface and embankment.
2. See Specification Section 31 23 00 for applicable requirements.
3. See Specification Section 33 05 15 for applicable requirements.

C. Groundwater Dewatering:

1. Where groundwater is, or is expected to be, encountered during excavation, install a dewatering system to prevent softening and disturbance of subgrade to allow subgrade stabilization, pipe, bedding and backfill material to be placed in the dry, and to maintain a stable trench wall or side slope.
2. Groundwater shall be drawn down and maintained at least 3 feet below the bottom of any trench or manhole excavation prior to excavation.
3. Review soils investigation before beginning excavation and determine where groundwater is likely to be encountered during excavation.
    a. Employ dewatering specialist for selecting and operating dewatering system.
4. Keep dewatering system in operation until dead load of pipe, structure and backfill exceeds possible buoyant uplift force on pipe or structure.
5. Dispose of groundwater to an area which will not interfere with construction operations or damage existing construction.
6. Install groundwater monitoring wells as necessary.
7. Shut off dewatering system at such a rate to prevent a quick upsurge of water that might weaken the subgrade.
8. Cost of groundwater dewatering shall be compensated under an allowance.

D. Trench Excavation:

1. Excavate trenches by open cut method to depth shown on Drawings and necessary to accommodate work.
    a. Support existing utility lines and yard piping where proposed work crosses at a lower elevation.
        1) Stabilize excavation to prevent undermining of existing utility and yard piping.
2. Open trench outside buildings, units, and structures:
    a. No more than the distance between two manholes, structures, units, or 300 LF, whichever is less.
    b. Field adjust limitations as weather conditions dictate.
3. Trenching within buildings, units, or structures:
    a. No more than 100 LF at any one time.
4. Any trench or portion of trench, which is opened and remains idle for seven calendar days, or longer, as determined by the Owner, may be directed to be immediately refilled, without completion of work, at no additional cost to Owner.
    a. Said trench may not be reopened until Owner is satisfied that work associated with trench will be prosecuted with dispatch.
5. Observe following trenching criteria:

a. Trench size:
    1) Excavate width to accommodate free working space.
    2) Minimum trench width at top of pipe or conduit shall be the pipe outside diameter plus 24 inches.:
    3) Cut trench walls vertically from bottom of trench to 1 foot above top of pipe, conduit, or utility service.
    4) Keep trenches free of surface water runoff.
        a) Include cost in Bid.
        b) No separate payment for surface water runoff pumping will be made.

E. Trenching for Electrical Installations:
1. Observe the preceding Trench Excavation paragraph in PART 3 of this Specification Section.
2. Modify for electrical installations as follows:
    a. Open no more than 600 linear foot of trench in exterior locations for trenches more than 12 inches but not more than 30 inches wide.
    b. Any length of trench may be opened in exterior locations for trenches which are 12 inches wide or less.
    c. Do not over excavate trench.
    d. Cut trenches for electrical runs with minimum 30 inches cover, unless otherwise specified or shown on Drawings.
    e. See Division 26 for additional requirements.

F. Flowable Fill:
1. Flowable fill shall be:
    a. Discharged from a mixer by any means acceptable to the Engineer into the area to be filled.
    b. Placed in 4 feet maximum lifts to the elevations indicated.
        1) Allow 12 hour set-up time before placing next lift or as approved by the Engineer.
        2) Place flowable fill lifts in such a manner as to prevent flotation of the pipe.
2. Flowable fill shall not be placed on frozen ground.
3. Subgrade on which flowable fill is placed shall be free of disturbed or softened material and water.
4. Conform to appropriate requirements of Specification Section 31 23 00.
5. Flowable fill batching, mixing, and placing may be started if weather conditions are favorable, and the air temperature is 34 degrees F and rising.
6. At the time of placement, flowable fill must have a temperature of at least 40 degrees F.
7. Mixing and placing shall stop when the air temperature is 38 degrees F or less and falling.
8. Each filling stage shall be as continuous an operation as is practicable.
9. Prevent traffic contact with flowable fill for at least 24 hours after placement or until flowable fill is hard enough to prevent rutting by construction equipment.
10. Flowable fill shall not be placed until water has been controlled or groundwater level has been lowered in conformance with the requirements of the preceding Groundwater Dewatering paragraph in PART 3 of this Specification Section.

3.3 PREPARATION OF FOUNDATION FOR PIPE LAYING

A. Over-Excavation:
1. Backfill and compact to 90% of maximum dry density per ASTM D698.
2. Backfill with granular bedding material as option.

B. Rock Excavation:

1. Excavate minimum of 6 inches below bottom exterior surface of the pipe or conduit.
2. Backfill to grade with suitable earth or granular material.
3. Form bell holes in trench bottom.

C. Subgrade Stabilization:

1. Stabilize the subgrade when directed by the Owner.
2. Observe the following requirements when unstable trench bottom materials are encountered.
    a. Notify Owner when unstable materials are encountered.
        1) Define by drawing station locations and limits.
    b. Remove unstable trench bottom caused by Contractor failure to dewater, rainfall, or Contractor operations.
        1) Replace with subgrade stabilization with no additional compensation.

3.4 BACKFILLING METHODS

A. Do not backfill until tests to be performed on system show system is in full compliance with specified requirements.

B. Carefully Compacted Backfill:

1. Furnish where indicated on Drawings, specified for trench embedment conditions and for compacted backfill conditions up to 12 inches above top of pipe or conduit.
2. Comply with the following:
    a. Place backfill in lifts not exceeding 8 inches (loose thickness).
    b. Hand place, shovel slice, and pneumatically tamp all carefully compacted backfill.
    c. Observe specific manufacturer's recommendations regarding backfilling and compaction.
    d. Compact each lift to specified requirements.

C. Common Trench Backfill:

1. Perform in accordance with the following:
    a. Place backfill in lift thicknesses capable of being compacted to densities specified.
    b. Observe specific manufacturer's recommendations regarding backfilling and compaction.
    c. Avoid displacing joints and appurtenances or causing any horizontal or vertical misalignment, separation, or distortion.

D. Water flushing for consolidation is not permitted.

E. Backfilling for Electrical Installations:

1. Observe the preceding Carefully Compacted Backfill paragraph or Common Trench Backfill paragraph in PART 3 of this Specification Section or when approved by the Engineer.
2. Modify for electrical installation as follows:
    a. Observe notes and details on electrical drawings for fill in immediate vicinity of direct burial cables.

3.5 COMPACTION

A. General:

1. Place and assure bedding, backfill, and fill materials achieve an equal or higher degree of compaction than undisturbed materials adjacent to the work.
2. In no case shall degree of compaction below minimum compactions specified be accepted.

B. Compaction Requirements:

1. Unless noted otherwise on Drawings or more stringently by other Specification Sections, comply with following minimum trench compaction criteria.
   a. Bedding material:

LOCATION	SOIL TYPE	COMPACTION DENSITY
All locations	Cohesionless soils	75% relative density by ASTM D4253 and ASTM D4254

   b. Carefully compacted backfill:

LOCATION	SOIL TYPE	COMPACTION DENSITY
All applicable areas	Cohesive soils	95% of maximum dry density by ASTM D698
	Cohesionless soils	75% relative density by ASTM D4253 and ASTM D4254

   c. Toe drain bedding and backfill:

LOCATION	SOIL TYPE	COMPACTION DENSITY
All locations	Cohesionless soils	60% relative density by ASTM D4253 and ASTM D4254

   d. Common trench backfill:

LOCATION	SOIL TYPE	COMPACTION DENSITY
Under pavements, roadways, surfaces within highway right-of-ways	Cohesive soils	95% of maximum dry density by ASTM D698
	Cohesionless soils	60% of relative density by ASTM D4253 and ASTM D4254
Under turfed, sodded, plant seeded, nontraffic areas	Cohesive soils	85% of maximum dry density by ATM D698
	Cohesionless soils	40% of relative density by ASTM D4253 and ASTM D4254

3.6 FIELD QUALITY CONTROL

A. Testing:

1. Perform in-place moisture-density tests as directed by the Owner.
2. Perform tests through recognized testing laboratory approved by Owner.
3. Costs of "Passing" tests paid by Owner.
4. Perform additional tests as directed until compaction meets or exceeds requirements.
5. Cost associated with "Failing" tests shall be paid by Contractor.
6. Reference to Engineer in this Specification Section will imply Geotechnical Engineer when employed by Owner and directed by Engineer to undertake necessary inspections as approvals as necessary.
7. Assure Owner has immediate access for testing of all soils related work.
8. Ensure excavations are safe for testing personnel.

END OF SECTION

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DIVISION 32

EXTERIOR IMPROVEMENTS

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SECTION 32 12 16

ASPHALTIC CONCRETE VEHICULAR PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Asphaltic concrete vehicular paving.
2. Line painting.

B. Related Specification Sections include but are not necessarily limited to:

1. Division 00 - Procurement and Contracting Requirements.
2. Division 01 - General Requirements.
3. 2020 Idaho Standards for Public Works Construction (ISPWC) Division 800 - Aggregates and Asphalt.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. 2020 Idaho Standards for Public Works Construction Section 800 - Aggregates and Asphalt.
2. AASHTO Standard Specifications for Transportation and Methods of Sampling and Testing.
3. WAQTC - Western Alliance for Quality Transportation Construction.

B. Test Methods

1. Particle size distribution of aggregates – AASHTO T 27
2. Mechanical Analysis of Extracted Aggregate – AASHTO T 30
3. Marshall – AASHTO T 245
4. Percent of Crushed Particles – AASHTO TP 61
5. Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt Paving Mixtures – AASHTO T 209
6. Bulk Specific Gravity of Compacted Bituminous Mixtures – AASHTO T 166 and T 275
7. Percentage of Coated particles in Bituminous Mixtures – Idaho T 96
8. Nuclear method for Determination of the Density of an Asphalt Pavement – Idaho WAQTC TM-8
9. Quantitative Extraction of Bitumen from Bituminous Paving Mixtures – AASHTO T 164
10. Standard Practice for Operating Inertial Profilers and Evaluating Pavement Profiles – AASHTO PP-50
11. Sampling Bituminous Paving Mixture – AASHTO T 168
12. Plastic Fines in Graded Aggregate and Soils by Use of the Sand Equivalent Test – AASHTO T 176
13. Determining the asphalt binder content of hot mix asphalt (HMA) by the ignition method – AASHTO T 308
14. Reducing Samples of Aggregate to Testing Size – AASHTO T 248
15. Moisture Content of Bituminous Mixes by Oven – WAQTC TM - 6

C. Construction standards:

1. State of Idaho, Idaho Standards for Public Works Construction (ISPWC), as amended to date.

1.3 SUBMITTALS

A. Mix Design:

1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. Product technical data including:
   a. Job mix formula (JMF) stamped by an engineer licensed in the State of Idaho for HMA pavement that complies with the Marshal mix requirements outlined in this specification.
   b. JMF design and applicable aggregate tests performed by qualified independent laboratories.
   c. Gradation test reports and applicable fracture count reports for all material in stockpiles.
   d. JMF design test reports whenever new stockpiles are made which have gradations that are not possible to blend to the overall gradation of the existing JMF design.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Hot Mix Asphalt Design

1. ½ inch Marshall Method Design Criteria:

TABLE 1

Parameter	Value
Number of compaction blows, each end of specimen	50
Stability, minimum	1,200
Flow	8 - 18
Air Voids, percent	3 - 5

2. Provide virgin aggregate for all mixes in a minimum of two separate stockpiles.
3. All HMA designs shall use a minimum one-half percent approved liquid anti-stripping additive by weight of asphalt. Lime may be used as the anti-stripping additive, if it was included in the job mix design.

B. Aggregates

1. Mixes to meet ½ inch requirements of ISPWC Section 803 – Plant Mix Aggregates.
2. Aggregate quality will be controlled at the hot plant.
   a. Conduct sampling and testing at hot plant to assure a uniform combined aggregate gradation is maintained. Aggregate gradation, sand equivalency, and fractured faces will be performed on cold feed samples as needed to control the operation but at least 1 test per each 1,500 tons of plant mix produced.
   b. Variation from the as crushed, combined stockpile average not to exceed ±4% on the No. 4 sieve and ±2% on the No. 200 sieve for samples from the combined aggregate feed.

C. Asphalt

1. Material to meet requirements of ISPWC Section 805 – Asphalt.
   a. Asphalt to be of the type and grade called for.
   b. Asphalt will be accepted at point of delivery.
2. All asphalt shall be furnished by one (1) supplier. If a change of liquid asphalt supplier is proposed, mix design testing and verification are required as conditions of approval.

D. Anti-Stripping Additive

1. Anti-Strip additive will be accepted at point of delivery.

PART 3 - EXECUTION

3.1 MIXING PLANT

A. The mixing plant shall be a commercially manufactured plant capable of producing a uniform mixture and conforming to the following requirements.

B. Dryer

1. Plant to be equipped with dryer or dryers that continuously agitate the aggregates during the heating process.

C. Asphalt control Unit

1. Provide satisfactory means of weighting or metering for obtaining and checking the amount of asphalt in the mix.
2. Asphalt control unit to be interconnected with the aggregate feed control and be capable of delivering asphalt to the mix within ±2% of the intended quantity throughout the range of plant operation.

D. Sampling Devices

1. Equip plant with adequate sampling devices on cold feed.
   a. Sampling device to be operable from the ground or a platform.
   b. Sampling device to move at a constant rate across the full width of the falling column of material from the discharge belt or chute.
   c. Equipment to achieve a representative sample, conveyed to the ground by means of a slide, chute or other means where the sampled material can be safely and conveniently collected.

3.2 HAULING EQUIPMENT

A. Trucks used for hauling plant mix to have tight, clean, smooth, metal beds.

B. All trucks to be equipped with suitable covers to protect the mixture from adverse weather or long hauls.

C. Do not use fuel oil or other petroleum-based oil as a release agent.

3.3 PAVER

A. Paver to be self-propelled with an activated heated screed.

B. All screed extensions to be activated and heated except for shoulder widening not exceeding 1 foot.

C. Extended screeds to be equipped with corresponding auger and tunnel extensions to ensure a uniform head of fresh material across the entire screed.

D. Screed to be equipped with automatic controls capable of adjustments in both transverse and longitudinal directions.

E. Sensing device to be adaptable to picking up grade from a string line, rail or ski.

F. Maintain to the extent possible, a continuous, non-stopped paving operation.

G. Do not use fuel or other petroleum-based oil as a release agent.

3.4 ROLLERS

A. Rollers to be of the steel wheel, vibratory or pneumatic tire type in good condition and capable of reversing direction.

B. Provide sufficient number of capacitive force rollers to achieve compaction as required for acceptance.

C. Equipment which produces excessive crushing of the aggregate is not allowed.

D. Roller producing pickup, washboard, uneven compaction of the surface or other undesirable results are not allowed.

E. Roller requirements

1. Vibratory Rollers
    a. Variable amplitude with at least two settings
    b. Variable frequency with minimum of 200 VPM
    c. Maximum rate of travel under vibration to be 2.5 mph – 220 feet/minute
    d. Vibratory rollers with pneumatic tired drive wheels to have smooth tires that leave no visible tracks
2. Pneumatic Tired Rollers
    a. Maximum rate of travel to be 5 mph
    b. Rollers to be equipped with smooth compactor tires

F. Do not use fuel or other petroleum based oil as a release agent

3.5 MIXING

A. Moisture content of mixture at the time of placement not to exceed 1%

B. Mixing temperature shall comply with the Viscosity-Temperature chart and be for the same type and source as the asphalt cement supplied to the project

3.6 SPREADING AND FINISHING

A. Surface must be approved prior to placing mixture.

B. Place pavement in lifts as required in the contract documents. Minimum ratio of lift thickness to nominal maximum aggregate size (tNMAS) is 3 unless otherwise approved.

C. Apply a think, uniform asphalt tack coat to the surfaces of curbing, gutters, manholes, asphalt cement pavement, Portland cement pavement, and other structure pavement will abut.

D. Paver to be equipped with a 24 inch wide slope shoe.

3.7 JOINTS

A. A joint is considered a cold joint when the surface temperature of the previously laid material has cooled to 175°F or less.

B. Test all joints for smoothness.

1. Furnish and use an approved 10-foot straight edge for checking joint smoothness.
2. Perform test and make necessary corrections before material drops below 185°F.

C. Do not allow rollers to pass over the unprotected edge of freshly laid mixes.

D. Cut back on previous run to expose a vertical edge, full depth of the course for transverse joints.

E. Apply an asphalt tack coat on contact surfaces of transverse and cold longitudinal joints just before mixture is placed against previously laid or existing material. CSS-1 emulsified asphalt at 0.05 gallons per SY.

F. Provide positive bond, density and finished surface at longitudinal joints equal in all respects to the mixture against which it is placed.

3.8 WEATHER LIMITATIONS

A. Do not place plant mix when weather or surface conditions otherwise prevent the proper handling or finishing of the plant mix material.

B. Conform to the following minimum temperatures for all plant mix pavement operations. Place plant mix only when the air and surface temperature are in accordance with Table 2.

TABLE 2

MINIMUM AIR AND SURFACE TEMPERATURE		
Compacted Thickness of each course	Top Course	Leveling and Courses Below Top Course
Less than 0.1 foot	60°F	50°F
0.1 foot to 0.18 foot	50°F	40°F
Over 0.18 foot	40°F	40°F

C. Do not start plant mix removal or otherwise alter the surface of existing plant mix unless the progress schedule realistically shows that the pavement can be replaced or completed.

3.9 **COMPACTION**

A. Do not operate vibratory rollers in vibratory mode when checking or cracking of the mat occurs.

B. When rollers are not operating, park off of new mat, shut off vibrator when roller is not in compactive position.

C. Use the same type, weight rolling equipment and operate at the same VPMs for production paving as was established at the beginning of the operation, unless otherwise approved.

D. Prevent adhesion of mixture to compaction equipment. Do not use diesel fuel, kerosene or other solvents.

E. Remove all of the mixture from the gutter surface prior to rolling. Protect adjoining concrete from damage. Repair all damage to concrete caused by Contractor's operation at the Contractor's expense.

3.10 **FIELD QUALITY ACCEPTANCE**

A. Obtain one sample from the mix being produced per 750 tons or fraction thereof. Minimum of one test per day. Test samples for asphalt cement content per AASHTO T 308 and gradation per AASHTO T 30. Test results must meet the requirements designated in Table 3.

TABLE 3

Parameter	Value
Asphalt Cement Content	± 0.4%
Passing 3/8" Sieve	± 7%
Passing No. 8 Sieve	± 5%
Passing No. 200 Sieve	± 2%

B. Compact pavement to the percentage range of the AASHTO T 209 theoretical maximum density value as outlined in 1 or 2 below.

1. 91.0 to 96.0 percent for in-place density values determined by WAQTC TM 8. Nuclear densometers must be correlated to cores tested in accordance with AASHTO T 166 at a frequency of one core for every 5 density tests performed, but not less than 3 cores per project. Density testing shall be performed randomly at a frequency of one test per 100 learn feet of pavement.
2. 92.0 to 95.0 percent for in-place density values determined from cores tested in accordance with AASHTO T 166. Density testing shall be performed randomly at a frequency of one test per 300 linear feet of pavement.

C. In-Place density tests shall be performed a minimum distance of 12 inches from joints.

D. Furnish new JMF design if results indicate difficulty in meeting existing JMF design requirements.

3.11 SURFACE SMOOTHNESS

A. Perform straight edge surface smoothness tests no later than the next working day following placement. Provide test results to contracting agency within one working day after testing. If corrective action is necessary, do not continue paving until corrective action has been taken.

1. Straight edge to be an approved device 10 feet in length.
2. Perform straight edge test in areas to be determined and randomly.
3. When straight edge is laid on the surface in a direction parallel or perpendicular to paving lane, surface variation shall not exceed 0.25 inches from the lower edge of the length of the straight edge.
4. Remove any highpoints found by grinding and add fog coat per ISPWC Section 813, at Contractor's expense.

END OF SECTION

SECTION 32 13 13
CONCRETE PAVEMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Concrete pavement.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 03 05 05 - Testing.
2. Section 03 31 30 - Concrete, Materials and Proportioning.
3. Section 03 31 31 - Concrete Mixing, Placing, Jointing, and Curing.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. M153, Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction (ASTM D1752).
   b. M171, Standard Specification for Sheet Materials for Curing Concrete (ASTM C1271).
   c. M182, Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats.
   d. M213, Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types) (ASTM D1751).
   e. M224, Standard Specification for Use of Protective Sealers for Portland Cement Concrete.
   f. M233, Standard Specification for Boiled Linseed Oil Mixture for Treatment of Portland Cement Concrete.
2. American Concrete Institute (ACI):
   a. 305R, Guide to Hot Weather Concreting.
   b. 306R, Guide to Cold Weather Concreting.
3. ASTM International (ASTM):
   a. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   b. A1064/A1064M, Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
   c. C33/C33M, Standard Specification for Concrete Aggregates.
   d. C150/C150M, Standard Specification for Portland Cement.
   e. C174/C174M, Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores.
   f. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
   g. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 feet-LBF/FT^3 (600 kN-M/M^3)).
   h. D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
   i. D1752, Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction.

j. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.

k. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.

4. Federal Specification (FS):

a. SS-S-1614, Sealants, Joint, Jet-Fuel-Resistant, Hot-Applied for Portland Cement and Tar Concrete Pavements (Withdrawn with no replacement).

b. Concrete installer shall have successfully completed at least three other projects of similar size and type.

1.3 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:

a. Acknowledgement that products submitted meet requirements of standards referenced.

2. Mix design(s) in accordance with Specification Section 03 31 30 and Specification Section 03 05 05.

3. Qualifications of concrete installer.

4. Drawings detailing all reinforcing.

5. Scaled cross section detail of crown template with dimensions showing off sets from level line.

6. Concrete pavement joint pattern for paved areas.

7. Test reports:

a. Concrete cylinder test results from field quality control.

B. Samples:

1. Samples of fabricated jointing materials and devices.

C. Contract Closeout Information:

1. Operation and Maintenance Data:

a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Portland Cement: ASTM C150/C150M, Type I or II.

B. Aggregates:

1. ASTM C33/C33M, gradation size #67, 3/4 inches to #4.

2. Clean, crushed gravel.

C. Water: Potable quality.

D. Admixtures: Comply with Specification Section 03 31 30.

E. Reinforcing Bars: ASTM A615/A615M, Grade 60.

F. Welded Wire Reinforcement:

1. ASTM A1064/A1064M.

2. Flat.

3. Clean, free from dirt, scale, rust.

G. Preformed Joint Filler:

1. Non-extruding cork, self-expanding cork, sponge rubber or cork rubber.

2. AASHTO M153 or AASHTO M213.

H. Hot-Poured Joint Sealing Material:

1. FS SS-S-1614.

I. Membrane Curing Compound: ASTM C309.

J. Cover Materials for Curing:

1. Burlap:
   a. AASHTO M182.
   b. Minimum Class 2, 8 oz material (1 yard x 42 inches).
2. Polyethylene film, AASHTO M171.

K. Paper Subgrade Cover: Polyethylene film, AASHTO M171.

L. Concrete Treatment:

1. Boiled linseed oil mixture.
2. AASHTO M233.

M. Forms:

1. Steel or wood.
2. Size and strength to resist movement during concrete placement and able to retain horizontal and vertical alignment.
3. Free of distortion and defects.
4. Full depth.
5. Metal side forms:
   a. Minimum 7/32 inches thick.
   b. Depth equal to edge thickness of concrete.
   c. Flat or rounded top minimum 1-3/4 inches wide.
   d. Base 8 inches wide or equal to height, whichever is less.
   e. Maximum deflection 1/8 inches under center load of 1,700 pounds.
   f. Use flexible spring steel forms or laminated boards to form radius bends.

2.2 MIXES

A. Mix design to provide 4,000 psi 28-day compressive strength, 1 inches slump, 6 ±1% air.

PART 3 - EXECUTION

3.1 PREPARATION

A. Subgrade Preparation:

1. Prepare using methods, procedures, and equipment necessary to attain required compaction densities, elevation and section.
2. Scarify and recompact top 12 inches of fills and embankments which will be under paved areas.
3. Remove soft or spongy areas.
   a. Replace with structural backfill.
   b. Coordinate with Geotechnical Engineer.
4. Compact to the following densities:
   a. Cohesive soils: 95% per ASTM D698.
5. Assure moisture content is within limits prescribed to achieve required compaction density.
6. Following compaction, trim and roll to exact cross section.
   a. Check with approved grading template.

7. Perform density tests on subgrade to determine that subgrade complies with the specification.
8. Coordinate aggregate course with Structural Engineer and Soils/Geotechnical Engineer.

B. Aggregate Course:

1. Place material in not more than 6 inches thick layers.
2. Spread, shape, and compact all material deposited on the subgrade during the same day.
3. Compact to 95% relative per ASTM D4253 and ASTM D4254.

C. Loose and Foreign Material: Remove loose and foreign material immediately before application of paving.

D. Appurtenance Preparation:

1. Block out or box out curb inlets and curb returns.
2. Provide for joint construction as detailed and dimensioned on Drawings.
3. Adjust manholes, inlets, valve boxes and any other utility appurtenances to design grade.
   a. Secure to elevation with concrete.
   b. Place concrete up to 5 inches below design grade.
4. Headers:
   a. Construct at open ends of pavements.
   b. Use same concrete to construct headers as that used in the abutting structure.
   c. Extend header full width of pavement and crown same as pavement.
5. Clean and oil forms.

3.2 INSTALLATION

A. Concrete Production: Comply with Specification Section 03 31 31.

B. Forms:

1. Form support:
   a. Compact soil foundation and cut to grade to support forms and superimposed machine loads.
   b. Use bearing stakes driven flush with bottom of form to supplement support as necessary.
   c. Do not use earth pedestals.
2. Staking forms:
   a. Joint forms neatly and tightly.
   b. Stake and pin securely with at least three pins for each 10 feet section.
3. Clean and oil forms prior to placement of concrete.
4. Set forms sufficiently in advance of work (minimum of 2 hours) to permit proper inspection.
5. Previously finished concrete pavement, curb or sidewalk contiguous with new work may serve as side form when specifically approved.

C. Reinforcing:

1. Locate longitudinal edge bars between 3 and 6 inches from edge of slab.
2. Lap mats one full space.
3. Tie end transverse member of upper mat securely to prevent curving.
4. Lap nonwelded bars 12 inches minimum.
5. Support:
   a. Place bars and heavy mats securely on chairs at called-for height.
   b. Place other fabric on the first of a two-course pour and cover promptly with final pour, or place fabric by a fabric-placer if procedure is reviewed and approved by Engineer.

D. Joints:

1. Hold joint location and alignment to within +1/4 inches.
2. Finish concrete surface adjacent to previously placed slab to within +1/8 inches, with tooled radius of 1/4 inches.
3. Metal keyway joints:
    a. Form by installing metal joint strip left in place.
    b. Stake and support like side form.
    c. Provide dowels or tie bars.
4. Weakened plane joints:
    a. Tooled joints:
        1) Form groove in freshly placed concrete with tooling device.
        2) Groove dimensions shall be 3/8 inches at surface and 1/4 inches at root.
    b. Sawed joints:
        1) Saw 1/4 inches groove in green concrete.
        2) Commence sawing as soon as concrete is hard enough to withstand operation without chipping, spalling or tearing, regardless of nighttime or weather.
        3) Thoroughly wet surface to protect membrane cure and recoat afterward.
        4) Complete saw cutting before shrinkage stresses cause cracking.
5. Stake in place load transfer device for expansion joints consisting of dowels:
    a. Supporting and spacing means and premolded joint filler as per Drawing details.
    b. Provide preformed joint filler at all junctions with existing curb, sidewalk, steps, or other structures.
6. Install construction joints at end of day's work or wherever concreting must be interrupted for 30 minutes or more.
7. Thoroughly clean and fill joints with joint sealing material as specified.
8. Fill joints without overflowing onto pavement surface.
9. Upper surface of filled joint to be flush to 1/8 inches below finish surface.

E. Place Concrete:

1. Comply with Specification Section 03 31 31.
2. Construct driveway openings, ramps, and other features as per Drawing details.

F. Cold and Hot Weather Concreting:

1. Cold weather:
    a. Cease concrete placing when descending air temperature in shade falls below 40 DEGF.
    b. Do not resume until ambient temperature rises to minimum 40 degrees F.
    c. If placing below 40 degrees F is authorized by Engineer, maintain temperature of mix between 60 and 80 degrees F.
    d. Heat aggregates or water or both.
    e. Water temperature may not exceed 175 degrees F.
    f. Aggregate temperature may not exceed 150 degrees F.
    g. Remove and replace frost damaged concrete.
    h. Salt or other antifreeze is not permitted.
    i. Comply with ACI 306R.
2. Hot weather:
    a. Cease concrete placing when plastic mix temperature cannot be maintained under 90 DEGF.

b. Aggregates or water or both may be cooled.
c. Cool water with crushed ice.
d. Cool aggregates by evaporation of water spray.
e. Never batch cement hotter than 160 degrees F.
f. Comply with ACI 305R.

G. Finishing:

1. As soon as placed, strike off and screed to crown and cross section, slightly above grade, so that consolidation and finishing will bring to final Drawing elevations.
2. Maintain uniform ridge full width with first pass of first screed.
3. Pavement and similar surfaces:
   a. Float by longitudinally reciprocating float, passing gradually from edge to edge.
   b. Assure successive advances do not exceed half the length of the float.
   c. Test level of slab with minimum 10 feet straightedge.
   d. Fill depressions with fresh material, consolidate and refinish.
   e. Cut down high areas and retest.
   f. Belt surface with two-ply canvas belt, using transverse strokes while advancing along center line.
   g. Provide final finish by full width burlap or carpet drag, drawn longitudinally.
   h. Keep drag clean to avoid build up and consequent scarring.
   i. Tool pavement edges with suitable edger.
   j. Retest with straightedge and if pavement shows deviation of more than 1/8 inches in 10 feet, remove and replace.

H. Curing:

1. Apply membrane curing compound complying with ASTM C309, and in accordance with manufacturer's directions but at a minimum rate of 200 square feet/GAL.
2. Apply curing compound within 4 hours after finishing or as soon as surface moisture has dissipated.
3. Cure for minimum of seven days.
4. When average daily temperature is below 50 degrees F, provide insulative protection of 12 inches minimum thickness loose dry straw, or equivalent, for 10 days.
5. Linseed oil sealant:
   a. Seal surface with linseed oil.
   b. Apply linseed oil to clean surface as per AASHTO M224 after concrete has cured for one month.
   c. Apply first application at minimum rate of 67 square yards per gallon.
   d. Apply second application to a dry surface at minimum rate of 40 square yards per gallon.

I. Protection of Concrete:

1. Protect concrete surfaces and appurtenances from traffic for minimum of 14 days.
2. Erect and maintain warning signs, lights, watchmen to direct traffic.
3. Repair or replace parts of concrete surfaces damaged by traffic, or other causes, occurring prior to final acceptance.
4. Protect concrete pavement against public traffic, construction traffic and traffic caused by employees and agents.
5. No equipment shall be driven or moved across concrete surfaces unless such equipment is rubber-tired and only if concrete is designed for and capable of sustaining loads to be imposed by the equipment.

6. Do not drive over new or existing concrete with tracked vehicles and equipment.

J. Opening to Traffic:

1. After 14 days, pavement may, at Owner's discretion, be opened to traffic if job cured test cylinders have attained a compressive strength of 3,000 pounds per square inch when tested in accordance with ASTM standard methods.
2. Prior to opening to traffic, clean and refill joints as required with the specified filler material.

K. Clean Up:

1. Assure clean up work is completed within two weeks after pavement has been opened to traffic.
2. No new work will begin until clean up work has been completed, or is maintained within two weeks after pavement has been opened to traffic.

L. Pavement Patching:

1. Comply with material and density requirements as mentioned elsewhere in this Specification except provide minimum 6 inches aggregate immediately below the patch.
2. Place pavement patch providing a thickened edge.
3. Assure that patch in plane of "cold" joint has a thickness 6 inches greater than that of the existing pavement.
4. Extend patch under existing pavement for a distance of 6 inches minimum.
5. Fill void under existing pavement with concrete.
6. Undercut existing pavement 6 inches all around patch and to a depth of 6 inches.
7. Prior to placing patch, sawcut edge of existing concrete to 1/4 depth and remove to provide a vertical face for a straight and true joint.

3.3 FIELD QUALITY CONTROL

A. Provide test cylinders in accordance with Specification Section 03 05 05 for each 100 CUYD of concrete placed, as requested by the Quality Assurance Testing Engineer.

B. Pavement Thickness Testing:

1. General:
   a. Core pavement to determine the actual thickness as directed by Engineer.
   b. Determine thickness by ASTM C174/C174M.
   c. Fill holes from removal of cores with concrete of the same mixture as specified.
   d. Cost incidental to coring of cores showing a deficiency greater than 1/4 inches shall be paid by the Contractor.
   e. Cost of cores showing a deficiency of 1/4 inches or less shall be paid by the Owner.
   f. If average pavement thickness, as directed by core measurement, is outside specified tolerances, payment will be reduced per PART 1 of this Specification Section.
   g. If deficiency in pavement thickness is 1 inch or more, remove and replace pavement at Contractor's expense.
2. Core categories:
   a. In determining the average thickness of acceptable pavement for which payment will be made, utilize the following core categories:

CATEGORY NUMBER	CORE THICKNESS IN RELATION TO DESIGN	CORE LENGTH USED IN CALCULATING
1	1 inches or more deficiency	NOT USED
2	Less than 1 inch deficiency through 1/2 inches excess	Actual Core Thickness

3	More than 1/2 inches excess	Design Thickness plus 1/2 inches

b. Core sampling:
   1) Take cores in each lane in each block.
c. Take cores at locations where the cement content was found to be low when checking the quantities of cement used during the progress of the work.
d. Each separately poured lane of the pavement to be considered as a unit.
e. A lane shall be considered to be the pavement surface between longitudinal construction joints, between a longitudinal construction joint and the edge, or between two pavement edges in cases where the entire width of the pavement is poured in one operation.
f. Should any core show a deficiency in thickness in excess of 1 inch, check cores shall be taken 5 feet on either side of this location parallel to the centerline of the pavement.
g. If both of these cores are within the 1 inch tolerance, no further special borings for this individual zone of deficiency will be made.
h. If either one or both of these cores are not within the 1 inch tolerance, the procedure will be to cut cores in the following order on either side of the original short core parallel to the centerline of the pavement:
   1) 25 feet, 50 feet, the same to be measured from the location of original core found to be deficient in thickness, then at 50 feet intervals until a thickness within the 1 inch tolerance is found in both directions.
   2) On either side of the original deficient core, the procedure will then be to make a coring approximately half the distance within the first core which comes within the 1 inch tolerance.
   3) Repeat the above procedure until the station (+5 feet), at which the pavement comes within the 1 inch tolerance is located.
   4) If for some reason two or more cores are taken at the same station and at least one of them is beyond the 1 inch tolerance, the section of pavement at the station shall be considered as unacceptable.

END OF SECTION

SECTION 32 16 23
CONCRETE SIDEWALK AND STEPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Concrete sidewalk and steps.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 03 31 30 - Concrete, Materials and Proportioning.
2. Section 03 31 31 - Concrete Mixing, Placing, Jointing, and Curing.
3. Section 03 05 05 - Testing.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. M153, Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
   b. M171, Sheet Materials for Curing Concrete.
   c. M182, Burlap Cloth Made from Jute or Kenaf.
   d. M213, Preformed Expansion Joint Fillers for Concrete Paving and Structure Construction (Nonextruding and Resilient Bituminous Types).
   e. M224, Use of Protective Sealers for Portland Cement Concrete.
   f. M233, Boiled Linseed Oil Mixture for Treatment of Portland Cement Concrete.
2. American Concrete Institute (ACI):
   a. 305R, Hot Weather Concreting.
   b. 306R, Cold Weather Concreting.
3. ASTM International (ASTM):
   a. A185, Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
   b. A615, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   c. A1064, Standard Specification for Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.
   d. C33, Standard Specification for Concrete Aggregates.
   e. C150, Standard Specification for Portland Cement.
   f. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
   g. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 feet-LBF/FT^3).
   h. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   i. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
4. Federal Specification (FS):
   a. SS-S-1614, Sealants, Joint, Jet-Fuel-Resistant, Hot-Applied for Portland Cement and Tar Concrete Pavements.
   b. TT-S 00227 E(3), Sealing Compound: Elastomeric Type, Multi-Component (for Calking, Sealing, and Glazing in Buildings and Other Structures).

1.3 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
    a. Acknowledgement that products submitted meet requirements of standards referenced.
2. Mix design(s) in accordance with Specification Section 03 31 30 and Specification Section 03 05 05.
3. Qualifications of concrete installer.
4. Drawings detailing all reinforcing.
5. Concrete cylinder test results from field quality control.

B. Samples:

1. Samples of fabricated jointing materials and devices.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Chemical admixtures:
    a. Sika Chemical Corporation.
    b. Master Builders Solutions.
    c. Protex Industries.
    d. W. R. Grace and Company.

2.2 MATERIALS

A. Portland Cement:

1. ASTM C150, Type I or II.

B. Aggregates:

1. ASTM C33, gradation size #67, 3/4 inches to #4.

C. Water:

1. Potable quality.

D. Admixtures:

1. Comply with Specification Section 03 31 30.

E. Reinforcing Bars:

1. ASTM A615, Grade 60.

F. Welded Wire Reinforcement:

1. ASTM A185 or ASTM A1064.
2. Flat.
3. Clean, free from dirt, scale, rust.

G. Preformed Joint Filler:

1. Nonextruding cork, self-expanding cork, sponge rubber or cork rubber.
2. Meet AASHTO M153 or AASHTO M213.

H. Hot-Poured Joint Sealing Material:

1. FS SS-S-1614.

I. Sidewalk Joint Sealant:

1. Two compound, polyurethane sealant.
2. Class A, Type 1.
3. Self-leveling.
4. Nontracking.
5. FS TT-S 00227 E(3).

J. Membrane Curing Compound:

1. ASTM C309.

K. Cover Materials for Curing:

1. Burlap:
   a. AASHTO M182.
   b. Minimum Class 2, 8 oz material (1 yard x 42 inches).
2. Polyethylene film:
   a. AASHTO M171.

L. Paper Subgrade Cover:

1. Polyethylene film, AASHTO M171.

M. Concrete Treatment:

1. Boiled linseed oil mixture.
2. Meets AASHTO M233.

N. Forms:

1. Steel or wood.
2. Size and strength to resist movement during concrete placement and to retain horizontal and vertical alignment.
3. Free of distortion and defects.
4. Full depth.
5. Metal Side Forms:
   a. Minimum 7/32 inches thick.
   b. Depth equal to edge thickness of concrete.
   c. Flat or rounded top minimum 1-3/4 inches wide.
   d. Base 8 inches wide or equal to height, whichever is less.
   e. Maximum deflection 1/8 inches under center load of 1700 pounds.
   f. Use flexible spring steel forms or laminated boards to form radius bends.

2.3 MIXES

A. Mix design to provide 4,000 psi 28-day compressive strength, 1-1/2 inches +1 inches slump, 6% air.

B. Comply with Specification Section 03 31 30 and Specification Section 03 31 31.

PART 3 - EXECUTION

3.1 PREPARATION

A. Subgrade Preparation:

1. Prepare using methods, procedures, and equipment necessary to attain required compaction densities, elevation and section.
2. Scarify and recompact top 6 inches of fills and embankments which will be sidewalk and step areas.
3. Remove soft or spongy areas.

a. Replace with aggregate material.

4. Compact to the following densities:
   a. Cohesive soils: 95% per ASTM D698.
   b. Noncohesive soils: 75% relative per ASTM D4253 and ASTM D4254.
5. Assure moisture content is within limits prescribed to achieve required compaction density.
6. Following compaction, trim and roll to exact cross section.
   a. Check with approved grading template.
7. Perform density tests on subgrade to determine that subgrade complies with the specification.

B. Aggregate Course:

1. Place material in not more than 6 inches thick layers.
2. Spread, shape, and compact all material deposited on the subgrade during the same day.
3. Compact to 75% relative per ASTM D4253 and ASTM D4254.

C. Loose and Foreign Material:

1. Remove loose and foreign material immediately before application of paving.

D. Appurtenance Preparation:

1. Block out or box out curb inlets and curb returns.
2. Provide for joint construction as detailed and dimensioned on Drawings.
3. Adjust manholes, inlets, valve boxes and any other utility appurtenances to design grade.
   a. Secure to elevation with concrete.
   b. Place concrete up to 5 inches below design grade.
4. Clean and oil forms.

3.2 ERECTION, INSTALLATION AND APPLICATION

A. Concrete Production:

1. Comply with Specification Section 03 31 31.

B. Forms:

1. Form support:
   a. Compact soil foundation and cut to grade to support forms.
   b. Use bearing stakes driven flush with bottom of form to supplement support as necessary.
   c. Do not use earth pedestals.
2. Staking forms:
   a. Joint forms neatly and tightly.
   b. Stake and pin securely with at least three pins for each 10 feet section.
3. Clean and oil forms prior to placement of concrete.
4. Set forms sufficiently in advance of work (minimum 2 hours) to permit proper inspection.
5. Previously finished pavement or curb and gutter contiguous with new work may serve as side form when specifically approved.

C. Reinforcing:

1. Lap mats one full space.
2. Tie end transverse member of upper mat securely to prevent curling.
3. Lap nonwelded bars 12 inches minimum.
4. Support:
   a. Place bars securely on chairs at called-for height.

b. Place other fabric on the first of a two-course pour and cover promptly with final pour, or place fabric by a fabric-placer if procedure is reviewed and approved by Engineer.

D. Joints:

1. Hold locations and alignment to within + 1/4 inches.
2. Finish concrete surface adjacent to previous section to within + 1/8 inches, with tooled radius of 1/4 inches.
3. Metal keyway joints:
   a. Form by installing metal joint strip, left in place.
   b. Stake and support like side form.
   c. Provide dowels or tie bars.
4. Weakened plane joints:
   a. Locate at 6 feet intervals.
   b. Tool groove in freshly placed concrete with tooling device.
   c. Groove dimensions shall be 3/8 inches at surface and 1/4 inches at root.
5. Install construction joints at end of day's work or wherever concreting must be interrupted for 30 minutes or more.
6. Expansion joints:
   a. Locate at 48 feet intervals and at all intersection curb returns.
   b. Stake in place load transfer device consisting of dowels.
   c. Supporting and spacing means and premolded joint filler as per Drawing details.
   d. Provide preformed joint filler at all junctions with existing sidewalks, steps, or other structures.
7. Thoroughly clean and fill joints with joint sealing material as specified.
8. Upper surface of filled joint to be flush to 1/8 inches below finish surface.

E. Place Concrete:

1. Comply with Specification Section 03 31 31.
2. Construct driveway openings and other features as per Drawing details.

F. Cold and Hot Weather Concreting:

1. Cold weather:
   a. Cease concrete placing when descending air temperature in shade falls below 40 degrees F.
   b. Do not resume until ambient temperature has risen to 40 degrees F.
   c. If placing is authorized below 40 degrees F by Engineer, maintain temperature of mix between 60 and 80 degrees F.
   d. Heat aggregates or water or both.
   e. Water temperature may not exceed 175 degrees F.
   f. Aggregate temperature may not exceed 150 degrees F.
   g. Remove and replace frost damaged concrete.
   h. Salt or other antifreeze is not permitted.
   i. Comply with ACI 306R.
2. Hot weather:
   a. Cease concrete placing when plastic mix temperature cannot be maintained under 90 degrees F.
   b. Aggregates or water or both may be cooled.
   c. Cool water with crushed ice.
   d. Cool aggregates by evaporation or water spray.

e. Never batch cement hotter than 160 degrees F.
f. Comply with ACI 305R.

G. Finishing:

1. As soon as placed, strike off and screed to crown and cross section, slightly above grade, so that consolidation and finishing will bring to final Drawing elevations.
2. Maintain uniform ridge full width with first pass of first screed.
3. Test with 6 feet straightedges equipped with long handles and operated from sidewalk.
4. Draw excess water and laitance off from surface.
5. Float finish so as to leave no disfiguring marks but to produce a uniform granular or sandy texture.
6. Broom finish after floating.
7. Tool edges with suitable edger.
8. Provide exposed aggregate surfaces in areas indicated on the Drawings.
9. Provide method such as abrasive blasting, bush hammering, or surface retarder acceptable to the Engineer.

H. Curing:

1. Apply membrane curing compound complying with ASTM C309, and in accordance with manufacturer's directions but at a rate of minimum 200 square feet per gallon.
2. Apply curing compound within 4 hours after finishing or as soon as surface moisture has dissipated.
3. Cure for minimum of seven days.
4. When average daily temperature is below 50 degrees F, provide insulative protection of 12 inches minimum thickness loose dry straw, or equivalent, for 10 days.
5. Linseed oil sealant:
   a. For concrete sidewalk and step, seal surface with linseed oil.
   b. Apply linseed oil to clean surface as per AASHTO M224 after concrete has cured for 1 month.
   c. Apply first application at rate of 67 square yards per gallon.
   d. Apply second application to a dry surface at rate of 40 square yards per gallon.

I. Protection of Concrete:

1. Protect new sidewalk, steps, and their appurtenances from traffic for a minimum of 14 days.
2. Repair or replace parts of sidewalk and steps damaged by traffic, or other causes, prior to final acceptance.

J. Opening to Traffic:

1. After 14 days, area may, at Owner's discretion, be opened to traffic if job cured cylinders have attained a compressive strength of 3000 pounds per square inch when tested in accordance with ASTM standard methods.
2. Prior to opening to traffic, clean and refill joints as required with specified filler material.

K. Clean Up:

1. Assure clean-up work is completed within two weeks after sidewalk has been opened to traffic.
2. No new work will begin until clean-up work has been completed, or is maintained within 2 weeks after sidewalk has been opened to traffic.

L. Handrails:

1. Provide handrails where required and as per Drawing details.

3.3 FIELD QUALITY CONTROL

A. Provide test cylinders in accordance with Specification Section 03 05 05 for each 100 CUYD of placed concrete.

END OF SECTION

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SECTION 32 31 13
CHAIN LINK FENCE AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Chain link fencing and gates.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 03 31 30 - Concrete Materials and Proportioning.
2. Section 31 23 00 - Earthwork.
3. Section 31 23 33 - Trenching, Backfilling, and Compacting for Utilities.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. ASTM International (ASTM):
   a. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   b. A392, Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.
   c. A824, Standard Specification for Metallic-Coated Steel Marcelled Tension Wire for Use with Chain-Link Fence.
   d. F552, Standard Terminology Relating to Chain Link Fencing.
   e. F567, Standard Practice for Installation of Chain-Link Fence.
   f. F626, Standard Specification for Fence Fittings.
   g. F900, Standard Specification for Industrial and Commercial Steel Swing Gates.
   h. F1043, Standard Specification for Strength and Protective Coatings on Steel Industrial Fence Framework.
   i. F1083, Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures.
2. American Welding Society (AWS).
3. National Fire Protection Association (NFPA):
   a. NFPA 70, National Electrical Code (NEC).
4. Underwriters Laboratories, Inc. (UL).

B. Qualifications:

1. Installer bonded and licensed in the Project state.
2. Installer shall have a minimum two years experience installing similar fencing.
3. Utilize only AWS certified welders.
4. Electric gate operators to be UL listed.
5. Grounding by an electrician licensed in Project state.

1.3 DEFINITIONS

A. See ASTM F552.

B. NPS: Nominal pipe size, in inches.

C. Installer or Applicator:

1. Installer or applicator is the person actually installing or applying the product in the field at the Project site.

2. Installer and applicator are synonymous.

1.4 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Manufacturer's installation instructions.
2. Scaled plan layout showing spacing of components, accessories, fittings, and post anchorage.
3. Mill certificates.
4. Source quality control test results.
5. Automatic gate system:
   a. Electrical circuitry and control wiring.
   b. Intercom system.
   c. Detector loop layout.
   d. Locking plan.
   e. Method of installation of detector loop.
   f. Sealant material for detector loops.

PART 2 - PRODUCTS

2.1 COMPONENTS

A. Chain Link Fabric:

1. Fabric type:
   a. ASTM A392 zinc-coated steel:
      1) Coated before weaving, 2.0 oz/SQFT.
2. Wire gage: 9.
3. Mesh size: 2 inches.
4. Selvage treatment:
   a. Top: Twisted and barbed.
   b. Bottom: Knuckled.

B. Concrete: See Specification Section 03 31 30 - Concrete Materials and Proportioning.

C. Line Post:

1. ASTM F1083 pipe:
   a. Schedule 40, NPS 2.

D. Corner or Terminal Posts:

1. ASTM F1083 pipe:
   a. Schedule 40, NPS 2-1/2.

E. Brace and Rails:

1. ASTM F1083 pipe:
   a. Schedule 40, NPS 1-1/4.

F. Tension Wire:

1. Top of fabric:
   a. ASTM A824, galvanized steel, Class 3.

G. Fence Fittings (Post and Line Caps, Rail and Brace Ends, Sleeves-Top Rail, Tie Wires and Clips, Tension and Brace Bands, Tension Bars, Truss Rods):

1. ASTM F626.

H. Barbed Wire:

1. Three strands.
2. Galvanized steel:
   a. ASTM A121.
   b. Class 3 zinc coating.
   c. Four-point barbs.

I. Barbed Wire Extension Arms:

1. ASTM F626.
2. Accommodate three strands of barbed wire.
3. Extend at a 45 degrees angle outside of the fence line.
4. Include corner posts.

2.2 SOURCE QUALITY CONTROL

A. Test related fence construction materials to meet the following standards:

1. Posts and rails: ASTM F1043, Heavy Industrial.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install Type 4 fence per ISPWC SD-2040I and this Specification Section.

B. Install in accordance with:

1. Manufacturer's instructions.
2. Lines and grades shown on Drawings.
3. ASTM F567.

C. Remove existing fencing and relocate as shown on Drawings prior to excavation for the new Headworks Building and adjacent retaining wall.

1. If excavation does not permit permanent fencing installation prior to excavation, install temporary security fencing until building and retaining walls are sufficiently complete to install permanent fencing.

D. Drill holes in firm, undisturbed or compacted soil.

E. Place fence with bottom edge of fabric at maximum clearance above grade, as shown on Drawings.

1. Correct minor irregularities in earth to maintain maximum clearance.

F. Space line posts at equal intervals not exceeding 10 feet on-center.

G. Provide post braces for each gate, corner, pull and terminal post and first adjacent line post.

H. Install tension bars full height of fabric.

I. Rails:

1. Fit rails with expansion couplings of outside sleeve type.
2. Rails continuous for outside sleeve type for full length of fence.

J. Provide expansion couplings in top rails at not more than 20 feet intervals.

K. Anchor top rails to main posts with appropriate wrought or malleable fittings.

L. Install bracing assemblies at all end and gate posts, as well as side, corner, and pull posts.

1. Locate compression members at mid-height of fabric.
2. Extend diagonal tension members from compression members to bases of posts.
3. Install so that posts are plumb when under correct tension.

M. Pull fabric taut and secure to posts and rails.

1. Secure so that fabric remains in tension after pulling force is released.
2. Secure to posts at not over 15 inches on-center, and to rails at not over 24 inches on-center, and to tension wire at not over 24 inches on-center.
3. Use U-shaped wire conforming to diameter of pipe to which attached, clasping pipe and fabric firmly with ends twisted at least two full turns.
4. Bend ends of wire to minimize hazards to persons or clothing.

N. Install post top at each post.

O. Gates:

1. Construct with fittings or by welding.
2. Provide rigid, weatherproof joints.
3. Assure right, non-sagging, non-twisting gate.
4. Coat welds with rust preventive paint, color to match pipe.

P. Install electric gate operator in accordance with NFPA 70.

END OF SECTION

SECTION 32 92 00
SEEDING, SODDING AND LANDSCAPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Seeding, sodding and landscape planting:
    a. Soil preparation.
    b. Sodding.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Nursery and Landscape Association/American National Standards Institute (ANLA/ANSI):
    a. Z60.1, American Standard for Nursery Stock.
2. AOAC International (AOAC).
3. ASTM International (ASTM):
    a. D2028, Standard Specification for Cutback Asphalt (Rapid-Curing Type).
    b. D5276, Standard Test Method for Drop Test of Loaded Containers by Free Fall.

B. Quality Control:

1. Fertilizer:
    a. If Engineer determines fertilizer requires sampling and testing to verify quality, testing will be done at Contractor's expense, in accordance with current methods of the AOAC.
    b. Upon completion of Project, a final check of total quantities of fertilizer used will be made against total area seeded.
    c. If minimum rates of application have not been met, Contractor will be required to distribute additional quantities to make up minimum application specified.

1.3 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
    a. Acknowledgement that products submitted meet requirements of standards referenced.
    b. Manufacturer's installation instructions.
    c. Signed copies of vendor's statement for seed mixture required, stating botanical and common name, place of origin, strain, percentage of purity, percentage of germination, and amount of Pure Live Seed (PLS) per bag.
    d. Type of herbicide to be used during first growing season to contain annual weeds and application rate.
    e. Source and location of sod, plants, and plant material, as per Paragraph 3.2A.1.

B. Informational Submittals:

1. Copies of invoices for fertilizer used on Project showing grade furnished, along with certification of quality and warranty.

1.4 SEQUENCING AND SCHEDULING

A. Installation Schedule:

1. Show schedule of when lawn type and other grass areas are anticipated to be planted.
2. Indicate planting schedules in relation to finish grading and topsoiling.

3. Indicate anticipated dates Engineer will be required to review installation for initial acceptance and final acceptance.

PART 2 - PRODUCTS

2.1 MANUFACTURERS AND SUPPLIERS

A. Subject to compliance with the Contract Documents, the manufacturers and suppliers listed in the applicable Articles below are acceptable.

2.2 MATERIALS

A. Sod:

1. Viable, dense, strongly rooted, not less than two years old.
2. 30% Kentucky Bluegrass, 20% Tall Fescue, 20% Chewing Fescue, and 30% Perennial Ryegrass.
3. Free of weeds and undesirable native grasses.
4. Strips 12 to 18 inches wide.
5. Mow prior to stripping from field.
6. Cut so 3/4 inches of soil is firmly attached to roots.
7. Not frozen or dormant.

B. Fertilizer:

1. Commercial fertilizer meeting applicable requirements of State and Federal law.
2. Cyanic compound or hydrated lime not permitted in mixed fertilizers.
3. For lawn-type seeding and sod: 5-10-5 analysis.

PART 3 - EXECUTION

3.1 SOIL PREPARATION

A. General:

1. Limit preparation to areas which will be planted soon after.
2. Provide facilities to protect and safeguard all persons on or about premises.
3. Protect existing trees designated to remain.
4. Verify location and existence of all underground utilities.
   a. Take necessary precaution to protect existing utilities from damage due to construction activity.
   b. Repair all damages to utility items at sole expense.
5. Provide facilities such as protective fences and/or watchmen to protect work from vandalism.
   a. Contractor to be responsible for vandalism until acceptance of work in whole or in part.

B. Preparation for Lawn-Type Seeding, Sprigging, Plugging or Sodding:

1. Loosen surface to minimum depth of 4 inches.
2. Remove stones over 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter.
3. Prior to applying fertilizer, loosen areas to be seeded with a double disc or other suitable device if the soil has become hard or compacted.
4. Correct any surface irregularities in order to prevent pocket or low areas which will allow water to stand.
5. Distribute fertilizer uniformly over areas to be seeded:
   a. For lawn-type seeding: 30 pounds per 1000 square feet.
   b. For pasture seeding: 200 pounds per acre.

6. Incorporate fertilizer into soil to a depth of at least 2 inches by disking, harrowing, or other approved methods.
7. Remove stones or other substances from surface which will interfere with turf development or subsequent mowing operations.
8. Grade lawn areas to a smooth, even surface with a loose, uniformly fine texture.
    a. Roll and rake, remove ridges and fill depressions, as required to meet finish grades.
    b. Limit fine grading to areas which can be planted soon after preparation.
9. Restore lawn areas to specified condition if eroded or otherwise disturbed after fine grading and before planting.

3.2 INSTALLATION

A. Sodding:

1. Notify Engineer of source and location of sod at least 30 days prior to sodding operation, to permit inspection.
    a. Submit species and percentages of purity and state botanical and common names.
2. Sod areas as designated and disturbed lawn areas which were sodded or established prior to construction.
3. Perform sodding only during climatic or weather conditions conducive to successful results.
    a. Lay within 24 hours of stripping.
    b. Do not use dormant or frozen sod.
    c. Sodding may be accomplished at all seasonal periods providing adequate provisions for sod protection are taken to ensure fitness and survival.
    d. Do not place sod when temperature is below 32 degrees F.
    e. Do not place frozen or dried out sod.
    f. Do not sod on frozen or dried out soil.
4. Lay sod to form a solid mass with tightly fitted joints.
    a. Butt ends and edges; do not overlap.
    b. Stagger joints.
    c. Tamp or roll lightly to ensure full contact with subgrade.
    d. Work sifted soil into minor cracks, avoid smothering adjacent grass.
    e. Peg sod on slopes to prevent slippage.
        1) Use sharpened 1 x 1 x 6 inches wooden pegs.

3.3 MAINTENANCE AND REPLACEMENT

A. General:

1. Begin maintenance of planted areas immediately after each portion is planted and continue until final acceptance or for a specific time period as stated below, whichever is the longer.
2. Provide and maintain temporary piping, hoses, and watering equipment as required to convey water from water sources and to keep planted areas uniformly moist as required for proper growth.
3. Protection of new materials:
    a. Provide barricades, coverings or other types of protection necessary to prevent damage to existing improvements indicated to remain.
    b. Repair and pay for all damaged items.
4. Replace unacceptable materials with materials and methods identical to the original specifications unless otherwise approved by the Engineer.

B. Seeded or Sodded Lawns:

1. Maintain sodded lawns: 30 days, minimum, after installation and review of entire project area to be sodded.

2. Maintenance period begins at completion of planting or installation of entire area to be seeded or sodded.
3. Engineer will review seeded or sodded lawn area after installation for initial acceptance.
4. Maintain lawns by watering, fertilizing, weeding, mowing, trimming, and other operations such as rolling, regrading, and replanting as required to establish a smooth, uniform lawn, free of weeds and eroded or bare areas.
5. Lay out temporary lawn watering system and arrange watering schedule to avoid walking over muddy and newly seeded areas.
    a. Use equipment and water to prevent puddling and water erosion and displacement of seed or mulch.
6. Mow lawns as soon as there is enough top growth to cut with mower set at recommended height for principal species planted.
    a. Repeat mowing as required to maintain height.
    b. Do not delay mowing until grass blades bend over and become matted.
    c. Do not mow when grass is wet.
    d. Time initial and subsequent mowings as required to maintain a height of 1-1/2 to 2 inches.
    e. Do not mow lower than 1-1/2 inches.
7. Remulch with new mulch in areas where mulch has been disturbed by wind or maintenance operations sufficiently to nullify its purpose.
    a. Anchor as required to prevent displacement.
8. Unacceptable plantings are those areas that do not meet the quality of the specified material, produce the specified results, or were not installed to the specified methods.
9. Replant bare areas using same materials specified.
10. Engineer will review final acceptability of installed areas at end of maintenance period.
11. Maintain repaired areas until remainder of maintenance period or approved by Engineer, whichever is the longer period.

END OF SECTION

DIVISION 33

UTILITIES

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SECTION 33 05 15
PRECAST CONCRETE UTILITY STRUCTURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Precast concrete utility structures, non-circular in plan, and appurtenant items.
    a. Valve and meter vaults.
    b. Stormwater catch basins.
2. Design and fabrication of precast concrete utility structures.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 03 21 00 - Reinforcement.
2. Section 03 31 30 - Concrete, Materials and Proportioning.
3. Section 03 31 31 - Concrete Mixing, Placing, Jointing, and Curing.
4. Section 08 31 00 - Access Doors.
5. Section 09 96 00 - High Performance Industrial Coatings.
6. Section 31 23 00 - Earthwork.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. ASTM International (ASTM):
    a. C857, Standard Practice for Minimum Design Loading for Underground Precast Concrete Utility Structures.
    b. C858, Standard Specification for Underground Precast Concrete Utility Structures.
    c. C890, Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures.
    d. C990, Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
    e. D1227, Standard Specification for Emulsified Asphalt Used as a Protective Coating for Roofing.

1.3 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
    a. Acknowledgement that products submitted meet requirements of standards referenced.
    b. Manufacturer's installation instructions.
2. Concrete mix design(s):
    a. Include submittal information defined in Specification Section 03 31 30.
    b. Certification in accordance with ASTM C858, Section 12.
3. Fabrication and/or layout drawings:
    a. Include detailed diagrams of utility structures showing typical components and dimensions, reinforcement, and other details.
    b. Itemize, on separate schedule, elevations or sectional breakdown of each utility structure with all components and refer to drawing identification number or notation.
    c. Indicate required penetration details for all piping entering each structure.

4. Drawings and calculations: All Drawings, including layout drawings, certifications and calculations shall be sealed by a Professional Engineer registered in the state where the project is located.
    a. Provide certification stating that calculations provided have been prepared specifically for this Project and that they match and pertain to the Shop Drawings provided.
    b. Provide a summary document as part of the above certification listing the design criteria used for precast design including:
        1) Codes and standards.
        2) Soil load.
        3) Exterior groundwater load.
        4) Live loads.
        5) Other loads.
5. Test Reports:
    a. Copies of source quality control tests, including compressive strength and air content, for units provided.

B. Contract Closeout Information:

1. Operation and Maintenance Data:
    a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

C. Informational Submittals:

1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.

1.4 SITE CONDITIONS

A. Design groundwater elevation for precast structure design shall be the 100-year flood elevation shown on the Contract Documents.

1. If the 100-year flood elevation is not shown on the Contract Documents, the design groundwater elevation shall be equal to the ground surface elevation at the structure.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Access doors:
    a. Conform to requirements of Specification Section 08 31 00.
2. Manhole rings, covers and frames:
    a. Neenah Foundry.
    b. Deeter Foundry.
    c. Clay and Bailey.
3. Vault steps:
    a. M.A. Industries.
    b. Neenah Foundry.
    c. Deeter Foundry.
4. Black mastic joint compound:
    a. Kalktite 340.
    b. Tufflex.
    c. Plastico.

5. Premolded joint sealant:
    a. NPC Bidco, Inc., C-56.
    b. Ram-Nek, Henry Co.
    c. EZ-Stik, Press-Seal Gasket Corp.
    d. CS-102, Conseal.
6. Elastomeric joint seals:
    a. Kent Seal.
7. External joint wrap.
    a. NPC, Bidco, Inc.
    b. EZ-Wrap, Press-Seal Gasket Corp.
    c. RUBR-Nek, Henry Co.
8. Emulsified fibrated asphalt compound:
    a. Sonneborn Hydrocide 700B Semi-Mastic.

2.2 PRECAST UTILITY STRUCTURE COMPONENTS

A. Provide utility structures with interior dimensions as shown on the Drawings.

1. Catch basins similar to ISPWC SD-603 with grating and frame similar to ISPWC SD-610 with H-20 load rating.

B. Provide the following components for each utility structure:

1. Precast base section with integral or cast in place base slab.
2. Precast wall section(s).
3. Precast flat top.
    a. Where reinforcement is shown for top slab, furnish slab with reinforcing as designed, but not less than reinforcing shown on Drawings.

C. Provide openings and appurtenances as shown on Drawings.

1. Access doors:
    a. Cast access doors into top slab.
    b. Where access door frames have drainage channels, cast PVC drain lines in top slab to drain location shown on Drawings. If no drain location is shown, drain frames to outer edge of top slab.
    c. Protect doors and frames from damage during concrete placement and shipping.
    d. See Specification Section 08 31 00.

D. Nonpressure Type Frames and Cover:

1. Cast iron frame and covers: ASTM A48, Class 35 (minimum).
2. Use only cast iron of best quality, free from imperfections and blow holes.
3. Furnish frame and cover of heavy-duty construction a minimum total weight of 450 pounds.
4. Machine all horizontal surfaces.
5. Furnish unit with solid nonventilated lid with concealed pickholes.
    a. Letter covers "SEWER" for all collection system manholes, "DRAIN" for all gravity unit drains returning flow to the headworks, and "STORM" for storm sewer systems.
6. Ensure minimum clear opening of 24 inches diameter.

E. Pressure Type Frame and Cover:

1. Provide covers meeting the requirements of the Nonpressure Type Frames and Cover paragraph above and as modified below.
2. Furnish frame and bolted cover of heavy-duty construction.

a. Equip unit with six stainless steel countersunk 3/8 inches diameter by 1-1/2 inches long bolts with stainless steel washers.

3. Provide solid lid and minimum 1/8 inches thick x 1/2 inches wide continuous strip neoprene gasket.
4. Furnish unit with a minimum of six anchorage holes and six, 6 inches long x 3/4 inches diameter stainless steel anchor bolts.

F. Vault Steps:

1. General:
   a. Provide maximum distance from surface to first rung is not greater than 16 inches and that maximum spacing on remaining steps is 16 inches on-center.
   b. Safety tread.
2. Copolymer polypropylene encapsulated 1/2 inches Grade 60 steel rod as manufactured by MA Industries, Inc., Peachtree City, GA.
   a. Minimum step width: 12 inches.
   b. Distance from face of wall to back of tread: 5-3/4 inches.
   c. Embedment: 3-3/8 inches.
   d. Encapsulating material thickness: MA Industries, Inc.

G. Concrete:

1. Conform to requirements of Specification Section 03 31 30.
2. Conform to requirements of ASTM C858, where stricter than Specification Section 03 31 30.
   a. Minimum 28-day compressive strength 4,500 psi.
   b. All portions of precast utility structure are considered to be exposed to freeze-thaw cycles.

H. Joints:

1. Joints of precast riser and top sections:
   a. Preformed flexible joint sealants: ASTM C990.
   b. Exterior joint wrap.
2. Pipe and conduit entry for utility structures.
   a. In accordance with Specification Section 01 73 20.

I. Coatings:

1. Vertical wall surfaces:
   a. Emulsified fibrated asphalt compound meeting ASTM D1227 Type I for all vertical wall exterior surfaces.

2.3 DESIGN

A. General Design Requirements:

1. Design precast units and appurtenances in accordance with ASTM C858.
   a. Notify Engineer and furnish cast-in-place structures if sizes of precast utility structures shown on Drawings can not be designed or fabricated.

B. Design loads:

1. Design precast units for all loads and load cases described in ASTM C857, with the following values and selections:
   a. Minimum uniform live load for exposed roof slabs shall be 150 PSF.
   b. Wheel loads shall be considered.
      1) Use wheel load designation A-16 (HS20-44) as shown in ASTM C857, Table 1.

2) Wheel loads and uniform live load do not act concurrently.

c. Unit weight of soil W shall be taken as no less than 100 LB/CUFT.

d. Minimum lateral soil pressure coefficient (K_0): 0.50.

C. Specific Design Requirements:

1. Out-of-plane shear:
   a. Out-of-plane shear shall be shown in the calculations.
   b. Wall thickness shall be determined based on meeting design requirements for out-of-plane shear resulting from soil and groundwater loads.
   c. Wall sections shall be designed as one-way spans between corners for calculation of out-of-plane shear. Transfer of shear or bending load shall not be considered to be transferred across joints between precast units or between walls and slabs, unless unit as integrally cast together.
   d. Use of shear steel reinforcement to increase out-of-plane shear capacity shall be prohibited.
2. The distribution of moments in adjacent walls of different lengths in rectangular structures shall be considered.
3. Design precast units taking into account reduced cross section at openings and penetrations.
4. Structure shall be checked for buoyancy.
   a. The minimum factor of safety for uplift with the design groundwater elevation shall be 1.25, unless a larger factor of safety is required by the local governing body or building code.
   b. The minimum factor of safety for uplift at the fully submerged condition shall be no less than 1.0.
   c. If the buoyant weight of soil above base slab extensions beyond the external dimensions of the structure is used to resist uplift, the volume of soil considered to resist uplift shall be limited to soil within the vertical projection of the edge of the base slab extensions.

PART 3 - EXECUTION

3.1 PRECAST UTILITY STRUCTURE CONSTRUCTION

A. General:

1. Prepare subgrade for base as required by Specification Section 31 23 00.
   a. For precast base slabs, place and compact 6 inches of Granular Fill or Bedding Material as shown on Drawings.
   b. For cast-in-place concrete base slabs, support base section and prepare bottom joint with preformed strip-type hydrophilic waterstop in accordance with Specification Section 03 31 31.
   c. Confirm that base is level and fully supported by stable material.
2. Ensure accurate vertical placement and leveling prior to placement of interior grout.
   a. Provide vertical alignment tolerance of maximum 1 inch horizontal to 10 feet vertical.

B. Build each structure to dimensions shown on plans and at such elevation that pipe sections built into wall of structure will be true line of pipe extensions.

C. For all horizontal mating surfaces between precast concrete units, apply premolded flexible joint sealant to clean mating surfaces in accordance with sealant manufacturer's written instructions. Apply sufficient pressure to each concrete unit to seat unit in sealant.

D. Seal all pipe penetrations in precast concrete structures.

1. Where post-installed seals are permitted, form pipe openings smooth and well shaped.

2. After installation, seal exterior of penetration with non-shrink grout.
3. After grout cures, wire brush smooth and apply two coats emulsified fibrated asphalt compound to minimum wet thickness of 1/8 inches to ensure complete seal.

E. Set top slab level to elevation shown on Drawings.

3.2 FIELD QUALITY CONTROL

A. Any proposed repairs of precast components or structures shall be submitted to Engineer for approval.

B. Structures shall be observed for signs of leakage during periods of high groundwater.

C. No leakage that includes visible flow through joints between precast concrete sections or through pipe penetrations shall be permitted.

D. Damp spots on interior wall surfaces shall be considered leakage and shall not be permitted.

1. Damp spots shall be defined as spots where moisture from a source outside the structure can be picked up on a dry hand.
2. Locate the source of water movement through the wall and permanently seal.

E. Dampness on the top of the base slab will not be construed as leakage.

END OF SECTION

SECTION 33 05 31.11

POLYVINYL CHLORIDE GRAVITY SEWER PIPE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. PVC gravity sewer pipe and fittings.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 31 23 33 - Trenching, Backfilling, Compacting For Utilities.
2. Section 40 05 00 - Pipe and Pipe Fittings - Basic Requirements.

1.2 QUALITY ASSURANCE

A. See Specification Section 40 05 00.

B. Referenced Standards:

1. ASTM International (ASTM):
   a. PVC (polyvinyl chloride) materials:
      1) D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
      2) D2564, Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
      3) D2729, Standard Specification for Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
      4) D3034, Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
      5) D3212, Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
      6) F477, Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
      7) F679, Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
      8) F1336, Standard Specification for Poly(Vinyl Chloride) (PVC) Gasketed Sewer Fittings
      9) D2321, Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.

1.3 DEFINITIONS

A. DR: Dimension Ratio, Outside Diameter/Minimum Wall Thickness, both in inches

B. Diametral Deflection: reduction in diameter caused by earth and surcharge loads acting on the installed pipe.

C. PS: Pipe Stiffness, PSI

D. SDR: Standard Dimension Ratio.

1.4 SUBMITTALS

A. Comply with Section 40 05 00 – Pipe and Pipe Fittings – Basic Requirements, relative to required Submittals.

B. Where an option for joint type is specified, submit jointing method(s) selected and where each will be used.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Chevron Phillips Chemical Company LP - Performance Pipe Division (DriscoPlex).
2. WL Plastics.
3. JM Eagle
4. Pipeline Plastics.
5. Or equal.

2.2 PVC DRAINAGE AND SEWER PIPING

A. Materials:

1. PVC pipe and fittings: rigid, unplasticized polyvinyl chloride (PVC) made of PVC plastic having a cell classification of 12454-B or 12454-C per ASTM D1784.

B. Pipe:

1. ASTM D3034
   a. DR 35.
2. Ensure impact strengths and pipe stiffnesses are in full compliance to these Specifications.

C. Joints

1. Elastomeric gasket joint meeting requirements of ASTM D3212.
   a. Gaskets (seals) per ASTM F477.

D. Fittings:

1. Elastomeric Joints: Per ASTM D3034.

PART 3 - EXECUTION

3.1 IDENTIFICATION

A. Identify each length of pipe clearly at intervals of 5 feet or less per governing ASTM Standard for each type of pipe used.

3.2 INSTALLATION

A. See Section 31 23 33 - Trenching, Backfilling, Compacting For Utilities.

B. Install pipe and fittings in accordance with ASTM D2321, the above referenced Specification Sections and as recommended by the manufacturer.

C. Infiltration and Exfiltration:

1. Infiltration and Exfiltration maximum rates: See Section 40 05 00
   a. Observe full instructions of the Engineer for carrying of testing procedures.
   b. Perform tests only during presence of the Engineer or his authorized representative.
2. Should any test on any section of pipeline disclose either infiltration rates greater than allowed or disclose air loss rate greater than that permitted, locate and repair the defective joints or pipes at no cost to Owner and retest until requirements stated are met.

D. Diametral Deflection:

1. After backfilling, check each section of pipe for diametral deflection by pulling a mandrel through the pipe.
2. Pipe with deflection exceeding 3% of the inside diameter: remove and replace to provide a deflection of less than 3%.
3. Retest any repaired pipe.

END OF SECTION

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SECTION 33 05 33.23

POLYETHYLENE PRESSURE PIPE AND TUBING (AWWA C901 AND AWWA C906)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. High-Density Polyethylene (HDPE) pipe, fittings, and appurtenances.

B. Related Sections include but are not necessarily limited to:

1. Section 31 23 33 - Trenching, Backfilling, and Compacting for Utilities.
2. Section 40 05 00 - Pipe and Fittings: General Requirements

1.2 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer of HDPE Pipe:
   a. Obtain all HDPE pipe and fittings from one manufacturer, unless otherwise acceptable to Owner and Engineer.
   b. Manufacturer of pipe required by this Section shall be regularly engaged in the business of manufacturing HDPE piping of the size and type(s) required for the Work. Upon Engineer's request, submit documentation of manufacturer's prior furnishing of HDPE pipe of the type(s) required for not less than five other projects, similar in size and complexity to the HDPE piping Work of this Project, in North America.
   c. Equipment:
      1) Qualify each extrusion line and molding machine to produce pressure rated products by taking representative production samples and performing sustained pressure tests in accordance with ASTM D1598.
   d. QA and QC Program:
      1) HDPE pipe manufacturer shall have documented quality assurance and quality control programs as part of manufacturer's routine business.
      2) HDPE piping manufacturer shall maintain permanent Quality Control (QC) and Quality Assurance (QA) records.
2. Installer:
   a. Use one entity for all HDPE pipe Work, unless otherwise acceptable to Owner and Engineer.
   b. Installer shall be experienced with HDPE piping installation work similar in scope and complexity to the Work of this Section. When required by Engineer, submit documentation of successful completion of not less than five similar projects to the HDPE piping Work completed within the past five years.
   c. Where HDPE pipe joints are made by fusing, fusion machine operators shall have been trained by fusion machine manufacturer within 12 months of starting to perform joint fusion Work. Submit documentation of such training, acceptable to Engineer, when requested by Engineer.
   d. Installer's training and qualifications shall be acceptable to HDPE pipe Supplier retained for the Project.

B. Referenced Standards:

1. American National Standards Institute (ANSI):
   a. B1.1, Unified Inch Screw Threads (UN and UNR Thread Form).
   b. B16.1, Cast-Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800.
   c. B16.21, Nonmetallic Flat Gaskets for Pipe Flanges.

2. ASTM International (ASTM):
    a. A182, Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
    b. A193, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
    c. A194, Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
    d. A536, Standard Specification for Ductile Iron Castings.
    e. B695, Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
    f. D638, Standard Test Method for Tensile Properties of Plastics.
    g. D1248, Specification for Polyethylene Plastics Molding and Extrusion Materials.
    h. D1505, Test Method for Density of Plastics by the Density-Gradient Technique.
    i. D1598, Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure.
    j. D1599, Test Method for Short-Time Hydraulic Failure Pressure of Plastics Pipe, Tubing and Fittings.
    k. D2239, Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.
    l. D2290, Test Method for Apparent Tensile Strength of Ring or Tubular Plastics and Reinforced Plastics by Split Disk Method.
    m. D2683, Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
    n. D2737, Standard Specification for Polyethylene (PE) Plastic Tubing.
    o. D2837, Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.
    p. D3035, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
    q. D3261, Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
    r. D3350, Standard Specification for Polyethylene (PE) Plastics Pipe and Fittings Materials.
    s. F714, Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.
    t. F1055, Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing.
    u. F2620, Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings.
3. American Water Works Association (AWWA).
    a. C207, Steel Pipe Flanges for Waterworks Service, Sizes 4 In. through 144 In.
    b. C901, Polyethylene (PE) Pressure Pipe and Tubing, ¾ In. through 3 In. for Water Service.
    c. C906, Polyethylene (PE) Pressure Pipe and Fittings, 4 In. through 65 In. for Waterworks.
4. Plastic Pipe Institute (PPI):
    a. TR-3, Policies and Procedures for Developing Recommended Hydrostatic Design Stresses for Thermoplastic Pipe Material.
    b. PPI TR-4, Recommended Hydrostatic Strengths and Design Stresses for Thermoplastic Pipe and Fittings Compounds.
5. Military Specification (Mil Spec):
    a. QQ-P-416F, Plating, Cadmium Electro Deposited.

6. National Sanitation Foundation International (NSF):
    a. 14, Plastic Piping Components and Related Materials.
    b. 61, Drinking Water System Components – Health Effects.

1.3 DEFINITIONS

A. DIOD: Ductile Iron Outside Diameter.

B. DR: Dimension Ratio, Outside Diameter/Minimum Wall Thickness, both in inches.

C. Diametral Deflection: reduction in diameter caused by earth and surcharge loads acting on the installed pipe.

D. ESCR: Environmental Stress Crack Resistance.

E. HDB: Hydrostatic Design Basis per ASTM D2837.

F. SDR: Standard Dimension Ratio.

G. SIDR: Standard Inside Diameter Ratio.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:
    a. Dimensioned, scaled drawings showing Contractor's proposed deviations from piping alignment shown on the Drawings.
    b. Where necessary, include both plans and profiles and section views in Shop Drawings.
2. Product Data:
    a. Manufacturer's published catalog information and specifications for each size and type of HDPE piping required, including pipe, fittings, and jointing materials.
    b. Clearly indicate in product data submittal the reference standards with which pipe and appurtenances comply.
    c. Where couplings are required, submit coupling manufacturer's catalog literature and specifications for the specific couplings proposed.

B. Informational Submittals; Submit the following:

1. Supplier Instructions:
    a. Submit manufacturer's written instructions for handling, storing, and installing piping furnished.
2. Source Quality Control:
    a. Submit documentation from manufacturer that piping materials furnished were inspected at the production facility and successfully passed manufacturer's quality control procedures.
    b. Manufacturer's affidavit certifying piping materials furnished comply with AWWA standard C901 or C906, as applicable.
3. Fusion machines proposed for joining pipe/fittings.
4. Field Quality Control:
    a. Documentation of temperature and pressure profiles from data logger for each butt fusion joint.
    b. Results of field quality control testing and inspections required in this Section.
    c. Documentation of temperature and pressure profiles from data logger for each butt fusion joint.
5. Qualifications:
    a. Piping materials manufacturer, when requested by Engineer.
    b. Installer, when requested by Engineer, including documentation of training in use of joint fusion equipment.

c. Documentation showing fusion machine operators have been trained within 12 months prior to installation.

1.5 DELIVERY, HANDLING, AND STORAGE

A. In addition to requirements elsewhere in the Contract Documents, also comply with the following:

1. During handling and installation avoid conditions where pipe bends excessively and avoid imparting kinks in the pipe.

PART 2 - PRODUCTS

2.1 MANUFACTURER'S

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. HDPE Pipe and Fittings:
   a. Chevron Phillips Chemical Company LP - Performance Pipe Division (DriscoPlex).
   b. WL Plastics.
   c. JM Eagle.
   d. Pipeline Plastics.
   e. Or equal.
2. Butt Fusion Equipment:
   a. McElroy Manufacturing, Inc.
   b. Or equal.
3. Adapter Couplings
   a. Central Plastics Co.
   b. Poly-Cam, Inc.
   c. Or equal.

2.2 MATERIALS

A. Pipe:

1. AWWA C901 or C906, as applicable.
   a. PE 4710 polyethylene material.
   b. ASTM D3350 cell classification 445574C.
   c. Minimum Hydrostatic Design Basis (HDB) of 1600 psi at 73 degF when tested in accordance with PPI TR-3.
   d. NSF 61 approved.

B. Fittings:

1. Same material and thickness as adjoining pipe.
   a. Fittings may be one DR lower (thicker) than the adjoining pipe.
2. Molded fittings:
   a. Butt fused: ASTM D3261.
   b. Socket: ASTM D2683.
   c. Electrofusion: ASTM F1055.
3. Fabricated fittings: Fabricate from same material as pipe.
4. NSF 61 approved.

C. Back-up flanges:

1. Stainless steel: ASTM A182, dimensions per AWWA C207, Class 150.

D. Nuts and Bolts:

1. Buried:
    a. T-Bolts for mechanical joints: Per AWWA/ANSI C111/A21.1
    b. Other bolts and nuts: ASTM A193/A194 Grade B8 Class 1.
2. Exposed: ASTM A193/A194 Grade B8M, Class 1.
3. Heads and dimensions per ASME B1.1.
4. Threaded per ASME B1.1.
5. Project ends 1/4 to 1/2 inches beyond nuts.

E. Gaskets: See individual piping systems in Section 40 05 00.

2.3 MANUFACTURED UNITS

A. Adapter Fittings:

1. Mechanical joint: Adapter fitting butt fused to pipe.
    a. Capable of developing same pressure rating as specified for pipe.
    b. Restrained.
    c. Central Plastics MJ Adaptor or equal.

B. Restrained Adapter Fitting:

1. Restrained coupling for pipe material transition.
2. Multi/Joint 3000 Plus, Type 3000.

C. Thermal Expansion and Contraction Joint Fittings:

1. Design Criteria:
    a. Design maximum ambient temperature: 85 DEGF.
    b. Design minimum ambient temperature: 50 DEGF.
    c. Thermal expansion coefficient: 1 IN/100 FT/10 DEGF. Verify with pipe manufacturer.
2. Acceptable Manufacturers:
    a. EBAA Iron, Inc. EX-TEND® Expansion and Contraction Joint.
    b. Smith-Blair Style 611.
    c. Dresser Style 63.
    d. Or equal.

D. Butt Fusion Equipment:

1. Designed to create a joint at least as strong as the adjacent pipe.
2. Equipment to contain stops to prevent excessive pressure on pipe ends during fusion process.
3. Equipment to plane pipe ends prior to fusion process.
4. Provide a data logger to document temperatures and pressures for each butt fusion joint.

E. Socket Fusion Equipment:

1. Designed to simultaneously heat inside of socket fitting and outside of pipe.
2. Provide a data logger to document temperatures and pressures for each socket fusion joint.

2.4 DESIGN CRITERIA

A. DR:

1. UW: DR 11.
2. W1: DR 11.

B. Design pipe and fittings to withstand stresses created by the maximum internal pressure and external loads

1. External loads:
    a. Earth backfill or cover as shown on Drawings.
    b. Single H-20 wheel load, with impact, in accordance with AASHTO Specifications.
    c. Design for both external loads acting simultaneously.
2. Internal pressure. Minimum test pressure of 112.5 PSI (1.25 x Working Pressure of 90 PSI).
3. Minimum Dimension Ratio DR (Pipe Outside Diameter divided by Pipe Minimum Wall Thickness): 11.

C. Pipe Outside Diameter (OD):

1. Minimum allowable pipe outside diameter:
    a. Per AWWA C901, Table 4 (IPS sizing).
    b. Per AWWA C906, Table 3 (IPS sizing).

D. Stub flanges: Design to develop full pressure specified for pipe with blind flange connected to back up flange.

2.5 FABRICATION

A. Pipe:

1. Clearly mark pipe and fittings per AWWA C901 or AWWA C906, as applicable.
2. Service Indication:
    a. Provide integral color or longitudinal color banding at 180 degrees apart.
        1) Water: Blue.
        2) Sewer: Green.
        3) Recycled Water: Purple.

B. Stub flanges:

1. Design for use with backing flange.
2. Fabricate per manufacturers recommendations to develop full pressure specified for pipe with blind flange attached.

2.6 SOURCE QUALITY CONTROL

A. Materials:

1. Incoming polyethylene materials:
    a. Inspect for density per ASTM D1505, melt rate per ASTM D1248, and carbon containment.
    b. Provide certification from material supplier for a minimum of 30% of all incoming polyethylene materials.
    c. HDPE pipe manufacturer shall verify certifications prior to processing into finished pipe or fittings.
2. Outgoing materials:
    a. Manufacturer to inspect for diameter, wall thickness, length, straightness, out-of-roundness, concentricity, toe-in, inside and outside surface finish, markings, and end cut.
    b. Perform tests to determine density, melt flow rate, carbon content, and carbon dispersion.
    c. Test representative samples of the pipe provided to determine hoop tensile strength and ductility by either quick burst per ASTM D1599 or ring tensile per ASTM D2290.

B. Equipment:

1. Qualify each extrusion line and molding machine to produce pressure rated products by taking representative production samples and performing sustained pressure tests in accordance with ASTM D1598.

C. Quality Control Program:

1. Pipe and fitting manufacturer shall maintain permanent Quality Control (QC) and Quality Assurance (QA) records.
2. Certified copies of the quality control data taken during product manufacture shall be supplied to the Owner upon request.

D. Factory Inspection:

1. PE pipe manufacturer's production and quality assurance facilities shall be open and available for inspection by Owner and its authorized representatives.

PART 3 - EXECUTION

3.1 GENERAL

1. Locations: Provide HDPE piping at the locations shown on the Drawings or as otherwise shown and indicated in the Contract Documents.
2. Install HDPE piping in accordance with:
   a. Section 31 23 33 - Trenching, Backfill, and Compacting for Utilities.
   b. Section 40 05 00 - Pipe and Pipe Fittings - Basic Requirements.
   c. Other provisions of the Contract Documents.
   d. Laws and Regulations.

3.2 INSTALLATION

A. General:

1. Locations: Provide HDPE piping at the locations shown on the Drawings or as otherwise shown and indicated in the Contract Documents.
2. Install HDPE piping in accordance with:
   a. Manufacturer's recommendations.
   b. Section 31 23 33 - Trenching, Backfill, and Compacting for Utilities.
   c. Section 40 05 00 - Pipe and Pipe Fittings - Basic Requirements.
   d. Other provisions of the Contract Documents.
   e. Laws and Regulations.
3. Field repairs of pipe and fittings are not permitted, with the exception that portions of straight pipe which are damaged may be cut off provided this alteration is in accordance with the manufacturer's established procedures.

B. Joining method - Fusion Joints:

1. Joint Fusing – General:
   a. Comply with ASTM F2620, the Contract Documents, pipe manufacturer's written instructions, and fusion machine manufacturer's written recommendations. Where any of the foregoing are inconsistent, comply with the more-stringent requirement. When unclear, request and obtain from Engineer written interpretation or clarification.
   b. Fusion joiner shall be appropriately qualified and experienced in making the type of fusion joint required (butt fusion, socket fusion or sidewall fusion). Fusion joiner shall perform fusion jointing only for the types of joints for which such person possesses appropriate qualifications and experience.
   c. Cost of certifying its workers and performing testing required for fused joints is Contractor's responsibility.
   d. Plane ends of joints in fusion machine prior to heating.

e. Push pipe ends together in fusion machine and visually inspect compatibility and alignment of the two ends.

f. Comply with pipe manufacturer's written procedures and recommended heating time for pipe ends based upon pipe diameter and ambient temperature.

g. Visually inspect joint immediately upon removal of heating element to verify blistering of pipe has not occurred. Blistering of pipe is unacceptable.

h. Do not remove pipe from fusion machine until pipe has cooled in accordance with the pipe manufacturer's written instructions.

i. Removal of Beads from Interior Surfaces of Fused Joints:

1) Remove internal beads resulting from the fusion process from all piping (including fittings) for all polyethylene piping.

2) Pipe manufacturer's qualified, factory-trained field service representative shall perform removal of beads on interior surfaces of piping in accordance with pipe manufacturer's written instructions.

3) Do not compromise pipe integrity while removing beads from interior surfaces after fusing.

2. HDPE pipe 1 inch diameter and smaller shall be socket fused.

3. HDPE pipe joints 1.5 inch diameter and larger shall be butt fused.

4. Electro-Fusion Fittings:

a. Comply with pipe fitting manufacturer's written instructions.

b. Ensure ends of connecting pipe are round when fusing.

c. Couplings: Provide means to place pipe ends in compression when fusion coupler is heated/cooled until connection process is complete.

C. Joining method – Flanged Joints:

1. Slide back up flange on HDPE pipe.

2. Install stub flange on end of pipe with butt fusion.

3. Make flange faces flat and perpendicular to pipe centerline.

4. Allow one flange free movement in any direction while bolts are being tightened.

5. Do not assemble adjoining flexible joints until flanged joints in piping system have been tightened.

6. Gradually tighten flange bolts uniformly to permit even gasket compression.

7. Check bolt torque after 24 hours to ensure that stress relief has not occurred.

D. Joining method – Mechanical Joint:

1. Use only for joining HDPE pipe to DIP or PVC (AWWA C900).

2. Install MJ adapter on end of HDPE pipe with butt fusion.

3. Clean components before installation.

a. Clean bolts and nuts by wire brushing.

b. Lubricate bolts with vegetable-based oil only.

4. Insert nuts and bolts (or studs), finger tighten, and progressively tighten diametrically opposite bolts uniformly around the flange to the proper tension.

5. Execute care when tightening joints to prevent undue strain upon adjoining pipe.

6. Test joint for leakage.

a. If joint leaks under pressure testing, loosen or remove nuts and bolts, reset, or replace the gasket, reinstall or retighten bolts and nuts, and retest the joints.

b. Completed joints shall be watertight.

7. Check bolt torque after 24 hours to ensure that stress relief has not occurred.

E. Install buried pipe per Section 40 05 00 and per details shown on Drawings.

1. Allow pipe to stabilize to trench bottom or casing temperature before final tie-in or backfilling.
2. For field sweeps, the minimum cold bending allowable radius:

DR	Minimum Radius
≤9	20 times pipe OD
>9 - 13.5	25 times pipe OD
>13.5 - 21	27 times pipe OD
>21	30 times pipe OD
With flange or fitting inside sweep	100 times pipe OD

3.3 FIELD QUALITY CONTROL

A. Use only fusion machine operators who have been trained by machine manufacturer no more than 12 months prior to installation of first fused joint.

B. Visually inspect all pipe for gouges.

1. Gouges in excess of 10% of the pipe wall thickness are not acceptable.
2. In area where excessive gouges are present, cut out affected pipe section and butt fused to remaining pipe to make a continuous section.

C. Check integrity of the heating plate in the fusion equipment a minimum of twice per each 8-hour work shift for temperature uniformity.

D. Butt-fused specimen joint inspection and testing per ASTM F2620, Appendix X4.

1. Visually inspect all joints during and after joining to ensure that the joint meets the requirements of the butt fusion welding procedure.
2. On every day that butt fusions are to be made, prepare a trial butt-fused joint specimen.
3. Allow specimen to cool completely and cut into test straps.
4. Test straps:
   a. Length: 12 inches (min) or 30 times the wall thickness.
   b. Location of fusion: Center of strap.
   c. Width: 1 inch (min) or 1.5 times the wall thickness.
5. Visually examine the straps for voids or discontinuities.
6. Deform the straps by bending, torque, or impact.
7. If failure of the joint occurs outside of the joint area, the test is acceptable.

E. Diametral Deflection:

1. After backfilling, check each section of pipe for deflection by pulling a mandrel through the pipe.
2. Pipe with deflection exceeding 5% of the inside diameter: remove backfill and replace to provide a deflection of less than 5%.
3. Retest any repaired pipe.

F. Hydrostatically test installed pipe and fittings in accordance with Section 40 05 00.

1. Provide butt fused stub flanges, back up flanges and blind flanges on both ends of each pipe string for hydrostatic testing prior to and following installation.

END OF SECTION

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SECTION 33 05 33.53
POLYETHYLENE GAS UTILITY PIPE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Polyethylene pipe, fittings, and appurtenances for gas service in accordance with the National Fuel Gas Code.

B. Related Requirements: Include but are not necessarily limited to:

1. Section 31 23 00 - Earthwork.
2. Section 31 23 33 - Trenching, Backfilling, and Compacting for Utilities.
3. Section 40 05 00 - Pipe and Pipe Fittings - Basic Requirements.

1.2 REFERENCES

A. Abbreviations: The abbreviations indicated below are used in this Section and have the meanings indicated below:

1. CTS: Copper tube size.
2. DR: "Dimension ratio", which is the pipe's average OD divided by minimum wall thickness (t)
3. Diametral Deflection: Reduction in diameter caused by earth and surcharge loads acting on the installed pipe.
4. ESCR: Environmental stress crack resistance.
5. HDB: Hydrostatic design basis in accordance with ASTM D2837.
6. HDPE: High density polyethylene.
7. HDS: Hydrostatic design stress
8. IPS: Iron pipe size.
9. MDPE: Medium density polyethylene.
10. SDR: Standard dimension ratio.

B. Reference Standards:

1. American National Standards Institute (ANSI):
   a. B16.1, Cast-Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800.
   b. B16.21, Nonmetallic Flat Gaskets for Pipe Flanges.
   c. Z223.1, National Fuel Gas Code.
2. ASTM International (ASTM):
   a. A182, Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
   b. A193, Standard Specification for Alloy-Steel and Stainless-Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   c. A194, Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   d. A536, Standard Specification for Ductile Iron Castings.
   e. B695, Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
   f. D638, Standard Test Method for Tensile Properties of Plastics.
   g. D1248, Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.

h. D1505, Test Method for Density of Plastics by the Density-Gradient Technique.
i. D1598, Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure.
j. D1599, Test Method for Short-Time Hydraulic Failure Pressure of Plastics Pipe, Tubing and Fittings.
k. D1693, Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics.
l. D2290, Test Method for Apparent Tensile Strength of Ring or Tubular Plastics and Reinforced Plastics by Split Disk Method.
m. D2513, Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings.
n. D2683, Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
o. D3261, Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
p. D3350, Standard Specification for Polyethylene (PE)Plastics Pipe and Fittings Materials.
q. F1055, Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing.
r. F1473, Test Method for Notch Tensile Test to Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins.
s. F2206, Standard Specification for Fabricated Fittings of Butt-Fused Polyethylene (PE).
t. F2620, Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings.

3. Society for Protective Coatings (SSPC):
   a. SP 3, Power Tool Cleaning.

1.3 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer of PE Pipe:
   a. Obtain all PE gas pipe and fittings from one manufacturer, unless otherwise acceptable to Owner and Engineer.
   b. Manufacturer of pipe required by this Section shall be regularly engaged in the business of manufacturing PE gas piping of the size and type(s) required for the Work. Upon Engineer's request, submit documentation of manufacturer's prior furnishing of PE gas pipe of the type(s) required for not less than five other projects, similar in size and complexity to the PE gas piping Work of this Project, in North America.
   c. Equipment:
      1) Qualify each extrusion line and molding machine to produce pressure rated products by taking representative production samples and performing sustained pressure tests in accordance with ASTM D1598.
   d. QA and QC Program:
      1) PE pipe manufacturer shall have documented quality assurance and quality control programs as part of manufacturer's routine business.
      2) PE piping manufacturer shall maintain permanent Quality Control (QC) and Quality Assurance (QA) records.
2. Installer:
   a. Use one entity for all PE gas pipe Work, unless otherwise acceptable to Owner and Engineer.
   b. Installer shall be experienced with PE gas piping installation work similar in scope and complexity to the Work of this Section. When required by Engineer, submit documentation of successful completion of not less than five similar projects to the PE gas piping Work completed within the past five years.

c. Installer of PE gas piping shall, where applicable, be licensed plumber, duly licensed by municipality or other authority having jurisdiction.

d. Where PE gas pipe joints are made by fusing, fusion machine operators shall have been trained by fusion machine manufacturer within 12 months of starting to perform joint fusion Work. Submit documentation of such training, acceptable to Engineer, when requested by Engineer.

e. Installer's training and qualifications shall be acceptable to PE gas pipe Supplier retained for the Project.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:
   a. Dimensioned, scaled drawings showing Contractor's proposed deviations from gas piping alignment shown on the Drawings. Where necessary, such Shop Drawings shall include both plans and profiles and section views.
2. Product Data:
   a. Manufacturer's published catalog information and specifications for each size and type of PE gas piping required, including pipe, fittings, and jointing materials.
   b. Clearly indicate in product data submittal the reference standards with which pipe and appurtenances comply.
   c. Where couplings are required, submit coupling manufacturer's catalog literature and specifications for the specific couplings proposed.

B. Informational Submittals: Submit the following:

1. Supplier Instructions:
   a. Submit manufacturer's written instructions for handling, storing, and installing piping furnished.
2. Source Quality Control:
   a. Submit documentation from manufacturer that piping materials furnished was inspected at the production facility and successfully passed manufacturer's quality control procedures.
   b. Manufacturer's affidavit of certifying piping materials furnished comply with ASTM D2513.
3. Fusion machines proposed for joining pipe/fittings.
4. Field Quality Control:
   a. Documentation of temperature and pressure profiles from data logger for each butt fusion joint.
   b. Results of field quality control testing and inspections required in this Section.
5. Qualifications:
   a. Piping materials manufacturer, when requested by Engineer.
   b. Installer, when requested by Engineer, including documentation of training in use of joint fusion equipment.

1.5 DELIVERY, HANDLING, AND STORAGE

A. In addition to requirements elsewhere in the Contract Documents, also comply with the following:

1. During handling and installation avoid conditions where pipe bends excessively and avoid imparting kinks in the pipe.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable for natural gas applications:

1. PE Pipe and Fittings:
    a. Performance Pipe.
    b. PolyPipe USA.
    c. JM Eagle.
    d. WL Plastics.
    e. Or equal..
2. Adapter Couplings:
    a. Smith-Blair.
    b. GF Central Plastics Co.
    c. Poly-Cam, Inc.
    d. Or equal.

B. Polyethylene materials used for manufacturing pipe and fittings shall be listed in PPI TR-4, Listed Materials.

2.2 MDPE PIPING

A. Description:

1. Provide PE 2708 pipe and fittings complying with ASTM D2513

B. Materials:

1. The following applies generally to MDPE piping unless indicated otherwise elsewhere in the Contract Documents:
    a. Cell Classification: In accordance with ASTM D3350 shall be PE-277373E, PE 234373E, or PE 234363E.
    b. Sizing Classifications:
        1) IPS for pipe greater than 1.75-inch diameter.
        2) CTS for pipe 1.75-inch diameter and less.
    c. Minimum Wall Thickness: SDR 11.
    d. Mark pipe to clearly indicate on the pipe: “GAS” and “ASTM D2513”.
2. Fittings:
    a. ASTM D2513.
    b. Provide fittings with not less than strength of connected pipe.
    c. Minimum Wall Thickness: SDR to match connected pipe.
    d. ASTM Classification:
        1) 0.5-inch to 1.75-inch diameter: ASTM D2683.
        2) Two-inch to 24-inch diameter: ASTM D3261.
    e. Mark each fitting with, “ASTM D2513” along with applicable fitting specification.
    f. Connections to Pipe:
        1) Socket fused ends for fittings 1.75-inch diameter and less.
        2) Butt-fused ends for fitting two-inch diameter and larger.
    g. Provide IPS reducers on main lines.
    h. Provide tapping tees or straight-outlet service saddles to join service laterals to main line.
    i. Mitered or field fabricated fittings are unacceptable.

2.3 HDPE PIPING – NATURAL GAS AND LP GAS

A. Description:

1. Provide PE 4710 pipe and fittings complying with ASTM D2513.
2. Identify each length of pipe in accordance with ASTM D2513.
   a. Include manufacturer's name and trademark.
   b. Nominal size of pipe, appurtenant information regarding polymer cell classification and critical identifications regarding performance specifications
   c. Mark pipe with “GAS” and “ASTM D2513”

B. Materials:

1. Unless required otherwise elsewhere in the Contract Documents, HDPE piping provided under this Article shall comply with the following:
   a. Cell Classification: In accordance with ASTM D3350, shall be PE-445574C or PE-445574E.
   b. Size Classification:
      1) IPS for piping larger than one-inch diameter.
      2) CTS for piping one-inch diameter or less.
   c. Minimum Wall Thickness: SDR 11.
2. Fittings:
   a. ASTM D2513.
   b. Provide fittings with not less than strength of connected pipe.
   c. Minimum Wall Thickness: SDR 11.
   d. ASTM Designation:
      1) 0.5-inch to 1.75-inch diameter: ASTM D2683.
      2) Two-inch to 2-inch diameter: ASTM D3261.
   e. Mark each fitting with, “ASTM D2513” and the applicable fitting specification.
   f. Connections to Pipe:
      1) Socket fused ends for fittings 1.75-inch diameter and less.
      2) Butt-fused ends for fitting two-inch diameter and larger.
   g. IPS reducers on main lines.
   h. Tapping tees or straight-outlet service saddles to join service laterals to main line.
   i. Mitered or field fabricated fittings are unacceptable.

2.4 ACCESSORIES

2.5 CASING

A. Casing Pipe:

1. Material: ASTM A53 steel, Grade B, black.
2. Size and wall thickness as shown or indicated on the Drawings.
3. Joints: Buttweld or socketweld.

B. Casing Accessories:

1. Casing Spacer/Isolators: PSI Model PE, or equal.
2. End Seal: PSI Model S, or equal.

2.6 SOURCE QUALITY CONTROL

A. Factory Tests and Inspections:

1. PE Materials to be Used in Manufacturing PE Pipe for the Work:

a. Inspect for density per ASTM D1505, melt rate per ASTM D1248, and carbon and color containment.
b. PE pipe manufacturer shall verify material certifications prior to incorporating the subject materials into the PE piping materials to be furnished for the Work.

2. Manufactured PE Pipe: Prior to shipping manufactured PE pipe from the manufacturing facility, PE pipe manufacturer shall perform the following and document the results per ASTM D2513 including Annexes A1 and A.2:
a. Inspect for diameter, wall thickness, length, straightness, out-of-roundness, concentricity, toe-in, inside and outside surface finish, markings, and end cut.
b. Perform tests to determine density, melt flow rate, carbon content, and carbon dispersion.
c. Test representative samples of the pipe provided to determine hoop tensile strength and ductility by either quick burst in accordance with ASTM D1599 or ring tensile in accordance with ASTM D2290.
d. Submit affidavit of compliance with all testing required by ASTM D2513 prior to installation of the pipe and fittings.
e. Do not ship to the Site (or other location for the Project) PE pipe materials found to be defective or that exhibit unacceptable manufacturing defects. Promptly furnish acceptable pipe in lieu of defective materials.

B. Factory Inspection:

1. PE pipe manufacturer's production and quality assurance facilities shall be open and available for inspection by Owner, Engineer, and Owner's other representatives.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation - General:

1. Locations: Provide PE gas piping at the locations shown on the Drawings or as otherwise shown and indicated in the Contract Documents.
2. Install PE gas piping in accordance with:
a. Section 31 23 33 – Trenching, Backfilling, and Compacting for Utilities.
b. Section 40 05 00 – Pipe and Pipe Fittings – Basic Requirements.
c. Other provisions of the Contract Documents.
d. Laws and Regulations.
e. Requirements of gas utility owner.
f. Written installation instructions of PE gas pipe manufacturer and, where joints will be fused, written instructions of joint fusing machine manufacturer.
3. In event of conflict between the above, obtain from Engineer written clarification or interpretation.

B. Installation of PE Gas Piping:

1. Maximum allowable diametral (cross sectional) deflection of installed piping: three percent of internal diameter.
2. Do not field-thread PE gas piping.
3. Comply with this Section's "Delivery, Handling, and Storage" Article.
4. Temporarily cap open ends of piping at end of each workday.
5. Connections for Service Laterals:
a. Provide connections for service laterals, if any, at locations shown on the Drawings.
b. Where completed PE gas piping will serve as conveyance for delivering gas to customers of utility owner and quantity, size, and location of connections for service

laterals are not shown or indicated, provide a 3/4-inch diameter connection per residential unit and one 1-inch diameter connection per commercial business.

c. Unless otherwise shown or indicated, provide service connection for each vacant lot or parcel of land along route of gas piping, based on lot lines on the date Bids were opened or, if there were no Bids, on the Effective Date of the Contract.

6. Changes in Direction of PE Piping:
   a. Pipe may be cold-bent to minimum radius listed in Paragraph 3.1 E. (sweeps) or with PE fittings.
7. Remove burrs resulting from cutting and threading piping.
8. Casings:
   a. Center pipe in casing with casing spacers.
   b. Slope casing pipe to one end for positive drainage.

C. Joining Method - Fusion Joints:

1. Comply with ASTM F2620, the Contract Documents, and written instructions of PE gas pipe manufacturer and fusion machine manufacturer. In event of conflict among such requirements, comply with the most-stringent, most-conservative requirements.
2. Fusion joiner personnel must be qualified by type of fusion (i.e., butt fusion, socket fusion or sidewall fusion) and fuse pipe only as qualified.
3. Fusing Method:
   a. Socket-fuse joints of pipe 1.25-inches diameter and smaller.
   b. Butt-fuse joints of pipe 1.5 inches diameter and larger.
4. Making the Joint:
   a. Prior to fusing, visually inspect each end of the planned joint, inside and outside, for burrs, damage, dirt, moisture, abnormalities, and other conditions unsuitable for jointing. Remedy unsuitable conditions before proceeding.
   b. Plane ends of joints in fusion machine prior to heating.
   c. In fusion machine, push pipe ends together and visually check compatibility and alignment of pipes' ends. Make necessary corrections.
   d. Comply with manufacturer's procedures and recommended heating time for pipe ends, based on pipe diameter and ambient temperature.
   e. Inspect joint immediately after removing heating element. Blistering of pipe is unacceptable.
   f. Remove piping from fusion machine after piping has cooled in accordance with pipe manufacturer's written installation instructions.

D. Joining Method: Flanged Joints:

1. Provide slip-on flange on PE gas pipe by slipping backup flange onto PE gas pipe prior to welding a PE stub flange to the pipe at each required location.
   a. Do not provide flanged joint where flanged joint will be subject to settlement or lateral movement.
   b. When the Contract Documents are unclear about whether flanged joint is required, submit to Engineer request for interpretation in accordance with the Contract Documents.
2. Provide stub flange on end of pipe with butt fusion.
3. Make flange faces flat and perpendicular to pipe centerline.
4. Allow one flange free movement in any direction while bolts are being tightened.
5. Do not assemble adjoining flexible joints until flanged joints in piping system have been tightened.
6. Gradually tighten flange bolts uniformly to permit even gasket compression.
7. Check bolt torque after 24 hours to ensure that stress relief has not occurred.

E. Installing PE Gas Piping in Trench:

1. Install buried piping in accordance with Section 40 05 00 – Pipe and Pipe Fittings Basic Requirements, and as shown and indicated on the Drawings.
2. Allow piping to stabilize to temperature of trench bottom or casing pipe, as applicable, before performing connections (tie-ins) to other piping (including service laterals) and backfilling.
3. For field bends (sweeps), minimum allowable cold bending radius is:

DR	Minimum Radius
7, 7.3, 9	20 times pipe OD
11, 13.5	25 times pipe OD
17, 21	27 times pipe OD
26	34 times pipe OD
32.5	42 times pipe OD
41	52 times pipe OD
With flange or fitting inside sweep	100 times pipe OD

3.2 FIELD QUALITY CONTROL

A. Field Tests and Inspections:

1. Visual Inspection Prior to Jointing and Installation:
   a. Visually inspect each pipe for gouges and other defects resulting from manufacturing or handling.
   b. Gouges with depth (measured from original, outside surface of pipe) in excess of 10 percent of pipe's wall thickness are unacceptable.
   c. Remedy unacceptable gouges as indicated in this Article.
   d. Other defects and damage are unacceptable when so indicated by pipe manufacturer's written installation instructions.
2. Fusing Machine and Fusion Quality Control:
   a. Verify integrity of heating plate in joint fusion machine, not less than twice per eight-hour work shift, for temperature uniformity.
      1) Criteria for acceptability: in accordance with written instructions of fusing machine manufacturer and PE gas pipe manufacturer.
      2) Do not use fusing machine in unacceptable condition.
   b. Daily Test Specimen:
      1) Each day of joint fusing, prior to starting fusing pipe joints in the Work, each fusing crew shall prepare trial fused joint specimen for each type of fusing required that day.
      2) Diameter of specimen shall be most-common size of pipe to be fused that day.
      3) When Engineer, Resident Project Representative (if any), or Owner's Site Representative (if any) is onsite at start of day's joint fusing, advise them of time of daily testing and allow to observe test joint and associated testing.
      4) Record results of each daily test, indicating crew and machine, size of test specimen, type of joint, and results of test.
      5) Allow specimen to cool completely and cut into test straps.
      6) Test straps:
         a) Length: Not less than 12 inches or 30 times pipe wall thickness.

b) Location of fusion: Center of strap.

c) Width: Not less than one inch or 1.5 times pipe wall thickness.

7) Visually examine straps for voids or discontinuities.

8) Deform straps by bending, torque, or impact.

9) If failure of joint occurs outside of joint area, test is acceptable.

10) Repeat daily test until acceptable results are achieved.

11) Perform joint fusing in the Work using same techniques that resulted in acceptable daily test, in accordance with the Contract Documents.

c. Perform butt-fused specimen joint inspection and testing in accordance with ASTM F2620, Appendix X4

3. During and After Pipe Joint Fusing:

a. Visually inspect each joint during and after joining to ensure that joint complies with fusion procedure.

4. Diametral Deflection:

a. After piping installation and backfilling, perform draw mandrel through piping to measure deflection.

b. Where deflection of the pipe's cross section exceeds three percent of pipe's ID, remove backfill, remedy the piping Work, and reinstall backfill.

1) Repeat mandrel test until acceptable results are obtained.

c. Record results of each mandrel test and submit to Engineer, clearly indicating segment of PE gas piping Work tested, pipe size, and measured deflection (including indication of percentage of pipe ID).

5. Gas-tightness Testing:

a. Pressure test installed PE gas piping in accordance with Section 40 05 00 – Pipe and Pipe Fittings Basic Requirements.

b. Provide butt fused stub flanges, back up flanges and blind flanges on both ends of each pipe string for hydrostatic testing prior to and following installation.

B. Defective Work:

1. Unacceptable Gouges: In areas of unacceptable gouges, cut out unacceptable pipe section and fuse together ends of acceptable pipe sections, on each side of removed section, to provide continuous section in accordance with the Contract Documents.

2. Other Manufacturing or Handling Defects or Damage: Remedy in accordance with pipe manufacturer's written instructions, or remove unacceptable pipe from site and provide acceptable, new pipe.

3. Deflection Test: Remedy for PE gas piping with unacceptable deflection is indicated in this Article.

4. Gas-tightness Testing: When PE gas piping gas-tightness testing has unacceptable results, determine locations of leaks and repair or remedy leaks and repeat testing until acceptable results are obtained.

END OF SECTION

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DIVISION 40

PROCESS INTERCONNECTIONS

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FSECTION 40 05 00

PIPE AND PIPE FITTINGS - BASIC REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Process piping systems.
2. Utility piping systems.
3. Plumbing piping systems.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 09 96 00 - High Performance Industrial Coatings.
2. Section 10 14 00 - Identification Devices.
3. Section 31 23 33 - Trenching, Backfilling, and Compacting for Utilities.
4. Section 40 05 07 - Pipe Support Systems.
5. Section 40 05 51 - Common Requirements for Process and Utility Valves.
6. Section 40 41 13 - Heat Tracing Cable.
7. Section 40 42 00 - Pipe, Duct and Equipment Insulation.
8. Section 40 73 00 - Pressure Instrumentation.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. M36, Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains (Equivalent ASTM A760).
   b. M190, Standard Specification for Bituminous Coated Corrugated Metal Culvert Pipe and Pipe Arches.
   c. M252, Standard Specification for Corrugated Polyethylene Drainage Tubing.
   d. M294, Interim Specification for Corrugated Polyethylene Pipe 12 to 24 Inch Diameter.
2. American Iron and Steel Institute (AISI).
3. American Society of Mechanical Engineers (ASME):
   a. B16.3, Malleable Iron Threaded Fittings.
   b. B16.5, Pipe Flanges and Flanged Fittings.
   c. B16.9, Factory-Made Wrought Steel Butt-Welding Fittings.
   d. B16.22, Wrought Copper and Bronze Solder - Joint Pressure Fittings.
   e. B16.26, Cast Copper Alloy Fittings for Flared Copper Tubes.
   f. B36.19, Stainless Steel Pipe.
   g. B40.100, Pressure Gauges and Gauge Attachments.
4. ASTM International (ASTM):
   a. A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   b. A74, Standard Specification for Cast Iron Soil Pipe and Fittings.
   c. A106, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
   d. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.

e. A182, Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
f. A197, Standard Specification for Cupola Malleable Iron.
g. A234, Standard Specification for Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
h. A269, Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
i. A312, Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
j. A518, Standard Specification for Corrosion-Resistant High-Silicon Iron Castings.
k. A536, Standard Specification for Ductile Iron Castings.
l. A587, Standard Specification for Electric-Resistance-Welded Low-Carbon Steel Pipe for the Chemical Industry.
m. A760, Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains.
n. A774, Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures.
o. A778, Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
p. C443, Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
q. C564, Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
r. D1785, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
s. D2466, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
t. D2467, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
u. D2683, Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
v. D3034, Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
w. D3035, Standards and Specifications for Polyethylene Pipes.
x. D3261, Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.D4101, Standard Specification for Polypropylene Plastic Injection and Extrusion Materials.
y. F439, Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
z. F441, Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.

5. American Water Works Association (AWWA):
   a. B300, Standard for Hypochlorites.
   b. C200, Standard for Steel Water Pipe - 6 inches and Larger.
   c. C207, Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 inches through 144 inches.
   d. C208, Standard for Dimensions for Fabricated Steel Water Pipe Fittings.
   e. C606, Standard for Grooved and Shouldered Joints.
   f. C651, Standard for Disinfecting Water Mains.
   g. C800, Standard for Underground Service Line Valves and Fittings.
6. American Water Works Association/American National Standards Institute (AWWA/ANSI):

a. C110/A21.10, Standard for Ductile-Iron and Gray-Iron Fittings.
b. C111/A21.11, Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
c. C115/A21.15, Standard for Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
d. C151/A21.51, Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water.
e. C153/A21.53, Standard for Ductile-Iron Compact Fittings for Water Service.

7. Chlorine Institute, Inc. (CI):
   a. Pamphlet 6, Piping Systems for Dry Chlorine.
8. Cast Iron Soil Pipe Institute (CISPI):
   a. 301, Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
9. International Plumbing Code (IPC).
10. National Fire Protection Association (NFPA):
    a. 54, National Fuel Gas Code.
    b. 69, Standard on Explosion Prevention Systems.
11. Underwriters Laboratories, Inc. (UL).

B. Coordinate flange dimensions and drillings between piping, valves, and equipment.

1.3 DEFINITIONS

A. Hazardous Gas Systems: Digester gas, chlorine gas, sulfur dioxide gas, carbon dioxide gas, lab gases.

B. HPIC: High performance industrial coating.

C. PVDF: Polyvinylidene fluoride.

1.4 SYSTEM DESCRIPTION

A. Piping Systems Organization and Definition:

1. Piping services are grouped into designated systems according to the chemical and physical properties of the fluid conveyed, system pressure, piping size and system materials of construction.
2. See PIPING SYSTEMS SCHEDULE in PART 3.

1.5 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Copies of manufacturer's written directions regarding material handling, delivery, storage and installation.
   c. Separate schedule sheet for each piping system scheduled in this Specification Section showing compliance of all system components.
      1) Attach technical product data on gaskets, pipe, fittings, and other components.
2. Fabrication and/or Layout Drawings:
   a. Exterior yard piping drawings (minimum scale 1 inch equals 10 feet) with information including:
      1) Dimensions of piping lengths.
      2) Invert or centerline elevations of piping crossings.
      3) Acknowledgement of bury depth requirements.
      4) Details of fittings, tapping locations, thrust blocks, restrained joint segments, harnessed joint segments, hydrants, and related appurtenances.

5) Acknowledge designated valve or gate tag numbers, manhole numbers, instrument tag numbers, pipe and line numbers.
6) Line slopes and vents.

b. Interior piping drawings (minimum scale 1/8 inches equals 1 foot) with information including:
1) Dimensions of piping from column lines or wall surfaces.
2) Dimensions of piping:
a) Gravity lines: invert dimensions.
b) Pressure lines: centerline dimensions.
3) Centerline elevation and size of intersecting ductwork, conduit/conduit racks, or other potential interferences requiring coordination.
4) Location and type of pipe supports and anchors.
5) Locations of valves and valve actuator type.
6) Details of fittings, tapping locations, equipment connections, flexible expansion joints, connections to equipment, and related appurtenances.
7) Acknowledgement of valve, equipment and instrument tag numbers.
8) Provisions for expansion and contraction.
9) Line slopes and air release vents.
10) Rough-in data for plumbing fixtures.

c. Schedule of interconnections to existing piping and method of connection.

B. Contract Closeout Information:

1. Operation and Maintenance Data:
a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

C. Informational Submittals:

1. Qualifications of lab performing disinfection analysis on water systems.
2. Test reports:
a. Copies of pressure test results on all piping systems.
b. Reports defining results of dielectric testing and corrective action taken.
c. Disinfection test report.
d. Notification of time and date of piping pressure tests.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Protect pipe coating during handling using methods recommended by manufacturer.

1. Use of bare cables, chains, hooks, metal bars or narrow skids in contact with coated pipe is not permitted.

B. Prevent damage to pipe during transit.

1. Repair abrasions, scars, and blemishes.
2. If repair of satisfactory quality cannot be achieved, replace damaged material immediately.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Insulating unions:
a. "Dielectric" by Epco.

2. Dirt strainers (Y type):
    a. Mueller (#351).
    b. Sarco.
    c. Armstrong.
3. Chemical strainers (Y type):
    a. Chemtrol.
    b. Asahi.
4. Dry disconnect couplings:
    a. Kamlock.
5. Dielectric flange kit:
    a. PSI.
    b. Maloney.
    c. Central Plastics.
6. Pipe saddles (for gauge installation):
    a. Dresser Style 91 (steel and ductile iron systems).
    b. Dresser Style 194 (nonmetallic systems).
7. Expansion joint at FRP and poly tanks:
    a. PROCO.
    b. Garlock, Style 215.
8. Elastomeric bellows type expansion joints:
    a. Garlock, Guardian 200/204.
    b. PROCO, equivalent model.
    c. Red Valve, equivalent model.
    d. Or equal.
9. Dismantling Joint
    a. Romac DJ400.
    b. Smith Blair 972.

2.2 PIPING SYSTEMS SCHEDULE

A. Piping system materials, fittings and appurtenances are subject to requirements of specific piping systems schedule located at the end of PART 3 of this Specification Section.

2.3 COMPONENTS AND ACCESSORIES

A. Insulating Components:
    1. Dielectric flange kits:
        a. Flat faced.
        b. 1/8 inches thick dielectric gasket, phenolic, non-asbestos.
        c. Suitable for 175 psi, 210 degrees F.
        d. 1/32 inches wall thickness bolt sleeves.
        e. 1/8 inches thick phenolic insulating washers.
    2. Dielectric unions:
        a. Screwed end connections.
        b. Rated at 175 psi, 210 degrees F.
        c. Provide dielectric gaskets suitable for continuous operation at union rated temperature and pressure.

B. Dirt Strainers:
    1. Y-type.

2. Composition bronze.
3. Rated for test pressure and temperature of system in which they are installed.
4. 20 mesh Monel screen.
5. Threaded bronze plug in the blowoff outlet.
6. Threaded NPT end connections.

C. Strainers for Chemical Applications:

1. Y-type.
2. Strainers of same material, test pressure, and temperature rating as system in which strainer is placed.

D. Reducers:

1. Furnish appropriate size reducers and reducing fittings to mate pipe to equipment connections.
2. Connection size requirements may change from those shown on Drawings depending on equipment furnished.

E. Protective Coating and Lining:

1. Include pipe, fittings, and appurtenances where coatings, linings, coating, tests and other items are specified.
2. Piping systems scheduled in the PIPING SYSTEM SCHEDULES Article of this Section that are indicated to receive HPIC per Specification Section 09 96 00 shall receive surface preparation and primer applied in the fabrication facility, at the coating applicator's shop, or other off-site location acceptable to the Engineer. Intermediate and topcoats are to be field applied unless noted otherwise.
    a. The following piping systems shall have the coating system shop-applied in its entirety:
        1) Piping System 2 – Exposed ductile iron.
        2) Piping System 3 – Exposed ductile iron and steel.
        3) Piping System 9 – Exposed ductile iron and steel.
        4) Piping System 10 – Exposed ductile iron and steel.

F. Underground Warning Tape:

1. See Specification Section 10 14 00.

G. Pressure Gauges:

1. See Specification Section 01 61 03 and Specification Section 40 73 00.

H. Dry Disconnect Couplings:

1. Adapters:
    a. Male adapters: Size shown on Drawings.
    b. Adapters:
        1) Female NPT end connection for sludge and flush applications.
        2) Male NPT end connection for chemical applications.
    c. Construct adapters for sludge applications from cast iron or steel.
    d. Construct adapters for chemical and PVC system applications 3 inches and below from polypropylene.
        1) Above 3 inches size, provide stainless steel units.
2. Couplers:
    a. Built-in valve and spring loaded poppet which close automatically when disconnected.
    b. Designed to remain with only one arm locked in closed position.
    c. Construct couplers for sludge applications fabricated from material utilized for adapters.

d. Construct couplers for chemical and PVC system applications 3 inches and less from polypropylene with stainless steel arms and pins.
    1) Above 3 inches, provide stainless steel units.
e. Gasket: Compatible with conveyed liquid.

3. Dust caps: For all adapters.

I. Sacrificial Anode Cathodic Protection:

1. 3 pound magnesium sacrificial anodes, prepackaged in a cloth bag containing 75% hydrated gypsum, 20% bentonite and 5% anhydrous sodium sulphate.
2. TW 600 V or an HMWPE insulated copper lead attached to the anode.

J. Valves:

1. See schematics and details for definition of manual valves used in each system.
2. See Specification Section 40 05 51.

K. Elastomeric Bellows Type Expansion Joints:

1. Provide reducing type where indicated on the Drawings.
2. Flanges: ANSI 125/150.
3. Materials:
    a. Bellows:
        1) Sludge service: Natural rubber.
        2) Hot Water (over 100 degrees F): EPDM.
        3) All other: Compatible with fluid.
    b. Restraint:
        1) Provide restraint limit bolts (control rods) and nuts to restrain joint at test pressure of piping.
        2) Control rod material: 316 stainless steel.
    c. Working pressure: Equal to or greater than test pressure of connecting piping.
    d. Minimum axial movement: 3/8 inches.
4. Arches:
    a. Sludge service: Provide single filled arches.
    b. All other service: Provide double open arches.

PART 3 - EXECUTION

3.1 EXTERIOR BURIED PIPING INSTALLATION

A. Unless otherwise shown on the Drawings, provide a minimum of 4 feet and maximum of 8 feet earth cover over exterior buried piping systems and appurtenances conveying water, fluids, or solutions subject to freezing.

B. Enter and exit through structure walls, floors, and ceilings by using penetrations and seals specified in Specification Section 01 73 20 and as shown on Drawings.

C. When entering or leaving structures or passing beneath the vertical projection of a structure wall use flexible joint piping with first joint installed within 2 feet of point where pipe enters or leaves structure.

1. Install second joint not more than 6 feet nor less than 4 feet from first joint.

D. When entering or leaving structures with buried mechanical joint piping, install flexible connection within 2 feet of point where pipe enters or leaves structure.

1. Install second joint not more than 6 feet nor less than 4 feet from first joint.

E. Install expansion devices as necessary to allow expansion and contraction movement.

F. Laying Pipe In Trench:

1. Excavate and backfill trench in accordance with Specification Section 31 23 33.
2. Clean each pipe length thoroughly and inspect for compliance to specifications.
3. Grade trench bottom and excavate for pipe bell and lay pipe on trench bottom.
4. Install gasket or joint material according to manufacturer's directions after joints have been thoroughly cleaned and examined.
5. Except for first two joints, before making final connections of joints, install two full sections of pipe with earth tamped alongside of pipe or final with bedding material placed.
6. Lay pipe in only suitable weather with good trench conditions.
    a. Never lay pipe in water except where approved by Engineer.
7. Seal open end of line with watertight plug if pipe laying stopped.
8. Remove water in trench before removal of plug.

G. Lining Up Push-On Joint Piping:

1. Lay piping on route lines shown on Drawings.
2. Deflect from straight alignments or grades by vertical or horizontal curves or offsets.
3. Observe maximum deflection values stated in manufacturer's written literature.
4. Provide special bends when specified or where required alignment exceeds allowable deflections stipulated.
5. Install shorter lengths of pipe in such length and number that angular deflection of any joint, as represented by specified maximum deflection, is not exceeded.

H. Anchorage and Blocking:

1. Provide reaction blocking, anchors, joint harnesses, or other acceptable means for preventing movement of piping caused by forces in or on buried piping tees, wye branches, plugs, or bends.
2. Place concrete blocking so that it extends from fitting into solid undisturbed earth wall.
    a. Concrete blocks shall not cover pipe joints.
3. Provide bearing area of concrete in accordance with drawing detail.

I. Install underground hazard warning tape per Specification Section 10 14 00.

J. Install insulating components where dissimilar metals are joined together.

3.2 INTERIOR AND EXPOSED EXTERIOR PIPING INSTALLATION

A. Install piping in vertical and horizontal alignment as shown on Drawings.

B. Alignment of piping smaller than 4 inches may not be shown; however, install according to Drawing intent and with clearance and allowance for:

1. Expansion and contraction.
2. Operation and access to equipment, doors, windows, hoists, moving equipment.
3. Headroom and walking space for working areas and aisles.
4. System drainage and air removal.

C. Enter and exit through structure walls, floor and ceilings using penetrations and seals specified in Specification Section 01 73 20 and as shown on the Drawings.

D. Install vertical piping runs plumb and horizontal piping runs parallel with structure walls.

E. Pipe Support:

1. Use methods of piping support as shown on Drawings and as required in Specification Section 40 05 07.

2. Where pipes run parallel and at same elevation or grade, they may be grouped and supported from common trapeze-type hanger, provided hanger rods are increased in size as specified for total supported weight.
    a. The pipe in the group requiring the least maximum distance between supports shall set the distance between trapeze hangers.
3. Size pipe supports with consideration to specific gravity of liquid being piped.

F. Locate and size sleeves and castings required for piping system.

1. Arrange for chases, recesses, inserts or anchors at proper elevation and location.

G. Use reducing fittings throughout piping systems.

1. Bushings will not be allowed unless specifically approved.

H. Equipment Drainage and Miscellaneous Piping:

1. Provide drip pans and piping at equipment where condensation may occur.
2. Hard pipe stuffing box leakage to nearest floor drain.
3. Avoid piping over electrical components such as motor control centers, panelboards, etc.
    a. If piping must be so routed, utilize 16 GA, 316 stainless steel drip pan under piping and over full length of electrical equipment.
    b. Hard pipe drainage to nearest floor drain.
4. Collect system condensate at drip pockets, traps and blowoff valves.
5. Provide drainage for process piping at locations shown on Drawings in accordance with Drawing details.
6. For applications defined above and for other miscellaneous piping which is not addressed by a specific piping service category in PART 1, provide 304 stainless steel piping and fittings.
    a. Size to handle application with 3/4 inches being minimum size provided.

I. Unions:

1. Install in position which will permit valve or equipment to be removed without dismantling adjacent piping.
2. Mechanical type couplings may serve as unions.
3. Additional flange unions are not required at flanged connections.

J. Install expansion devices as necessary to allow expansion/contraction movement.

K. Provide full face gaskets on all systems.

L. Anchorage and Blocking:

1. Block, anchor, or harness exposed piping subjected to forces in which joints are installed to prevent separation of joints and transmission of stress into equipment or structural components not designed to resist those stresses.

M. Equipment Pipe Connections:

1. Equipment - General:
    a. Exercise care in bolting flanged joints so that there is no restraint on the opposite end of pipe or fitting which would prevent uniform gasket pressure at connection or would cause unnecessary stresses to be transmitted to equipment flanges.
    b. Where push-on joints are used in conjunction with flanged joints, final positioning of push-on joints shall not be made until flange joints have been tightened without strain.
    c. Tighten flange bolts at uniform rate which will result in uniform gasket compression over entire area of joint.
        1) Provide tightening torque in accordance with manufacturer's recommendations.

d. Support and match flange faces to uniform contact over their entire face area prior to installation of any bolt between the piping flange and equipment connecting flange.

e. Permit piping connected to equipment to freely move in directions parallel to longitudinal centerline when and while bolts in connection flange are tightened.

f. Align, level, and wedge equipment into place during fitting and alignment of connecting piping.

g. Grout equipment into place prior to final bolting of piping but not before initial fitting and alignment.

h. To provide maximum flexibility and ease of alignment, assemble connecting piping with gaskets in place and minimum of four bolts per joint installed and tightened.

1) Test alignment by loosening flange bolts to see if there is any change in relationship of piping flange with equipment connecting flange.

2) Realign as necessary, install flange bolts and make equipment connection.

i. Provide utility connections to equipment shown on Drawings, scheduled or specified.

2. Plumbing and HVAC equipment:

a. Make piping connections to plumbing and HVAC equipment, including but not limited to installation of fittings, strainers, pressure reducing valves, flow control valves and relief valves provided with or as integral part of equipment.

b. Furnish and install sinks, fittings, strainers, pressure reducing valves, flow control valves, pressure relief valves, and shock absorbers which are not specified to be provided with or as integral part of equipment.

c. For each water supply piping connection to equipment, furnish and install union and gate or angle valve.

1) Provide wheel handle stop valve at each laboratory sink water supply.

2) Minimum size: 1/2 inches.

d. Furnish and install "P" trap for each waste piping connection to equipment if waste is connected directly to building sewer system.

1) Size trap as required by IPC.

e. Stub piping for equipment, sinks, lavatories, supply and drain fittings, key stops, "P" traps, miscellaneous traps and miscellaneous brass through wall or floor and cap and protect until such time when later installation is performed.

N. Provide insulating components where dissimilar metals are joined together.

O. Instrument Connections:

1. See drawing details.

3.3 CONNECTIONS WITH EXISTING PIPING

A. Where connection between new work and existing work is made, use suitable and proper fittings to suit conditions encountered.

B. Perform connections with existing piping at time and under conditions which will least interfere with service to customers affected by such operation.

C. Undertake connections in fashion which will disturb system as little as possible.

D. Provide suitable equipment and facilities to dewater, drain, and dispose of liquid removed without damage to adjacent property.

E. Where connections to existing systems necessitate employment of past installation methods not currently part of trade practice, utilize necessary special piping components.

F. Where connection involves potable water systems, provide disinfection methods as prescribed in this Specification Section.

G. Once tie-in to each existing system is initiated, continue work continuously until tie-in is made and tested.

3.4 ACCESS PROVISIONS

A. Provide access doors or panels in walls, floors, and ceilings to permit access to valves, piping and piping appurtenances requiring service.

B. Size of access panels to allow inspection and removal of items served, minimum 10 x 14 inches size.

C. See Specification Section 08 31 00 - Access Doors.

3.5 CATHODIC PROTECTION

A. Isolate, dielectrically, all piping from all other metals including reinforcing bars in concrete slabs, other pipe lines, and miscellaneous metal.

B. Make all connections from wire or cable by Thermit Cadwelding accomplished by operators experienced in this process.

C. Install all cables with a loop and overhead knot around each pipe and slack equal to at least 50% of the straight line length.

D. After cadwelding, coat all exposed metallic surfaces with hot applied tape.

3.6 HEAT TRACING

A. See Specification Section 40 41 13 - Heat Tracing Cable.

3.7 PRESSURE GAUGES

A. Provide at locations shown on the Drawings and specified.

B. See Specification Section 01 61 03 and Section 40 73 00.

3.8 FIELD QUALITY CONTROL

A. Pipe Testing - General:

1. Test piping systems as follows:
    a. Test exposed, non-insulated piping systems upon completion of system.
    b. Test exposed, insulated piping systems upon completion of system but prior to application of insulation.
    c. Test concealed interior piping systems prior to concealment and, if system is insulated, prior to application of insulation.
    d. Test buried piping (insulated and non-insulated) prior to backfilling and, if insulated, prior to application of insulation.
2. Isolate equipment which may be damaged by the specified pressure test conditions.
3. Perform pressure test using calibrated pressure gauges and calibrated volumetric measuring equipment to determine leakage rates.
    a. Select each gauge so that the specified test pressure falls within the upper half of the gauge's range.
    b. Notify the Engineer 24 hours prior to each test.
4. Completely assemble and test new piping systems prior to connection to existing pipe systems.
5. Acknowledge satisfactory performance of tests and inspections in writing to Engineer prior to final acceptance.
6. Bear the cost of all testing and inspecting, locating and remedying of leaks and any necessary retesting and re-examination.

B. Pressure Testing:

1. Testing medium: Unless otherwise specified in the PIPING SYSTEMS SCHEDULE, utilize the following test media.
    a. Process systems:

PIPE LINE SIZE	SPECIFIED TEST PRESSURE	TESTING MEDIUM
2 inches and smaller	75 psi or less	Water
2 inches and smaller	Greater than 75 psi	Water
Greater than 2 inches	3 psi or less	Water
Greater than 2 inches	Greater than 3 psi	Water

b. Laboratory gases and natural gas systems: Cylinder nitrogen.

c. Liquid systems:

PIPE LINE SIZE (DIA)	GRAVITY OR PUMPED	SPECIFIED TEST PRESSURE	TESTING MEDIUM
Up to and including 48 inches	Gravity	25 psiG or less	Water
Above 48 inches	Gravity	25 psiG or less	Water
All sizes	Pumped	250 psiG or less	Water

2. Allowable leakage rates:
   a. Hazardous gas systems, all exposed piping systems, all pressure piping systems and all buried, insulated piping systems which are hydrostatically pressure tested shall have zero leakage goal at the specified test pressure throughout the duration of the test.
   b. Hydrostatic exfiltration and infiltration for sanitary and stormwater sewers (groundwater level is below the top of pipe):
      1) Leakage rate: 200 GAL per inch diameter per mile of pipe per day at average head on test section of 3 feet.
      2) Average head is defined from groundwater elevation to average pipe crown.
      3) Acceptable test head leakage rate for heads greater than 3 feet: Acceptable leakage rate (gallons per inch diameter per mile per day) equals 115 by (actual test head to the 1/2 power).
   c. Hydrostatic infiltration test for sanitary and stormwater sewers (groundwater level is above the top of pipe):
      1) Allowable leakage rate: 200 GAL per inch diameter per mile of pipe per day when depth of groundwater over top of pipe is 2 to 6 feet.
      2) Leakage rate at heads greater than 6 feet: Allowable leakage rate (gallons per inch diameter per mile of pipe per day) equals 82 by (actual head to the 1/2 power).
   d. Large diameter (above 48 inches) gravity plant piping systems shall have a maximum exfiltration of 25 GPD per inch-mile.
   e. Non-hazardous gas and air systems which are tested with air shall have a maximum pressure drop of 5% of the specified test pressure throughout the duration of the test.
   f. For low pressure (less than 25 psiG) air testing, the acceptable time for loss of 1 psiG of air pressure shall be:

PIPE SIZE (IN DIA)	TIME, MINUTES/100 feet
4	0.3
6	0.7
8	1.2

PIPE SIZE (IN DIA)	TIME, MINUTES/100 feet
10	1.5
12	1.8
15	2.1
18	2.4
21	3.0
24	3.6
27	4.2
30	4.8
33	5.4
36	6.0
42	7.3
48	7.6

3. Hydrostatic pressure testing methodology:
    a. General:
        1) All joints, including welds, are to be left exposed for examination during the test.
        2) Provide additional temporary supports for piping systems designed for vapor or gas to support the weight of the test water.
        3) Provide temporary restraints for expansion joints for additional pressure load under test.
        4) Isolate equipment in piping system with rated pressure lower than pipe test pressure.
        5) Do not coat or insulate exposed piping until successful performance of pressure test.
    b. Soil, waste, drain and vent systems:
        1) Test at completion of installation of each stack or section of piping by filling system with water and checking joints and fittings for leaks.
        2) Eliminate leaks before proceeding with work or concealing piping.
        3) Minimum test heights shall be 10 feet above highest stack inlet.
    c. Larger diameter (above 36 inches) gravity plant piping:
        1) Plug downstream end of segment to be tested.
            a) Provide bracing as required.
        2) Fill segment and upstream structure to normal operating level as per hydraulic profile.
        3) Allow 24 hours for absorption losses.
            a) Refill to original level.
        4) Provide reservoir to maintain constant head over duration of test.
        5) Record reservoir water volume at beginning and end of test.
4. Natural gas systems - testing methodology:
    a. Maintain specified test pressure until each joint has been thoroughly examined for leaks by means of soap suds and glycerin.
    b. Wipe joints clean after test.
5. Air testing methodology:
    a. General:

1) Assure air is ambient temperature.

b. Low pressure air testing:

1) Place plugs in line and inflate to manufacturer's designated seal pressure.

2) Check plugs for proper sealing.

3) Introduce low pressure air into sealed line segment until air pressure reaches 4 psiG greater than ground water or allowable limits of ASTM F1417.

a) Use test gauge conforming to ASME B40.100 with 0 to 15 psi scale and accuracy of 1% of full range.

4) Allow 2 minutes for air pressure to stabilize.

5) After stabilization period (3.5 psiG minimum pressure in pipe) discontinue air supply to line segment.

6) Record pressure at beginning and end of test.

C. Dielectric Testing Methods and Criteria:

1. Provide electrical check between metallic non-ferrous pipe or appurtenances and ferrous elements of construction to assure discontinuity has been maintained.
2. Wherever electrical contact is demonstrated by such test, locate the point or points of continuity and correct the condition.

3.9 CLEANING, DISINFECTION AND PURGING

A. Cleaning:

1. Clean interior of piping systems thoroughly before installing.
2. Maintain pipe in clean condition during installation.
3. Before jointing piping, thoroughly clean and wipe joint contact surfaces and then properly dress and make joint.
   a. Pig high pressure air piping before connecting to valves or instruments.
4. At completion of work and prior to Final Acceptance, thoroughly clean work installed under these Specifications.
   a. Clean equipment, fixtures, pipe, valves, and fittings of grease, metal cuttings, and sludge which may have accumulated by operation of system, from testing, or from other causes.
   b. Repair any stoppage or discoloration or other damage to parts of building, its finish, or furnishings, due to failure to properly clean piping system, without cost to Owner.
5. After erection of piping and tubing, but prior to installation of service outlet valves, blow natural gas systems clear of free moisture and foreign matter by means of air, nitrogen or carbon dioxide.
   a. Oxygen shall never be used.

B. Disinfection of Potable Water Systems:

1. After favorable performance of pressure test and prior to Final Acceptance, thoroughly flush entire potable water piping system including supply, source and any appurtenant devices and perform disinfection as prescribed.
2. Perform work, including preventative measures during construction, in full compliance with AWWA C651.
3. Perform disinfection using sodium hypochlorite complying with AWWA B300.
4. Flush each segment of system to provide flushing velocity of not less than 2.5 feet per second.
5. Drain flushing water to sanitary sewer.
   a. Do not drain flushing water to receiving stream.
6. Use continuous feed method of application.
   a. Tag system during disinfection procedure to prevent use.

7. After required contact period, flush system to remove traces of heavily chlorinated water.
8. After final flushing and before placing water in service, obtain an independent laboratory approved by the Owner to collect samples and test for bacteriological quality.
    a. Repeat entire disinfection procedures until satisfactory results are obtained.
9. Secure and deliver to Owner, satisfactory bacteriological reports on samples taken from system.
    a. Ensure sampling and testing procedures are in full compliance to AWWA C651, local water purveyor and applicable requirements of State of Idaho.

C. Purging Natural Gas:

1. Existing piping:
    a. Turn off gas supply.
    b. Vent line pressure outdoors.
    c. If section exceeds the following, then remaining gas shall be displaced with an inert gas.
        1) 50 feet for 2-1/2 inches pipe.
        2) 30 feet for 3 inches pipe.
        3) 15 feet for 4 inches pipe.
        4) 10 feet for 6 inches pipe.
        5) Any length for 8 inches or larger pipe.
2. New piping:
    a. Including but not limited to:
        1) All fuel gas piping.
        2) Fuel gas trains.
    b. Purge air filled system with fuel gas:
        1) Providing piping length is less than:
            a) 30 feet for 3 inches pipe.
            b) 15 feet for 4 inches pipe.
            c) 10 feet for 6 inches pipe.
            d) Any length for 8 inches and larger pipe.
        2) Providing a moderately rapid and continuous flow of fuel gas is introduced.
            a) Introduce fuel gas at one end.
            b) Vent air at opposite end.
        3) Provided fuel gas flow is continuous without interruption until vented gas is free of air.
        4) The point of discharge shall not be left unattended during purging.
    c. If the piping is 3 inches or larger and exceeds lengths stated above.
        1) Purge air with inert gas in accordance with NFPA 54 and NFPA 69.
        2) Purge inert gas with fuel gas.
3. Discharge of purged gases:
    a. Open end of piping shall not discharge into confined spaces or areas where there are sources of ignition.

3.10 LOCATION OF BURIED OBSTACLES

A. Furnish exact location and description of buried utilities encountered and thrust block placement.

B. Reference items to definitive reference point locations such as found property corners, entrances to buildings, existing structure lines, fire hydrants and related fixed structures.

C. Include such information as location, elevation, coverage, supports and additional pertinent information.

D. Incorporate information on "As-Recorded" Drawings.

3.11 PIPE INSULATION

A. Insulate pipe and pipe fittings in accordance with Specification Section 40 42 00.

3.12 GASKET MATERIAL SCHEDULE

A. Table A: Material Rating for Elastomers:

1. X: Can be used for service identified.
2. -: Shall not used for service identified.

CHEMICAL OR GAS	NEOPRENE	BUNA-N	NATURAL	URETHANE	EPDM	SILICONE	HYPALON	VITON	TEFLON
Methane (Natural Gas)	-	X	-	-	-	-	-	X	X

3.13 PIPING SYSTEM SCHEDULES

A. Piping System 1 – Buried, Ductile Iron Gravity Sewer, Facility Influent and Effluent (up through 48-inch diameter). NOT USED.

B. Piping System 2 – Buried and Exposed, Ductile Iron, Gravity and Low-Head, Process Piping within a Facility (up to 48-inch diameter).

1. General:
   a. Piping symbol and service:
      1) DGS - Degritted Sewage.
   b. Test requirements:
      1) Test medium: Water.
      2) Pressure: 25 psiG.
      3) Duration: 6 hours.
   c. Gaskets:
      1) Flanged, push-on, and mechanical joints (ductile iron): Rubber, AWWA/ANSI C111/A21.11.
2. System components:
   a. Pipe size 3 inches through 48 inches:
      1) Exposed service:
         a) Material:
            (1) Flanged: Ductile iron, Class 50.
            (2) Grooved type joint system: Use pipe thickness per AWWA C606.
         b) Reference: AWWA/ANSI C115/A21.15.
         c) Lining: Cement.
         d) Coating: HPIC; See Specification Section 09 96 00.
         e) Fittings: Either AWWA/ANSI C110/A21.10 ductile or gray iron.
         f) Joints: AWWA/ANSI C115/A21.15 flanged joints with flanges at valves and structure penetrations.
      2) Buried service:
         a) Materials: C900 PVC Pipe, DR 25.
         b) Reference: AWWA C900.
         c) Lining: None.
         d) Coating: None.

e) Fittings: Either AWWA/ANSI C110/A21.10 ductile or gray iron.
(1) Provide polyethylene encasement for buried ductile or gray iron fittings.
f) Joints: Push-on joints with mechanical (stuffing box type) joints at fittings and valves. All fittings shall be restrained.

C. Piping System 3 – Buried and Exposed, Ductile Iron and Steel, Process Piping Operating Under Pressure at up to 100 psiG.
1. General:
a. Piping symbol and service:
1) DGS - Degritted Sewage.
a) Bid Alternate – Batch Tank Pumping.
2) GR - Grit (glass-lined).
3) PD - Pumped Drainage.
4) RS - Raw Sewage.
b. Test requirements:
1) Test medium: Water.
2) Pressure: 1.25 x working pressure.
3) Duration: 6 hours.
c. Gaskets:
1) Flanged, push-on and mechanical joints (ductile iron): Rubber, AWWA/ANSI C111/A21.11.
2) Grooved coupling joints (ductile and steel): Rubber, AWWA C606.
3) Flanged joints (steel): AWWA C207.
2. System components:
a. Pipe size less than 3 inches:
1) Exposed service:
a) Material: PVC, Type 1, Grade 1, Schedule 80.
b) Reference: ASTM D1785.
c) Lining: None.
d) Coating: None.
e) Fittings: Solvent welded socket type complying with ASTM D2467.
f) Joints: Solvent welded with unions at valves, penetrations through structures and equipment connections for pipe 2 inches and less and flanges at those locations for pipe above 2 inches.
2) Buried service:
a) Materials: PVC, Type 1, Grade 1, Schedule 80.
b) Reference: ASTM D1785.
c) Lining: None.
d) Coating: None.
e) Fittings: Solvent welded socket type complying with ASTM D2467.
f) Joints: Solvent welded.
b. Pipe size 3 inches through 24 inches:
1) Exposed service:
a) Material:
(1) Flanged: Ductile iron, Class 50.
(2) Grooved type joint system: Use pipe thickness per AWWA C606.
b) Reference: AWWA/ANSI C115/A21.15.
c) Lining: Cement.

(1) Grit piping shall be glass-lined.

d) Coating: HPIC; See Specification Section 09 96 00.

e) Fittings: Either AWWA/ANSI C110/A21.10 ductile or gray iron.

(1) Grit system elbow fittings shall be HammerTek Smart Elbow® Deflection Elbows or Engineer-approved equal.

f) Joints:

(1) Flanged or grooved type mechanical coupling (AWWA C606) joints.

(2) With both systems, provide screwed-on flanges at equipment, valves and structure penetrations.

2) Buried service:

a) Materials: C900 PVC, DR 25.

b) Reference: AWWA C900.

c) Lining: None.

d) Coating: None.

e) Fittings: Either AWWA/ANSI C110/A21.10 ductile or gray iron.

(1) Provide polyethylene encasement for buried ductile or gray iron fittings.

f) Joints: Push-on with mechanical (stuffing box type) joints at fittings and valves. All fitting shall be restrained.

D. Piping System 4 – Exposed Steel Process Piping for Sludge Cake of 24 to 30+ Percent dry Solids (up to 26-inch diameter). NOT USED.

E. Piping System 5 – Natural Gas Piping, Buried and Exposed Steel, and Buried Polyethylene.

1. General:

a. Piping symbol and service:

1) NG - Natural Gas.

b. Test requirements:

1) Test medium: Cylinder Nitrogen.

2) Pressures in accordance with IDAPA 24.39.70:

a) Working Pressure up to 10 inches W.C.: 20 PSIG minimum.

b) Working Pressure > 10 inches W.C., ≤ 10 PSIG: 60 PSIG minimum.

c) Working Pressure > 10 PSIG: 6 x Working Pressure.

3) Duration in accordance with IDAPA 24.39.70: 20 minutes minimum.

2. System components:

a. Pipe size through 26 inches:

1) Exposed service:

a) Material: Steel, Grade B, black, Schedule 40.

b) Reference: ASTM A53.

c) Lining: None.

d) Coating: HPIC; See Specification Section 09 96 00.

e) Fittings: Malleable iron meeting ASTM A197, ASME B16.3, Class 150.

f) Joints: Threaded, ASME B16.9 steel butt- or socket-welded joints.

2) Buried service:

a) Materials: Polyethylene.

b) Reference: ASTM D2513.

c) Lining: None.

d) Coatings: None.

e) Fittings: Socket fusion or butt fusion fittings complying with ASTM D2683 and ASTM D3261.

f) Joints: Fusion jointing system or as directed by local gas company.

3. Natural Gas Piping Installation:
   a. Install piping in accordance with NFPA, local gas company regulations, codes and local ordinances, complete with necessary appurtenances.
   b. Install buried pipe at approximately 30 inches deep.
   c. Gas cocks:
      1) Install before gas utilization equipment connected to system, at each branch main and at connection to meter.
      2) Design to operate safely under pressures indicated.
      3) Install ground joint unions at intervals to facilitate repairs.
      4) Cocks shall be of type and lubricant recommended by manufacturer for this class of service, and as approved by local gas company.
   d. Pipe drainage:
      1) Drain horizontal piping to risers.
      2) Locate drains where required for system drainage.
      3) Install tee fitting with bottom outlet plugged or provide with threaded, capped nipple at bottom of risers or in accordance with applicable codes.
   e. Make piping connections with shellacked joints or ground joint unions.
   f. Provide vents from gas regulators, pressure reducing valves, and other vented devices to the outdoors and terminate in accordance with applicable codes.
   g. Connect piping to pressure reducing valve outside each building as shown on drawings and schedule.
   h. Provide flexible connections to vibration isolated equipment suitable for pressures, local and national codes and intended application.
   i. Remove cutting and threading burrs.
   j. Plug each gas outlet (including valves) with threaded plugs or caps immediately after installation and retain until the piping or equipment connections are completed.
   k. Continuously ground gas piping electrically, bond tightly to the grounding connection.
   l. Install piping parallel to other piping, but maintain a minimum 12 inches clearance between gas piping and any piping that could reach 200 degrees F.
   m. All gas piping in air plenums to be all-welded and encased in a Schedule 40 pipe sleeve.
      1) Ends of the sleeve open to atmosphere or sealed with the annulus vented (gas pipe size) to atmosphere.

F. Piping System 6 – Buried and Exposed Heating and Chilled Water Supply and Return Piping and Related Piping. NOT USED.

G. Piping System 7 – Exposed Process Piping, PVC and CPVC, for Liquid Chemical and Gaseous Service. NOT USED.

H. Piping System 8 – Buried and Exposed Liquid Ferric Chloride, Liquid Sodium Hydroxide, and Other Liquid Chemical Piping. NOT USED.

I. Piping System 9 – Buried and Exposed Process Piping for Non-Potable Water, Seal Water, Service Water, and Similar Applications.

1. General:
   a. Piping symbol and service:
      1) UW - Utility Water.
   b. Test requirements:

1) Test medium: Water.
2) Pressure: 1.25 x working pressure.
3) Duration: 6 hours.

c. Gaskets and O-rings:
1) O-rings and flanged joints: Neoprene or rubber.

2. System components:
a. Pipe size less than 1 inch:
a) Material: PVC, Type 1, Grade 1, Schedule 80.
b) Reference: ASTM D1785.
c) Lining: None.
d) Coating: None.
e) Fittings: Solvent welded socket type complying with ASTM D2467.
f) Joints: Solvent welded with unions at valves, penetrations through structures and equipment connections.

b. Pipe size 1 inch to 3 inches:
1) Material: high-density polyethylene (HDPE), SDR 11.
2) Reference: AWWA C901.
3) Lining: None.
4) Coating: None.
5) Fittings: Socket fusion or butt fusion fittings complying with ASTM D2683 and ASTM D3261 with unions at valves, penetrations through structures and equipment connections for pipe 2 inches and less and flanges at those locations for pipe above 2 inches.
6) Joints: Socket fusion or butt fusion fittings complying with ASTM D2683 and ASTM D3261.

c. Pipe size greater than 3 inches:
1) Material: high-density polyethylene (HDPE), SDR 11.
2) Reference: AWWA C906.
3) Lining: None.
4) Coating: None.
5) Fittings: Socket fusion or butt fusion fittings complying with ASTM D2683 and ASTM D3261.
6) Joints: Socket fusion or butt fusion fittings complying with ASTM D2683 and ASTM D3261 with flanges at valves, equipment, and structure penetration.

J. Piping System 10 – Buried and Exposed Potable Water Piping.

1. General:
a. Brass and copper piping and fittings are not acceptable within Headworks Building due to hydrogen sulfide corrosion.
b. Piping symbol and service:
1) W1 - Potable Water.
c. Test requirements:
1) Test medium: Water.
2) Pressure: 1.25 x working pressure.
3) Duration: 6 hours.
d. Gaskets and O-rings:
1) O-rings and flanged joints: Neoprene or rubber.

2. System components:

a. Pipe size to 3 inches:
   1) Material: high-density polyethylene (HDPE), SDR 11.
   2) Reference: AWWA C901.
   3) Lining: None.
   4) Coating: None.
   5) Fittings: Socket fusion or butt fusion fittings complying with ASTM D2683 and ASTM D3261.
   6) Joints: Socket fusion or butt fusion fittings complying with ASTM D2683 and ASTM D3261.

b. Pipe size greater than 3 inches:
   1) Material: high-density polyethylene (HDPE), SDR 11.
   2) Reference: AWWA C906.
   3) Lining: None.
   4) Coating: None.
   5) Fittings: Socket fusion or butt fusion fittings complying with ASTM D2683 and ASTM D3261.

3. Install drain tees with capped nipples of HDPE 3 inches long at low points.
   a. If low point occurs in concealed piping, provide approved flush access panel.
   b. These drains are not shown on Drawings.
4. Slope water lines down to drain points not less than 1 inch in 60 feet.
5. Install all threaded piping with clean-cut tapered threads and with ends thoroughly reamed after cutting to remove burrs.
   a. Pipe joint cement permitted only on external threads.
6. For screwed nipples for connections to flush valves, lavatory supplies, and other equipment with threaded connections use HDPE pipe.
7. Install ball, butterfly and plug valves where indicated or required to adequately service all parts of system and equipment.
   a. Install valves on each branch serving restroom.
   b. Install valves on inlet and outlet connections of heat exchangers and on other equipment connected to water lines.
8. Install unions between valves and connections to each piece of equipment and install sufficient number of unions throughout piping system to facilitate installation and servicing.
9. Construct and equip plumbing fixtures and equipment with anti-siphon devices as to entirely eliminate any danger of siphoning waste material into potable water supply system.
10. Where exposed pipes 6 inches in size and smaller pass through floors, finished walls, or finished ceilings, fit with chrome-plated plates large enough to completely close hole around pipes.
    a. Secure plates to pipe by set screw in approved manner.
11. Size supply branches to individual fixtures as scheduled or indicated on Drawings.
12. Install piping so as to be free to expand with proper loops, anchors and joints without injury to system or structure.
13. Provide branches to wall hydrants or hose bibbs in exterior locations with interior shutoff and drain valves.
14. Provide approved type vacuum breaker and backflow preventer installations indicated or as required by Code.
15. Install concealed in finished structures such as administration and office facilities and at locations shown on Drawings.

K. Piping System 11 – Buried and Exposed Piping for Plant Compressed Air and Instrument Air Service up to 100 psiG. NOT USED.

L. Piping System 12 – Exposed Process Piping for Low-Pressure Air Service up to 25 psiG. NOT USED.

M. Piping System 13 – Buried and Exposed Sludge Digester Gas Piping. NOT USED.

N. Piping System 14 – Buried and Exposed Steel Process Piping for Chlorine Gas Under Pressure, Liquid Chlorine, Sulfur Dioxide Gas Under Pressure, and Sulfur Dioxide Solution. NOT USED.

O. Piping System 15 – Buried Concrete Pipe for Storm Sewer Service. NOT USED.

P. Piping System 16 – Buried Corrugated Metal Storm Water Culverts. NOT USED.

Q. Piping System 17 – Buried Polyethylene and PVC Foundation Drain and Cut-Off Drain Piping. NOT USED.

R. Piping System 18 – Buried and Exposed Ash and Ash Slurry Piping. NOT USED.

S. Piping System 19 – Exposed Piping for Refrigerants.

1. General:
    a. Piping symbol and service:
        1) RL - Refrigerant Liquid.
        2) RS - Refrigerant Suction.
    b. Test requirements:
        1) Test medium: R-22 refrigerant.
        2) Pressure: Normal full load operating pressures as specified by cooling equipment manufacturer.
        3) Duration: 6 hours.
        4) Leak location method: Test all fittings with bubble solution followed by Halide torch or electronic platinum diode meter.
2. System components:
    a. Pipe size up to 2 inches:
        1) Exposed service:
            a) Material: Factory pre-charged copper line sets sized per manufacturer recommendations for 2 degrees F line loss.
            b) Solder: High temperature (melting point not less than 1000 degrees F) silver solder compatible with tubing and fittings.
            c) Lining: None.
            d) Coating: HPIC; See Specification Section 09 96 00.
            e) Fittings: Copper, as required to adapt line sets to equipment.
            f) Joints: Soldered.

T. Piping System 20 - Acid Waste and Acid Vent Applications. NOT USED.

U. Piping System 21 – Buried and Exposed Building Storm Water, Waste, and Vent Piping.

1. General:
    a. Piping symbol and service:
        1) D - Drain.
        2) RD – Roof Drain.
        3) SD – Storm Drain.
        4) VT – Vent.
    b. Test requirements:
        1) Test medium: Water.
        2) Pressure: See the FIELD QUALITY CONTROL Article in PART 3 of this Specification Section.

3) Duration: 6 hours.

c. Gaskets: Rubber, ASTM C564.

2. System components:
   a. Pipe size 1-1/4 inches and 1-1/2 inches:
      1) Exposed service.
         a) Material: Galvanized steel, Schedule 40.
         b) Reference: ASTM A53.
         c) Lining: Galvanized.
         d) Coating: HPIC; See Specification Section 09 96 00.
         e) Fittings: Cast iron drainage.
            (1) ASTM A126, Class B.
         f) Joints: Threaded.
   b. Pipe size 2 inches and larger:
      1) Exposed service.
         a) Material: Cast iron soil pipe.
         b) Reference: ASTM A74, CISPI 301.
         c) Lining: None.
         d) Coating: HPIC; See Specification Section 09 96 00.
         e) Fittings: ASTM A74.
         f) Joints: No-hub with elastomeric sealing sleeve and stainless steel clamp assembly conforming to CISPI 301.
      2) Buried service (to 5 feet outside of structure):
         a) Material: Cast-iron soil pipe.
         b) Reference: ASTM A74.
         c) Lining: None.
         d) Coating: Bituminous.
         e) Fittings: ASTM A74.
         f) Joints: Hub and spigot.
   c. Exposed and buried service, 3 to 15 inches (Headworks floor and process drains only):
      1) Material: PVC, DR 35.
      2) Reference: ASTM D3034.
      3) Lining: None.
      4) Coating: None.
      5) Fittings: ASTM D3034.
      6) Joints: elastomeric gasket joint per ASTM D3212.
3. Soil and Waste Piping Installation:
   a. Install horizontal soil or waste lines less than 4 inches diameter with a slope of not less than 1/4 inches/FT or 2% toward the point of disposal.
   b. Install 4 inches and larger piping at 1/8 inches per foot.
   c. Install as close to construction as possible to maintain maximum head room.
   d. Make changes of direction with 1/8 bends and junctions with wye fittings.
   e. Use short wye fittings in vertical pipe only.
   f. Install handhole test tee at base of each stack.
   g. Install cleanouts at dead ends, at changes of direction and at 50 feet intervals on horizontal runs.
      1) Where cleanouts occur in concealed spaces, provide with extensions to floors above or to walls as required.

h. Install piping true to grade and alignment.
   1) Begin at the system low point.
i. Locate vertical extensions of underground piping below partition walls for concealment in wall.
   1) In locations where hubs are wider than partition, set hubs 1 inch below final floor.
j. Install concealed in finished structures such as administration and office facilities and at locations shown on Drawings.
k. For hub and spigot joints, install hub facing flow.

4. Vent Piping Installation:
   a. Run vent stack parallel to each soil or waste stack to receive branch vents from fixtures.
   b. Originate each vent stack from soil or waste pipe at its base.
   c. Where possible, combine soil, waste or vent stacks before passing through roof so as to minimize roof openings.
   d. Offset pipes running close to exterior walls away from such walls before passing through roof to permit proper flashing.
   e. Provide pipes passing through roofs with cast iron increasers minimum of 12 inches below roof one size larger than pipe but in no case less than 4 inches.
   f. Terminate each vent with approved frostproof jacket.
   g. Carry vent stacks 4 inches and larger full size through roof.
      1) Extend vent stacks at least 12 inches above roofing.
   h. Pipe vents from pressure regulating devices in compliance with local codes.
   i. Install concealed in finished structures such as administration and office facilities and at locations shown on Drawings.

V. Piping System 22 – Buried and Exposed Fuel Oil Supply and Return Piping. NOT USED.

W. Piping System 23 – Buried Vitrified Clay and Ductile Iron Sanitary Sewer Piping for In-plant Applications. NOT USED.

X. Piping System 24 – Buried and Exposed Process Piping for Sulfuric Acid and Potassium Permanganate Service. NOT USED.

Y. Piping System 25 – Exposed Process Piping for Low-Pressure/High-Abrasion Service, Including Dry Chemicals and Kiln Dust, Below 30 psiG. NOT USED.

Z. Piping System 26 – Buried and Exposed, Ductile Iron and Steel, Process Piping Operating Under Pressure of 100-200 psiG. NOT USED.

AA. Piping System 27 – Buried and Exposed, PVC and Steel, Process Liquid Sample Piping. NOT USED.

BB. Piping System 28 – Exposed, Stainless Steel Process Piping for Laboratory Gas Service. NOT USED.

3.14 SERVICE SYSTEM SUMMARY

A. Service System is defined in Table B:

TABLE B - SERVICE SYSTEM SUMMARY

SYMBOL	SERVICE	SYSTEM NO	CONSTRUCTION	SIZE (IN)	PIPE MATERIAL	TEST PRESSURE SPECIFIER (PSI)
DGS	Degritted Sewage	2	Buried and Exposed	3 to 48	C900 PVC	25 PSIG
		3	Buried and Exposed	3 to 24	C900 PVC	1.25 x WP
GR	Grit	3	Buried and Exposed	3 to 24	Ductile Iron (GL)	1.25 x WP
PD		3	Buried and Exposed	< 3	Sch. 40 PVC	1.25 x WP

TABLE B - SERVICE SYSTEM SUMMARY						
SYMBOL	SERVICE	SYSTEM NO	CONSTRUCTION	SIZE (IN)	PIPE MATERIAL	TEST PRESSURE SPECIFIER (PSI)
	Pumped Drainage			3 to 24	C900 PVC	1.25 x WP
RS	Raw Sewage	3	Buried and Exposed	3 to 24	C900 PVC	1.25 x WP
NG	Natural Gas	5	Exposed	< 26	Sch. 40 Black Steel	≤ 10 inches W.C.: 20 PSIG > 10 inches W.C.; ≤ 10 PSIG: 60 PSIG > 10 PSIG: 6 x WP
			Buried	< 26	Polyethylene	≤ 10 inches W.C.: 20 PSIG > 10 inches W.C.; ≤ 10 PSIG: 60 PSIG > 10 PSIG: 6 x WP
UW	Utility Water (Non-Potable)	9	Buried and Exposed	All	HDPE	1.25 x WP
W1	Potable Water	10	Buried and Exposed	All	HDPE	1.25 x WP
RL	Refrigerant Liquid	19	Exposed	All	Copper	As req'd by MFR
RS	Refrigerant Suction	19	Exposed	All	Copper	As req'd by MFR
D	Drain	21	Exposed	1-1/4 to 1-1/2	Sch. 40 Galvanized Steel	Per Article 3.8
			Buried and Exposed	≥ 2	DR 35 PVC	Per Article 3.8
RD	Roof Drain	21	1-1/4 to 1-1/2	Sch. 40 Galvanized Steel	Per Article 3.8	1-1/4 to 1-1/2
			≥ 2	Cast Iron Soil Pipe	Per Article 3.8	≥ 2
VT	Vent	21	1-1/4 to 1-1/2	Sch. 40 Galvanized Steel	Per Article 3.8	1-1/4 to 1-1/2
			≥ 2	Cast Iron Soil Pipe	Per Article 3.8	≥ 2

WP = Working Pressure; MFR = Manufacturer

END OF SECTION

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SECTION 40 05 07
PIPE SUPPORT SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe support and anchor systems.
2. Design of Pipe Support Systems as specified.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 01 81 10 - Wind and Seismic Design Criteria
2. Section 03 15 19 - Anchorage to Concrete.
3. Section 05 50 00 - Metal Fabrications.
4. Section 09 96 00 - High Performance Industrial Coatings.
5. Section 40 42 00 - Pipe, Duct and Equipment Insulation.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Society of Mechanical Engineers (ASME):
   a. B31.3, Process Piping.
2. ASTM International (ASTM):
   a. A36, Standard Specification for Carbon Structural Steel.
   b. A123/123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   c. A153/153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   d. A276, Standard Specification for Stainless Steel Bars and Shapes.
   e. A575, Standard Specification for Steel Bars, Carbon, Merchant Quality, M-Grades.
   f. A576, Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
   g. A917, Standard Specification for Steel Sheet, Coated by the Electrolytic Process for Applications Requiring Designation of the Coating Mass on Each Surface (General Requirements).
   h. A918, Standard Specification for Steel Sheet, Zinc-Nickel Alloy Coated by the Electrolytic Process for Applications Requiring Designation of the Coating Mass on Each Surface.
   i. B633, Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
3. American Welding Society (AWS):
   a. D1.1, Structural Welding Code - Steel.
   b. D1.6, Structural Welding Code - Stainless Steel.
4. Manufacturers Standardization Society of the Valve and Fittings Industry Inc. (MSS):
   a. SP-58, Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

B. Responsibility:

1. Support systems for piping greater than 12 inches diameter, or with internal pressure over 100 psi, or piping with product temperatures over 200 degrees F, are shown on the Drawings and are not to be designed by Contractor unless indicated in Contract Documents.

2. Design complete support systems for piping 12 inches and smaller where supports are not shown on the Drawings.
3. Provide all labor, materials, equipment and incidentals as shown, specified and required to design, furnish and install the system of hangers, supports, guidance, anchorage and appurtenances.
4. General piping support details may be indicated on the Drawings in certain locations for pipe 12 inches diameter and smaller.
5. Incorporate those details with requirements of this Specification Section to provide the piping support system.

C. Each type of pipe hanger or support shall be the product of one manufacturer.

D. Qualifications:

1. Pipe support designer:
   a. Licensed Professional Engineer registered in the State of Idaho.
   b. Minimum of five years experience designing pipe supports for projects of similar size and complexity.

1.3 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Scaled drawings showing location, installation, material, loads and forces, and deflection of all hangers and supports.
   b. Analyze each pipe system for all loads and forces on hangers and supports and their reaction forces to the structure to which they are fastened.
   c. Where Contract Documents indicate contractor is to design pipe support systems, submit detail design calculations and scaled drawings signed by Pipe support designer.
2. Product data:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Manufacturer's installation instructions.
   c. Itemized list of wall sleeves, anchors, support devices and all other items related to pipe support system.

B. Informational Submittals:

1. Certifications.
   a. Pipe support designer qualifications

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Empire Industries, Inc.
2. ASC Engineered Solutions (ANVIL).
3. National Pipe Hanger Corp.
4. PHD Manufacturing, Inc.
5. Atkore International (Unistrut, Powerstrut and Aickinstrut).
6. Or Equal.

2.2 MANUFACTURED UNITS

A. General:

1. Galvanized components:

a. Hot-dip galvanized components:
   1) General: ASTM 123/123M.
   2) Fasteners and hardware: ASTM 153/153M.

2. Dissimilar metals protection:
   a. Galvanized-to-galvanized and galvanized-to-aluminum: No protection required.
   b. All other galvanized-to-dissimilar metal connections: Neoprene or nylon pads, shims, grommets, etc.
3. Fiberglass Reinforced Plastic (FRP) components:
   a. Material: Vinyl ester.
   b. Channels: similar to Aickinstrut F2000 or F2100.
   c. Pipe Clamps: similar to Aickinstrut FPS or FRPC.
   d. Clevis Hangers: similar to Aickinstrut FMCH.
   e. Beam Clamp: similar to Aickinstrut FMBC.
   f. Column Base: similar to Aickinstrut F2852, F5853 or 5854

B. Hanger Rods:

1. Material:
   a. Minimum allowable tensile stress of 12,000 psi at 650 degrees F per MSS SP-58.
   b. Corrosion resistant: 304 or 316 stainless steel per ASTM A276.
2. Continuously threaded.
3. Load limit:

NOMINAL ROD DIAMETER	MAXIMUM SAFE LOAD, (LBS)
3/8 inches diameter (min)	610
1/2 inches diameter	1,130
5/8 inches diameter	1,810
3/4 inches diameter	2,710
7/8 inches diameter	3,770
1 inches diameter	4,960

C. Hangers:

1. Materials for corrosive areas: 316 stainless steel.
2. Hangers for use other than directly on copper pipe: 316 stainless steel.
3. Hanger type schedule:

APPLICATION	PIPE SIZE	HANGER TYPE
All except noted	4 inches and less	MSS Type 1 or 12 Similar to Empire Figure 41.
All except noted	Over 4 inches	MSS Type 1 Similar to Empire Figure 11.
Steam, condensate, and hot water	All	MSS Type 43 Similar to Empire Figure 272 w/ spring hanger.
Service in chemical storage areas and as indicated on drawings for corrosion resistance	All	FRP trapeze hangers or clevis hangers as specified below.

D. Concrete Inserts for Hanger Rods:
    1. Continuous slots: Unistrut #P1000.
    2. Individual inserts: Similar to ANVIL Figure 281.
    3. See Specification Section 03 15 19, mechanical anchors.

E. Beam Clamps for Hanger Rods:
    1. MSS SP-58, Type 21.
    2. Material: 316 stainless steel.
    3. Standard duty.
    4. Similar to Empire Industries Figure 155.

F. Trapeze Hangers for Suspended Piping:
    1. General:
        a. Material: 316 stainless steel.
        b. Angles, channels, or other structural shapes.
        c. Curved roller surfaces at support point corresponding with type of hanger required.
        d. See Specification Section 05 50 00.
    2. In chemical storage and feed areas and as indicated on the drawings:
        a. Materials: FRP.
        b. Aikinstrut fiberglass channel or equal.

G. Vertical Pipe Supports:
    1. At base of riser.
        a. Material: 316 stainless steel.
    2. Lateral movement:
        a. Clamps or brackets:
            1) MSS SP-58, Type 8 or 42.
            2) Stainless steel.
            3) Similar to Empire Industries Figure 50.

H. Expanding Pipe Supports:
    1. Spring hanger type.
    2. MSS SP-58, Type 51.

I. Pipe Support Saddle:
    1. For pipe located 3 feet or less from floor elevation, except as otherwise indicated on Drawings.
    2. MSS SP-58 Type 38.
    3. Material: 316 stainless steel.
    4. Similar to Empire Industries Figure 426.

J. Pipe Support Risers/Stanchions:
    1. Schedule 40 pipe.
    2. Material: match pipe support saddle.
    3. Size: As recommended by saddle manufacturer.
    4. Provide low carbon stainless steel for welded fabrications.

K. Pipe Support Base Plate:

1. 4 inches larger than support.
2. Collar 3/16 inches thickness, circular in shape, and sleeve type connection to pipe.
3. Collar fitted over outside of support pipe and extended 2 inches from floor plate.
4. Collar welded to floor plate.
5. Edges ground smooth.
6. Material: match pipe support saddle.
7. Provide low carbon stainless steel for welded fabrications.

L. Pipe Covering Protection Saddle:

1. For insulated pipe at point of support.
2. MSS SP-58 Type 40.
3. Material: 316 stainless steel.
4. Stainless steel: Similar to Empire Industries Figure 167.

M. Wall Brackets:

1. For pipe located near walls and 8 feet or more above floor elevation or as otherwise indicated on the Drawings.
2. MSS SP-58, Type 33.
3. Material: 316 stainless steel.
4. Similar to Empire Industries Figure 802.

N. Pipe Anchors:

1. For locations shown on the Drawings.
2. 1/4 inches steel plate construction.
3. Hot-dip galvanized after fabrication.
4. Designed to prevent movement of pipe at point of attachment.

O. Pipe Guides:

1. For locations on both sides on each expansion joint or loop.
2. To ensure proper alignment of expanding or contracting pipe.
3. Material: 316 stainless steel.
4. Similar to Empire Industries Figure 255.

P. Sway Strut:

1. ANVIL Figure 640.

2.3 DESIGN REQUIREMENTS

A. Supports capable of supporting the pipe for all service and testing conditions.

1. Provide 5 to 1 safety factor.

B. Allow free expansion and contraction of the piping to prevent excessive stress resulting from service and testing conditions or from weight transferred from the piping or attached equipment.

C. Design supports and hangers to allow for proper pitch of pipes.

D. For chemical and waste piping, design, materials of construction and installation of pipe hangers, supports, guides, restraints, and anchors:

1. ASME B31.3.
2. MSS SP-58.
3. Except where modified by this Specification.

E. For steam and hot and cold water process piping, design, materials of construction and installation of pipe hangers, supports, guides, restraints, and anchors:

1. ASME B31.1.
2. MSS SP-58.

F. Check all physical clearances between piping, support system and structure.

1. Provide for vertical adjustment after erection.

G. Support vertical pipe runs in pipe chases at base of riser.

1. Support pipes for lateral movement with clamps or brackets.

H. Place hangers are to be installed on outside of pipe insulation.

1. Use a pipe covering protection saddle for insulated pipe at support point.
2. Insulated piping 1-1/2 inches and less:
   a. Provide a 9 inches length of high density perlite or high density calcium silicate at saddle.
3. Insulated piping over 1-1/2 inches: Provide a 12 inches length of high density perlite or high density calcium silicate at saddle.
4. See Specification Section 40 42 00.

I. Provide 20 GA pipe saddle for fiberglass and plastic pipe support points to ensure minimum contact width of 4 inches.

1. Material: match support.

J. Pipe Support Spacing:

1. General:
   a. Factor loads by specific weight of liquid conveyed if specific weight is greater than water.
   b. Locate pipe supports at maximum spacing scheduled unless indicated otherwise on the Drawings.
   c. Provide at least one support for each length of pipe at each change of direction and at each valve.
2. Steel, stainless steel, cast-iron pipe support schedule:

PIPE SIZES - IN	MAXIMUM SPAN - FT
1-1/2 and less	5
2 thru 4	10
5 thru 8	15
10 and greater	20

3. PVC pipe support schedule:

PIPE SIZES - IN	MAXIMUM SPAN - FT
1-1/4 and less	3
1-1/2 thru 3	4
4 and greater	5

* Maximum fluid temperature of 120 degrees F.

4. Support each length and every fitting:
    a. Bell and spigot piping:
        1) At least one hanger.
        2) Applied at bell.
    b. Mechanical coupling joints:
        1) Place hanger within 2 feet of each side of fittings to keep pipes in alignment.
5. Space supports for soil and waste pipe and other piping systems not included above every 5 feet.
6. Provide continuous support for nylon tubing.
7. For PVC and FRP piping:
    a. Provide Unistrut Unicushion wrap of pipe at each support.

2.4 ACCESSORIES

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide piping systems exhibiting pulsation, vibration, swaying, or impact with suitable constraints to correct the condition.

1. Included in this requirement are movements from:
    a. Trap discharge.
    b. Water hammer.
    c. Similar internal forces.

B. Weld Supports:

1. AWS D1.1.
2. Weld anchors to pipe in accordance with ASME B31.3.
3. AWS D1.6 for stainless steel supports.

C. Locate piping and pipe supports as to not interfere with open accesses, walkways, platforms, and with maintenance or disassembly of equipment.

D. Inspect hangers for:

1. Design offset.
2. Adequacy of clearance for piping and supports in the hot and cold positions.
3. Guides to permit movement without binding.
4. Adequacy of anchors.

E. Inspect hangers after erection of piping systems and prior to pipe testing and flushing.

F. Anchorage to Concrete - reference Specification Section 03 15 19.

G. Install individual or continuous slot concrete inserts for use with hangers for piping and equipment.

1. Install concrete inserts as concrete forms are installed.

H. Welding:

1. Welding rods: ASTM and AWS standards.
2. Integral attachments:
    a. Include welded-on ears, shoes, plates and angle clips.
    b. Ensure material for integral attachments is of good weldable quality.
3. Preheating, welding and postheat treating: ASME B31.3, Chapter V.

I. Field Painting:

1. Comply with Specification Section 09 96 00.

END OF SECTION

SECTION 40 05 19
DUCTILE IRON PROCESS PIPE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ductile iron piping, fittings, and appurtenances.

B. Related Sections include but are not necessarily limited to:

1. Section 40 05 00 - Pipe and Pipe Fittings: Basic Requirements.

1.2 REFERENCE

A. Referenced Standards:

1. American Society of Mechanical Engineers (ASME):
   a. B1.1, Unified Inch Screw Threads (UN and UNR Thread Form).
   b. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
2. ASTM International (ASTM):
   a. A193, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   b. A194, Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   c. A536, Standard Specification for Ductile Iron Castings
   d. B695, Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
   e. B1000, Standard Practices for Casting Preparation and Test Procedure of Porcelain Enamel-lined Pipe, Fittings, and Valves for Use in the Municipal Wastewater, Sewage, and Water Treatment Industry
3. American Water Works Association (AWWA):
   a. C203, Standard for Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot Applied.
   b. C217, Microcrystalline Wax and Petrolatum Tape Coating Systems for Steel Water Pipe.
   c. C606, Standard for Grooved and Shouldered Joints.
4. American Water Works Association/American National Standards Institute (AWWA/ANSI):
   a. C104/A21.4, Standard for Cement–Mortar Lining for Ductile-Iron Pipe and Fittings.
   b. C105/A21.5, Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems.
   c. C110/A21.10, Standard for Ductile-Iron and Gray-Iron Fittings.
   d. C111/A21.11, Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   e. C115/A21.15, Standard for Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
   f. C150/A21.50, Standard for Thickness Design of Ductile-Iron Pipe.
   g. C151/A21.51, Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water.
   h. C153/A21.53, Standard for Ductile-Iron Compact Fittings for Water Service.
   i. C217, Microcrystalline Wax and Petrolatum Tape Coating Systems for Steel Water Pipe and Fittings.
5. International Organization for Standardization (ISO):
   a. ISO 8179-1, Ductile Iron Pipes – External Zinc-Based Coating.

1.3 SUBMITTALS

A. Shop Drawings:

1. Comply with Section 40 05 00 - Pipe - Basic Requirements.
2. Certification of factory hydrostatic testing.
3. If mechanical coupling system is used, submit piping, fittings, and appurtenant items which will be utilized to meet system requirements.

B. Contract Closeout Information:

1. Operation and Maintenance Data:
   a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Flanged Adapters (flanged coupling adapters):
   a. Smith Blair, Style 913 (steel).
   b. Dresser, Style 128 (steel).
   c. Romac Style FCA501 (cast iron).
2. Restrained Flanged Adapters (restrained flanged coupling adapters):
   a. Romac Style Alpha FC (ductile iron).
   b. Smith Blair Style 911 (ductile iron).
3. Compression Sleeve Coupling:
   a. Smith Blair, Style 411 (steel).
   b. Dresser, Style 38 (steel).
   c. Romac Industries, Style 400 (steel).
4. Mechanical (Grooved) coupling:
   a. Victaulic, Style 31.
5. Insulating Couplings:
   a. Smith Blair, Style 416.
   b. Dresser, Style 39.
   c. Romac, Style IC400
6. Reducing Couplings:
   a. Smith Blair, Style 415.
   b. Dresser, Style 62.
   c. Romac, Style RC501 (ductile).
7. Transition Coupling:
   a. Smith Blair, Style 413.
   b. Dresser, Style 62.
   c. Romac, Style TC400.
8. Glass Lining:
   a. C&B Piping: CBGL911 Porcelain Glass Lining.
   b. US Pipe: Vitco SG-14 Glass Lining.
9. Polyethylene Encasement Tape:
   a. Chase, Chasekote 750.
   b. Kendall, Polyken 900.

c. 3 M, Scotchrap 50.
d. V-Bio Polywrap.

10. Restrained joints:
    a. American (Flex-Ring) - 4 inches to 54 inches.
    b. U.S. Pipe (TR-Flex) - 4 inches to 36 inches.
    c. Or equal.
11. Expansion joints:
    a. Smith-Blair (Style 611).
    b. Dresser (Style 63).
    c. Romac (Style EJ400).
    d. Or equal.
12. Dismantling joints:
    a. Romac (Style DJ400).
    b. Smith-Blair (Style 975).
    c. Dresser (Style 131).
    d. Or equal.

2.2 MATERIALS

A. Ductile Iron Pipe:
   1. AWWA/ANSI C115/A21.15.
   2. AWWA/ANSI C151/A21.51.

B. Fittings and Flanges:
   1. AWWA/ANSI C110/A21.10.
   2. AWWA/ANSI C153/A21.53
      a. Do not use for pump suction piping.
   3. AWWA/ANSI C115/A21.15.
   4. Flanges drilled and faced per ASME B16.1 for both 125 and 250 psi applications.

C. Nuts and Bolts:
   1. Buried:
      a. T-Bolts for mechanical joints: Per AWWA/ANSI C111/A21.1
      b. Other bolts and nuts: ASTM A193/A194 Grade B8 Class 1.
   2. Fluoropolymer coating ....Exposed: ASTM A193/A194 Grade B8, Class 1.
   3. Heads and dimensions per ASME B1.1.
   4. Threaded per ASME B1.1.
   5. Project ends 1/4 to 1/2 inches beyond nuts.

D. Gaskets: See individual piping system requirements in Section 40 05 00.

E. If mechanical coupling system is used, utilize pipe thickness and grade in accordance with AWWA C606.
   1. Manufactured from ductile iron conforming to ASTM A536.
   2. Gaskets: Flushseal® type, grade to suit the intended service.

F. Polyethylene Encasement: Per AWWA/ANSI C105/A21.5.

G. See Piping Schedules in Section 40 05 00.

2.3 MANUFACTURED UNITS

A. Couplings:

1. Flanged adapters:
    a. Unit consisting of steel or carbon steel body sleeve, flange, followers, Grade 30 rubber gaskets.
    b. Provide units specified in the MANUFACTURERS Article.
    c. Supply flanges meeting standards of adjoining flanges.
    d. Rate entire assembly for test pressure specified on piping schedule for each respective application.
2. Compression sleeve coupling:
    a. Unit consisting of steel sleeve, followers, Grade 30 rubber gaskets.
    b. Provide units specified in the MANUFACTURERS Article.
    c. Supply flanges meeting standards of adjoining flanges.
    d. The working pressure rating of the entire assembly shall be greater than or equal to the test pressure specified on piping schedule for each respective piping application.
    e. Provide field coating for buried couplings per AWWA C203.
3. Mechanical (grooved) couplings:
    a. Use of mechanical couplings and fittings in lieu of flanged joints is acceptable where specifically specified in Section 40 05 00.
    b. Provide all mechanical groove couplings, flange adapters. fittings, and appurtenant items from the same manufacturer.
    c. Utilize units defined in the MANUFACTURERS Article.

2.4 FABRICATION

A. Furnish and install without outside coatings of bituminous material any exposed pipe scheduled to be painted.

B. Furnish cast parts with lacquer finish compatible with finish coat.

2.5 LININGS AND COATINGS

A. Cement mortar lining: per AWWA/ANSI C104/A21.4
    1. Standard thickness

B. Glass Lining:
    1. Minimum two-coat process.
        a. Base coat heated to solidly fuse glass to pipe surface.
        b. Subsequent coat(s) heated to form integral bond with preceding coat.
    2. Final finish parameters:
        a. Thickness: 8-12 mils.
        b. Hardness: Above 5 on MOHS scale.
        c. Density: 2.5-3.0 grams per cubic centimeter.
        d. Metal to lining bonding: Capable of withstanding strain of 0.0001 inches/IN without damage to lining.
    3. Complete compatibility between fittings and piping.
    4. Provide in accordance with ASTM B1000.

C. Zinc Coating:
    1. Provide in accordance with ISO 8179-1.

2.6 SOURCE QUALITY CONTROL

A. Factory Test:
    1. Subject pipe to hydrostatic test of not less than 500 psi with the pipe under the full test pressure for at least 10 seconds.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Joining Method - Push-On Mechanical (Gland-Type) Joints:

1. Install in accordance with AWWA/ANSI C111/A21.11.
2. Assemble mechanical joints carefully according to manufacturer's recommendations.
3. If effective sealing is not obtained, disassemble, thoroughly clean, and reassemble the joint.
4. Do not overstress bolts.
5. Where piping utilizes mechanical joints with tie rods, align joint holes to permit installation of harness bolts.

B. Joining Method - Push-On Joints:

1. Install in accordance with AWWA/ANSI C151/A21.51.
2. Assemble push-on joints in accordance with manufacturer's directions.
3. Bevel and lubricate spigot end of pipe to facilitate assembly without damage to gasket.
    a. Use lubricant that is non-toxic, does not support the growth of bacteria, has no deteriorating effects on the gasket material, and imparts no taste or odor to water in pipe.
4. Assure the gasket groove is thoroughly clean.
5. For cold weather installation, warm gasket prior to placement in bell.
6. Taper of bevel shall be approximately 30 degrees with centerline of pipe and approximately 1/4 inches back.

C. Joining Method - Flanged Joints:

1. Install in accordance with AWWA/ANSI C115/A21.15.
2. Extend pipe completely through screwed-on flanged and machine flange face and pipe in single operation.
3. Make flange faces flat and perpendicular to pipe centerline.
4. When bolting flange joints, exercise extreme care to ensure that there is no restraint on opposite end of pipe or fitting which would prevent uniform gasket compression or would cause unnecessary stress, bending or torsional strains to be applied to cast flanges or flanged fittings.
5. Allow one flange free movement in any direction while bolts are being tightened.
6. Do not assemble adjoining flexible joints until flanged joints in piping system have been tightened.
7. Gradually tighten flange bolts uniformly to permit even gasket compression.

D. Joining Method – Mechanical (Grooved) Coupling Joint:

1. Arrange piping so that pipe ends are in full contact.
2. Groove and shoulder ends of piping in accordance with manufacturer's recommendations.
3. Provide coupling and grooving technique assuring a connection which passes pressure testing requirements.
4. Utilize grooving tools from the same manufacturer of the couplings and fittings.

E. Flange Adaptors 12 inches and Less:

1. Locate and drill holes for anchor studs after pipe is in place and bolted tight.
2. Drill holes not more than 1/8 inches larger than diameter of stud projection.

F. Cutting:

1. Do not damage interior lining material during cutting.
2. Use abrasive wheel cutters or saws.

3. Make square cuts.
4. Bevel and free cut ends of sharp edges after cutting.

G. Support exposed pipe in accordance with Section 40 05 00.

H. Where specified in Section 40 05 00 under individual piping system, install polyethylene encasement in full compliance to AWWA/ANSI C105/A21.5.

1. Encase underground appurtenances required as part of installation.
2. Where tapping polyethylene encased pipe, first wrap location of tap with three (3) layers of polyethylene adhesive tape.
   a. Make tap through tape.
3. Make sections 2 feet longer than pipe section to be covered.
4. Slip tube over pipe while pipe is suspended immediately before placing in trench.
5. After installing in trench, pull tube ends over joint and overlap.
6. Fasten securely in-place on each side of each joint with joint tape or strapping.
7. Pull loose tube along pipe barrel up snugly around pipe and fasten in-place with joint tape at 3 feet intervals.
8. Completely cover fittings and connections with film held snugly in-place with joint tape or strapping.

I. Install buried piping in accordance with Section 40 05 00.

J. Install restrained joint systems where specified in Section 40 05 00 under specific piping system.

3.2 FIELD QUALITY CONTROL

A. Test piping systems in accordance with Section 40 05 00.

END OF SECTION

SECTION 40 05 24
PIPE - STEEL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel pipe, fittings, and appurtenances.

B. Related Sections include but are not necessarily limited to:

1. Section 09 96 00 - High Performance Industrial Coatings.
2. Section 40 05 00 - Pipe and Pipe Fittings - Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Society of Mechanical Engineers (ASME):
   a. B1.1, Unified Inch Screw Threads (UN and UNR Thread Form).
   b. B1.2, Gages and Gaging for Unified Inch Screw Threads.
   c. B16.3, Malleable Iron Threaded Fittings.
   d. B16.5, Pipe Flanges and Flanged Fittings.
   a. B16.9, Factory-Made Wrought Steel Butt-Welding Fittings.
   b. B16.11, Forged Steel Fittings, Socket Welding and Threaded.
   c. B16.47, Large Diameter Steel Flanges NPS 26 Through NPS 60 Metric/Inch Standard
   d. B31.1, Power Piping.
   e. B31.3, Process Piping.
   f. B31.9, Building Services Piping.
   g. Section IX, Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.
2. ASTM International (ASTM):
   a. A36, Standard Specification for Carbon Structural Steel.
   b. A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   c. A181, Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.
   d. A193, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.
   e. A194/A194M, Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   f. A234, Standard Specification for Pipe Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
   g. A283, Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
   h. A307, Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60 000 psi Tensile Strength
   i. A572, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
   j. A1011, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
   k. B6, Standard Specification for Zinc.

3. American Water Works Association (AWWA):
    a. C200, Standard for Steel Water Pipe - 6 inches and Larger.
    b. C203, Standard for Coal-Tar Protective Coatings and Linings for Steel water Pipeline - Enamel and Tape - Hot Applied.
    c. C205, Standard for Cement-Mortar Lining and Coating for Steel Water Pipe - 4 inches and Larger - Shop Applied.
    d. C206, Standard for Field Welding of Steel Water Pipe.
    e. C207, Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 inches through 144 inches.
    f. C208, Standard for Dimensions for Fabricated Steel Water Pipe Fittings.
    g. C209, Standard for Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
    h. C210, Standard for Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
    i. C606, Standard for Grooved and Shouldered Joints.
    j. M11, Steel Pipe - A Guide for Design and Installation.
4. Society of Automotive Engineers (SAE):
    a. AMS-QQ-P-416, Cadmium Plating Electro deposited.

B. Qualifications:

1. Application of coating materials including preparation of surfaces, priming, and lining and coating of pipe, fittings, and specials, in shop, repairs of any damage to lining or coating occurring during shipment or any other time, and field lining and coating of ends where linings or coatings have been held back for welded field joints, shall be done by established and recognized pipe company acceptable to Engineer.
2. Use only certified welders meeting procedures and performance outlined in ASME Section IX, AWWA C200 Section 3.3.3 and other codes and requirements per local building and utility requirements.

1.3 SUBMITTALS

A. Shop Drawings:

1. See Specification Section 40 05 00.
2. Factory test reports.
3. If mechanical grooved type coupling system is used, submit piping, fittings, and appurtenant items which will be utilized.
4. Coating manufacturer's qualifications.
5. Welders certificates.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Flanged adapters:
    a. Rockwell (Style 913 (steel)).
    b. Dresser (Style 128 (steel)).
    c. Victaulic Depend O Lok FCA (ExE (unrestrained)).
    d. Victaulic Vic Flange Adapter (Style 741 (steel)).
2. Insulating couplings:
    a. Rockwell (Style 416).

b. Dresser (Style 39).

3. Reducing couplings:
   a. Rockwell (Style 415).
   b. Dresser (Style 62).
4. Transition coupling:
   a. Rockwell (Style 413).
   b. Dresser (Style 62).
5. Compression sleeve coupling:
   a. Rockwell (Style 411 (steel)).
   b. Dresser (Style 38 (steel)).
   c. Victaulic Depend O Lok (ExE (unrestrained)).
6. Mechanical couplings and fittings:
   a. Victaulic (Style 07 or 77).
   b. Gruvlok (ASC Engineered Solutions) Figure 7001 or Figure 7401.
7. Vibration isolation equipment connections for natural gas:
   a. Flexonics (Model 401H).
8. Flexible connectors for hot water equipment:
   a. Flexonics (FLG Series).
   b. Thermo Tech (F/J/R Series).
9. Factory-applied plastic or epoxy coatings:
   a. "Encoat" Division of Energy Coating Company.
   b. "Scotchkote" Division of 3M Company.

2.2 MATERIALS

A. All materials used in steel piping systems defined in Section 40 05 00 shall meet or exceed pressure test requirements specified for each respective system.

B. Steel Pipe (Mill Type): ASTM A53, Type E or S.

C. Fittings (For Mill Type Pipe):

1. ASTM A234.
2. ASME B16.3, ASME B16.5, ASME B16.9, ASME B16.11.

D. Flanges (Mill Type Pipe):

1. ASME B16.5.
2. Flat faced.
3. Slip-on flanges.

E. Nuts and Bolts:

1. Buried:
   a. Bolts and nuts: ASTM A193/A194 Grade B8 Class 1.
2. Heads and dimensions per ASME B1.1.
3. Threaded per ASME B1.1.
4. Project ends 1/4 to 1/2 inches beyond nuts.

F. Gaskets: See individual piping systems in Section 40 05 00.

2.3 MANUFACTURED UNITS

A. Couplings:

1. Flanged adapters:

a. Steel or carbon steel body sleeve, flange, followers and Grade 30 rubber gaskets.
b. Provide units specified in Article 2.1.
c. Flanges meeting standards of adjoining flanges.
d. Entire assembly to be rated for test pressure specified on Piping Schedule for each respective application.

2. Compression sleeve coupling:
a. Steel sleeve, followers Grade 30 and rubber gaskets.
b. Provide units specified in Article 2.1.
c. Flanges meeting standards of adjoining flanges.
d. Entire assembly to be rated for test pressure specified on Piping Schedule for each respective application.
e. Provide field coating for buried couplings per AWWA C203.

3. Mechanical coupling joint:
a. Use of mechanical grooved (AWWA C606) type couplings and fittings in lieu of flanged joints is acceptable where specifically specified in Section 40 05 00.
b. Utilize units defined in Article 2.1.

2.4 ACCESSORIES

A. Natural Gas Equipment Isolator: 316L stainless steel, T-321 stainless steel braid with connections compatible with joints in piping system.

2.5 FABRICATION

A. Provide piping (mill or fabricated) for use in this Project with minimum wall thicknesses as follows:

1. 1/8 - 5 inches diameter pipe: Schedule 40.
2. 6 - 10 inches diameter pipe: 3/16 inches.
3. 12 - 14 inches diameter pipe: 7/32 inches.
4. 16 - 48 inches diameter pipe: 1/4 inches.
5. 54 - 60 inches diameter pipe: 5/16 inches.
6. 66 - 72 inches diameter pipe: 3/8 inches.
7. Sizes through 24 inches are nominal OD.
a. Sizes greater than 24 are ID.
8. Wall thicknesses indicated are for standard weight pipe.
a. Design pipe in accordance with operating pressures shown in Piping Schedules for a design stress limited to 50% of yield.

B. Furnish cast parts with lacquer finish compatible with finish coating.

C. Furnish without outside coating of bituminous material any exposed pipe scheduled to be painted.

D. Pipe Coatings:

1. 3M "Scotchkote" or Energy Coatings Company "Encoat" in accordance with manufacturer's recommendations.

2.6 SOURCE QUALITY CONTROL

A. Testing:

1. Shop hydrostatic test fabricated steel pipe and fittings.
2. Field hydrostatic test all pipe as specified in Section 40 05 00.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Joining Methods - Flanges:

1. Facing method:
    a. Insert slip-on flange on pipe.
    b. Assure maximum tolerances for flange faces from normal with respect to axis of pipe is 0.005 inches per foot of flange diameter.
    c. Test flanges after welding to pipe for true to face condition and reface, if necessary, to bring to specified tolerance.
2. Joining method:
    a. Leave 1/8 to 3/8 inches of flange bolts projecting beyond face of nut after tightening.
    b. Coordinate dimensions and drillings of flanges with flanges for valves, pumps, equipment, tank, and other interconnecting piping systems.
    c. When bolting flange joints, exercise extreme care to assure that there is no restraint on opposite end of pipe or fitting which would prevent uniform gasket compression or cause unnecessary stress, bending or torsional strains being applied to cast flanges or flanged fittings.
        1) Allow one flange free movement in any direction while bolts are being tightened.
    d. Do not assemble adjoining flexible coupled, mechanical coupled or welded joints until flanged joints in piping system have been tightened.
    e. Gradually tighten flange bolts uniformly to permit even gasket compression.
    f. Do not overstress bolts to compensate for poor installation.

C. Joining Method - Welded Joints:

1. Perform welding in accordance with AWWA C206 and this Section.
2. For flange attachment perform in accordance with AWWA C207.
3. Have each welding operator affix an assigned symbol to all his welds.
    a. Mark each longitudinal joint at the extent of each operator's welding.
    b. Mark each circumferential joint, nozzle, or other weld into places 180 degrees apart.
4. Welding for all process piping shall conform to ASME B31.3.
    a. Welding of utility piping 125 psi and less shall be welded per ASME B31.9.
    b. Utility piping above 125 psi shall conform to ASME B31.1.
5. Provide caps, tees, elbows, reducers, etc., manufactured for welded applications.
6. Weldolets may be used for 5 inches and larger pipe provided all slag is removed from inside the pipe.
7. Weld-in nozzles may be used for branch connections to mains and where approved by Engineer.
8. Use all long radius welding elbows for expansion loops and bends.
9. Use long radius reducing welding elbows 90 degrees bends and size changes are required.

D. Joining Method - Couplings:

1. Compression and split sleeve:
    a. Install coupling to allow space of not less than 1/4 inches but not more than 1 inch.
    b. Provide harnessed joint.
        1) Use joint harness arrangements detailed in AWWA M11.
        2) Provide ASTM A108 Carbon Steel restraint end rings per manufacture’s recommendations for Split sleeve type couplings.

c. Design harness assembly with adequate number of tie rods for test pressures indicated in Section 40 05 00 and allow for expansion of pipe.
d. Provide ends to be joined or fitted with compression or split sleeve couplings of the plain end type.
e. Grind smooth welds the length of one coupling on either side of joint to be fitted with any coupling.
f. Assure that outside diameter and out-of-round tolerances are within limits required by coupling manufacturer.

2. Mechanical coupling:
a. Arrange piping so that pipe ends are in full contact.
b. Groove and shoulder ends of piping in accordance with manufacturer's recommendations.
c. Provide coupling and grooving technique assuring a connection which passes pressure testing requirements.

E. Joining Method - Threaded and Coupled (T/C):
1. Provide T/C end conditions that meet ASME B1.2 requirements.
2. Furnish pipe with factory-made T/C ends.
3. Field cut additional threads full and clean with sharp dies.
4. Leave not more than three pipe threads exposed at each branch connection.
5. Ream ends of pipe after threading and before assembly to remove burrs.
6. Use Teflon thread tape on male thread in mating joints.

F. Support exposed piping in accordance with Section 40 05 00.

G. Install buried piping per Section 40 05 00.

3.2 FIELD QUALITY CONTROL

A. Test piping systems in accordance with Section 40 05 00.

END OF SECTION

SECTION 40 05 26
PIPE - CAST-IRON SOIL

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cast-iron soil piping, fittings, and appurtenances.

B. Related Sections include but are not necessarily limited to:

1. Section 40 05 00 - Pipe and Pipe Fittings - Basic Requirements.

1.2 QUALITY ASSURANCE

A. See Section 40 05 00.

B. Provide joint type specifically approved by applicable plumbing code.

C. Referenced Standards:

1. ASTM International (ASTM):
   a. A74, Standard Specification for Cast-Iron Soil Pipe and Fittings.
   b. C564, Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
2. Cast Iron Soil Pipe Institute (CISPI):
   a. 301, Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
   b. 310,Standard for Coupling for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
3. Federal Specifications (FS):
   a. QQ-C-40, Calking: Lead Wool and Lead Pig.

1.3 SUBMITTALS

A. Shop Drawings:

1. See Section 40 05 00.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Pipe (General Application):

1. ASTM A74.
   a. SV service.
2. No hub: CISPI 301.

B. Joints (General Application):

1. Standard:
   a. Oakum.
   b. Lead, FS QQ-C-40 Type 1.
2. Compression joint: Neoprene gasket, ASTM C564.
3. Mechanical: No hub, CISPI 310.

C. See Piping Schedules in Section 40 05 00.

2.2 FABRICATION

A. Cast-Iron Soil Pipe:

1. SV service rated.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Observe manufacturer's recommendation for handling, cutting, jointing, installing, and testing.

B. Install products in accordance with CISPI.

C. Support exposed piping in accordance with Section 40 05 00.

D. Install buried piping in accordance with Section 40 05 00.

E. If "standard joint" is used, assure lead is run in one continuous pour.

1. No second pouring or driving of lead is permitted.
2. Provide minimum of 12 oz of lead per inch of pipe diameter per joint.

3.2 FIELD QUALITY CONTROL

A. Test piping systems in accordance with Section 40 05 00.

END OF SECTION

SECTION 40 05 31
PIPE - PLASTIC

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Plastic pipe.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 40 05 00 - Pipe and Pipe Fittings - Basic Requirements.

1.2 QUALITY ASSURANCE

A. See Specification Section 40 05 00.

B. Referenced Standards:

1. ASTM International (ASTM):
   a. PVC (polyvinyl chloride) materials:
      1) D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
      2) D1785, Standard Specification for Poly(Vinyl Chloride) PVC Plastic Pipe, Schedules 40, 80 and 120.
      3) D2467, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
      4) D3034, Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
      5) D3139, Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
      6) D3212, Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
      7) F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
      8) F679, Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
      9) F794, Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter.
      10) F949, Standard Specification for Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings.
   b. Installation:
      1) D2321, Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
2. American Water Works Association (AWWA):
   a. PVC (polyvinyl chloride) materials:
      1) C900, Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 60 In.
   b. Polyethylene (PE) materials:
      1) C901, Standard for Polyethylene (PE) Pressure Pipe and Tubing, 1/2 inches through 3 IN, for Water Service.
3. NSF International (NSF).

1.3 SUBMITTALS

A. See Specification Section 40 05 00.

PART 2 - PRODUCTS

2.1 PVC PRESSURE PIPING (EXPOSED)

A. General:

1. Provide Schedule 80 pipe with Schedule 80 fittings and appurtenances to locations shown on Drawings, unless noted otherwise in Section 40 05 00.
2. Furnish materials in full compliance to following material specifications:
    a. Manufacture pipe, fittings and appurtenances from polyvinyl chloride (PVC) compound which meets the requirements of Type 1, Grade 1 (12454-B) Polyvinyl Chloride as outlined in ASTM D1784.
    b. Manufacture pipe, fittings and valves from materials that have been tested and approved for conveying potable water by the NSF.

B. Pipe:

1. Furnish pipe meeting requirements of ASTM D1785.
2. Pipe 2 inches and less to be solvent welded.
3. Pipe larger than 2 inches may be either flanged or solvent welded unless shown otherwise on Drawings.

C. Fittings: Provide ASTM D2467 PVC socket type fittings having the same pressure and temperature rating as the pipe.

D. Flanges/Unions:

1. Furnish flanges and unions at locations shown on Drawings.
2. Provide either flanges or unions at valves, penetrations through structures and equipment connections.
3. For pipe larger than 2 inches, provide 150 pound socket type PVC flange.
4. For pipe 2 inches and less, provide socket type PVC union with Buna O-rings.
5. Use flat, full faced natural rubber gaskets at flanged connections.
    a. Furnish heavy hex head bolts, each with one heavy hex nut, ASTM F593 Type 316 stainless steel.
6. Use spacers supplied by pipe manufacturer when mating raised-faced flanges to other flanges.

E. Installation:

1. Field threading PVC will not be permitted.
    a. Perform required threaded connections or attachments by the use of factory molded socket by threaded adapters.
    b. Female adapters are not acceptable.
2. Employ installation and pipe support practices and solvent welding all in compliance to the manufacturer's printed recommendation.
    a. Continuously support PVC piping at liquid operating temperatures in excess of 100 DEGF.
    b. For vertical piping, band the pipe at intervals to rigidly support load of twice vertical load.
    c. Support riser clamps on spring hangers.
    d. Do not clamp PVC tightly or restrict movement for expansion and contraction.

2.2 PRESSURE PIPING (UNDERGROUND)

A. See Section 40 05 31.3 - Polyvinyl Chloride Pressure Process Pipe (AWWA C900).

2.3 PVC DRAINAGE, SEWER PIPING

A. See Section 33 05 31.11 - Polyvinyl Chloride Gravity Sewer Pipe.

2.4 PVC TUBING

A. General: Provide nylon tubing with fittings and appurtenances as shown on Drawings.

B. Materials:

1. Furnish clear outer braided tubing with braid outside the walls.
2. Have tubing manufactured of nylon with working temperatures from 5 to 180 degrees F.
3. Design tubing with a minimum safety factor of 4 to 1 ratio of burst pressure to working pressure at maximum temperature.
4. Provide tubing with working pressure of 75 psi at 180 degrees F.
5. Ensure that tubing is self-extinguishing and fire resistant.

C. Fittings:

1. Install tubing with nylon fittings and connectors.
2. Use barbed type adapters with stainless steel clamps.
3. Provide fittings capable of withstanding temperatures from a -70 to 250 degrees F.
4. Ensure fittings have the same pressure and temperature rating as the tubing.

PART 3 - EXECUTION

3.1 IDENTIFICATION

A. Identify each length of pipe clearly at intervals of 5 feet or less.

1. Include manufacturer's name and trademark.
2. Nominal size of pipe, appurtenant information regarding polymer cell classification and critical identifications regarding performance specifications and NSF approvals when applicable.

3.2 PRESSURE PIPING (UNDERGROUND)

A. Installation:

1. Field threading of PVC pipe will not be permitted.
2. Perform installation procedures, handling, thrust blocking, connections, and other appurtenant operations in full compliance to the manufacturer's printed recommendations and in full observance to plan details when more stringent.

3.3 PVC DRAINAGE, SEWER PIPING

A. Installation: Install pipe and fittings in accordance with ASTM D2321 and as recommended by the manufacturer.

1. Provide for a maximum deflection of not more than 5%.

B. Infiltration and Exfiltration:

1. The maximum allowable infiltration measured by test shall not exceed 100 GAL per inch of pipe diameter per mile per 24 hours.
2. For exfiltration, all the pipe and fittings shall exceed performance requirements by the test procedure as specified in Section 40 05 00.
3. Observe full instructions of the Engineer for carrying of testing procedures.
   a. Perform tests only during presence of the Engineer or his authorized representative.
4. Should any test on any section of pipe line disclose either infiltration rates greater than allowed or disclose air loss rate greater than that permitted, locate and repair the defective joints or pipes at no cost to Owner and retest until requirements stated are met.

C. Deflection:

1. After backfilling, each section of pipe shall be checked for deflection by pulling a mandrel through the pipe.

2. Pipe with deflection exceeding 5% of the inside diameter shall have backfill removed and replaced to provide a deflection of less than 5%.
3. Any repaired pipe shall be retested.

3.4 PVC TUBING

A. Fittings:

1. Install tubing with nylon fittings and connectors.
2. Use barbed type adapters with stainless steel clamps.
3. Provide fittings capable of withstanding temperatures from a -70 to 250 degrees F.
4. Ensure fittings have the same pressure and temperature rating as the tubing.

B. Trays:

1. Flat smoothed bottom tray for supporting flexible hoses when there is a chance that the hoses may pulse or move.

END OF SECTION

SECTION 40 05 31.3

POLYVINYL CHLORIDE PRESSURE PROCESS PIPE (AWWA C900)

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. AWWA C900 PVC pipe, fittings, and appurtenances.

B. Related Sections include but are not necessarily limited to:

1. Section 31 23 33 - Trenching, Backfilling, and Compacting for Utilities.
2. Section 40 05 00 – Pipe and Pipe Fittings – Basic Requirements.
3. Section 40 05 19 – Ductile Iron Process Pipe.

1.2 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer of AWWA C900 Pipe:
   a. Obtain all pipe from one manufacturer, unless otherwise acceptable to Owner and Engineer.
   b. Manufacturer of pipe required by this Section shall be regularly engaged in the business of manufacturing PVC piping of the size and pressure class required for the Work.
      1) Upon Engineer's request, submit documentation of manufacturer's prior furnishing of PVC pipe of the pressure class required for not less than five other North American projects, similar in size and complexity to the PVC piping Work of this Project.
   c. QA and QC Program:
      1) PVC pipe manufacturer shall have documented quality assurance and quality control programs as part of manufacturer's routine business.
      2) PVC piping manufacturer shall maintain permanent Quality Control (QC) and Quality Assurance (QA) records.
2. Installer:
   a. Use one entity for all PVC pipe Work, unless otherwise acceptable to Owner and Engineer.
   b. Installer shall be experienced with PVC piping installation work similar in scope and complexity to the Work of this Section.
      1) When required by Engineer, submit documentation of successful completion of not less than five similar projects to the PVC piping Work completed within the past five years.
   c. Installer's training and qualifications shall be acceptable to PVC pipe Supplier retained for the Project.

B. Referenced Standards:

1. American National Standards Institute (ANSI):
   a. B1.1, Unified Inch Screw Threads (UN and UNR Thread Form).
   b. B16.1, Cast-Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800.
   c. B16.21, Nonmetallic Flat Gaskets for Pipe Flanges.
2. ASTM International (ASTM):
   a. A182, Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.

b. A193, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
c. A194, Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
d. A536, Standard Specification for Ductile Iron Castings.
e. B695, Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
f. D638, Standard Test Method for Tensile Properties of Plastics.
g. D1598, Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure.
h. D1599, Test Method for Short-Time Hydraulic Failure Pressure of Plastics Pipe, Tubing and Fittings.
i. D1784, Standard Classification System and Basis for Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
j. D2290, Test Method for Apparent Tensile Strength of Ring or Tubular Plastics and Reinforced Plastics by Split Disk Method.
k. D2837, Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.
l. F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

3. American Water Works Association (AWWA).
   a. C207, Steel Pipe Flanges for Waterworks Service, Sizes 4 In. through 144 In.
   b. C900, Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. through 60 In., for Water Service.
   a. C907, Injection-Molded Polyvinyl Chloride (PVC) Pressure Fittings, 4 In. Through 12 In. (100 mm Through 300 mm), for Water, Wastewater, and Reclaimed Water Service.).
4. American Water Works Association/American National Standards Institute (AWWA/ANSI):
   a. C104/A21.4 - Standard for Cement–Mortar Lining for Ductile-Iron Pipe and Fittings.
   b. C105/A21.5 - Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems.
   c. C110/A21.10 - Standard for Ductile-Iron and Gray-Iron Fittings.
5. Plastic Pipe Institute (PPI):
   a. TR-3, Policies and Procedures for Developing Recommended Hydrostatic Design Stresses for Thermoplastic Pipe Material.
   b. PPI TR-4, Recommended Hydrostatic Strengths and Design Stresses for Thermo-plastic Pipe and Fittings Compounds.
6. Military Specification (Mil Spec):
   a. QQ-P-416F, Plating, Cadmium Electro Deposited.
7. National Sanitation Foundation International (NSF):
   a. 14, Plastic Piping Components and Related Materials.

1.3 DEFINITIONS

A. DIOD: Ductile Iron Outside Diameter, equal to CIOD (Cast Iron Outside Diameter).

B. DR: Dimension Ratio, Outside Diameter/Minimum Wall Thickness, both in inches.

C. Diametral Deflection: eccentricity (ellipse) caused by earth and surcharge loads acting on the installed pipe.

D. ESCR: Environmental Stress Crack Resistance.

E. HDB: Hydrostatic Design Basis per ASTM D2837.

F. IPS: Iron Pipe Size.

G. PC: Pressure Class.

H. SDR: Standard Dimension Ratio.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:

1. Shop Drawings:
   a. Dimensioned, scaled drawings showing Contractor's proposed deviations from piping alignment shown on the Drawings.
   b. Where necessary, include both plans and profiles and section views in Shop Drawings.
2. Product Data:
   a. Manufacturer's published catalog information and specifications for each size and type of PVC piping required, including pipe, fittings (DI), and jointing materials.
   b. Clearly indicate in product data submittal the reference standards with which pipe and appurtenances comply.
   c. Where couplings are required, submit coupling manufacturer's catalog literature and specifications for the specific couplings proposed.

B. Informational Submittals; Submit the following:

1. Supplier Instructions:
   a. Submit manufacturer's written instructions for handling, storing, and installing piping furnished.
2. Source Quality Control:
   a. Submit documentation from manufacturer that piping materials furnished were inspected at the production facility and successfully passed manufacturer's quality control procedures.
   b. Manufacturer's affidavit certifying piping materials furnished comply with AWWA standard C900.
3. Field Quality Control:
   a. Results of field quality control testing and inspections required in this Section or in Section 40 05 00.
4. Qualifications:
   a. Piping materials manufacturer, when requested by Engineer.
   b. Installer, when requested by Engineer.

1.5 DELIVERY, HANDLING, AND STORAGE

A. In addition to requirements elsewhere in the Contract Documents, also comply with the following:

1. During handling and installation avoid conditions where pipe bends excessively and avoid imparting kinks in the pipe.

PART 2 - PRODUCTS

2.1 MANUFACTURER'S

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. PVC Pipe and Fittings:
   a. JM Eagle.
   b. Westlake Pipe & Fittings
   c. Or equal.
2. DI Fittings: See Section 40 05 19.

2.2 MATERIALS

A. Pipe:

1. AWWA C900.
    a. PVC: Physical and chemical properties equal to or exceeding ASTM D1784 cell class 12454.
    b. Minimum Hydrostatic Design Basis (HDB) of 4000 psi at 73.4 degF when tested in accordance with PPI TR-3.

B. Joints:

1. Gasketed bell and spigot per ASTM D3139.

C. Fittings:

1. Ductile iron: Per Section 40 05 19.

D. Nuts and Bolts:

1. Buried:
    a. T-Bolts for mechanical joints: Per AWWA/ANSI C111/A21.1
    b. Other bolts and nuts: ASTM A193/A194 Grade B8 Class 1.
2. Exposed: ASTM A193/A194 Grade B8, Class 1.
3. Heads and dimensions per ASME B1.1.
4. Threaded per ASME B1.1.
5. Project ends 1/4 to 1/2 inches beyond nuts.

E. Gaskets:

1. See individual piping systems in Section 40 05 00.

2.3 MANUFACTURED UNITS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Joint restraints (Bell and Spigot):
    a. EBAA Iron, Inc.
        1) 4”-12”: 1900 Split Serrated Restraint Harness.
        2) 14”-54”: 2800 Megalug® Restraint Harness.
    b. Star Pipe Products: Series 1100C (4”-48”).
    c. Or equal.
2. Joint restraints (MJ Fittings):
    a. EBAA Iron, Inc., Megalug®.
    b. Star Pipe Products, Stargrip®.
    c. Or equal
3. Compression Sleeve Coupling:
    a. Smith Blair, Style 411 (steel).
    b. Dresser, Style 38 (steel).
    c. Romac Industries, Style 400 (steel).
4. Reducing Couplings:
    a. Smith Blair, Style 415.
    b. Dresser, Style 62.
    c. Romac, Style RC501 (ductile).
5. Transition Coupling:
        1) Smith Blair, Style 413.

2) Dresser, Style 62.
3) Romac, Style TC400.

6. Restrained Compression Couplings:
   a. Georg Fisher Waga N.V., Multi/Joint® 3000 Plus (2”-33”).
      1) May be used as transition coupling.
   b. Or equal.
7. Flanged coupling adapters (FCAs):
   a. Sigma, Sigmaflange™ (3”-36”).
   b. Smith Blair, Style 912 (cast iron), 3”-24”.
   c. Dresser, Style 127 (cast iron), 3”-24”.
   d. Romac Style FCA501 (cast iron 3”-16”).
8. Restrained flanged coupling adapters (RCFAs):
   a. Georg Fisher Waga N.V., Multi/Joint® 3000 Plus (2”-33”).
   b. Romac, RCFA-PVC (3”-24”).

2.4 DESIGN CRITERIA

A. Pressure Class (PC): 165 PSI (DR 25).

2.5 FABRICATION

A. Pipe:
   1. Clearly mark pipe per AWWA C900.
   2. Service Indication:
      a. Provide integral color or longitudinal color banding at 180 degrees apart.
         1) Water: Blue.
         2) Sewer: Green.
         3) Recycled Water: Purple.

2.6 SOURCE QUALITY CONTROL

A. Materials:
   1. Incoming PVC materials:
      a. Inspect for density per ASTM D1505, and carbon containment.
      b. Provide certification from material supplier for a minimum of 30% of all incoming PVC materials.
      c. PVC pipe manufacturer shall verify certifications prior to processing into finished pipe or fittings.
   2. Outgoing materials:
      a. Manufacturer to inspect for diameter, wall thickness, length, straightness, out-of-roundness, concentricity, toe-in, inside and outside surface finish, markings, and end cut.
      b. Perform tests to determine density, carbon content, and carbon dispersion.
      c. Test representative samples of the pipe provided to determine hoop tensile strength and ductility by either quick burst per ASTM D1599 or ring tensile per ASTM D2290.

B. Equipment:
   1. Qualify each extrusion line and molding machine to produce pressure rated products by taking representative production samples and performing sustained pressure tests in accordance with ASTM D1598.

C. Quality Control Program:

1. Pipe manufacturer shall maintain permanent Quality Control (QC) and Quality Assurance (QA) records.
2. Certified copies of the quality control data taken during product manufacture shall be supplied to the Owner upon request.

D. Factory Inspection:

1. PVC pipe manufacturer's production and quality assurance facilities shall be open and available for inspection by Owner and its authorized representatives.

PART 3 - EXECUTION

3.1 GENERAL

1. Locations: Provide PVC piping at the locations shown on the Drawings or as otherwise shown and indicated in the Contract Documents.
2. Install PVC piping in accordance with:
   a. Section 31 23 33 – Trenching, Backfilling, and Compacting for Utilities.
   b. Section 40 05 00 - Pipe and Pipe Fittings - Basic Requirements.
   c. Other provisions of the Contract Documents.
   d. Laws and Regulations.

3.2 INSTALLATION

A. General:

1. Locations: Provide PVC piping at the locations shown on the Drawings or as otherwise shown and indicated in the Contract Documents.
2. Install PVC piping in accordance with:
   a. Manufacturer's recommendations.
   b. Section 31 23 33 – Trenching, Backfilling, and Compacting for Utilities.
   c. Section 40 05 00 - Pipe and Pipe Fittings - Basic Requirements.
   d. Other provisions of the Contract Documents.
   e. Laws and Regulations.
3. Field repairs of pipe are not permitted, with the exception that portions of straight pipe which are damaged may be cut off provided this alteration is in accordance with the manufacturer's established procedures.

B. Joining Method - Push-On Joints:

1. Assemble push-on joints in accordance with manufacturer's directions.
2. Bevel and lubricate spigot end of pipe to facilitate assembly without damage to gasket.
   a. Use lubricant that is non-toxic, does not support the growth of bacteria, has no deteriorating effects on the gasket material, and imparts no taste or odor to water in pipe.
3. Assure the gasket groove is thoroughly clean.
4. Flex rubber gasket inward and insert in the gasket recess of the bell socket.
   a. For cold weather installation, warm gasket prior to placement in bell.
5. Enter spigot end of the pipe into the socket with care used to keep the joint from contacting the ground.
   a. Complete the joint by forcing the plain end to the bottom of the socket in a manner approved by the ENGINEER.
6. Check each joint with a feeler gauge to ensure proper installation of the gasket.
7. Mark pipe that is not furnished with a depth mark before assembly to assure that the spigot end is inserted to the full depth of the joint.

8. File or grind field cut pipe joints to resemble a spigot end as recommended by the manufacturer.
9. Field-cut end repairs are to be done in accordance with the pipe manufacturer's recommendations.
    a. Taper of bevel: approximately 30 degrees with centerline of pipe and approximately 1/4 inches back.

C. Joining method – Flanged Joints:

1. Use flanged coupling adapters to mate PVC to flanged valves and equipment.
2. Make flange faces flat and perpendicular to pipe centerline.
3. Do not assemble adjoining flexible joints until flanged joints in piping system have been tightened.
4. Gradually tighten flange bolts uniformly to permit even gasket compression.
    a. Torque to gasket manufacturer's recommended torque.
5. Check bolt torque after 24 hours to ensure that stress relief has not occurred.

D. Joining method – Mechanical Joint:

1. Clean components before installation.
    a. Clean bolts and nuts by wire brushing.
    b. Lubricate bolts with vegetable-based oil only.
2. Insert nuts and bolts (or studs), finger tighten, and progressively tighten diametrically opposite bolts uniformly around the flange to the proper tension.
3. Execute care when tightening joints to prevent undue strain upon adjoining pipe.
4. Test joint for leakage.
    a. If joint leaks under pressure testing, loosen or remove nuts and bolts, reset, or replace the gasket, reinstall or retighten bolts and nuts, and retest the joints.
    b. Completed joints shall be watertight.
5. Check bolt torque after 24 hours to ensure that stress relief has not occurred.

E. Joining method - Fusion Joints: NOT ALLOWED.

F. Install buried pipe per Section 40 05 00 and per details shown on Drawings.

1. Allow pipe to stabilize to trench bottom or casing temperature before final tie-in or backfilling.

3.3 FIELD QUALITY CONTROL

A. Visually inspect all pipe for gouges.

1. Gouges in excess of 10% of the pipe wall thickness are not acceptable.
2. In area where excessive gouges are present, cut out affected pipe section and join to remaining pipe to make a continuous section.

B. Diametral Deflection:

1. After backfilling, check each section of pipe for deflection by pulling a mandrel through the pipe.
2. Pipe with deflection exceeding 5% of the inside diameter: remove backfill and replace to provide a deflection of less than 5%.
3. Retest any repaired pipe.

C. Hydrostatically test installed pipe and fittings in accordance with Section 40 05 00.

1. Provide suitable caps, plugs or blind flanges on both ends of each pipe string for hydrostatic testing following installation.

END OF SECTION

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SECTION 40 05 51

COMMON REQUIREMENTS FOR PROCESS AND UTILITY VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Valving and valving appurtenances.

B. Related Sections include but are not necessarily limited to:

1. Section 01 61 03 - Equipment - Basic Requirements.
2. Section 09 96 00 - High Performance Industrial Coatings.
3. Section 40 05 00 - Pipe and Pipe Fittings - Basic Requirements.
4. Section 40 05 57 - Actuators for Process Valves and Gates.
5. Section 40 05 62 - Plug Valves.
6. Section 40 05 63 - Ball Valves.

1.2 REFERENCES

A. Definitions:

1. The following are definitions of abbreviations used in this Specification Section or one of the individual valve sections:
   a. CWP: Cold water working pressure.
   b. SWP: Steam working pressure.
   c. WOG: Water, oil, gas working pressure.
   d. WWP: Water working pressure.

B. Referenced Standards:

1. American Society of Mechanical Engineers (ASME):
   a. B1.20.1, Pipe Threads, General Purpose.
   b. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   c. B16.18, Cast Copper Alloy Solder Joint Pressure Fittings.
2. ASTM International (ASTM):
   a. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   b. D256, Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics.
   c. D638, Standard Test Method for Tensile Properties of Plastics.
   d. D648, Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.
   e. D695, Standard Test Method for Compressive Properties of Rigid Plastics.
   f. D2240, Standard Test Method for Rubber Property-Durometer Hardness.
3. American Water Works Association (AWWA):
   a. C207, Standard for Steel Pipe Flanges for Waterworks Service - Sizes 4 inches through 144 inches.
   b. C500, Standard for Metal-Seated Gate Valves for Water Supply Service.
   c. C504, Standard for Rubber-Seated Butterfly Valves.
   d. C507, Standard for Ball Valves, 6 inches through 48 inches (150 mm through 1200 mm).
   e. C509, Standard for Resilient-Seated Gate Valves for Water Supply Service.

f. C550, Standard for Protective Coatings for Valves and Hydrants.
g. C606, Standard for Grooved and Shouldered Joints.

4. American Water Works Association/American National Standards Institute (AWWA/ANSI):
   a. C111/A21.11, Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
5. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. MG 1, Motors and Generators.
6. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).

1.3 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. See Section 40 05 57 - Actuators for Process Valves and Gates.
2. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Manufacturer's installation instructions.
   c. Valve pressure and temperature rating.
   d. Valve material of construction.
   e. Special linings.
   f. Valve dimensions and weight.
   g. Valve flow coefficient.

B. Informational Submittals:

1. Test reports if required in the individual valve specification.

C. Closeout Submittals:

1. Operation and Maintenance Data:
   a. Submit in accordance with Section 01 78 23 - Operation and Maintenance Data.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, refer to individual valve Specification Sections for acceptable manufacturers.

2.2 MATERIALS

A. Refer to individual valve Specification Sections.

2.3 FABRICATION

A. End Connections:

1. Provide the type of end connections for valves as required in the Piping Schedules presented in Section 40 05 00 or as shown on the Drawings.
2. Comply with the following standards:
   a. Threaded: ASME B1.20.1.
   b. Flanged: ASME B16.1, Class 125 unless otherwise noted or AWWA C207.
   c. Bell and spigot or mechanical (gland) type: AWWA/ANSI C111/A21.11.
   d. Soldered: ASME B16.18.
   e. Grooved: Rigid joints per Table 5 of AWWA C606.

B. Refer to individual valve Specification Sections for specifications of each type of valve used on Project.

C. Nuts, Bolts, and Washers:

1. Wetted or internal to be stainless steel.
    a. Exposed to be zinc or cadmium plated.
2. Buried:
    a. T-Bolts for mechanical joints: Per AWWA/ANSI C111/A21.1
    b. Other bolts and nuts: ASTM A193/A194 Grade B8 Class 1.
3. Exposed: ASTM A193/A194 Grade B8, Class 1.
4. Heads and dimensions per ASME B1.1.
5. Threaded per ASME B1.1.
6. Project ends 1/4 to 1/2 inches beyond nuts.

D. On Insulated Piping: Provide valves with extended stems to permit proper insulation application without interference from handle.

E. Epoxy Interior Coating: Provide epoxy interior coating for all ferrous surfaces in accordance with AWWA C550.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Painting Requirements: Comply with Section 09 96 00 for High Performance Industrial Coatings.

C. Setting Buried Valves:

1. Locate valves installed in pipe trenches where buried pipe indicated on Drawings.
2. Set valves and valve boxes plumb.
3. Place valve boxes directly over valves with top of box being brought to surface of finished grade.
4. Install in closed position.
5. Place valve on firm footing in trench to prevent settling and excessive strain on connection to pipe.
6. After installation, backfill up to top of box for a minimum distance of 4 feet on each side of box.

D. Support exposed valves and piping adjacent to valves independently to eliminate pipe loads being transferred to valve and valve loads being transferred to the piping.

E. For grooved coupling valves, install rigid type couplings or provide separate support to prevent rotation of valve from installed position.

F. For threaded valves, provide union on one side within 2 feet of valve to allow valve removal.

G. Install valves accessible for operation, inspection, and maintenance.

3.2 ADJUSTMENT

A. See section 40 05 57 for adjustment requirements.

3.3 VALVE SCHEDULE

A. See Valve Schedule on Drawings.

3.4 CLOSEOUT ACTIVITIES

A. Refer to Section 01 81 33 - Cyber-Security Requirements for cyber security related closeout requirements.

END OF SECTION

SECTION 40 05 52
MISCELLANEOUS VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Solenoid valves.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 01 61 03 - Equipment - Basic Requirements.
2. Section 40 05 51 - Common Requirements for Process and Utility Valves.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
2. American Water Works Association (AWWA):
   a. C512, Standard for Air-Release, Air-Vacuum, and Combination Air Valves for Waterworks Service.
   b. C550, Standard for Protective Interior Coatings for Valves and Hydrants.
3. Canadian Standards Association (CSA).
4. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).

1.3 SUBMITTALS

A. Shop Drawings:

1. See Specification Section 40 05 51.

B. Contract Closeout Information:

1. Operation and Maintenance Data:
   a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the manufacturers listed in the applicable Articles below are acceptable.

2.2 SOLENOID VALVES (1 INCHES AND SMALLER)

A. General Service (Air - Water):

1. Acceptable manufacturer:
   a. ASCO.
2. Materials:
   a. Body: Stainless steel.
   b. Seat: Buna-N.
   c. Insulation: Class F.
3. Design requirements:
   a. 110 VAC.

b. Two-way, normally closed.
c. Enclosure: Compatible with area classifications indicated on Drawings.
d. Working pressure, air and water: 125 psiG.

4. Accessories: Provide strainer on supply.

2.3 ACCESSORIES

A. Furnish any accessories required to provide a completely operable valve.

2.4 FABRICATION

A. Completely shop assemble unit including any interconnecting piping, speed control valves, control isolation valves and electrical components.

B. Provide internal epoxy coating suitable for potable water for all iron body valves in accordance with AWWA C550.

2.5 SOURCE QUALITY CONTROL

A. Shop hydrostatically test to piping system test pressure.

2.6 MAINTENANCE MATERIALS

A. Provide one set of any special tools or wrenches required for operation or maintenance for each type valve.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: See Specification Section 01 61 03 and Specification Section 40 05 51.

3.2 FIELD QUALITY CONTROL

A. Clean, inspect, and operate valve to ensure all parts are operable and valve seats properly.

B. Check and adjust valves and accessories in accordance with manufacturer's instructions and place into operation.

END OF SECTION

SECTION 40 05 57
ACTUATORS FOR PROCESS VALVES AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Actuators for valves and gates.
    a. Manual actuators.
    b. Electric actuators.

B. Related Sections include but are not necessarily limited to:

1. Section 01 61 03 - Equipment - Basic Requirements.
2. Section 01 81 33 - Cyber Security Requirements.
3. Section 09 96 00 - High Performance Industrial Coatings.
4. Section 40 05 51 - Common Requirements for Process and Utility Valves.
5. Section 40 05 59 - Fabricated Stainless Steel Slide Gates.
6. Section 40 05 62 - Plug Valves.
7. Section 40 05 63 - Ball Valves.

1.2 REFERENCES

A. Definitions:

1. The following are definitions of abbreviations used in this Specification Section:
    a. CPU: Central Processing Unit.
    b. NRTL: Nationally Recognized Testing Laboratory.
    c. OEM: Original Equipment Manufacturer.
    d. OIT: Operator Interface Terminal.

B. Referenced Standards:

1. American National Standards Institute/Underwriters Laboratory (ANSI/UL):
    a. 429, UL Standard for Safety Electrically Operated Valves.
    b. 50, UL Standard for Safety Enclosures for Electrical Equipment, Non-Environmental Considerations.
    c. 50E, UL Standard for Safety Enclosures for Electrical Equipment, Environmental Considerations.
2. ASTM International (ASTM):
    a. A266, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
    b. A269, Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
    c. A276, Standard Specification for Stainless Steel Bars and Shapes.
    d. A564, Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.
    e. A693, Standard Specification for Precipitation-Hardening Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
3. American Water Works Association (AWWA):
    a. C500, Standard for Metal-Seated Gate Valves for Water Supply Valves.
    b. C541, Standard for Hydraulic and Pneumatic Cylinder and Vane-Type Actuators for Valves and Slide Gates.

c. C542, Standard for Electric Motor Actuators for Valves and Slide Gates.
d. C550, Standard for Protective Coatings for Valves and Hydrants.
e. C561, Standard for Fabricated Stainless Steel Slide Gates.

4. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. MG 1, Motors and Generators.
5. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).

1.3 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer: actuator manufacturers must have at least 100 installations with each type of proposed actuators.

1.4 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Provide actuators that are fully compatible with valve or gate for which it is intended.
2. Contractor to coordinate valve/gate manufacturer and actuator manufacturer for proper sizing of actuator.
   a. See below for safety factors.
3. Mounting hardware by actuator manufacturer.
4. Install actuators at valve/gate manufacturers facility to allow for testing prior to shipping to site.

1.5 SUBMITTALS

A. Action Submittals:

1. Shop Drawings.
   a. Layout drawings with dimensions.
      1) Include those dimensions necessary for interfacing with valve/gate.
   b. Include wiring and control diagrams for electric, cylinder actuators, and electro-hydraulic actuators.
2. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Torque or thrust output.
   c. Travel speed.
   d. Input power (voltage, phase, frequency).
   e. Input current draw.
   f. Control methodology.
   g. Control Accessories.
   h. Short Circuit Current Rating (SCCR) nameplate marking in accordance with NFPA 70.
      1) Include any required calculations in accordance with Section 01 61 03.
3. Samples of the factory finish colors available at no additional cost to Owner for selection by Engineer.
4. Test reports.

B. Informational Submittals:

1. Manufacturer's installation instructions.
2. Acknowledgement that the Manufacturer meets the number of installations criteria.
   a. Submit for each different manufacturer.

b. Submit detailed installation list if requested by Engineer.

3. Recommended storage procedures.
4. Certificate of Proper Installation that includes verification from actuator manufacturer that actuators have been installed properly, that all limit switches and position potentiometers have been properly adjusted, and that the actuator responds correctly to the position command.
5. Test Reports.

C. Closeout Information:

1. Operation and Maintenance Data:
   a. See Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.
   b. Lubrication Guide.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Manual Valve Actuators:
   a. By valve manufacturer.
2. Manual Gate actuators:
   a. By gate manufacturer.
3. For other types of actuators, refer to the individual article for that actuator type for acceptable manufacturers.

2.2 MATERIALS

A. Refer to individual Articles for materials.

2.3 VALVE ACTUATORS

A. Valve Actuators - General:

1. Refer to Section 01 81 33 - Cyber Security Requirements for cyber security related product requirements.
2. Provide actuators as shown on Drawings or specified.
3. Counter-clockwise opening as viewed from the top.
4. Direction of opening and the word OPEN to be cast in handwheel or valve bonnet.
   a. Paint in a contrasting color such as white.
5. Size actuator to produce required torque with a maximum pull of 80 pounds at the maximum pressure rating of the valve provided and withstand without damage a pull of 200 pounds on handwheel or chainwheel or 300 foot-pounds torque on the operating nut.
6. Unless otherwise specified, actuators for valves to be buried, submerged or installed in vaults or manholes shall be sealed to withstand at least 20 FT of submergence.
7. Valve Lockout Devices:
   a. Device manufactured from same material as valve actuator, preventing access to valve actuator, to accept lock shackle.
8. Extension stem:
   a. Install where shown or specified.
   b. Solid steel with actuator key and nut, diameter not less than stem of valve actuator shaft.
   c. Pin all stem connections.
   d. Center in valve box or grating opening band with guide bushing.

9. Coatings: Provide actuator manufacturer's standard factory finish suitable for long-term exposure in the installation environment at final location at the Site.

B. Exposed Valve Manual Actuators:

1. Provide for all exposed valves not having electric, cylinder or electro-hydraulic actuators.
2. Provide lever actuators for plug valves, butterfly valves and ball valves 3 inches diameter and smaller.
   a. Provide lever actuators for butterfly valves with a minimum of five intermediate lock positions between full open and full close.
   b. Provide at least two levers for each type and size of valve furnished.
3. Gear actuators required for plug valves, butterfly valves, and ball valves 4 inches diameter and larger.
4. Gear actuators to be totally enclosed, permanently lubricated and with sealed bearings.
5. Provide chain actuators for valves 6 feet or higher from finish floor to valve centerline.
   a. Cadmium-plated chain looped to within 3 feet of finish floor.
   b. Equip chain wheels with chain guides to permit rapid operation with reasonable side pull without "gagging" the wheel.
   c. For smaller valves with lever or handle actuators, provide offset tee handles with attached chain for operation from the operating floor.
   d. Provide chain storage device for each chain.
      1) Chain-Away Bucket by Chain Away Corporation.
      2) Chain-Up by Trumbull Manufacturing.
      3) Or equal.
6. Provide cast iron floor stands where shown on Drawings.
   a. Stands to be furnished by valve manufacturer with actuator.
   b. Stands or actuator to include thrust bearings for valve operation and weight of accessories.

C. Electric Actuators: See Paragraph 2.6 below.

D.

2.4 GATE ACTUATORS AND LIFTS

A. Gate Actuators and Lifts - General:

1. Provide lifts in accordance with AWWA C561 as modified in this Specification Section.
2. Limit speed of travel for powered actuators to 10-14 inches/minute.
3. Rising stem lifts:
   a. Provide clear butyrate plastic stem cover with Mylar open-close indicator.
4. Gate Lockout Devices:
   a. Device manufactured from same material as gate actuator, preventing access to gate actuator, to accept lock shackle.

B. Manual Actuators:

1. Equip the lift mechanism with a pedestal, torque tube, or baseplate, machined and drilled for installing the lift housing and ready for bolting to the operating floor, top wall mounting bracket, or gate yoke, as shown on Drawings or specified.
2. Centerline of crank or handwheel: Approximately 36 IN above operating floor, unless otherwise shown.
3. Crank wheel: Removable and fitted with a corrosion resistant rotating handle.
4. Size mechanism to produce required torque with a maximum pull of 40 pounds, or 50 foot-pounds torque on the lift nut or input shaft at the maximum seating or unseating head, whichever is greater of the gate provided.

a. Provide mechanism capable of withstand without damage a pull of 200 pounds on handwheel/crank or 300 foot-pounds torque on the operating nut.

5. Maximum handwheel diameter: 30 inches.
6. Maximum crank radius: 15 inches.
7. Direction of opening and the word OPEN to be cast in handwheel or hand crank.
   a. Paint in a contrasting color such as white.

C.

2.5 COMMUNICATIONS PROTOCOL FOR POWERED ACTUATORS

A. Hard Wired.

1. Dry contacts for discrete input/output.
2. 4-20 mA for position control/feedback for modulating valves/gates.

2.6 ELECTRIC ACTUATORS

A. Comply with AWWA C542 as modified herein.

B. Provide actuators with a NRTL label.

C. Electric Motor Actuators - General:

1. Provide electric motor actuators for valves and gates so indicated: on the Drawings, in valve/gate schedules in the Specifications, or elsewhere in the Contract Documents.
2. Size actuators for 125% of required torque to operate valve/gate under design pressure/head unless specified otherwise.
3. Unless otherwise specified, provide each electric motor actuator with integral control devices for operation, including pushbuttons.
   a. When actuator's integral control station would be 5 feet or more above the nearest operating floor, or when integral control station would be out of reach of facility personnel standing on the nearest operating floor:
      1) Integral control station on actuator is not required but does not need to be removed if integral to the valve.
      2) Provide remotely located control station, with pushbuttons, in accordance with this Section.
4. Locate and orient integral control station for ease of reading and use by personnel standing on nearest operating floor.
5. Locations of remotely located control stations: as shown on the Drawings.
   a. If location of remotely located operator station is not shown or indicated on the Drawings, obtain Engineer's direction on required location, which will be in reasonable proximity to associated actuator.
   b. Locate each remotely located control station approximately 4 feet above associated operating floor and position for ease of reading and operation.
   c. Furnish and install cabling between actuator and remote station if not provided by the actuator manufacturer.
6. Provide equipment or control panels with Short Circuit Current Rating (SCCR) labeling as required by NFPA 70 and other applicable codes.
   a. See Section 01 61 03 for information on how to determine the available fault current, such that, the SCCR rating meets or exceeds the available fault current.

D. Electric Motor Actuators (Standard Duty):

1. Furnish electric actuator integral with valve/gate consisting of:
   a. Motor.
   b. Gearing.
   c. Handwheel.

d. Limit and torque switches.
e. Lubricants.
f. Heating elements.
g. Wiring.
h. Terminals for motor power and controls.
i. Drive nut.

2. Quarter Turn.
3. Housing/enclosure:
   a. Provide cast iron gear housing and cast iron load bearing enclosure for motor, gearing and control assembly.
   b. Non load bearing enclosure and housing: Aluminum or cast iron.
   c. NEMA 7.
   d. Provide O-ring seals for covers and entries.
   e. Terminal and limit switch compartment covers are to be fastened to gear housing by stainless steel fasteners with capture device to prevent loss.
4. Motors:
   a. Provide motors suitable for 480V, 3PH, 60 HZ.
   b. Provide motors that are totally enclosed, high torque design made expressly for valve/gate actuator service and capable of operating the valve/gate under full differential pressure for complete open-close and reverse cycle of travel at least twice in immediate succession without overheating.
   c. Provide motors rated for continuous duty for modulating actuators.
   d. Provide motors in accordance with NEMA MG 1 standards where applicable, with Class F insulation with a Class B temperature rise, and to operate successfully at any voltage within 10% above or below rated voltage.
   e. Provide positive method to ensure motor bearings are permanently lubricated.
   f. Provide three thermal switches imbedded in windings:
      1) 120 degrees apart.
      2) Provide motor shutdown at high temperature.
   g. Motor housing:
      1) Aluminum or cast iron.
      2) Totally enclosed nonventilated with cooling fins.
   h. Provide motor capable of operating in any position.
   i. Provide motor sealed from gearcase to allow any mounting position.
5. Gearing:
   a. Provide power gearing consisting of heat treated steel helical gears, carburized and hardened alloy steel worm, and alloy bronze worm gear, all grease or oil bath lubricated, designed for 100% overload, and effectively sealed against entrance of foreign matter.
   b. Provide gearing mechanism constructed to permit field changes of reduction gear ratio.
   c. Design actuators so that motor comes up to speed before stem load is encountered in either opening or closing operation.
   d. Limit switch gearings and feedback device reduction gearing:
      1) Steel or bronze.
   e. Support rotating shafts with anti-friction bearings.
   f. Provide separate drive nut/thrust bearing assembly:
      1) Mounted to base of actuator.
      2) High tensile bronze.

3) Quarter turn actuator: Provide 90 degrees mounting intervals.
4) Provide grease fitting on drive assembly.

6. Handwheel:
   a. Permanently attached for manual operation.
   b. Positive declutch mechanism to engage and disengage handwheel.
   c. Design such that handwheel does not rotate during motor operation.
   d. Design such that inoperable motor does not prevent manual operation.
   e. Direction of opening and the word OPEN to be cast in handwheel.
      1) Paint in a contrasting color such as white.
7. Limit torque and thrust loads in both closing and opening directions by torque limit switches or equivalent integral hardware and software programming.
   a. Provide torque switches with micrometer adjustment and reference setting indicator.
      1) Assure adjustment variation of approximately 40% in torque setting.
   b. Provide switches having rating of not less than 6 A at 120 Vac and 2.2 A at 115 Vdc.
   c. Provide limit and torque switches with totally sealed contacts.
8. Furnish electric actuator with two geared limit switch assemblies (or equivalent integral hardware and software programming) with each switch assembly having four separate limit switches:
   a. Assure each limit switch assembly is geared to driving mechanism and is independently adjustable to trip at any point at and between the fully open and fully closed valve position.
   b. Provide minimum of two normally open contacts and two normally closed contacts at each end of valve travel.
   c. Provide switches with inductive contact rating of not less than 1.5 A at 120 / 240 Vac, 1.5 A at 24 Vdc.
   d. Limit switches to be fully field adjustable when power is applied to actuator.
9. Size space heating elements to prevent condensation in both motor and geared limit switch compartment(s).
   a. Furnish heating elements rated at 120 Vac with heaters continuously energized.
10. Open-close actuator controls:
   a. Provide control assembly with necessary holding relays, reversing starter, control transformers of sufficient capacity to provide control power, space heating element power and valve position transmitter.
   b. Sealed, non-intrusive design.
   c. Provide pushbutton station with enclosure rated for area classification shown on Drawings with:
      1) Open pushbutton.
      2) Close pushbutton.
      3) Stop pushbutton.
      4) Remote/local switch.
      5) Full open light.
      6) Full close light.
      7) Open and close relays as required.
      8) Provide control enclosure to accept:
         a) Remote open/close control.
      9) Provide contacts in control enclosure:
         a) Remote status.
         b) Full open status.

c) Full close status.

10) Wire all components to an internal terminal strip and include mounted wiring diagram inside enclosure.

11. Additional requirements for modulating valve/gate actuators:
    a. Proportional position servo-amplifier installed integral with the actuator control compartment.
    b. Positioning of valve: proportional to an input signal.
    c. Servo-amplifier adjustments: zero, span, gain, and dead-band.
    d. Provide position control as shown on the Drawings that interfaces with the position control/position feedback instrumentation wiring to and from PLC.
12. Input/output protocol. See Paragraph 2.5.
13. Acceptable Manufacturers:
    a. Auma Actuators, Inc.
    b. Emerson – Bettis.
    c. Emerson – Keystone.
    d. Flowserve Corporation – Limitorque.
    e. Rotork plc.
    f. Or equal.

2.7 SOURCE QUALITY CONTROL

A. Source Quality Control – General:

1. Prior to shipping equipment from the production or fabrication facility, perform manufacturer's standard factory tests and inspections and submit documentation of successful completion to Engineer.

B. Standard Duty Electric Actuators:

1. Proof of Design Test: in conformance with AWWA C542 Section 5.2.
2. Performance Test: in conformance with AWWA C542 Section 5.3.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Location and Orientation:

1. Provide actuators and operators as shown on the Drawings.
2. When not expressly shown on the Drawings, orient valve actuators so valve operator is in a position reasonably convenient for facility personnel.
    a. Unless otherwise shown, install electric or cylinder actuators above or horizontally adjacent to valve and gear box to optimize access to controls and external handwheel.
3. When orientation of actuator, operator location, or both are unclear, submit to Engineer a request for interpretation and obtain Engineer's response before furnishing the associated Submittal and in no event, later than purchasing the associated valve and actuator.
4. Contractor is responsible for costs and delays incurred to remedy valve actuators furnished or installed in inconvenient or difficult-to-access positions and locations unless the Contract Documents require otherwise.
5. Contractor is not responsible for providing permanent platforms, stairs, or other extraordinary, permanent access measures unless so required by the Contract Documents.

C. Touch Up Painting Requirements:

1. Repair scuffs and scratches on factory-applied finishes using materials furnished by the actuator manufacturer, applied in accordance with the written instructions of both the actuator manufacturer and the Supplier of the touch-up material(s).

D. Install electric or cylinder actuators above or horizontally adjacent to valve and gear box to optimize access to controls and external handwheel.

3.2 FIELD QUALITY CONTROL

A. Demonstrate that all powered valves operate properly after installation.

3.3 ADJUSTMENT

A. Adjust valves/gates, actuators, and appurtenant equipment to comply with Section 01 75 00.

1. Operate valve, open and close at system pressures.

B. For all 120 Vac and 480 Vac electric actuators, employ and pay for services of valve actuator manufacturer's field service representative to:

1. Inspect valve actuators covered by this Specification Section.
2. Program/configure actuator integral software.
3. Supervise adjustments and installation checks:
    a. Open and close valves electrically under local manual and demonstrate that all limit switches are properly adjusted and that switch contacts are functioning properly by verifying the inputs are received at the remote input/output (RIO) panels or local control panel as appropriate.
    b. Position powered modulating valves under local manual control and demonstrate that the valve position feedback potentiometer is properly adjusted and that the feedback signal is received at the RIO panels or local control panel as appropriate.
    c. Simulate a valve position command signal at the RIO panel or local control panel as appropriate and demonstrate that the valve is controlled to the desired position without excessive hunting.
4. Submit to Owner a Certificate of Proper Installation (COPI) from the valve actuator manufacturer that includes:
    a. Verification that the actuators have been installed properly.
    b. Verification that all limit switches and position potentiometers have been properly adjusted.
    c. Verification that the valve actuator responds correctly to the valve position command.

3.4 SCHEDULE

A. See Drawings for electrically actuated valve schedule.

B. See Section 40 05 59 - Fabricated Stainless Steel Slide Gates for gate schedules.

END OF SECTION

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SECTION 40 05 59
FABRICATED STAINLESS STEEL SLIDE GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fabricated Stainless Steel Slide Gates.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 01 61 03 - Equipment - Basic Requirements.
2. Section 09 96 00 - High Performance Industrial Coatings.
3. Section 10 14 00 - Identification Devices.
4. Section 40 05 51 - Common Requirements for Process and Utility Valves.
5. Section 40 05 57 – Actuators for Process Valves and Gates.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Water Works Association (AWWA):
   a. C561, Fabricated Stainless Steel Slide Gates.
2. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
3. Society for Protective Coatings/NACE International (SSPC/NACE):
   a. SP 5/NACE No. 1, White Metal Blast Cleaning.

1.3 SUBMITTALS

A. Shop Drawings:

1. See Specification Section 01 61 03.
2. Product technical data including:
   a. Acknowledgment that products submitted meet the requirements of standards referenced.
   b. Calculations that demonstrate compliance with the deflections, stress and factor of safety specified.
   c. Certified drawings and material specifications for all components.
   d. Test records.
      1) Performance Test
      2) Leakage Test

B. Operation and Maintenance Manuals:

   a. The mechanics and administration of the submittal process.
   b. The content of Operation and Maintenance Manuals.

C. Affidavit of Compliance: See AWWA C561.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. RW Gate Company.

2. Whipps.
3. Aquanox / Fontaine.
4. Hydro-Gate (Mueller).
5. Golden Harvest.
6. Rodney-Hunt – Jash.
7. Waterman.

2.2 EQUIPMENT – SLIDE GATES

A. General: Provide gates, stems, lifts and other appurtenances of size, type, material and construction shown on the Contract Drawings and as specified herein.

B. Comply with requirements of Specification Section 01 61 03.

C. Gates: Meet all requirements of AWWA C561 as modified per this Specification Section.

D. Materials:

1. Materials subject to dezincification or dealuminization prohibited.
2. "L" grades for all welded components.
3. Thimble, frame, guides, slide, yoke and stem guides:
   a. Stainless steel, Type 316 and Type 316L.
4. Gear housing:
   a. Cast iron, steel or ductile iron.
5. Actuator pedestal:
   a. Stainless steel, Type 316.
6. Rising stem thrust nuts:
   a. Stainless steel, Type 316.
7. Stem couplings:
   a. Stainless steel, Type 316.
8. Stem guide bushings:
   a. Cast or extruded UV stabilized UHMW-PE.
9. Stems:
   a. Stainless steel, Type 316.
10. Seals:
    a. UV stabilized UHMW-PE.
11. Anchor bolts and fasteners: Stainless steel, Type 316.
12. Flush-bottom sill retainer: Stainless steel, Type 316.
13. Wedges and Pressure Pads: UV stabilized UHMW-PE if required.

E. Fabrication: One-piece frames.

   a. One-piece frame: Self-contained.
2. Flush bottom seals: Easily replaceable without disassembly of the gate.
3. Side and top seals of gate: Replaceable without removing gate or without dewatering.

2.3 GATE OPERATORS AND LIFTS

A. General: Provide lifts in accordance with AWWA C541 and C542, or as modified in this Specification Section.

B. Rising Stem: Provide clear butyrate plastic stem cover with Mylar open-close indicator.

C. Manual Operators:

1. Equip the lift mechanism with a pedestal, torque tube, or baseplate, machined and drilled for mounting the lift housing and ready for bolting to the operating floor, top wall mounting bracket, or gate yoke, as shown on Drawings or specified.
2. Centerline of crank or handwheel: Approximately 36 inches above operating floor.

2.4 FABRICATION

A. Specified in AWWA C561.

B. Welded Stainless Steel: Passivated after fabrication.

2.5 SOURCE QUALITY CONTROL

A. Factory Tests:

1. Shop leakage tests.
2. Travel speed tests.
3. Other tests.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. For identification and tagging, and for warning or caution signs, comply with Specification Section 10 14 00.

3.2 FIELD QUALITY CONTROL

A. Employ and pay for services of equipment manufacturer's field service representative(s) to:

1. Inspect equipment covered by this Specification Section.
2. Supervise adjustments and installation checks.
3. Provide test equipment, tools, and instruments necessary to accomplish equipment testing.
4. Conduct initial start-up of equipment, perform operational checks, and supervise acceptance testing.
5. Provide, through Contractor, a written statement that manufacturer's equipment has been installed properly, started up and is ready for operation by Owner's personnel.
6. Instruct Owner's personnel on operation and maintenance of furnished equipment.
7. Field Leakage Test for Stainless Steel Slide Gates: Test gate under design seating head and adjust to maximum leakage specified.

3.3 DEMONSTRATION

A. See Specification Section 01 75 00.

B. Personnel Training:

1. Provide 1 day of the manufacturer's technical representative's time for the training of the Owner's personnel.

3.4 GATE SCHEDULE:

A. The following table is a schedule of the fabricated slide gates.

GATE EQUIPMENT ID#	SIZE WxH (IN)[g]	DESIGN HEAD, (FT) [a] SEATING	UNSEATING	OPENING DIRECTION [b]	TYPE OF CLOSURE [c]	TYPE OF LIFT MECHANISM [d]	RISING OR NON-RISING STEM [e]	THIMBLE REQUIRED [f]
GTE-02-01	36x24	2.5	2.5	Up Op	FB	Hdwl	R	No
GTE-02-02	36x24	2.5	2.5	Up Op	FB	Hdwl	R	No
GTE-02-03	24x24	2.5	2.5	Up Op	FB	CH	NR	No
GTE-02-04	24x24	2.5	2.5	Up Op	FB	CH	NR	No
GTE-02-05	24x24	2.5	2.5	Up Op	FB	Hdwl	R	No
GTE-02-06	24x24	2.5	2.5	Up Op	FB	Hdwl	R	No
GTE-02-07	24x24	2.5	2.5	Up Op	FB	CH	NR	No
GTE-02-08	24x24	2.5	2.5	Up Op	FB	CH	NR	No
GTE-02-09	30x24	2.5	2.5	Up Op	FB	Hdwl	R	No
GTE-02-10	18x30	2.5	2.5	Up Op	FM	Hdwl	R	no
GTE-02-11	24x42	2.5	2.5	Up Op	FB	Hdwl	R	No

Abbreviations:

a Design Head: Measured from surface of water to centerline of gate, in feet.
b Opening Direction: Dn Op = Downward Opening; Up Op = Upward Opening.
c Type of Closure: W = Weir Service; FB = Flush Bottom (Embedded); FM = Face Mounted.
d Type of Lift Mechanism: Ped = Pedestal; Elec = Electric; Hdwl = Handwheel; Hyd = Hydraulic, CH = Crank Handle, SQN = Square Nut.
e Rising or Nonrising Stem: R = Rising; NR = Nonrising.
f Thimble Required: Wall Thimble is required = YES; Wall Thimble is not required = No.
g Width refers to concrete channel width. Height refers to height of slide.

END OF SECTION

SECTION 40 05 62
PLUG VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Plug valves.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 40 05 51 - Common Requirements for Process and Utility Valves.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125 and 250.
2. ASTM International (ASTM):
   a. A126, Standard Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings.
   b. A536, Standard Specification for Ductile Iron Castings.
   c. D2240, Standard Test Method for Rubber Property-Durometer Hardness.
3. American Water Works Association (AWWA):
   a. C517 Resilient-Seated Cast-Iron Eccentric Plug Valves

1.3 SUBMITTALS

A. Shop Drawings:

1. See Specification Section 40 05 51.

B. Contract Closeout Information:

1. Operation and Maintenance Data:
   a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.
2. See Specification Section 40 05 51.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the manufacturers listed under the specific valve types are acceptable.

2.2 NON-LUBRICATED ECCENTRIC PLUG VALVES (SEWAGE, SLUDGE, SEWAGE GAS APPLICATIONS)

A. Manufacturers:

1. DeZurik.
2. Henry Pratt.
3. Millikin.
4. ValMatic.

B. Materials:

1. Body: Cast-iron ASTM A126, Class B.

2. Plug: One or two-piece construction ductile iron, ASTM A536 65-45-12 or cast iron, ASTM A126 Class B.
3. Plug facing: Grease and/or petroleum-resistant resilient Neoprene or Buna-N compound, 70 Type A durometer hardness per ASTM D2240.
4. Shaft bearing bushings: Permanently lubricated TFE or Delrin sleeve type stainless steel or bronze.
5. Valve seats: Welded-in overlay of 90% nickel, (minimum 1/8 inches thick).
6. Stem seal: per AWWA C517, Section 4.4.7.

2.3 LUBRICATED SEAL PLUG VALVES (NATURAL GAS APPLICATIONS)

A. Manufacturers:

1. Nordstrom.
2. Walworth.
3. Millikin.

B. Materials:

1. Body: Cast iron ASTM A126, Class B.
2. Plug: Cast iron ASTM A126, Class B.
3. Plug facing: Teflon on tapered plug.
4. Valve seats: Gas-resistant lubricant/sealant.

2.4 ACCESSORIES

A. Refer to Drawings and valve schedule for type of actuator.

1. Furnish actuator integral with valve.

B. Refer to Specification Section 40 05 51 for actuator requirements.

2.5 DESIGN REQUIREMENTS

A. Non-Lubricated Eccentric Plug Valves (Wastewater, Sludge):

1. Port area:
   a. Valves 4 inches through 20 inches: Equal to or exceed 80% of full pipe area.
   b. Valves greater than 20 inches: 100% equivalent full pipe area.
2. Valve body: Fitted with bolted bonnet.
3. End connections: See Specification Section 40 05 51.
4. Stem seal: Adjustable and replaceable without disassembling valve or bonnet.
5. Designed for seating drip tight in any flow direction.
6. Rating:
   a. 1/2 through 12 inches, 175 psi working pressure.
   b. 14 through 36 inches, 150 psi working pressure.
   c. Three-way valves, 125 psi working pressure.
7. Actuator:
   a. Actuator gearing in enclosure suitable for running in oil with seals on shaft to prevent entry of dirt or water.
   b. Positive identification on actuator indicating valve position.
   c. Adjustable stop to set closing torque.

B. Lubricated Plug Valves (Natural Gas):

1. Pressure lubricated valve with sealed ports and grooves.
   a. Re-seatable under full pressure in any position.
2. Pressure rating: 200 psi WOG.

3. Port area: Minimum 60% of pipe area.
4. Acceptable to local gas company.

2.6 FABRICATION

A. See Specification Section 40 05 51.

PART 3 - EXECUTION

3.1 INSTALLATION

A. See Specification Section 40 05 51.

B. Install valves with valve stem horizontal, plug seat on inlet side and with plug rotating up into the open position for valves in horizontal lines.

C. Install valve with actuator above pipe or plug centerline.

END OF SECTION

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SECTION 40 05 63
BALL VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Ball valves.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 40 05 51 - Common Requirements for Process and Utility Valves.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. ASTM International (ASTM):
   a. A48, Standard Specification for Gray Iron Castings.
   b. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   c. A276, Standard Specification for Stainless Steel Bars and Shapes.
   d. A351, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
   e. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
2. American Water Works Association (AWWA):
   a. C507, Standard for Ball Valves, 6 inches through 48 inches.
3. Manufacturers Standardization Society of the Valve and Fittings Industry Inc. (MSS):
   a. SP-110, Ball Valves; Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.

1.3 DEFINITIONS

A. PVDF: Polyvinylidene fluoride.

B. PTFE: Polytetrafluoroethylene.

C. RPTFE: Reinforced PolyTetraFluoroEthylene.

1.4 SUBMITTALS

A. Shop Drawings:

1. See Specification Section 40 05 51.
2. Test results for AWWA valves.

B. Contract Closeout Information:

1. Operation and Maintenance Data:
   a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the manufacturers listed in the applicable Articles below are acceptable.

2.2 METALLIC BALL VALVES 1/4 TO 3 INCHES DIAMETER

A. Comply with MSS SP-110.

B. Manufacturers:

1. Apollo.
2. Jamesbury.
3. Watts.
4. Stockham.
5. Nibco.

C. Materials (All Stainless Steel):

1. Body: Three-part stainless steel, ASTM A351 CF8M.
2. Ball: Stainless steel ASTM A276.
3. Seats: RPTFE.

D. Design Requirements:

1. Rated for a minimum of:
   a. 500 psi CWP.
   b. 150 psi of saturated steam.
   c. 29 inches vacuum.
2. Two-position lockable handle.
3. Stem with blowout-proof design.
4. Balancing stop for all applications.
5. Bodies with mounting pad for applications requiring actuators.

2.3 PLASTIC BALL VALVES: 1/2 INCHES TO 4 INCHES DIAMETER

A. Manufacturers:

1. Chemtrol/NIBCO.
2. Spears.
3. ASAHI/America.

B. Materials:

1. Body, stem, ball, handle, end connectors:
   a. PVC ASTM D1784-12454B.
2. Ball Seat: Teflon.
3. O-rings: Viton.

C. Design Requirements:

1. Rated at 150 psi at 75 degrees F.
2. Double or "true union" design.
3. Blocks both directions, upstream and downstream.
4. Union nut capable of compensating for seat wear.
5. Body with mounting pad for actuators where required.
6. Capable of being disconnected at downstream end under full line pressure.

2.4 ACCESSORIES

A. Refer to Drawings and valve schedule for type of actuators.

1. Furnish actuator integral with valve.

B. Refer to Specification Section 40 05 51 for actuator requirements.

2.5 SOURCE QUALITY CONTROL

A. Furnish record of testing.

B. Product Testing: MSS SP-110.

PART 3 - EXECUTION

3.1 INSTALLATION

A. See Specification Section 40 05 51.

END OF SECTION

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SECTION 40 05 66
CHECK VALVES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Swing check valves, three-inch to 24-inch diameter.

B. Related Requirements: Include but are not necessarily limited to:

1. Section 40 05 51 - Common Requirements for Process and Utility Valves.

1.2 REFERENCES

A. Referenced Standards:

1. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
2. American Water Works Association (AWWA):
   a. C508, Standard for Swing-Check Valves for Waterworks Service, 2 in. through 24 in. NPS.
3. Manufacturers Standardization Society of the Valve and Fittings Industry Inc. (MSS):
   a. SP-71, Gray Iron Swing Check Valves, Flanged and Threaded Ends.
   b. SP-80, Bronze Gate, Globe, Angle and Check Valves.

1.3 QUALITY ASSURANCE

A. Qualifications:

1. Valve Manufacturers:
   a. Manufacturer shall be a business regularly engaged in manufacturing and furnishing check valves of the type required and similar equipment.
   b. Manufacturer shall be able to document having furnished not less than 50 check valves, of the type required, of size equal to or larger than those required for the Work, during the past five years.
   c. When requested by Engineer, submit qualifications statement indicating manufacturer's record of manufacturing and furnishing check valves of the types and sizes required and furnish documentation of compliance with qualifications requirements of this Article.

1.4 SUBMITTALS

A. Action Submittals: Submit the following:

1. In accordance with Section 40 05 51.

B. Informational Submittals: Submit the following:

1. In accordance with Section 40 05 51.
2. Manufacturer's Instructions:
   a. Manufacturer's written instructions for delivery, handling, storage, installation, and startup.

C. Closeout Submittals: Submit the following:

1. Operation and Maintenance Data:
   a. Submit in accordance with Section 01 78 23 - Operations and Maintenance Manuals.

PART 2 - PRODUCTS

2.1 SWING CHECK VALVES: 3 INCHES TO 24 INCHES

A. Swing Check Valves (Water, Wastewater, Sludge):

1. Comply with AWWA C508.
2. Manufacturers:
    a. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
        1) Clow.
        2) America Darling.
        3) GA Industries.
3. Materials:
    a. Body and cover: Cast iron.
    b. Seat ring, hinge: Bronze.
    c. Disc:
        1) 3 to 4 inches: Bronze.
        2) 6 to 24 inches: Cast iron with bronze face.
    d. Hinge shaft: Stainless steel.
    e. Bearings, connecting hardware: Bronze.
4. Design requirements:
    a. 175 psi working pressure (3 to 12 inches).
    b. 150 psi working pressure (14 to 24 inches).
    c. Furnish with outside weight and lever or lever and spring.

2.2 SOURCE QUALITY CONTROL

A. Factory Tests and Inspections:

1. Perform manufacturer's standard factory tests and inspections on materials and equipment furnished. Correct defects prior to shipment to the Site.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation – General:

1. Provide check valves at locations shown and indicated in the Contract Documents.
2. Install in accordance with the Contract Documents and manufacturer's written instructions. In event of conflict between the Contract Documents and manufacturer's written instructions, obtain written interpretation or clarification from Engineer.
3. Comply with:
    a. Section 01 61 03 - Equipment - Basic Requirements.
    b. Section 40 05 51 - Common Requirements for Process and Utility Valves.
    c. Section 40 05 00 - Pipe and Pipe Fittings - Basic Requirements.
4. Before installing, ensure each check valve is clean and free of dirt and debris.

3.2 FIELD QUALITY CONTROL

A. Field Tests and Inspections:

1. Promptly after installing, before installing connecting pipe, verify proper and free operation of check valve.
2. Hydrostatically test check valves together with associated piping.

3. To extent practical, prior to Substantial Completion, verify proper operation of each installed check valve.

END OF SECTION

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SECTION 40 41 13
HEAT TRACING CABLE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Heat tracing cable as required for heat tracing of pipes and/or equipment as indicated on the Drawings.

B. Related Sections include but are not necessarily limited to:

1. Section 26 05 00 - Electrical - Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).

1.3 SUBMITTALS

A. Shop Drawings:

1. Product technical data:
   a. Power requirements for each circuit based upon actual length of heat trace and maintained temperature.
   b. Circuit breaker rating based upon inrush current at minimum expected start-up temperature.
   c. Length of heat tape for each pipe size and run.
   d. Coordinate and verify length and Watts/FT of heat tape required based upon pipe size and insulation thickness.
      1) Include the calculations to support the heat tape output.
   e. See Section 26 05 00 for additional requirements.
2. Fabrication and/or layout drawings:
   a. Wiring diagrams showing physical locations of thermostats and heat trace power supply.

B. Contract Closeout Information:

1. Operation and Maintenance Data:
   a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

C. Informational Submittals:

1. Test reports: Megger test results.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Shall be stored such that they are not exposed to sunlight or other UV rays.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:

1. Chemelex Division; Raychem Corp.

2. Chromalox.
3. Delta-Therm.
4. Thermon.

2.2 HEAT TRACING

A. Design Parameters (AGR-02-08):

1. AGR-02-08:
   a. Equipment Length to be Heat Traced: Approximately 12 feet (exterior of headworks building).
   b. Equipment Trough Nominal Circumference: See Drawings and 41 12 13 - Conveyors - Screw.
   c. Pipe insulation type and thickness: See Drawings and 40 42 00 - Pipe, Duct and Equipment Insulation.
   d. Heat trace and controls located in a classified area shall meet the heat trace manufacturer's recommendations for installation in a classified area.
2. Plant Drain Piping:
   a. Pipe diameter, length, and material: See Drawings and relevant piping Specifications.
   b. Flange, valve, pipe support size: See Drawings and relevant piping Specifications.
   c. Pipe insulation type and thickness: See Drawings and 40 42 00 - Pipe, Duct and Equipment Insulation.
   d. Heat trace and controls located in a classified area shall meet the heat trace manufacturer's recommendations for installation in a classified area.
3. Temperatures requirements:
   a. Low ambient temperature for the specific location: -6 DEGF.
   b. Start-up temperature (alarm thermostat set point):
      1) Water/wastewater lines and equipment: 40 DEGF.
   c. Maintain temperature (power thermostat set point):
      1) Water/wastewater lines and equipment: 40 DEGF.
   d. High temperature exposure with power off: 185 DEGF.
4. Wind factor for the specific location: 10 MPH.
5. Electrical requirements:
   a. Voltage: 120 V.
   b. Circuit breaker: Field coordinate if other than 20A GFEPCI type.
6. Safety factor: 10%.

B. Self-regulating or power-limiting parallel circuit construction consisting of an inner core of conductive material between parallel copper bus wires, with inverse temperature - conductivity characteristics with metal overbraid.

C. Thermostats adjustable between 35 and 200 degrees F minimum with maximum differential range of 9 degrees F, furnished complete with NEMA 4 enclosures in all areas, stainless steel temperature bulb and capillary. Provide with dry contact for remote monitoring of alarm condition.

D. All necessary or required components and accessories, such as power connection boxes, end seals, straps, tape and fitting brackets.

E. In noncorrosive and nonhazardous locations, insulation shall be Polyolefin.

F. In corrosive, hazardous and hydrocarbon locations insulation shall be Fluoropolymer (Teflon).

PART 3 - EXECUTION

3.1 PREPARATION

A. Install materials after piping has been tested and approved.

3.2 INSTALLATION

A. Insulate and heat trace equipment as indicated on Drawings.

B. Install materials in accordance with manufacturer's instructions.

1. Each circuit shall not exceed the manufacturer's recommended maximum length.

C. For Metallic Piping:

1. Heat tracing shall be installed completely wired.
2. Cut heat trace to lengths as required and secure to pipe with glass or polyester fiber tape.

D. For Nonmetallic Piping:

1. Allow for extra heat trace output because nonmetallic pipe has a lower heat transfer.
   a. Heat tracing shall be installed completely wired.
2. Cut heat trace to lengths as required and secure to pipe with aluminum tape throughout the length of the trace.

E. Protection and Control Requirements:

1. Protection by a GFEPCI circuit breaker.
   a. Breaker amperage rating shall be coordinated with Contractor when different than the Contract Drawings.
2. Provide two line sensing thermostats, one for power and one for alarm.
3. The alarm thermostat shall be placed on the opposite end of the circuit from the power thermostat or power connection to allow for annunciation of partial failure of a circuit or the loss of power from a tripped GFEPCI circuit breaker.
4. Provide a monitoring module that monitors the voltage (circuit breaker status) to each circuit.
5. The alarm from the alarm thermostat and monitor module shall be annunciated on the indicated control system.

3.3 TESTING

A. Megger the cables at the manufacturers recommended voltage level three times.

1. Before installation.
2. After attachment to pipe but before insulation is installed.
3. After pipe insulation is installed but before energization.

END OF SECTION

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SECTION 40 42 00
PIPE, DUCT AND EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Insulation:
    a. Piping insulation.
    b. Duct insulation.
    c. Equipment insulation.
2. Adhesives, mastics, sealants, and finishes.
3. Grease and air ventilation duct wrap fire protection systems.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 40 05 07 - Pipe Support Systems.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. ASTM International (ASTM):
    a. C177, Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of Guarded-Hot-Plate Apparatus.
    b. C411, Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.
    c. C423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
    d. C553, Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
    e. C612, Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
    f. C1071, Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
    g. D1056, Standard Specification for Flexible Cellular Materials-Sponge or Expanded Rubber.
    h. E96, Standard Test Methods for Water Vapor Transmission of Materials.
    i. F25, Standard Test Method for Sizing and Counting Airborne Particulate Contamination in Cleanrooms and Other Dust-Controlled Areas.
2. National Fire Protection Association (NFPA):
    a. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
3. Underwriters Laboratories, Inc. (UL):
    a. 723, Standard for Test for Surface Burning Characteristics of Building Materials.
4. National Commercial and Industrial Insulation Standards (2013 seventh edition).
    a. Published by Midwest Insulation Contractors Association (MICA).
    b. Endorsed by National Insulation Association (NIA).
    c. MICA plate numbers listed in this specification reference this document.

1.3 SUBMITTALS

A. Shop Drawings:

1. Product technical data including:
    a. Acknowledgement that products submitted meet requirements of standards referenced.

b. Manufacturer's installation instructions.
c. Submit complete specification of insulation materials, adhesives, cement, together with manufacturer's recommended methods of application and coverage for coatings and adhesives.

2. Submit itemized schedule by building of proposed insulation systems showing density, thermal conductivity, thickness, adhesive, jackets and vapor barriers.
3. Certifications: Products will meet the requirements of the Contract Documents.

B. Informational Submittals:

1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Elastomeric insulation:
   a. Rubatex.
   b. Armstrong.
2. Fiberglass insulation:
   a. CertainTeed Corporation.
   b. Johns Manville.
   c. Owens Corning.
   d. Knauf.
3. PVC jacket:
   a. Ceel-Co.
   b. PIC Plastics.
4. Equipment insulation:
   a. CertainTeed Corporation.
   b. Johns Manville.
   c. Owens Corning.
5. Ductwork insulation:
   a. CertainTeed.
   b. Johns Manville.
   c. Owens Corning.
6. High density perlite:
   a. Johns Manville.
   b. Industrial Insulation Group (LIC).
7. High density calcium silicate:
   a. Industrial Insulation Group (LIC).
8. Adhesives, mastics, sealants, and finishes:
   a. Foster Products.
   b. Childers.
   c. Dow Corning.
   d. Johns Manville.
   e. Knauf.

2.2 PIPING INSULATION - ELASTOMERIC

A. General:

1. Insulation fire and smoke hazard ratings for composite (insulation, jacket or facing, and adhesive used to adhere the facing or jacket to the insulation), as tested by procedure ASTM E84, NFPA 255 and UL 723, not exceeding:
   a. Flame spread: 25.
   b. Smoke developed: 50.
2. Accessories (adhesives, mastics, cements, and tapes: Same component ratings as listed above.
3. Indicate on product labels or their shipping cartons: Flame and smoke ratings do not exceed above requirements.
4. Permanent treatment of jackets or facings to impart flame and smoke safety is required.
   a. Water-soluble treatments are prohibited.
5. Insulated shields at pipe support points.

B. Pipe, Fitting, and Valve Insulation:

1. Flexible elastomeric closed cell pipe insulation.
   a. Average thermal conductivity not to exceed 0.27 (BTU-IN)/(HR-FT^2-DEGF) at mean temperature of 75 degrees F, temperature range -40 to 220 degrees F; permeability not to exceed 0.20 by ASTM E96; water absorption 3% by ASTM D1056 and ozone resistance.
2. Provide minimum insulation thickness conforming to schedules or as shown on the Drawings.

2.3 PIPING INSULATION - FIBERGLASS

A. Pipe and Fitting Insulation:

1. Preformed fiberglass pipe insulation:
   a. Density: 4 pounds/CUFT.
   b. Temperature rated: 650 degrees F.
   c. Average thermal conductivity not to exceed 0.23 (BTU-IN)/(HR-FT^2-DEGF) at mean temperature of 75 degrees F.
   d. Fire hazard rating:
      1) UL 723, ASTM E84, NFPA 255.
      2) Flame spread not exceeding 25 and smoke developed not exceeding 50.
2. Moisture adsorption:
   a. ASTM C553.
   b. Not greater than 5% moisture by volume when exposed to moisture laden air at 120 degrees F and 96% RH.
3. Fungi and bacteria resistance:
   a. ASTM C665.
   b. Does not breed or promote growth.
   c. Flame attenuated glass fibers bonded with thermosetting resin.
4. Piping jackets (general applications):
   a. Aluminum: 16 mil embossed aluminum.
   b. PVC: Preformed 0.028 inches thick PVC jackets fabricated from Johns Manville, or approved equal, PVC sheeting V-66 with proven resistance to ultraviolet degradation when temperatures do not exceed the limits of PVC.
   c. Piping jacket not required on concealed piping.

5. Provide minimum insulation thickness conforming to schedules or as shown on the Drawings.

2.4 PIPE INSULATION INSERTS AT HANGERS

A. High Density Perlite:

1. Pre-formed.
2. Fire hazard rating:
   a. UL 723, ASTM E84, NFPA 255.
   b. Flame spread: Zero.
   c. Smoke developed: Zero.
3. Average density: 13 pounds/CUFT.
4. Compressive strength: 80 psi to produce 5% compression.
5. Maximum surface temperature: 1,200 degrees F.

B. High Density Calcium Silicate:

1. Pre-formed.
2. Fire hazard rating:
   a. UL 723, ASTM E84, NFPA 255.
   b. Flame spread: Zero.
   c. Smoke developed: Zero.
3. Average density: 14 pounds/CUFT.
4. Compressive strength: 100 psi to produce 5% compression.
5. Maximum surface temperature: 1,200 degrees F.

2.5 EQUIPMENT INSULATION

A. Insulation for Equipment:

1. Fire hazard classification:
   a. UL 723, ASTM E84, NFPA 255.
   b. Flame spread not exceeding 25 and smoke developed not exceeding 50.
2. Provide minimum insulation thickness conforming to Schedules, or as shown on Drawings.
3. Equipment insulation jackets: 16 mil embossed aluminum for outdoor service.

2.6 DUCTWORK INSULATION: FIBERGLASS

A. Flexible Insulation:

1. Material: Commercial-grade fiberglass thermal insulation, formaldehyde free.
2. Scheduled thickness and installed R-value. Installed R-value when compressed to a maximum of 25% following recommended duct wrap stretch outs.
3. Factory-applied foil scrim vapor barrier facing.
4. Average thermal conductivity not to exceed 0.27 (BTU-IN)/(HR-FT^2-DEGF) at a mean temperature of 75 degrees F (installed).
5. Fungi and bacteria resistance:
   a. ASTM C1338.
   b. Does not breed or promote growth.
6. Fire hazard classification:
   a. UL 723, ASTM E84, NFPA 255.
   b. Flame spread not exceeding 25 and smoke developed not exceeding 50.
7. Basis of design: Johns Manville Microlite fiberglass duct wrap insulation.

B. Semi-Rigid Insulation for Indoor Installation:

1. Scheduled thickness and R-value.
2. Factory applied vapor barrier facing-white scrim foil.
3. Average thermal conductivity not to exceed 0.23 (BTU-IN)/(HR-FT^2-DEGF) at a mean temperature of 75 degrees F.
4. Fungi and bacteria resistance:
    a. ASTM C1338.
    b. Does not breed or promote growth.
5. Moisture adsorption:
    a. ASTM C553.
    b. Not greater than 0.5% moisture by volume when exposed to moisture laden air at 120 degrees F and 96% RH.

C. Semi-Rigid Insulation for Outdoor Installation:

1. Scheduled thickness and R-value.
2. Factory-applied foil scrim vapor barrier facing.
3. Average thermal conductivity not to exceed 0.23 (Btu-IN)/(HR-FT^2-DegF) at mean temperature of 75 degrees F.
4. Minimum density: 3 pounds/CUFT.
5. Fungi and bacteria resistance:
    a. ASTM C1338.
    b. Does not breed or promote growth.
6. Basis of Design: Johns Manville #815 SPIN-GLASS fiberglass duct insulation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. General:

1. Piping below ground covered with earth shall be buried below frost depth and will not be insulated.
    a. Buried piping that crosses above the frost depth elevation shall be heat traced and insulated per Section 40 41 13 and this Section.
2. Consider ductwork, piping and equipment as exposed, except as otherwise indicated.
3. Consider ductwork, piping and equipment in walls, partitions, floors, pipe chases, pipe shafts and duct shafts as concealed.
    a. Consider ductwork, piping and equipment above ceilings as concealed.
4. Provide release for insulation application after installation and testing is complete.
    a. Apply insulation on clean, dry surfaces after inspection.
5. Provide insulation continuous through wall, roof and ceiling openings, pipe hangers, supports and sleeves.
6. Provide insulation with vapor barrier for piping, ductwork and equipment where surfaces may be cooler than surrounding air temperatures.
    a. Provide vapor barrier (0.17 perm-IN; ASTM C553) continuous and unbroken.
    b. Hangers, supports, anchors, and related items that are secured directly to cold surfaces must be adequately insulated and vapor-sealed to prevent condensation.
7. Apply specified adhesives, mastics and coatings at the manufacturer's recommended coverage per unit volume.

C. Piping Insulation - Elastomeric:

1. Do not insulate until satisfactory completion of required pressure testing.

2. Apply insulation to clean, dry surfaces.
3. Slip insulation on pipe prior to connection.
    a. Whenever the slip-on technique is not possible provide insulation neatly slit and snapped over the pipe.
4. Fabricate and install fitting cover insulation according to manufacturer's recommendations.
5. Seal joints, slits, miter-cuts and other exposed edges of insulation with adhesive, recommended by the insulation manufacturer, to ensure complete vapor barrier.

D. Piping Insulation - Fiberglass:

1. Apply over clean dry pipe.
    a. Butt all joints together firmly.
2. Seal joints, slits, miter-cuts and other exposed edges of insulation as recommended by the insulation manufacturer.
3. Insulate fittings, valves, and flanges with insulation thickness equal to adjacent pipe.
4. PVC pipe jacket:
    a. Apply jacketing with a minimum of 1 inch overlap.
        1) Weld longitudinal and circumferential seams with adhesives as recommended by manufacturer.
    b. Provide slip-joints every 30 feet and between fittings if distance exceeds 8 feet.
        1) Construct slip-joints by overlapping jacket sections 6 to 10 inches.
    c. Provide pre-molded PVC covers of same material and manufacturer as jacket for fittings, valves, flanges, and related items in insulated piping systems.
5. Aluminum pipe jacket:
    a. Field-applied aluminum jacket with vapor-sealed longitudinal and butt joints.
    b. Provide smooth and straight joint with a minimum 2 inches overlap.
    c. Secure joints with corrosion-resistant screws spaced 0.25 to 0.50 inches back from edge.
    d. Center spacing of screws 5 inches maximum or as required to provide smooth tight-fitted joints.
    e. Place joints on least exposed side of piping to obtain neat appearance.

E. Equipment: Install per manufacturer's instructions.

F. Ductwork Insulation - Fiberglass:

1. Flexible insulation:
    a. Butt edges tightly.
        1) Secure insulation with Benjamin Foster 85-20 adhesive applied in 6 inches strips on 12 IN centers and/or pins, applied on not more than 18 inches centers so that the insulation conforms to the duct surfaces uniformly and firmly.
    b. Seal joints with facing overlap or 4 inches wide strips of like facing material adhered and stapled in place.
    c. Properly seal any penetration in vapor barrier facing with Benjamin Foster 85-20.
    d. Cut insulation slightly longer than the perimeter of the duct to ensure full thickness at corners.
2. Semi-rigid insulation:
    a. Impaling over pins.
        1) Apply insulation with edges tightly butted.
        2) Apply insulation with mechanically welded fasteners to the duct and secured with speed clips.
        3) Clip pins off close to clip.

4) Space pins as required to hold insulation firmly against duct surface but not less than one pin per 1.5 square feet.
5) Seal joints and speed clips with 3 inches wide strip of facing adhered with Benjamin Foster 85-20 adhesive.

b. If the welded pin method is impossible, secure insulation to the duct with Benjamin Foster 85-20 adhesive.
1) Cover the entire surface of duct with adhesive.
2) Use corner metal angle to protect edge of insulation.
3) Protect edge of insulation.
4) Seal joints as above.

c. For outdoor application finish with Benjamin Foster #4610 weatherproof mastic with white glass fabric membrane.

3.2 REPAIR

A. Whenever any factory applied insulation or job-applied insulation is removed or damaged, replace with the same quality of material and workmanship.

3.3 SCHEDULES

A. Refrigeration Lines (35-60 degrees F):

1. Elastomeric.
2. 1/2 inches thickness for lines 1 inch and smaller.

B. Pipe, Fittings and Valves:

1. Fiberglass.

APPLICATION	PIPE SIZE	THICKNESS	JACKET
Roof Drain	2-1/2 to 6 inches	1/2 inches	PVC
Hot Water (domestic)	1-1/2 inches and less	1 inches	PVC
	Over 1-1/2 inches	1-1/2 inches	PVC
Cold Water (domestic)	All sizes	1 inches	PVC
Refrigeration Lines (35 - 60 degrees F)	All	1 inches	PVC
Condensate Vent	2 inches and less	1 inches	PVC
	2-1/2 inches to 6 inches	1-1/2 inches	
	Over 6 inches	2 inches	
Pumped Drainage	Over 4 inches	1 inches	Alum

C. Equipment:

EQUIPMENT	INSULATION SYSTEM
Hot water and steam, heating equipment, heat exchangers, air separators, strainers, condensate, receivers	2 inches fiberglass insulation. Glass mesh jacket adhered and coated with two coats of Foster 30-36 white insulation coatings.
Hot water pumps, flash tanks, compression tanks	Uninsulated

EQUIPMENT	INSULATION SYSTEM
Below drain pans serving cooling coils, pre-heat systems, domestic water heaters	1 inches flexible elastomeric closed cell sheet.
Cold water meter	Uninsulated

D. Ductwork:

1. Fiberglass.

DUCT SERVICE	INSULATION AND THICKNESS	MINIMUM R-VALUE $(HR\text{-}FT^2\text{-}DEGF)/BTU$
Outside air and supply air downstream of heat recovery units, outside building	2-1/2 inches semi-rigid for outdoor installation	12.0
Outside air ducts, inside building	2-1/2 inches semi-rigid with vapor barrier	12.0
Supply [and return] air ducts inside building	2 inches flexible with vapor barrier	6.0
Supply and return air ducts outside building and where exposed to atmospheric air	2-1/2 inches semi-rigid for outdoor installation	12.0
Return air duct in non-conditioned areas including shafts	2-1/2 inches flexible with vapor barrier	12.0
Exhaust air ducts upstream of heat recovery units, inside building	1-1/2 inches semi-rigid	6.0
Exhaust air ducts upstream of heat recovery units, outside building	2-1/2 inches semi-rigid for outdoor installation	12.0
All other ductwork	Uninsulated	N/A

END OF SECTION

SECTION 40 71 00
FLOW INSTRUMENTATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Flow Transmitters:
    a. Magnetic Flow Meters (Inline).
2. Flow Switches:
    a. Thermal Dispersion Type Flow Switches

B. The instruments specified in this Specification Section are the primary element components for the control loops which are specified in Specification Section 40 90 05 and shown on the Control System Drawings.

1. These instruments are integrated with other control system components specified under Specification Section 40 90 00 to produce the functional control system defined in the Contract Documents

C. Related Specification Sections include but are not necessarily limited to:

1. Section 40 90 00 - Instrumentation for Process Control - Basic Requirements.
2. Section 40 90 05 - Control Loop Descriptions.

D. Referenced Standards:

1. American Gas Association (AGA):
    a. Gas Measurement Committee Report #3.
2. American Society of Mechanical Engineers (ASME):
    a. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
    b. A240, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
    c. B16.5, Pipe Flanges and Flanged Fittings.
    d. B626, Standard Specification for Welded Nickel and Nickel-Cobalt Alloy Tube.
    e. PTC 19.5, Application of Fluid Meters, Part 2.
3. ASTM International (ASTM):
    a. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
4. American Water Works Association (AWWA).
5. National Sanitation Foundation (NSF).
6. US Department of Interior Bureau of Reclamation (USDIBR):
    a. Water Measurement Manual.

1.2 SUBMITTALS

A. Shop Drawings:

1. See Specification Section 40 90 00.

B. Operation and Maintenance Manuals:

1. See Specification Section 01 78 23 for requirements for:
    a. The mechanics and administration of the submittal process.
    b. The content of Operation and Maintenance Manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the manufacturers listed in the Articles describing the elements are acceptable.

2.2 FLOW TRANSMITTERS

A. Magnetic Flow Meters (Inline):

1. Acceptable manufacturers:
   a. Endress + Hauser (ProMag).
   b. ABB (WaterMaster).
   c. Krohne (OPTIFLUX).
   d. Rosemount (8700 Series).
   e. Siemens (SITRANS F M).
2. Design and fabrication:
   a. Utilize characterized field principle of electromagnetic induction to produce signal directly proportional to flow rate.
   b. High input impedance pre-amplifiers.
      1) Minimum impedance: 10^{10} ohms.
   c. Provide flanged end connections per ASME B16.5 up to 24 inches rated for piping system operating and test conditions. Meter body shall be rated to same pressure as the flanges.
   d. Grounding requirements:
      1) Nonmetallic or lined pipe:
         a) Inlet and outlet grounding rings of same material as electrode or as recommended by manufacturer to meet process requirements.
      2) Conductive piping:
         a) Conductive path between the meter and the piping flanges.
   e. Provide cable between magnetic flow meter and remote transmitter where applicable.
      1) Cable shall be potted and fitted by manufacturer at the factory.
   f. Pulsed DC magnetic field excitation.
   g. Automatic zero.
   h. Adjustable low flow cutoff.
   i. Minimum signal lock (empty tube zero) to prevent false measurement when tube is empty.
   j. Inaccuracy: ±0.4% of rate.
   k. 4-20 mA DC HART isolated output into maximum 800 ohms.
   l. Power supply: 117 V ±10%, 60 Hz.
   m. Indication of flow rate and totalized flow at transmitter.
   n. Meter operable as specified in liquids with 5.0 micro mho/cm or more conductivity.
   o. Transmitter electronics shall use microprocessor based architecture and be configured using parameters.
   p. All meters for drinking water service shall be NSF 61 certified.
3. Schedule:

TAG NUMBER	SERVICE	FLOW RANGE (GPM)	METER SIZE (IN)	NEMA (IP) RATING
FE/FIT-01-01	RS	350 to 10,600	12”	

TAG NUMBER	SERVICE	FLOW RANGE (GPM)	METER SIZE (IN)	NEMA (IP) RATING
FE/FIT-01-02	RS	250 to 7,500	10”	
FE/FIT-04-01[1]	DGS	155 to 5,700[2]	12”	
FE/FIT-04-02[1]	DGS	155 to 5,700[2]	12”	

[1] Bid Alternate – Batch Tank Pumping.

[2] 0 x Diam inlet/outlet runs.

TAG NUMBER	LINER MATERIAL	ELECTRODE MATERIAL	INTEGRAL, FIELD OR PANEL-MOUNTED TRANSMITTER
FE/FIT-01-01			
FE/FIT-01-02			
FE/FIT-04-01[1]			
FE/FIT-04-02[1]			

[1] Bid Alternate – Batch Tank Pumping.

2.3 FLOW SWITCHES

A. Thermal Dispersion Type Flow Switches:

1. Acceptable manufacturer:
   a. Endress + Hauser (Proline T-mass).
   b. Fluid Components, Inc.
   c. Kurz Instruments, Inc.
   d. Magnetrol (Thermatel TD1/TD2).
2. Materials:
   a. All wetted surfaces: Hastelloy C.
   b. Enclosure: Cast iron or aluminum.
3. Design and fabrication:
   a. Solid state electronics.
   b. Inaccuracy, gas: ±2.5% of reading or ±2 SFPS.
   c. Repeatability: ±1% of full signal.
   d. Utilize two platinum RTD's in thermowells in flow stream for differential temperature measurement.
   e. SPDT switch points.
      1) Contacts rated:
      2) 1 amp inductive at 125 VDC.
      3) 1 amp inductive at 120 VAC.
   f. Process connections: 3/4 inches MNPT.
   g. Power supply: 120 VAC, 60 Hz.
   h. Process temperature: -40 to 110 degrees F.
   i. Ability to set flow switching point in field.
4. Schedule:

TAG NUMBER	SERVICE	FLOW RANGE (SCFM)	PROCESS			PIPE SIZE (IN)	NEMA (IP) RATING
			MEDIUM	TEMP	PRESSURE		
FSL-02-01	HVAC Channel Exhaust						
FSL-02-02	HVAC Room Exhaust						
FSL-02-03	HVAC Air Inlet						

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

3.2 TRAINING

A. Provide on-site training in accordance with Specification Section 01 79 23.

END OF SECTION

SECTION 40 72 00
LEVEL INSTRUMENTATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Level Transmitters:
   a. Non-contact Radar Level Sensor and Transmitter.
2. Level Switches:
   a. Float-Tilt Type Level Switch.

A. The instruments specified in this Specification Section are the primary element components for the control loops which are specified in Specification Section 40 90 05 and shown on the Control System Drawings.

1. These instruments are integrated with other control system components specified under Specification Section 40 90 00 to produce the functional control system defined in the Contract Documents

B. Related Specification Sections include but are not necessarily limited to:

1. Section 40 90 00 - Instrumentation for Process Control - Basic Requirements.
2. Section 40 90 05 - Control Loop Descriptions.
3. Section 40 70 06 - Schedule of Instrumentation for Process Systems

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Society of Mechanical Engineers (ASME):
   a. B16.5, Pipe Flanges and Flanged Fittings.
2. ASTM International (ASTM):
   a. A106, Standard Specification for Seamless Carbon Steel Pipe for High Temperature Service.
   b. A743, Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application

1.3 SUBMITTALS

A. Shop Drawings:

1. See Specification Section 40 90 00.

B. Operation and Maintenance Manuals:

1. See Specification Section 01 78 23 for requirements for:
   a. The mechanics and administration of the submittal process.
   b. The content of Operation and Maintenance Manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the manufacturers listed in the Articles describing the elements are acceptable.

2.2 LEVEL TRANSMITTERS

A. Non-Contact Type Radar Level Transmitter:

1. Manufacturers:
    a. Endress + Hauser (*Micropilot* FMR20) with E&H RIA15 remote level indication display.
    b. Emerson Rosemount (5408 Series) with remote level indication display.
    c. Emerson Rosemount (1408A Series) with remote level indication display.
    d. .Siemens (*Sitrans* LR) with remote level indication display.
2. Specifications:
    a. General:
        1) Measurement Principle: Continuous level measurement via non-contact radar signal measuring the “time of flight” for the signal to travel from the sensor to the measured surface and back again.
            a) Level Measurement.
            b) Connection as shown on Drawings.
            c) Blanking Distance: Up to 12 inches.
            d) Application: Liquids or Solids that are viscous or corrosive.
        2) Measurement Range (see Schedule):
            a) Varies according to Antenna (High or Low) and Beam Angle (9 to 37 degrees).
            b) Maximum range: 10 to 115 feet.
        3) Accuracy:
            a) ±0.1 inches (low frequency).
            b) ±0.4 inches (high frequency).
        4) Resolution: 0.04 inches.
        5) Temperature Stability: ±0.05%.
        6) Response Time: 1 second.
    b. Process Connection:
        1) Threaded (NPT): See Schedule.
        2) Flange (ASME): See Schedule.
    c. Display and Configuration:
        1) Remote Display for live measurement and configuration.
        2) Adjustable zero and span.
        3) Output variable: Level.
        4) Output Units: Feet, inches, meters, or millimeters (mm).
    d. Electrical:
        1) Signal Power: Loop-powered, 2-wire, 24 VDC.
        2) Current Output: Analog 4-20 Ma into a 400 ohm loop.
        3) High/Low signal alarms (< 4.0 mA and > 20.0 mA).
        4) Optional Communication: HART.
        5) Configuration: With remote hand-held configurator.
        6) Cable entry: 1/2 inches NPT connection.
        7) Complies with FCC Part 15.
    e. Materials of Construction:
        1) Antenna:
            a) Materials chemically inert in the mounting environment.
            b) Cone Antenna
            c) Sensor module: 316L SST
            d) Cone Antenna: 316 L SST.
        2) Housing: 316.

3) O-rings: Viton.
4) Flanges (ASME B16.5): 316 stainless steel.

f. Environment:
1) Ambient Temperature: -40 to 158 degrees F (-40 to 70 degrees C).
2) Humidity: Up to 99%.
3) Process Temperature: -4 to 185 degrees F (-20 to 85 degrees C).
4) Process Pressure: 0 to 150 psiG.
5) Protection: Refer to Area Classification Drawings.

3. Schedule (or Instrument List):

TAG NUMBER	SERVICE	ANTENNA TYPE and SIZE (IF HORN)	SPAN	MOUNT TYPE and SIZE
LE/LIT-01-01	Woodside Influent Lift Station (RS)		0 – 26 FT	
LE/LIT-04-01	Batch Tank (DGS)		0 – 11 FT	

2.3 LEVEL SWITCHES

A. Float-Tilt Type Level Switch:

1. Manufacturers:
a. Anchor Scientific Inc.
b. Consolidated Electric.
c. Contegra.
2. Materials:
a. Float material: Polypropylene or Teflon coated type 316 stainless steel.
b. Cable jacket: PVC, neoprene.
c. Cable clamp: Polypropylene or 316 stainless steel.
3. Design and fabrication:
a. Mercury-free switch.
b. Provide switch complete with flexible electrical cables.
c. SPDT contact rated at 1 amp at 120 VAC.
d. Direct acting float switch:
1) Switch actuates on rising level.
2) Switch deactuates when liquid falls 1 inch below actuation level.
e. Terminate cables in junction box.
f. Process temperature: max. 120 degrees F.
g. Install floats per drawing details.
4. Schedule (or Instrument List):

TAG NUMBER	SERVICE	CONTACT NO / NC / NO-NC	MOUNTING ELEVATION	MOUNTING (Suspended or Pipe)
LSL-01-01	Woodside Influent Lift Station (RS)			Pipe
LSH-01-01	Woodside Influent Lift Station (RS)			Pipe

TAG NUMBER	SERVICE	CONTACT NO / NC / NO-NC	MOUNTING ELEVATION	MOUNTING (Suspended or Pipe)
LSH-01-02	Woodside Influent Lift Station (RS)			Pipe
LSH-01-03	Woodside Influent Lift Station (RS)			Pipe
LSHH-01-01	Woodside Influent Lift Station (RS)			Pipe
LSL-04-01	Batch Tank (DGS)			Pipe
LSH-04-01	Batch Tank (DGS)			Pipe
LSH-04-02	Batch Tank (DGS)			Pipe
LSH-04-03	Batch Tank (DGS)			Pipe
LSHH-04-01	Batch Tank (DGS)			Pipe

2.4 ACCESSORIES

A. Furnish all mounting brackets, hardware and appurtenances required for mounting primary elements and transmitters.

1. Materials, unless otherwise specified, shall be as follows:
   a. Bolts, nuts, washers, expansion anchors: 316 stainless steel.
   b. Mounting brackets:
      1) Standard: 316 stainless steel.
      2) Highly corrosive areas: Aluminum.
   c. Mounting plates, angles:
      1) Standard: Carbon steel.
      2) Corrosive areas: Aluminum.
   d. Instrument pipe stands:
      1) Standard: Hot-dip galvanized 2 inches schedule 40, ASTM A106, Grade B carbon steel.
      2) Corrosive areas: Aluminum.

B. Provide handheld communicator compatible for all intelligent transmitters furnished.

1. Hand held communicator shall provide capability to check calibration, change transmitter range, and provide diagnostics.
2. If these features are provided with the intelligent transmitter that is accessible, the hand held communicator is not required.

C. Cable lengths between sensors and transmitters shall be continuous (without splices) and as required to accommodate locations as shown on Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install instrument mounting pipe stands level and plumb.

C. Instrument Valves:

1. Orient stems for proper operation.
2. Install arrays orderly and neat in appearance with true horizontal and vertical lines.
3. Provide a minimum of 2 inches clearance between valve handle turning radii where there are multiple valve handles appearing in a straight line.
4. Valves shall have bonnets and any soft seals removed during welding or soldering into the line.
    a. When cool, reassemble the valves.
5. Support each valve individually.
    a. The tubing system does not qualify as support for the valve.

D. Locate instrument piping and tubing so as to be free of vibration and interference with other piping, conduit, or equipment.

E. Keep foreign matter out of the system.

F. Remove all oil on piping and tubing with solvent before piping and tubing installation.

G. Plug all open ends and connections to keep out contaminants.

H. Threaded Connection Seals:

1. Use Tite-Seal or acceptable alternate.
2. Use of lead base pipe dope or Teflon tape is not acceptable.
3. Do not apply Tite-Seal to tubing threads of compression fittings.

I. Instrument Mounting:

1. Mount all instruments where they will be accessible from fixed ladders, platforms, or grade.
2. Mount all local indicating instruments with face forward toward the normal operating area, within reading distance, and in the line of sight.
3. Mount instruments level, plumb, and support rigidly.
4. Mount to provide:
    a. Protect from heat, shock, and vibrations.
    b. Provide accessibility for maintenance.
    c. Free from interference with piping, conduit and equipment.

3.2 TRAINING

A. Provide on-site training in accordance with Specification Section 01 79 23.

END OF SECTION

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SECTION 40 73 00
PRESSURE INSTRUMENTATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pressure Indicators.
    a. Pressure Gauges – Mechanical.
2. Isolation Devices.
    a. Diaphragm Seals.
    b. In-Line Isolation Sleeve (Annular Seal).

B. Related Specification Sections include but are not necessarily limited to:

1. Section 40 90 00 - Process Control Systems General Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Society of Mechanical Engineers (ASME):
    a. B16.5, Pipe Flanges and Flanged Fittings
2. ASTM International (ASTM):
    a. A106/A106M, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.

1.3 SUBMITTALS

A. Shop Drawings:

1. See Specification Section 40 90 00.

B. Operation and Maintenance Manuals:

1. See Specification Section 01 78 23 for requirements for:
    a. The mechanics and administration of the submittal process.
    b. The content of Operation and Maintenance Manuals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the manufacturers listed in the Articles describing the elements are acceptable.

2.2 PRESSURE INDICATORS

A. Pressure Gauge - Mechanical:

1. Manufacturers:
    a. Ametek / USGauge (Solfrunt Model 1980).
    b. Ashcroft (Type 1279 or 1379).
2. Materials:
    a. Bourdon tube, socket, connecting tube: 316 stainless steel.
    b. Case: Phenolic.
    c. Pressure snubber:
        1) Filter disc: 316 stainless steel.

2) Housing: 316 stainless steel.

3. Accessories:
   a. Provide valve at point of connection to equipment and at panel if panel mounted.
   b. Utilize pressure snubber with porous metal discs to provide pulsation dampening on gauge applications as shown on schedule.
   c. Provide 1/2 inches stainless steel anti-siphon pigtail inlet connection for hot water and steam applications.
4. Design and fabrication:
   a. All components suitable for service at:
      1) 250 degrees F.
      2) The maximum process temperature to which the gauge is to be exposed.
   b. Provide viewer protection from element rupture.
   c. Calibrate gauges at jobsite for pressure and temperature in accordance with manufacturer's instructions.
   d. Unless otherwise required by codes, provide stem mounted or flush mounted, as required, with dial diameter as follows:

PIPE SIZE	DIAL SIZE	GAUGE CONNECTION
1-1/2 inches or less	2-1/2 inches	1/4 inches
Larger than 1-1/2 inches	4-1/2 inches	1/2 inches

   e. Equip with white faces, black numerals and black pointers.
   f. Gauge tapping position to be clear of equipment functions and movements, and protected from maintenance and operation of equipment.
      1) Gauge to be readable from an accessible standing position.
   g. Gauge accuracy: 1% of full range.
   h. Select gauge range so that:
      1) The normal operating value is in the middle third of the dial.
      2) Maximum operating pressure does not exceed 75% of the full scale range.

2.3 ISOLATION DEVICES

A. Sludge or Scum Service Instrument Isolators:
   1. Manufacturers:
      a. Ashcroft, Inc. (Model 106).
      b. Or equal.
   2. Materials:
      a. Diaphragm: 316 stainless steel.
      b. Lower Housing: 316 stainless steel.
   3. Design and fabrication:
      a. Isolates instruments from process fluids which are corrosive or contain solids.
      b. Upper housing with bleed screw.
      c. Lower housing with flushing connection.
      d. Fill fluid:
         1) Utilize halocarbon fill for process applications involving strong oxidizing agents.
            a) Agents include but are not limited to: Cl_2, $KMNO_4$, FeCl, NaOH, and NaOCl.
         2) Utilize manufacturer's standard fill for other applications.
            a) Ensure fill is suitable for application temperatures.

e. Process connections:
1) 0.5 inches female NPT.
2) Process: In-lined flanged, match line size
4. Install instrument isolators for pressure gauges on GR – Grit process piping.

2.4 ACCESSORIES

A. Furnish all mounting brackets, hardware and appurtenances required for mounting primary elements and transmitters.

1. Materials, unless otherwise specified, shall be as follows:
a. Bolts, nuts, washers, expansion anchors: 316 stainless steel.
b. Mounting brackets:
1) Standard: 316 stainless steel.
2) Highly corrosive areas: Aluminum.
c. Mounting plates, angles:
1) Standard: Carbon steel.
2) Corrosive areas: Aluminum.
d. Instrument pipe stands:
1) Standard: Hot-dip galvanized 2 inches schedule 40, ASTM A106, Grade B carbon steel.
2) Corrosive areas: Aluminum.

B. Tubing Support Angles and Brackets:

1. Any of the following materials are acceptable:
a. Aluminum support with dielectric material between support and tubing.
b. Type 316 stainless steel.
c. Fiberglass.

C. Tubing Tray or Channel:

1. Aluminum.
2. Provide dielectric material between tray or channel and tubing.

D. Provide handheld communicator compatible with all intelligent transmitters furnished.

1. Hand held communicator shall provide capability to check calibration, change transmitter range, and provide diagnostics.
2. If these features are provided with the intelligent transmitter, the hand held communicator is not required.

E. Cable lengths between sensors and transmitters shall be continuous (without splices) and as required to accommodate locations as shown on Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Provide pressure gages on suction and discharge of each pump and blower and at locations indicated on Drawings or otherwise specified.

C. Provide compound type on pump suction gages which show at least 10 psi vacuum.

D. Install instrument mounting pipe stands level and plumb.

E. Instrument Valves:

1. Orient stems for proper operation.

2. Install arrays orderly and neat in appearance with true horizontal and vertical lines.
3. Provide a minimum of 2 inches clearance between valve handle turning radii where there are multiple valve handles appearing in a straight line.
4. Valves shall have bonnets and any soft seals removed during welding or soldering into the line.
    a. When cool, reassemble the valves.
5. Support each valve individually.
    a. The tubing system does not qualify as support for the valve.

F. Locate instrument piping and tubing so as to be free of vibration and interference with other piping, conduit, or equipment.

G. Keep foreign matter out of the system.

H. Remove all oil on piping and tubing with solvent before piping and tubing installation.

I. Plug all open ends and connections to keep out contaminants.

J. Threaded Connection Seals:

1. Use Tite-Seal or acceptable alternate.
2. Use of lead base pipe dope or Teflon tape is not acceptable.
3. Do not apply Tite-Seal to tubing threads of compression fittings.

K. Instrument Mounting:

1. Mount all instruments where they will be accessible from fixed ladders, platforms, or grade.
2. Mount all local indicating instruments with face forward toward the normal operating area, within reading distance, and in the line of sight.
3. Mount instruments level, plumb, and support rigidly.
4. Mount to provide:
    a. Protection from heat, shock, and vibrations.
    b. Accessibility for maintenance.
    c. Freedom from interference with piping, conduit and equipment.

3.2 TRAINING

A. Provide on-site training in accordance with Specification Section 01 75 00.

END OF SECTION

SECTION 40 90 00

PROCESS CONTROL SYSTEM: BASIC REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Basic requirements for complete instrumentation system for process control.

B. Related Specification Sections include but are not necessarily limited to:

1. Division 00 - Procurement and Contracting Requirements.
2. Division 01 - General Requirements.
3. Division 26 - Electrical
4. Section 10 14 00 - Identification Devices.
5. Section 40 98 00 - Control Panels and Enclosures.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. The International Society of Automation (ISA):
   a. 7.0.01, Quality Standard for Instrument Air.
   b. S5.1, Instrumentation Symbols and Identification.
   c. S5.3, Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Systems.
   d. S5.4, Standard Instrument Loop Diagrams.
   e. S20, Standard Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves.
   f. 101 Human Machine Interfaces
   g. 95 Enterprise-Control System Integration
2. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
3. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
4. Underwriters Laboratories, Inc. (UL):
   a. 913, Standard for Safety, Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, and III, Division 1, Hazardous (Classified) Locations.

B. Qualifications:

1. Instrumentation subcontractor:
   a. Experience:
      1) Have satisfactorily provided a control system for a minimum of five (5) projects of similar magnitude and function.

C. Miscellaneous:

1. Comply with electrical classifications and NEMA enclosure types shown on Drawings.

1.3 DEFINITIONS

A. Architecturally finished area: Offices, laboratories, conference rooms, restrooms, corridors and other similar occupied spaces.

B. Non-architecturally Finished Area: Pump, chemical, mechanical, electrical rooms and other similar process type rooms.

C. Hazardous Areas: Class I, II or III areas as defined in NFPA 70.

D. Highly Corrosive and Corrosive Areas: Rooms or areas identified on the Drawings where there is a varying degree of spillage or splashing of corrosive materials such as water, wastewater or chemical solutions; or chronic exposure to corrosive, caustic or acidic agents, chemicals, chemical fumes or chemical mixtures.

E. Outdoor Area: Exterior locations where the equipment is normally exposed to the weather and including below grade structures, such as vaults, manholes, handholes and in-ground pump stations.

F. Instrument Air Header: The segment of air supply piping and tubing which transports air from the compressed instrument air source through the branch isolation valve of any takeoff (branch) line.

G. Branch Line: The segment of air supply piping and tubing which transports air from the outlet of the air header branch isolation valve through an air user's isolation valve.

H. Intrinsically Safe Circuit: A circuit in which any spark or thermal effect is incapable of causing ignition of a mixture of flammable or combustible material in air under test conditions as prescribed in UL 913.

I. Calibrate: To standardize a device so that it provides a specified response to known inputs.

1.4 CONTROL SYSTEM REQUIREMENTS:

1. This Specification Section provides the general requirements for the instrument and control system.
2. The instrument and control system consist of all primary elements, transmitters, switches, controllers, computers, recorders, indicators, panels, signal converters, signal boosters, amplifiers, special power supplies, special or shielded cable, special grounding or isolation, auxiliaries, software, wiring, and other devices required to provide complete control of the plant as specified in the Contract Documents.
3. The existing Process Instrumentation and Control Systems (PICS) design and associated native Ethernet IP network protocol is based on the existing plant Rockwell Automation platform. Network standardization is required to maximize operational efficiency and effectiveness, and minimize network operational costs.
    a. All new equipment connected to PICS via Ethernet shall utilize native Ethernet IP protocol. The term “native” used in this context means that the protocol is integral to the equipment—a converter or gateway to convert from one protocol to another (e.g., Modbus Plus to Ethernet IP) is not required. *The use of protocol converters and gateways for substitute equipment is not acceptable.*
    b. All proposals for substitute products shall demonstrate equipment compatibility with existing software and hardware systems, replacement parts requirements, and training requirements. The bid price of the proposed substitute products shall include:
        1) 8 hours of training (in addition to that specified herein) for Owner operations personnel
        2) Spare parts (for each type/size) including control and power boards or modules, operator interface units, and communication and input/output modules

        PICS modification design, programming, and integration costs required to accommodate the proposed substitute.

B. All signals shall be directly linearly proportional to measured variable unless specifically noted otherwise.

C. Single Instrumentation Subcontractor:

1. Furnish and coordinate instrumentation system through a single instrumentation subcontractor.
    a. The instrumentation subcontractor shall be responsible for functional operations of all systems, performance of control system engineering, supervision of installation, final

connections, calibrations, preparation of Drawings and Operation and Maintenance Manuals, start-up, training, demonstration of substantial completion and all other aspects of the control system.

2. Ensure coordination of instrumentation with other work to ensure that necessary wiring, conduits, contacts, relays, converters, and incidentals are provided in order to transmit, receive, and control necessary signals to other control elements, to control panels, and to receiving stations.
3. Prior to Shop Drawing preparation, the Instrumentation Subcontractor shall inspect the Owner's existing equipment and as-constructed electrical documentation so as to be able to fully coordinate the interface of new and existing instrumentation and controls. All costs associated with this Work shall be incorporated into the original bid. Although such Work is not specifically indicated, furnish and install all supplementary or miscellaneous items, appurtenances and devices incidental to or necessary for a sound, secure, complete and compatible installation.

1.5 BASIS OF DESIGN

A. Basis of design includes the following:

1. Equipment and motors as shown in the PID's, network diagram, electrical one-line drawing(s) and load/panel schedules.
2. Digital control systems and associated network protocols and software based on a specific technology platform. Such digital control systems are often proprietary in nature and include, but are not limited to, lighting control systems, generator control systems, fire alarm systems, Process Instrumentation and Control System PICS (i.e., SCADA) systems, and motor control systems.
3. Unless otherwise noted, all new control equipment components connected to the PICS via Ethernet shall utilize native Ethernet/IP protocol. The term "native" used in this context means that the protocol is integral to the equipment—a converter, gateway or card used to convert from one protocol to another (e.g., Modbus Plus to Ethernet IP) is not required. The use of these devices is not acceptable.

B. If different equipment or sizes are provided in order for the vendor's equipment to meet mechanical performance requirements, the contractor shall coordinate various suppliers, vendors, and subcontractors to change the required electrical conduit, circuits, breakers, motor control center sections, motor controllers, and accessories, etc. as necessary to meet the vendor's equipment installation requirements. The traits and characteristics of all provided materials, equipment, and devices shall meet the specifications. These changes to materials, equipment, and devices shall be at no cost to the Owner. Electrical submittal information shall be coordinated with the equipment and motors provided.

C. The contract for the work will be based on materials and equipment included in the Contract Documents, and those "or-equal" and substitute products subsequently approved as outlined in Bidding Requirements, Conditions of the Contract, and Division 1. The burden of proof regarding proposed product merit and the associated cost by the Engineer/Owner to evaluate the product merit is upon the Bidder. Any assumptions regarding the possibility of post-bid approvals of or-equal or substitution requests are made at Bidder's sole risk.

D. "Or-Equal" or Substitute Digital Control System Materials and Software:

1. Technology platform standardization is required to maximize performance, efficiency, and effectiveness and to minimize technology platform total cost of ownership (TCO). Therefore, the determination of associated "or-equal" or substitute materials and equipment will be based on these elements in addition to those specified in the Contract Documents.
2. TCO includes initial engineering/design costs, construction administration costs, equipment acquisition and installation costs, and ongoing operating costs and personnel/resource costs associated with management and support after construction is completed.
    a. Design costs include digital control system design documents including, but not limited to, network diagrams, riser diagrams, I/O matrixes, schematics, wiring diagrams, equipment layouts, and bill of materials based on the specified product.

b. Construction administration costs include anticipated submittal reviews, RFI's, construction changes, and record drawing development based on the specified product.

c. Acquisition and installation costs include software, hardware, implementation, customization, user licenses, data migration, user training, integrating third-party systems, and physical equipment installation.

d. Operating costs include replacement parts, additional user licenses, ongoing personnel training, software and firmware maintenance and support, additional integrations, downtime, associated third party service contracts, and electronic security.

e. Personnel/resource costs include personnel required to manage the system, keeping the system secure, and keeping up with technology obsolescence and maintenance.

3. All associated written requests for approval shall include as a minimum:

a. Assurance that the proposed system is compatible with any existing digital control system software and hardware system elements proposed to remain in place. Depending on the Owner's familiarity, a workshop with the Engineer and Owner may also be required to demonstrate compatibility.

b. TCO breakdown comparison for both the substitute product and that specified. Include actual and verifiable data from similar recent projects to validate.

c. Net present value (NPV) analysis for both the substitute product TCO and that specified to present to the Owner for evaluation. If elements of the existing digital control systems are proposed to remain in place, the NPV analysis shall also include ongoing operating costs and personnel/resource costs associated with managing both technology types. All Owner related ongoing operating costs and personnel/resource costs forecasted after construction shall be validated and agreed upon by the Owner.

d. Modified design documents showing updated network diagrams, schematics, wiring diagrams, bill of materials, and any other design related changes to accommodate the substitute equipment.

4. Contractor represents the proposals for "or-equal" and substitute products also include:

a. 8 hours of training (in addition to that specified herein) for Owner operations personnel.

b. Spare parts (one for each type/size) including control and power boards or modules, operator interface units, and communication and input/output modules.

c. Engineering design and construction administration costs that may result or are required to accommodate the proposed substitute. Engineer will define these costs during evaluation of substitute.

1.6 SUBMITTALS

A. Shop Drawings:

1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. Submittals shall be original printed material or clear unblemished photocopies of original printed material.
   a. Facsimile information is not acceptable.
3. Limit the scope of each submittal to one (1) Specification Section.
   a. Each submittal must be submitted under the Specification Section containing requirements of submittal contents.
   b. Do not provide any submittals for Specification Section 40 90 00.
4. Product technical data including:
   a. Equipment catalog cut sheets.
   b. Instrument data sheets:
      1) ISA S20 or approved equal.
      2) Separate data sheet for each instrument.

c. Materials of construction.
d. Minimum and maximum flow ranges.
e. Pressure loss curves.
f. Physical limits of components including temperature and pressure limits.
g. Size and weight.
h. Electrical power requirements and wiring diagrams.
i. NEMA rating of housings.

5. Submittals shall be marked with arrows to show exact features to be provided. Comprehensive set of wiring diagrams as specified in Specification Section 40 98 00.
6. Panel fabrication drawings as specified in Specification Section 40 98 00.
7. PLC/DCS equipment drawings.
8. HMI graphics.
9. Nameplate layout drawings.
10. Drawings, systems, and other elements are represented schematically in accordance with plant standards.
    a. The nomenclature, tag numbers, equipment numbers, panel numbers, and related series identification contained in the Contract Documents shall be employed exclusively throughout submittals.
11. All Shop Drawings shall be modified with as-built information/corrections.
12. All panel and wiring drawings shall be provided in both hardcopy and softcopy.
    a. Furnish electronic files on thumb drive.
    b. Drawings in AUTO CAD format.
13. Provide a parameter setting summary sheet for each field configurable device.
14. Certifications:
    a. Documentation verifying that calibration equipment is certified with NIST traceability.
    b. Approvals from independent testing laboratories or approval agencies, such as UL..
        1) Certification documentation is required for all equipment for which the specifications require independent agency approval.
15. Testing reports: Source quality control reports.

B. Contract Closeout Information:

1. Operation and Maintenance Data:
    a. See Specification Section 01 33 00 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.
2. Warranties: Provide copies of warranties and list of factory authorized service agents.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Do not remove shipping blocks, plugs, caps, and desiccant dryers installed to protect the instrumentation during shipment until the instruments are installed and permanent connections are made.

1.8 SITE CONDITIONS

A. Unless designated otherwise on the Drawings, area designations are as follows:

1. Outdoor area:
    a. Wet.
    b. Corrosive and/or hazardous when specifically designated on the Drawings or in the Specifications.
    c. Below grade vaults and manholes:
        1) Subject to temporary submergence when specifically designated on the Drawings or Specifications.

2. Architecturally finished area:
    a. Dry.
    b. Noncorrosive unless designated otherwise on the Drawings or in the Specifications.
    c. Nonhazardous unless designated otherwise on the Drawings or in the Specifications.
3. Non-architecturally finished area: As designated elsewhere on the Drawings or in the Specifications.

PART 2 - PRODUCTS

2.1 NEMA TYPE REQUIREMENTS

A. Provide enclosures/housing for control system components in accordance with the following:

1. Areas designated as wet: NEMA Type 4.
2. Areas designated as wet and/or corrosive: NEMA Type 4X.
3. Areas designated as Class I hazardous, Groups A, B, C, or D as defined in NFPA 70:
    a. NEMA Type 7 unless all electrical components within enclosure utilize intrinsically safe circuitry.
        1) Utilize intrinsically safe circuits to the maximum extent practical and as depicted in the Contract Documents.
4. Areas designated as Class II hazardous, Groups E, F, or G as defined in NFPA 70:
    a. NEMA Type 9 unless all electrical components within enclosure utilize intrinsically safe circuitry.
        1) Utilize intrinsically safe circuits to the maximum extent practical and as depicted in the Contract Documents.
5. Either architecturally or non-architecturally finished areas designated as dry, noncorrosive, and nonhazardous: NEMA Type 12.
6. Areas designated to be subject to temporary submersion: NEMA 6P.

2.2 PERFORMANCE AND DESIGN REQUIREMENTS

A. System Operating Criteria:

1. Stability: After controls have taken corrective action, as result of a change in the controlled variable or a change in setpoint, oscillation of final control element shall not exceed two (2) cycles per minute or a magnitude of movement of 0.5 percent full travel.
2. Response: Any change in setpoint or change in controlled variable shall produce a corresponding corrective change in position of final control element and become stabilized within 30 seconds.
3. Agreement: Setpoint indication of controlled variable and measured indication of controlled variable shall agree within 3 percent of full scale over a 6:1 operating range.
4. Repeatability: For any repeated magnitude of control signal, from either an increasing or decreasing direction, the final control element shall take a repeated position within 0.5 percent of full travel regardless of force required to position final element.
5. Sensitivity: Controls shall respond to setpoint deviations and measured variable deviations within 1.0 percent of full scale.
6. Performance: All instruments and control devices shall perform in accordance with manufacturer's specifications.

2.3 ACCESSORIES

A. Provide identification devices for instrumentation system components in accordance with Specification Section 10 14 00.

B. Provide corrosion resistant spacers to maintain 1/4 IN separation between equipment and mounting surface in wet areas, on below grade walls and on walls of liquid containment or processing areas such as Clarifiers, Digesters, Reservoirs, etc.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Wherever feasible, use bottom entry for all conduit entry to control panels, instruments and junction boxes.

B. Install electrical components per the requirements of the Electrical design and specifications.

C. Panel-Mounted Instruments:

1. Mount and wire so removal or replacement may be accomplished without interruption of service to adjacent devices.
2. Locate all devices mounted inside enclosures so terminals and adjustment devices are readily accessible without use of special tools and with terminal markings clearly visible.

D. See Specification Section 26 05 19.

3.2 FIELD QUALITY CONTROL

A. Maintain accurate daily log of all startup activities, calibration functions, and final setpoint adjustments.

1. Documentation requirements include the utilization of the forms located at the end of this Specification Section.
   a. Loop Check-out Sheet.
   b. Instrument Certification Sheet.
   c. Final Control Element Certification Sheet.

B. In the event that instrument air is not available during calibration and testing, supply either filtered, dry, instrument quality air from a portable compressor or bottled, dry, instrument quality air.

1. Do not, under any circumstances, apply hydrostatic test to any part of the air supply system or pneumatic control system.

C. Pneumatic Signal Tubing Testing:

1. Before the leak test is begun, blow clean with dry air.
2. Test signal tubing per ISA 7.0.01, except for tubing runs of less than 10 FT where simple soap bubble testing will suffice.
3. If a leak is detected, repair the leak and repeat the leak test.
4. After completion of the leak test, check each signal line for obstructions.
   a. If any are indicated, remove and retest.

D. Instrumentation Calibration:

1. Verify that all instruments and control devices are calibrated to provide the performance required by the Contract Documents.
2. Calibrate all field-mounted instruments, other than local pressure and temperature gages, after the device is mounted in place to assure proper installed operation.
3. Calibrate in accordance with the manufacturer's specifications.
4. Bench calibrate pressure and temperature gages.
   a. Field mount gage within seven (7) days of calibration.
5. Check the calibration of each transmitter and gage across its specified range at 0, 25, 50, 75, and 100 percent.
   a. Check for both increasing and decreasing input signals to detect hysteresis.

6. Replace any instrument which cannot be properly adjusted.
7. Stroke control valves with clean dry air to verify control action, positioner settings, and solenoid functions.
8. Calibration equipment shall be certified by an independent agency with traceability to NIST.
    a. Certification shall be up-to-date.
    b. Use of equipment with expired certifications shall not be permitted.
9. Calibration equipment shall be at least three (3) times more accurate as the device being calibrated.

E. I/O Loop Testing

1. General Testing Procedures: The System Integrator and electrical contractor shall provide all necessary labor, tools, and equipment to field test, inspect and adjust each instrument installed under this contract to its specified performance requirement in accordance with manufacturer's specifications and instructions.
2. The System Integrator in coordination with the electrical contractor shall test all wiring and primary control devices. The system integrator shall provide documentation to the Owner of the testing procedures and results of the following:
    a. All Process Control Panels are installed, connected to power, and fully wired for all I/O points shown on the Process Control Panel Shop drawings.
    b. All field instruments are installed, wired, powered and produce the appropriate signal at the Process Control Panel.
    c. All panels and devices capable of being powered on and off have had power cycled for verification and have been documented as functional.
3. When possible, the Contractor shall simulate events of actual processes during testing.
    a. All I/O points shall be tested. The results of the test shall be documented.
    b. Any I/O point that is not tested shall be documented as well as the reason for not being tested.
4. If system malfunctions are found during I/O testing, efforts to correct malfunctions must be made. Any malfunction not capable of being corrected prior to submitting I/O testing documentation shall be documented including the procedures and actions taken attempting to correct the malfunction.
5. Point to point testing shall be performed on all digital inputs, digital outputs, analog inputs, and analog outputs. Testing shall be performed without unwiring and rewiring when possible.
    a. Digital input testing shall be performed and completed by exercising the field instrument or device. Continuity between the field side of the disconnect terminal block and input field wiring terminal block shall be verified. Results of the tests shall be documented with field device name and input number.
    b. Analog inputs shall be verified and documented for proper current /voltage range received at the PLC panel from the powered field instrument. Document the results of the tests. If the field instrument is unavailable, verify wiring is correct and proper current/voltage range is received at the panel using a signal generating device such as a process meter or other loop calibrator.
    c. Digital output circuits shall be tested by jumping the digital output relay contacts in the process control panel. The proper response should be observed and verified at the field instrument or device. Document the results of the tests.
    d. Analog outputs should be tested using a process style test meter that can provide a 4-20mA simulated source. An appropriate response should be observed and verified at the field device. Document the results of the tests.
6. All motors and valves with automated controls and a Hand-Off-Auto switch shall be operated in Hand to verify functionality. Results of the test shall be documented.

F. Functional check-out requirements are as follows:

1. Functional testing shall prove out the control system operates as outlined in the contract documents and the Process Control Description.
2. All alarm conditions shall be simulated and verified that alarms are generated and properly notified through the SCADA system.
3. The Operator shall be capable of system navigation and adjustment of all Operator adjustable set points from SCADA and at local HMI's.
4. Provide documentation of all conditions and alarms tested and provided with project closeout material.
5. Testing shall be completed when the system is capable of being automatically operated (without manual Operator intervention) for a period of approximately one week. At the end of this time period, the Owner shall sign-off as testing complete and system operational. Alternatively, the Owner may sign-off before the one week time period if completely satisfied and willing to sign off early.

Loop Check-out Sheet

Project Name:		Owner's Project No. (if applicable):	Page of
Project Owner:		Regulatory Agency Project No. (if applicable):	
HDR Project No.:		Date:	

LEAK AND TERMINATION/CONTINUITY CHECKS

DESCRIPTION	FIELD					CONTROL CAB	
	LEAK CHECK(1)			TERM/CONT CHECK(2)		TERM/CONT CHECK(2)	
	Device Tag No.	Process Conn.	Signal Tube	Device Tag No.	Termination Ident.	Device Tag No.	Termination Ident.

.. Leak check for pneumatic signal tubing to be per ISA-PR7.1.

:. Termination/continuity check includes check at terminated equipment for: (a) correct polarity, (b) appropriate signal generation, transmission and reception, and (c) correct shield & ground terminations.

OPERATOR INTERFACE CHECK-OUT

MONITORING POINTS OBSERVED

PARAMETER TYPE	TAG NO.	TAG NO.	TAG NO.	TAG NO.	TAG NO.	TAG NO.
PROCESS VAR						
EQUIP STATUS						
ALARM POINT						

OPERATOR CONTROL FUNCTIONS CHECKED

FUNCTION TYPE	TAG NO.	LOCATION	TAG NO.	LOCATION	TAG NO.	LOCATION

FINAL CONFIGURED SETTINGS

TAG NO.	SWITCH & ALARM SP	CONTROLLERS			
		Gain	Reset, rpm	Deriv. (rate), min	PV Set Point

Describe all interlocks checked, equipment started/stopped, valves/operators stroked. Describe modes of operation checked, and location of operator interface (local/remote).

I certify that the control loop referenced on this page has been completely checked and functions in accordance with applicable drawings and specifications.

Certified by:_____ Date:_____

(Work Performed By)

Instrument Certification Sheet

Project Name:	Owner's Project No. (if applicable):
Project Owner:	Regulatory Agency Project No. (if applicable):
HDR Project No.	Date:
Control Loop No.:	
Instrument Tag No.	Transmitter/gauge span:
Manufacturer:	Switch set-point:
Model No.	Switch dead band:
Serial No.	Switch range:

TRANSMITTERS AND INDICATORS

	INCREASING INPUT			DECREASING INPUT		
% OF SPAN	**INPUT**	**OUTPUT**	**ERROR (% of span)**	**INPUT**	**OUTPUT**	**ERROR (% of span)**
0%						
25%						
50%						
75%						
100%						
Other (if applicable)						
Other (if applicable)						

SWITCHES

	INCREASING INPUT			DECREASING INPUT		
ACTUATION POINT	**INPUT**	**OUTPUT**	**ERROR (% of range)**	**INPUT**	**OUTPUT**	**ERROR (% of range)**
High (Increasing input)						
Low (Decreasing input)						

Maximum allowable error (per Contract Documents): _____

Remarks: _____

_____

_____

CALIBRATION EQUIPMENT UTILIZED

DEVICE TYPE	MFR/MODEL NO.	ACCURACY	NIST TRACEABILITY?

Certified by: _____ Date Certified: _____

Final Control Element Certification Sheet

Project Name:	Owner's Project No. (if applicable):
Project Owner:	Regulatory Agency Project No. (if applicable):
HDR Project No.	Date:
Control Loop No.:	

Tag No.	
Description:	
Manufacturer:	
Model No.	
Serial No.	

Actuator:	Pneumatic: _____ Electric: _____
Positioner:	Direct: _____ Reverse: _____
Positioner:	Input: _____ Output: _____
I/P Converter:	Input: _____ Output: _____
Valve to	_____ on air failure
Valve to	_____ on power failure

I/P CONVERTER

	INCREASING INPUT			DECREASING INPUT		
% OF SPAN	**INPUT**	**OUTPUT**	**ERROR (% of span)**	**INPUT**	**OUTPUT**	**ERROR (% of span)**
0%						
25%						
50%						
75%						
100%						

Specified I/P converter accuracy: _____ % of span.

FINAL CONTROL ELEMENT

	INCREASING INPUT			DECREASING INPUT		
% OF SPAN	**INPUT**	**TRAVEL**	**ERROR (% of full travel)**	**INPUT**	**TRAVEL**	**ERROR (% of full travel)**
0%						
25%						
50%						
75%						
100%						

Remarks: _____

CALIBRATION EQUIPMENT UTILIZED

DEVICE TYPE	MFR/MODEL NO.	ACCURACY	NIST TRACEABILITY?

Certified by: _____ Date Certified: _____

SECTION 40 90 05
CONTROL LOOP DESCRIPTIONS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Equipment and instrumentation control loops.

B. Plant SCADA configuration and integration services will be provided by the Owner's system integrator under a separate contract, as described in Section 01 11 00 – Summary of Work.

1. This Section is included in Project Manual for reference only.

C. Related Specification Sections include but are not necessarily limited to:

1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
2. Division 01 - General Requirements.
3. Section 40 90 00 - Instrumentation for Process Control: Basic Requirements.
4. Section 40 96 52 – Configuration Requirements Human Machine Interface and Reports

1.2 QUALITY ASSURANCE

A. See Specification Section 40 90 00.

1.1 DEFINITIONS

A. PLC - Programmable Logic Controller.

B. SCADA - Supervisory Control and Data Acquisition system.

C. OIS - Operator Interface Station.

D. HIM - Human Interface Module - Used for local control of Variable frequency drives.

E. REMOTE (AUTO) - Control is directed automatically from the PLC and Monitored by the SCADA system.

F. REMOTE (MANUAL) - Allows the operator to manually override remote (auto) controls and operate equipment manually from the SCADA or OIS stations [A1]

G. LOCAL (MANUAL) - Local manual control at the MCC or Local control station from physical switches.

1.2 SYSTEM DESCRIPTION

A. The control loop descriptions provide the functional requirements of the control loops represented in the Contract Documents.

1. Descriptions are provided as follows:
   a. Control system overview and general description.
   b. Major equipment to be controlled.
   c. Major field mounted instruments (does not include local gauges).
   d. Manual control functions.
   e. Automatic control functions/interlocks.
   f. Major indications provided at local control panels and motor starters/VFD's.
   g. Remote indications and alarms.

B. The control loop descriptions are not intended to be an inclusive listing of all elements and appurtenances required to execute loop functions, but are rather intended to supplement and complement the Drawings and other Specification Sections.

1. The control loop descriptions shall not be considered equal to a bill of materials.
2. The control loop descriptions for existing equipment shall not be altered unless otherwise noted in Part 3 - Execution.

C. Provide instrumentation hardware and software as necessary to perform control functions specified herein and shown on Drawings.

D. Ensure coordination of instrumentation manufacturer with other work to ensure that necessary wiring, conduits, contacts, interposing relays, loop-isolators, converters, and incidentals are provided in order to transmit, receive, and control necessary signals to other control elements, to control panels, and to receiving stations.

PART 2 - PRODUCTS - (NOT APPLICABLE TO THIS SPECIFICATION SECTION)

PART 3 - EXECUTION

3.1 AREA 1 – WOODSIDE INFLUENT LIFT STATION

A. Woodside Influent Pumps (Control Strategy 01-01)

1. P&ID Sheets: Y-001.
2. Description:
   a. Lift raw influent wastewater from the Woodside Influent Lift Station into the Screen Influent Channel.
3. Equipment Schedule:

Description	Location	Equipment Tag No.
Woodside Influent Pump 01	Woodside Influent Lift Station	P-01-01
Woodside Influent Pump 02	Woodside Influent Lift Station	P-01-02
Woodside Influent Pump 03	Woodside Influent Lift Station	P-01-03
Woodside Influent Lift Station Level Sensor	Woodside Influent Lift Station	LE/LIT-01-01
Woodside Influent Lift Station Level Switch Low	Woodside Influent Lift Station	LSL-01-01
Woodside Influent Lift Station Level Switch High 01	Woodside Influent Lift Station	LSH-01-01
Woodside Influent Lift Station Level Switch High 02	Woodside Influent Lift Station	LSH-01-02
Woodside Influent Lift Station Level Switch High 03	Woodside Influent Lift Station	LSH-01-03
Woodside Influent Lift Station Level Switch High High	Woodside Influent Lift Station	LSHH-01-01
Woodside Influent Flow Meter	Influent Flow Meter Vault	FE/FIT-01-01
Riverside Influent Flow Meter	Influent Flow Meter Vault	FE/FIT-01-02

4. Equipment Protection:
   a. VFD fault turns off pump.
   b. TSH-01-01, TSH-01-02, and TSH-01-03 high motor temperature shutdown for Woodside Influent pumps.
   c. XSH-01-01, XSH-01-02, and XSH-01-03 integrated moisture sensor for Woodside Influent pumps.
   d. Float switch LSL-01-01 will provide run dry protection for pumps.
5. Local Control:
   a. Local control switch HAND/OFF/AUTO (HOA) selector switch is installed at each pump VFD enclosure. When in the HAND position, the pump will operate. The pump speed will be based on operator input at the VFD keypad also mounted to the front of the VFD enclosure.
6. Plant PLC Control:

a. With the local HOA selector switch in the AUTO position the pump is controlled by Plant Control System. The operator can select between HMI MANUAL or HMI AUTOMATIC.
    1) HMI MANUAL:
        a) Each pump may be started and stopped from the HMI and the operating speed may be manually adjusted from the HMI.
    2) HMI AUTOMATIC:
        a) The Woodside Influent pumps are to run based on level in the Woodside Influent Lift Station.
        b) The pumps will be automatically controlled using duplex pump control with +1 redundancy logic with automatic alternation.
            (1) The lead and lag pumps will start and run based on the operator adjustable level setpoints in the Woodside Influent Lift Station as measured by LE/LIT-01-01. The third pump will serve as a stand-by and come online as the lag pump in case either the lead or lag pump faults or is offline.
                (a) Lead pump shall operate when the water depth is above the low-level shutoff approximately 1.60 feet (elevation 5215.00)
                (b) Lag pump shall turn on at water depth of 8.00 feet (elevation 5221.40). Lead pump and lag pump speed shall be automatically adjusted to operate at the same frequency to maintain lift station level.
                (c) Operator adjustable high level setpoint from LE/LIT-01-01 shall trigger at 9.60 feet (elevation 5223.00) of water depth. Lead and lag pump shall both operate at full speed until level returns to lag pump ON setpoint.
                (d) All pumps shall shut off when level reaches pump minimum submergence at water depth of 1.27 feet (elevation 5214.67).
            (2) Float Switches:
                (a) The float switches will provide secondary pump control and alarming should there be a failure of the lift station level transmitter or PLC.
                (b) LSL-01-01 shall be set to trigger at a depth of 1.27 feet (elevation 5214.67) for pump run dry protection. Integrator to verify minimum submergence required by Woodside Influent pumps with Engineer.
                (c) LSH-01-01 shall turn on pump P-01-01 and alarm at a level depth of 7.00 feet (elevation 5220.40) and turn on the lead pump.
                (d) LSH-01-02 shall turn on pump P-01-02 at a switch point of 8.00 feet (elevation 5221.40).
                (e) LSH-01-03 will turn on pump P-01-03 at a switch point of 9.60 feet (elevation 5223.00).
                (f) LSHH-01-01 shall provide critical high level alarm at a switch point of 10.00 feet (elevation 5223.40).
            (3) Woodside Influent Flow Meter (FE/FIT-01-01) is informational only, for the Woodside Influent Lift Station.
            (4) Riverside Influent Flow Meter (FE/FIT-01-02) is informational only, for the Riverside Influent Lift Station.

7. SCADA HMI Configuration
    a. Status Display:
        1) Pump remote (3)
        2) Pump running (3)
        3) Pump VFD speed feedback (3)
        4) Influent flow rate (2)
        5) Lift station level (1)
    b. Operator Entries:
        1) Low Level Shutoff level (1)
        2) Lead Pump Start level (1)
        3) Lag Pump Start level (1)
        4) Manual/Auto Mode selection (3)

5) Manual Start/Stop control (3)
6) Manual speed control (3)
7) Pump alternating time entry

c. Alarms:
1) Pump VFD fault (3) – Level 2
2) Pump high temperature (3) – Level 2
3) Pump moisture alarm (3) – Level 2
4) High level alarm (3) - Level 1
5) High High level alarm – Level 1
6) Level Transmitter out of range – Level 4

3.2 AREA 3 – GRIT REMOVAL

A. Grit Handling Equipment (Control Strategy 03-01):

1. P&ID Sheets: Y-004.
2. Description:
   a. Grit settles in a free vortex grit chamber and removed by a submersible grit pump.
   b. The grit classifier with hydrocyclone to dewater grit. The remaining liquid is returned to the process flow stream upstream of the grit chamber.
3. Equipment Schedule:

Description	Location	Equipment Tag No.
Grit Classifier with Hydrocyclone	Headworks Building	GC-03-01

4. Equipment Protection:
   a. Grit classifier is equipped with a trip cable.
5. Local Control:
   a. Local control switch HAND/OFF/AUTO (HOA) keypad is installed at the motor starter enclosure for the hydrocyclone. When in the HAND position, the grit classifier will operate. The grit classifier will include a local control station with HOA and E-stop for manual operation.
6. Plant PLC Control:
   a. With the local HOA selector switch in the AUTO position the pump is controlled by Plant Control System. The operator can select between HMI MANUAL or HMI AUTOMATIC.
      1) HMI MANUAL:
         a) Grit classifier may be started and stopped from the HMI.
      2) HMI AUTOMATIC:
         a) Grit classifier operation shall be interlocked with the grit pump (P-03-01).
7. SCADA HMI Configuration
   a. Status Display:
      1) Classifier remote (1)
      2) Classifier running (1)
   b. Operator Entries:
      1) Manual/Auto Mode selection (1)
      2) Manual Start/Stop control (1)
   c. Alarms:
      1) Classifier motor starter fault (1) – Level 2
      2) Grit classifier E-STOP – Level 1

B. Grit Pumping (Control Strategy 03-02):

1. P&ID Sheets: Y-004.
2. Description:
   a. The grit pump transports the grit slurry from the grit chamber into a grit classifier with hydrocyclone for dewatering of grit.
   b. Sump pumps in the grit pump basement area transports grit slurry and cleanup water to the Screen Effluent Channel.

3. Equipment Schedule:

Description	Location	Equipment Tag No.
Grit Pump	Headworks Basement	P-03-01
Grit Chamber Sump Flush Valve	Headworks Basement	BV-03-01
Grit Discharge Flush Valve	Headworks Basement	BV-03-02

4. Equipment Protection:
   a. XSH-03-01 integrated moisture sensor for Grit Pump.
5. Local Control:
   a. Local control switch HAND/OFF/AUTO (HOA) keypad is installed at the pump motor starter. When in the HAND position, the pump will operate.
6. Plant PLC Control:
   a. With the local HOA selector switch in the AUTO position the pump is controlled by Plant Control System. The operator can select between HMI MANUAL or HMI AUTOMATIC.
      1) HMI MANUAL:
         a) The pump may be started and stopped from the HMI.
      2) HMI AUTOMATIC:
         a) Grit pump shall be interlocked with the grit chamber ON/OFF toggle.
            (1) Grit pump shall run for an operator adjustable duration. The run sequence shall start at the beginning of each hour and operate for the timer duration. Timer shall be adjustable from 0 to 60 minutes per hour.
               (a) Initial timer setpoint shall be set at 30 minutes per hour.
            (2)
            (3) Grit chamber sump and discharge flush valves (BV-03-01 & BV-03-02) shall be interlocked with grit pump starting sequence.
               (a) Grit chamber sump and discharge flush valves shall open for an operator adjustable duration before grit pump starting sequence.
               (b) Initial setpoint for grit chamber sump and discharge flush valve open time: one (1) minute.
7. SCADA HMI Configuration
   a. Status Display:
      1) Pump remote (1)
      2) Pump running (1)
      3) Valve open/close status (2)
   b. Operator Entries:
      1) Manual/Auto Mode selection (1)
      2) Manual Start/Stop control (1)
      3) Pump run timer (1)
      4) Valve open timer (2)
   c. Alarms:
      1) Pump motor starter fault (1) – Level 2
      2) Pump moisture alarm (1) – Level 2
      3) Valve fail to open (2) – Level 2
      4) Valve fail to close (2) – Level 2

3.3 AREA 4 – BATCH TANK (BID ALTERNATE – BATCH TANK PUMPING)

A. Batch Tank Pumps (Control Strategy 04-01)

1. P&ID Sheets: Y-005.
2. Description:
   a. Lift degritted wastewater from the Batch Tank to one of the two SBRs.
3. Equipment Schedule:

Description	Location	Equipment Tag No.
Batch Tank Pump 01	Batch Tank	P-04-01
Batch Tank Pump 02	Batch Tank	P-04-02
Batch Tank Pump 03	Batch Tank	P-04-03
Batch Tank Level Sensor	Batch Tank	LE/LIT-04-01
Batch Tank Level Switch Low	Batch Tank	LSL-04-01
Batch Tank Level Switch High 01	Batch Tank	LSH-04-01
Batch Tank Level Switch High 02	Batch Tank	LSH-04-02
Batch Tank Level Switch High 03	Batch Tank	LSH-04-03
Batch Tank Level Switch High High	Batch Tank	LSHH-04-01
SBR 1 Influent Flow Meter 01	SBR 1 Valve Vault 01	FE/FIT-04-01
SBR 1 Influent Flow Control Valve 01	SBR 1 Valve Vault 01	PV-04-01
SBR 2 Influent Flow Meter	SBR 2 Valve Vault	FE/FIT-04-04
SBR 2 Influent Flow Control Valve	SBR 2 Valve Vault	FE/FIT-04-04

4. Equipment Protection:
   a. VFD fault turns off pump.
   b. TSH-04-01, TSH-04-02, and TSH-04-03 high motor temperature shutdown for Batch Tank pumps.
   c. XSH-04-01, XSH-04-02, and XSH-04-03 integrated moisture sensor for Batch Tank pumps.
5. Local Control:
   a. Local control switch HAND/OFF/AUTO (HOA) selector switch is installed at each pump VFD enclosure. When in the HAND position, the pump will operate. The pump speed will be based on operator input at the VFD keypad.
6. Plant PLC Control:
   a. With the local HOA selector switch in the AUTO position the pump is controlled by Plant Control System. The operator can select between HMI MANUAL or HMI AUTOMATIC.
      1) HMI MANUAL:
         a) Each pump may be started and stopped from the HMI and the operating speed may be manually adjusted from the HMI.
         b) Valve positions may be manually adjusted, on a 0 to 100 PCT range.
      2) HMI AUTOMATIC:
         a) The Batch Tank pumps and influent flow control valves are to operate based on the cycle status of the existing SBR control system which will communicate with the new headworks PLC and the existing SBR PLC over Ethernet/IP communications..
            (1) PV-04-01 and PV-04-02 shall be interlocked with SBR fill phases. The influent flow control valves shall fully open when its designated SBR is sequenced to the fill phase.
               (a) PV-04-01 shall be interlocked with SBR 1 fill phase.
               (b) PV-04-02 shall be interlocked with SBR 2 fill phase.

b) The pumps will be automatically controlled using duplex pump control with +1 redundancy and automatic alternation..
   (1) The lead and lag pumps will start and run based on the operator adjustable SBR fill rates based on FE/FIT-04-01 and FE/FIT-04-02 respectively. The setpoints are an addition to the existing system that will need to be added to accomplish this functionality. The third pump will serve as a stand-by and come online as the lag pump in case either the lead or lag pump faults or is offline.
   (2) The lead and lag pumps will start and run based on the operator adjustable flow setpoint in the SBR influent flow meters (FE/FIT-04-01 and FE/FIT-04-02).
      (a) Pumps shall stop filling SBR based on existing fill completion control structure.
      (b) Lead pump shall operate when the water depth is above the low-level shutoff setpoint in the batch tank.
      (c) Lag pump shall turn on as required to attain operator adjustable flow setpoint. Lead pump and lag pump speed shall be automatically adjusted to operate at the same frequency to maintain flow setpoint.
      (d) All pumps shall shut off when level reaches pump minimum submergence at water depth of 1.43 feet (elevation 5242.88).
      (e) Pumps shall be interlocked to the respective SBR fill valve and not allowed to operate if the valve is not opened.
   (3) Float Switches:
      (a) The float switches will provide secondary pump control and alarming should there be a failure of the Batch Tank level transmitter or PLC.
      (b) LSL-04-01 shall be set to trigger at a depth of 1.43 feet (elevation 5242.88) for pump run dry protection. Integrator to verify minimum submergence required by Woodside Influent pumps with Engineer.
      (c) LSH-04-01 shall alarm at level depth of 8.00 feet (elevation 5249.45). Alarm shall remain ON until reset locally by an operator.
      (d) LSH-04-02 shall alarm at level depth of 8.50 feet (elevation 5249.95). Alarm shall remain ON until reset locally by an operator.
      (e) LSH-04-03 shall alarm at level depth of 9.00 feet (elevation 5250.45). Alarm shall remain ON until reset locally by an operator.
      (f) LSHH-04-01 shall provide critical high level alarm at a switch point of 9.15 feet (elevation 5250.60). Alarm shall remain ON until reset locally by an operator.

7. SCADA HMI Configuration
   a. Status Display:
      1) Pump remote (3)
      2) Pump running (3)
      3) Pump VFD speed feedback (3)
      4) Influent flow rate (2)
      5) Valve position status (2)
      6) Batch tank level (1)
   b. Operator Entries:
      1) Low Level Shutoff level (1)
      2) SBR Influent fill rate (1)
      3) Manual/Auto Mode selection (3)
      4) Manual Start/Stop control (3)
      5) Manual speed control (3)
      6) Valve position (2)
      7) Pump alternating time entry
   c. Alarms:
      1) Pump VFD fault (3) – Level 2

2) Pump high temperature (3) – Level 2
3) Pump moisture alarm (3) – Level 2
4) High level alarm (1) – Level 1
5) High high level alarm – Level 1
6) Valve failure to open (2) – Level 1
7) Valve failure to close (2) – Level 1

END OF SECTION

SECTION 40 91 10
PRIMARY METERS AND TRANSMITTERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Flow components.
2. Pressure components.
3. Analytical components.
4. Temperature components.
5. Level Components.
6. Pipe, tubing and fittings.
7. Instrument valves.

B. Related Specification Sections include but are not necessarily limited to:

1. Division 00 - Procurement and Contracting Requirements.
2. Division 01 - General Requirements.
3. Section 40 90 00 - Instrumentation for Process Control: Basic Requirements.
4. Section 40 90 05 – Process Control Descriptions.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Gas Association (AGA):
   a. Gas Measurement Committee Report #3.
2. American Society of Mechanical Engineers (ASME):
   a. B16.5, Pipe Flanges and Flanged Fittings.
   b. B31.1, Power Piping.
   c. PTC 19.3, Instruments and Apparatus, Part 3 Temperature Measurement.
   d. PTC 19.5, Application of Fluid Meters, Part 2.
   e. Section II, Part A SA-182, Forged or Rolled Alloy Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
   f. Section II, Part A SA-479, Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels.
3. ASTM International (ASTM):
   a. A106, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
   b. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   c. A182, Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
   d. A269, Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
   e. A276, Standard Specification for Stainless Steel Bars and Shapes.
   f. A479, Standard Specification for Stainless Steel Bars and Shapes for Use in Boilers and Other Pressure Vessels.
   g. B16, Standard Specification for Free-Cutting Brass Rod, Bar and Shapes for Use in Screw Machines.

h. B75, Standard Specification for Seamless Copper Tube.
i. B124, Standard Specification for Copper and Copper Alloy Forging Rod, Bar, and Shapes.
j. B283, Standard Specification for Copper and Copper-Alloy Die Forgings (Hot-Pressed).
k. B453, Standard Specification for Copper-Zinc-Lead Alloy (Leaded-Brass) Rod, Bar, and Shapes.

4. Federal Communications Commission (FCC)
   a. 47 CFR 15, Radio Frequency Devices.
5. The International Electrotechnical Commission (IEC)
   a. IEC 751 Platinum Resistance Thermometer Sensor
6. The International Society of Automation (ISA):
   a. MC96.1, Temperature Measurement Thermocouples.
7. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
8. US Department of Interior Bureau of Reclamation (USDIBR):
   a. Water Measurement Manual.

1.3 SYSTEM DESCRIPTION

A. The instruments specified in this Specification Section are the primary element components for the control loops shown on the "PID" series Drawings and specified in Specification Section 40 90 05.

   1. These instruments are integrated with other control system components specified under Specification Section 40 90 00 series to produce the functional control defined in the Contract Documents.

B. Single Instrumentation Subcontractor:

   1. Furnish and coordinate instrumentation system through a single instrumentation subcontractor.
      a. The instrumentation subcontractor shall be responsible for functional operations of all systems, performance of control system engineering, supervision of installation, final connections, calibrations, preparation of Drawings and Operation and Maintenance Manuals, start-up, training, demonstration of substantial completion and all other aspects of the control system.
   2. Ensure coordination of instrumentation with other work to ensure that necessary wiring, conduits, contacts, relays, converters, and incidentals are provided in order to transmit, receive, and control necessary signals to other control elements, to control panels, and to receiving stations.
   3. Prior to Shop Drawing preparation, the Instrumentation Subcontractor shall inspect the Owner's existing equipment and as-constructed electrical documentation so as to be able to fully coordinate the interface of new and existing instrumentation and controls. All costs associated with this Work shall be incorporated into the original bid. Although such Work is not specifically indicated, furnish and install all supplementary or miscellaneous items, appurtenances and devices incidental to or necessary for a sound, secure, complete and compatible installation.

1.4 SUBMITTALS

A. Shop Drawings:

   1. See Specification Section 01 78 23 for requirements for the mechanics and administration of the submittal process.
   2. See Specification Section 40 90 00.

B. Contract Closeout Information:

1. Operation and Maintenance Data:
    a. See Specification Section 01 33 00 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the manufacturers listed in the Articles describing the elements are acceptable.

B. Submit request for substitution in accordance with Specification Section 01 25 00.

2.2 TEMPERATURE COMPONENTS

A. Thermometer:

1. Acceptable manufacturers:
    a. Ashcroft.
    b. Ametek.
    c. Or approved equal.
2. Materials:
    a. Case: 316 stainless steel.
    b. Ring: 316 stainless steel.
    c. Stem: 316 stainless steel.
    d. Thermowell: ASTM A182, F316 stainless steel.
    e. Bulb: AISI 316 stainless steel.
3. Design and fabrication:
    a. Type:
        1) Bimetallic for applications not exceeding 800 DEGF.
        2) Inert gas filled for applications exceeding 800 DEGF.
    b. Every angle case connection.
    c. Hermetically sealed case with external adjustment.
    d. Dial:
        1) Minimum 4-1/2 IN.
        2) White face.
        3) Black numbers and pointer.
    e. Thermometer well:
        1) Extension neck for insulated lines.
    f. Accuracy +/-1 PCT of full span.
    g. Shatterproof glass.

A. RTD's:

1. Acceptable manufacturers:
    a. Endress & Hauser
    b. Rosemount.
    c. Moore Industries
    d. Or approved equal
2. Materials:
    a. Sensor: Platinum.

b. Sheath:
1) 900 DEGF maximum: Type 316 stainless steel.
2) 1200 DEGF maximum: Inconel.
c. Insulation: Ceramic or metallic oxide.

3. Design and fabrication:
a. IEC 60751 Class A type
b. 100 ohms at 0 DEGC.
c. Spring loaded.
d. Lead wire compensation: Three- or four-wire.
e. Accuracy: +0.15 DEGF or +0.5 PCT of measured temperature, whichever is greater.
f. Sheath diameter: 1/4 IN.

B. Thermocouples:

1. Acceptable manufacturers:
a. Endress & Hauser
b. Rosemount.
c. Moore Industries
d. Or approved equal

2. Materials:
a. Sheath:
1) 1600 DEGF maximum: Type 304 or 316 stainless steel.
2) 2100 DEGF maximum: Inconel.
b. Insulation: Ceramic or metallic oxide.

3. Design and fabrication:
a. Type: J.
b. Spring loaded.
c. Ungrounded.
d. Sheath diameter: 1/4 IN.
e. Lead wires: 20 AWG minimum.
f. Color-coded wire insulation per ISA MC96.1.
g. Tolerance per ISA MC96.1.

C. Thermowells:

1. Acceptable manufacturers:
a. Endress & Hauser
b. Rosemount.
c. Moore Industries
d. Or approved equal

2. Materials:
a. Well: ASTM A182, F316 stainless steel.
b. Head: Cast iron.

3. Design and fabrication:
a. Constructed in accordance with ASME PTC 19.3, Part 3, Chapter 1, Paragraphs 8-19.
b. Lagging extension sufficient to provide wrench clearance above lagging.
c. Seal welded on applications where process pressure exceeds 450 PSI.
d. Test thermowells shall be supplied with watertight cap and chain.

D. Temperature Transmitters:

1. Acceptable manufacturers:
   a. Endress & Hauser TMT162.
   b. Rosemount, Model 3144.
   c. Moore Industries TDZ.
   d. Or approved equal.
2. Materials:
   a. Housing: Aluminum.
3. Design and fabrication:
   a. Smart transmitter utilizing microprocessor based electronics.
   b. Input: RTD, thermocouple or millivolt, as specified in schedule.
   c. Transmitter inaccuracy shall be in consistent with with the type & class of element it is connected to :
      1) 100 ohm platinum RTD input: +/-0.63 DEGF at -148 DEGF and +/-2.07 DEGF at 500 DEGF.
      2) Type E thermocouple input: 0 to 900 DEGC +/-1.7 DEGC or +/- +0.5 PCT of span, whichever is greater.
      3) Type J thermocouple input: 0 to 750 DEGC +/-2.2 DEGC or +/- +0.75 PCT of span, whichever is greater.
      4) Type K thermocouple input: 0 to 1250 DEGC +/-2.2 DEGC or +/- +0.75 PCT of span, whichever is greater.
      5) Type R thermocouple input: 0 to 1450 DEGC +/-1.5 DEGC or +/- +0.25 PCT of span, whichever is greater.
      6) Type S thermocouple input: 0 to 1450 DEGC +/-1.5 DEGC or +/- +0.25 PCT of span, whichever is greater.
      7) Type T thermocouple input: -200 to 0 DEGC +/-1 DEGC or +/- +1.5 PCT of span, whichever is greater
      8) Millivolt input: +/-0.015 mV +0.02 PCT of span or +/-8 microvolts +0.025 PCT of span, whichever is greater.
   d. Stability:
      1) Any of the following drift limits are acceptable:
         a) Greater of: 0.1 PCT of reading or 0.1 DEGC per 12 months.
         b) 0.05 PCT of input reading plus 0.043 PCT of span per 12 months.
         c) 0.05 PCT of maximum span per 12 months.
   e. Ambient temperature effects (including digital, D/A conversion, and cold junction effects):
      1) Any of the following effects per 50 DEGF change are acceptable:
         a) One-half reference inaccuracy plus 0.18 DEGF.
         b) Effects in accordance with the following inputs:
            (1) 100 platinum RTD input: +/-0.08 DEGC +0.025 PCT of (reading +200) +0.025 PCT of span +0.02 PCT of (reading - lower range value).
            (2) Type E thermocouple input: +/-0.10 DEGC +0.012 PCT of (reading +200) +0.025 PCT of span +0.02 PCT of (reading - lower range value).
            (3) Type J thermocouple input:
               (a) Readings above 0 DEGC: +/-0.11 DEGC +0.008 PCT of (reading +200) +0.025 PCT of span +0.02 PCT of (reading - lower range value).
               (b) Readings below 0 DEGC: +/-0.11 DEGC +0.056 PCT of absolute value of reading +0.025 PCT of span +0.02 PCT of (reading - lower range value).

(4) Type K thermocouple input:
(a) Readings above 0 DEGC: +/-0.13 DEGC +0.015 PCT of (reading +200) +0.025 PCT of span +0.02 PCT of (reading - lower range value).
(b) Readings below 0 DEGC: +/-0.13 DEGC +0.056 PCT of absolute value of reading +0.025 PCT of span +0.02 PCT of (reading - lower range value).
(5) Type N thermocouple input: +/-0.15 DEGC +0.010 PCT of reading +0.025 PCT of span +0.02 PCT of (reading - lower range value).
(6) Type R thermocouple input:
(a) Readings above 200 DEGC: +/-0.42 DEGC +0.025 PCT of span +0.02 PCT of (reading - lower range value).
(b) Readings below 200 DEGC: +/-0.60 DEGC - 0.090 PCT of reading +0.025 PCT of span +0.02 PCT of (reading - lower range value).
(7) Type S thermocouple input:
(a) Readings above 200 DEGC: +/-0.42 DEGC +0.025 PCT of span +0.02 PCT of (reading - lower range value).
(b) Readings below 200 DEGC: +/-0.60 DEGC - 0.090 PCT of reading +0.025 PCT of span +0.02 PCT of (reading - lower range value).
(8) Type T thermocouple input:
(a) Readings above 0 DEGC: +/-0.13 DEGC +0.025 PCT of span +0.02 PCT of (reading - lower range value).
(b) Readings below 0 DEGC: +/-0.13 DEGC 0.100 PCT of absolute value of reading +0.025 PCT of span +0.02 PCT of (reading - lower range value).
(9) Millivolt input: 0.003 mV +0.012 PCT of absolute value of reading +.025 PCT of span +0.02 PCT of (reading - lower range value).

f. Ambient temperature limits:
1) -40 to 185 DEGF.
2) Integral LCD meter: -4 to 158 DEGF.
g. Output: 4-20 mA HART protocol signal linearly proportional to temperature.
h. Power supply: 24 VDC.
i. Adjustable span.
j. Adjustable zero.

E. Temperature Switches:
1. Acceptable manufacturers:
a. Ashcroft.
b. United Electric.
c. Or approved equal
2. Design and fabrication:
a. Contact rating:
1) 1 amp inductive at 125 VDC.
2) 5 amp inductive at 120 VAC.
b. Switch accuracy: 1 PCT or better.

2.3 FLOW COMPONENTS

A. Magnetic Flow Meters:
1. Acceptable manufacturers:
a. Endress & Hauser
b. Or approved equal

2. Materials used shall be fully compatible with process and service requirements:
    a. Meter tube of 304 or 316 stainless steel.
    b. The flow tube liner shall be hard rubber elastomer, Neoprene or PTFE to meet temperature, pressure rating. The liner shall be chemically and mechanically compatible with the process fluids being measured.
        1) The measuring electrodes/sensors shall be Titanium or Alloy C electrodes. The electrodes shall be chemically and mechanically compatible with the process fluids being measured.
    c. Grounding rings: 316 stainless steel, or as noted.
3. Design and fabrication:
    a. Utilize characterized field principle of electromagnetic induction to produce signal directly proportional to flow rate.
    b. Service: As noted. Percent solids content of thickened sludge type process streams is identified in the Schedule below.
    c. Meters identified with the “High Noise” are to be designed to measure process streams with high solids contents and high noise conditions.
    d. Provide cable between magnetic flow meter and transmitter with length as required for the installation.
    e. Pulsed DC magnetic field excitation.
    f. Inaccuracy:
        1) Above 10 percent of range: ±1.0 percent of rate.
        2) Below 10 percent of range: ±0.1 percent of range setting.
        3) Add +0.1 percent of range to above inaccuracies for analog outputs.
    g. Meter operable as specified in liquids with 5.0 micro mho/cm or more conductivity.
    h. Flow Tube:
        1) Provide flanged end connections per ASME B16.5 rated for piping system operating and test conditions.
        2) Operating pressure: 0 to 150 psi.
        3) Operating temperature: 20 to 150 DegF.
        4) Inlet and outlet grounding rings.
        5) Flow Tube sensor coil resistance:
            a) Normal service: 350 Ohms maximum.
            b) High noise service: 12 Ohms maximum.
        6) Process liquid conductivity limits:
            a) Normal service: 5 microsiemens/cm, minimum.
            b) High noise service: 50 microsiemens/cm, minimum.
        7) Shall carry the minimum rating IP65 for indoor installations, IP67 for outdoor installations or IP68 in areas prone to flooding or where the meter tube will be mounted in a vault. In remote apllications flow transmitter shall be installed as specified on plans or adjacent to vault.
        8) Flowmeter tube shall be capable of 0 pipe diameter installation upstream and downstream.
    i. Transmitter:
        1) Each flow meter shall be furnished with a separately-mounted transmitter, unless shown otherwise.
        2) Transmitter electronics shall use microprocessor based architecture and be configured using field adjustable parameters via front panel keypad and HART calibrator.
        3) Output: 4-20mA DC isolated output into maximum 800 ohms, 1 relay rated at 1A and Ethernet/IP communications.

4) Communication: HART, Ethernet/IP.
5) Housing requirements: watertight, NEMA 4X rated, wall-mount enclosure.
6) Power supply: 120VAC +/- 10 percent, 60 Hz and/or 24VDC
7) Indication of flow rate and totalized flow in engineering units.
8) Adjustable low flow cutoff.
9) Automatic zero.
10) Minimum signal lock (empty tube zero) to prevent false measurement when tube is empty.
11) High signal type operation where required to measure process streams with high solids contents and high noise conditions.
12) Signal damping: adjustable between 02 and 256 seconds.
13) Transmitter may be configured using hand-held HART Communicator.
14) Provide protection from the effects of UV radiation where mounted in direct sunlight or in outdoor areas.

B. Thermal Dispersion Type Flow Switches:

1. Acceptable manufacturer:
   a. Magnetrol Thermatel TD2 w/ Spherical Tip.
2. Materials:
   a. All wetted surfaces: 316 stainless steel.
   b. Enclosure: Cast iron or aluminum.
3. Design and fabrication:
   a. Solid state electronics.
   b. Repeatability: +/-1 percent of full signal.
   c. Response time: Adjustable down to 1 second.
   d. Utilize two (2) platinum RTD's in thermowells in flow stream for differential temperature measurement.
   e. Two switch points.
   f. Two (2) SPDT switch contacts rated:
      1) 1 amp inductive at 24 Vdc.
      2) 5 amp inductive at 120 Vac.
   g. Process connections: 3/4 IN MNPT.
   h. Power supply: 115 Vac, +/-10 percent at 60 Hz.
   i. Process temperature: 140 DEGF .
   j. Process pressure: WAS = 15psi, Duct mounted 0-4 in H2O.

2.4 LEVEL ELEMENTS

A. Ultrasonic Level Sensor and Transmitter:

1. Acceptable manufacturers:
   a. Endress + Hauser.
   b. Rosemount.
   c. Or approved equal
2. Materials:
   a. Sensor wetted parts: PVC, polypropylene, KYNAR or polyvinylidene fluoride (PVDF).
3. Design and fabrication:
   a. Sensor:
      1) Emits ultrasonic sound.

2) Detects return echo reflected from surface and converts it to electrical energy proportional to level.

b. Temperature compensated.

c. Capable of being configured to ignore false targets.

d. Operating temperature: -4 to 140 DegF.

e. Humidity: 95 percent non-condensing.

f. Sensors shall be provided with optional flood protection tube when installed in areas that are prone to submergence.

g. Unit shall have ATEX, FM, CSA or IECEx approvals as required.Transmitter:

1) Capable of producing output signal proportional to level of 4-20 mA HART.

2) Power supply: 24VDC 2-wire loop powered.

3) Inaccuracy: 0.25 percent of range or 0.24 IN, whichever is greater.

4) Resolution: 0.1 percent of span or 0.08 IN, whichever is greater.

5) Display: Four-digit LED or LCD scalable to engineering units with selectable decimal point.

6) Temperature: -5 to 122 DegF.

7) Humidity: 95 percent noncondensing.

8) Memory: EEPROM (non-volitile).

9) Keypad programmer.

10) Provide cable between sensor and transmitter as required.

B. Radar Level Sensor and Transmitter:

1. Acceptable manufacturers:

a. Endress + Hauser.

b. Rosemount.

c. Or approved equal

2. Materials:

a. Antenna: PVC, polypropylene, KYNAR or polyvinylidene fluoride (PVDF).

3. Design and fabrication:

a. Sensor:

1) Emits microwave signals.

2) Detects return signals reflected from surface and converts it to determine the distance to the medium surface.

b. Capable of being configured to ignore false targets.

c. Operating temperature: -4 to 140 DegF.

d. Humidity: 95 percent non-condensing.

e. Provide all hardware and brackets necessary for complete installation.

f. Transmitter:

1) Capable of producing output signal proportional to level of 4-20 mA HART.

2) Power supply: 24VDC 2-wire loop powered.

3) Inaccuracy: 0.25 percent of range or 0.24 IN, whichever is greater.

4) Resolution: 0.1 percent of span or 0.08 IN, whichever is greater.

5) Display: Four-digit LED or LCD scalable to engineering units with selectable decimal point.

6) Temperature: -5 to 122 DegF.

7) Humidity: 95 percent noncondensing.

8) Memory: EEPROM (non-volitile).

9) Keypad programmer.

10) Provide protection from UV sunlight
11) Sensors shall be provided with optional flood protection tube when installed in areas that are prone to submergence.
12) Unit shall have ATEX, FM, CSA or IECEx approvals as required.

C. Mechanical Tilt Switches
1. Acceptable manufacturers:
a. Gems Series M
b. Or approved equal
2. Materials
a. Impact and corrosion resistant ABS
b. Oil resistant cable
3. Design and Fabrication:
a. Non-Mercury switch
b. Provides SPDT, Form C switch closure at approximately 2-8” of tilting angle
c. Contact Rating: 13A @ 120/240VAC
d. Operating Temperature: 32 DEGF – 140 DEGF
e. Narrow angle

2.5 PRESSURE COMPONENTS

A. Pressure Transmitters:
1. Acceptable manufacturers:
a. Endress & Hauser Cerabar
b. Rosemount, Model 3051S.
c. Foxboro, I/A series.
d. Or approved equal
2. Materials:
a. Isolating diaphragm: 316 stainless steel.
b. Process flanges and adapters: 316 stainless steel.
c. Housing: Aluminum.
d. Vent/drain valve: 316 stainless steel.
e. Fill fluid:
1) Utilize halocarbon fill for process applications involving strong oxidizing agents.
a) Agents include but are not limited to: Cl2, KMN04, FeCl, Na0H, and Na0Cl.
2) Utilize manufacturer's standard fill for other applications.
a) Ensure fill is suitable for application temperatures.
3. Design and fabrication:
a. Smart transmitters utilizing microprocessor based electronics.
b. Output: 4-20 mA HART DC proportional to pressure.
c. Nonvolatile EEPROM memory.
d. Power supply: 24 VDC 2-wire loop powered.
e. Adjustable zero and span.
f. Temperature limits: -20 to 180 DegF.
1) -4 to 175 DegF for LCD indicators.
g. Overpressure limits: Withstand 150 percent of stated maximum service pressure without damage.
h. Humidity limits: 0 to 100 percent relative humidity.

i. Damping: Adjustable between 0 and 32 seconds.
j. Inaccuracy (includes effects of linearity, repeatability and hysteresis): +/-0.10 percent of calibrated span for 15:1 rangeability.
k. Stability: +/-0.2 percent of upper range limit for 12 months.
l. Temperature effect:
1) Total effect including span and zero errors: +/-0.2 percent of upper range limit per 100 DegF for minimum 15:1 rangeability.
m. Minimum 1/2 IN pressure connection.
n. Equip with test jacks or accessible terminals for testing output.
o. Equip with isolation valve and test connections with isolation valves and/or plugs.
p. Pressure rating: To meet requirements of the application.

B. Adjustable Pressure Switches
1. Acceptable manufacturers
a. Mercoid
b. Ashcroft
c. Or approved equal
2. Materials:
a. Wetted switch elements: 316 stainless steel.
b. Diaphragm seal housing: 316 stainless steel.
3. Accessories:
a. Provide ball valve to isolate pressure switch from source.
b. Utilize pressure snubbers with porous metal discs to provide pulsation dampening on pressure switch as shown on schedule.
c. On applications where a pressure switch and a pressure gage are used at the same location, it is permissible to utilize one (1) pulsation dampener and diaphragm seal to isolate both elements from the process fluid.
4. Design and fabrication:
a. Utilize hermetically sealed mercury contact switches.
b. Two (2) SPDT contacts rated:
1) 1 amp inductive at 24 Vdc.
2) 5 amp inductive at 120 Vac.
c. Adjustable switch set points:
1) Above 1,000 psi:
a) Between 30 and 35 percent of switch rated working range.
b) Operating pressure range not to exceed 35 percent of switch rated working pressure.
2) Below 1,000 psi:
a) Set points between 30 and 70 percent of switch rated working range.
b) Operating pressure not to exceed 75 percent of switch rated working range.
d. Accuracy: Better than 1 percent of full scale.
e. Process connection: Minimum of 1/4 IN.
f. Clear dials or LCD screen for setpoint adjustment.

C. Pressure Gage:
1. Acceptable manufacturers:
a. Ashcroft.
b. Ametek.

c. Or approved equal

2. Materials:
   a. Bourdon tube, socket, connecting tube: 316 stainless steel.
   b. Case: Phenolic.
   c. Pressure snubber:
      1) Filter disc: 316 stainless steel.
      2) Housing: 316 stainless steel.
3. Accessories:
   a. Provide valve at point of connection to equipment and at panel if panel mounted.
   b. Utilize pressure snubbers with porous metal discs to provide pulsation dampening on gage applications as shown on schedule.
   c. Provide 1/2 IN stainless steel antisiphon pigtail inlet connection for hot water and steam applications.
4. Design and fabrication:
   a. All components suitable for service at:
      1) 250 DegF.
      2) The maximum process temperature to which the gage is to be exposed.
   b. Provide viewer protection from element rupture.
   c. Calibrate gages at jobsite for pressure and temperature in accordance with manufacturer's instructions.
   d. Unless otherwise required by codes, provide stem mounted or flush mounted, as required, with dial diameter as follows:

Pipe Size	Dial Size	Gage Connection
1-1/2 IN or less	2-1/2 IN	1/4 IN
Larger than 1-1/2 IN	4-1/2 IN	1/2 IN

   e. Equip with white faces, black numerals and black pointers.
   f. Gage tapping position to be clear of equipment functions and movements, and protected from maintenance and operation of equipment.
      1) Gage to be readable from an accessible standing position.
   g. Gage accuracy: 1 percent of full range.
   h. Select gage range so that:
      1) The normal operating value is in the middle third of the dial.
      2) Maximum operating pressure does not exceed 75 percent of the full scale range.
5. Diaphragm Seal:
   a. Acceptable manufacturers:
      1) Ashcroft.
      2) Ametek.
   b. Materials:
      1) Lower housing: 316 stainless steel.
      2) Diaphragm material: 316 stainless steel.
   c. Design and fabrication:
      1) Isolates instrument from process fluids which are corrosive or contain solids.
      2) Upper housing with bleed screw.
      3) Lower housing with flushing connection.
      4) Fill fluid:

a) Utilize halocarbon fill for process applications involving strong oxidizing agents.
(1) Agents include but are not limited to: Cl2, KMNO4, FeCl, NaOH, and NaOCl.
b) Utilize manufacturer's standard fill for other applications.
(1) Ensure fill is suitable for application temperatures.
5) Process connections:
a) Instrument: 1/2 IN NPT.
b) Process: 0.5 IN female NPT.
c) PVC pipe applications: Use a socket weld connection.
d. Installed where specified or shown on Drawings.

D. In-Line Isolation Sleeve (Annular Seal):
1. Acceptable manufacturers:
a. Red Valve.
b. Or approved equal.
2. Materials:
a. Body: carbon steel.
b. Flanges: carbon steel.
c. Flexible liner: Buna-N.
3. Design and fabrication:
a. Provide full 360 degree annular pressure sensor with flexible in-line sleeve.
b. Sensor shall not restrict the process flow (non-intrusive).
c. ANSI Class 150.
d. Instrument connection: 0.5 IN female NPT.
e. Fill fluid:
1) Utilize halocarbon fill for process applications involving strong oxidizing agents.
a) Agents include but are not limited to: Cl2, KMNO4, FeCl, NaOH, and NaOCl.
2) Utilize manufacturer's standard fill for other applications.
a) Ensure fill is suitable for application temperatures.
3) Pressure rating: To meet requirements of the application.
f. Installed where specified or shown on Drawings.

2.6 ANALYTICAL ELEMENTS

A. Combustible and Toxic Gas Detectors:
1. Acceptable manufacturers:
a. Honeywell.
b. MSA Instruments.
c. Oldham
d. Or approved equal
2. Control unit:
a. Front mounted indication.
1) Minimum three-digit display of gas concentration associated with each sensor.
2) Alarm status indicators for each gas sensing channel:
a) Trouble.
b) High gas level detected.
c) High high gas level detected.

b. Alarm relay outputs:
    1) Separate contacts for each alarm or trouble condition associated with each gas sensing channel.
    2) Separate "system trouble" contact to indicate trouble in the event any of the following conditions are true:
        a) System power loss.
        b) Signal loss from any sensor.
        c) Signal out of appropriate range.
        d) Control module malfunction or removal.
    3) Each output contact shall be Form C, SPDT, rated for 3 amps resistive at 120 Vac.
c. Output signals: 4-20 mA signal representing gas concentration for each gas sensor.
d. Temperature range: 32 to 158 DegF.
e. Relative humidity range: 0-95 percent non-condensing.

3. Sensor and transmitter design and fabrication:
    a. Sensor mounting type shall be as indicated on schedule: Either diffusion mounted, duct mounted, or sample draw mounted.
    b. For sensors required by schedule to be sample draw type:
        1) Provide a compressed air aspirator or motorized pump to draw a sample past the sensor.
        2) Utilize a flow switch to provide annunciation of low sample flow rate to the sensor.
    c. Duct mounted gas sensor shall be able to monitor gas flow rates up to 85 fps.
    d. Combustible gas sensor shall be catalytic bead type with demonstrated resistance to poisoning by silicones and hydrogen sulfide gases.
    e. Toxic gas sensor shall be the electrochemical type and shall not require the periodic addition of reagents.
    f. Interconnect wiring from sensor to transmitter (if not integral) or control unit shall be 3 wire shielded cable.
    g. Sensing element shall have minimum useful life of one (1) year.
    h. Transmitter output: 4-20 mA signal proportional to measured gas level.
        1) Capable of driving 600 ohm load at 24 Vdc supply voltage.
    i. Accuracy:
        1) Combustible gas detection:
            a) +3 percent LEL to 50 percent full scale.
            b) +5 percent LEL, 50 to 100 percent full scale.
        2) Toxic gas detection:
            a) +10 percent full scale or 2 PPM, whichever is greater.
    j. Environmental:
        1) Ambient operating temperature: -40 to 185 DegF.
        2) Relative humidity: 0-95 percent non-condensing.
    k. Housing: In accordance with the area classification shown on Drawings.
    l. Provide nonintrusive means of calibration.
    m. Local displays:
        1) 3-1/2 digit LCD or LED display of measured gas level.
        2) Fault LED.
    n. Stand alone sensors and transmitters (without central control unit):
        1) Provide relay contacts rated at 1/2 amps at 120 Vac for each of the following conditions:
            a) High gas level (warning level).

b) High high gas level (alarm level).
c) Sensor fault condition.

o. Relay contacts shall be normally energized (normally closed); contacts shall open in the event of a warning, alarm or trouble condition.
p. Minimum detector response time when exposed to 100 percent LEL gas concentration:
1) 10 seconds to 50 percent LEL.
2) 30 seconds to 90 percent LEL.
q. Store calibration data in nonvolatile memory or back up with battery.

4. Provide one (1) calibration kit for each type of gas monitored.
a. Calibration kits shall be furnished complete with all tubing, regulators, fittings, communication devices, and accessories required to calibrate sensors.
b. Calibration kit shall utilize nonintrusive means of calibrating sensors/transmitters.
5. Provide two (2) full cylinders of each type of calibration check gas.
a. Cylinder size: 17 liters.
6. Provide the same quantity of zero air cylinders as the total required number of calibration check gas cylinders (of all types).

2.7 PIPE, TUBING, AND FITTINGS

A. Acceptable Manufacturers:
1. Tube fittings:
a. Parker CPI.
b. Swagelok.
c. Or approved equal.

B. Instrument Tubing and Fittings:
1. Material:
a. Tubing: ASTM A269, Grade TP 316 stainless steel.
b. Straight fittings: 316 stainless steel per ASME SA-479 or ASTM A276.
c. Shaped bodies: ASME SA-182 F316 stainless steel.
2. Design and fabrication:
a. Tubing:
1) Seamless.
2) Fully annealed.
3) Maximum hardness: 80 Rb.
4) Free from surface scratches and imperfections.
5) Diameter: 1/2 IN OD unless specified otherwise.
6) Wall thickness:
a) Meet requirements of ASME B31.1, Paragraph 122.3.
b) Minimum 0.049 IN for 1/2 IN OD tubing.
b. Fittings:
1) Flareless.
2) Compression type.

C. Instrument Piping:
1. For applications where the instrument is supported solely by the sensing line, (e.g., pressure gauge directly mounted to process line) utilize piping as specified below.
a. Diameter: 1/2 IN unless specified otherwise.
b. Schedule 80.

c. 316 stainless steel. fittings per ASTM A234}.

D. Pneumatic Signal Tubing:

1. Material: Copper per ASTM B75.
2. Design and fabrication:
   a. Soft annealed.
   b. Free from surface scratches and imperfections.
   c. Wall thickness:
      1) 0.030 IN for 1/4 IN OD.
      2) 0.035 IN for 3/8 IN OD.

E. Pneumatic Tube Fittings:

1. Material:
   a. Straight fittings: Brass per ASTM B16 and ASTM B453.
   b. Shaped bodies: Brass per ASTM B124 Alloy 377 or ASTM B283.
2. Design and fabrication:
   a. Flareless.
   b. Compression type.

2.8 INSTRUMENT VALVES

A. Process instrument multi-valve manifolds, isolation, vent and blow-down valves:

1. Acceptable manufacturers:
   a. Whitey Co.
   b. Anderson-Greenwood USA, Inc.
   c. Or approved equal.
2. Materials:
   a. Packing:
      1) 450 DegF and above: Graphite.
      2) Below 450 DegF: Graphite or Teflon.
   b. Body: 316 stainless steel per ASTM A479.
   c. Stem: 316 stainless steel per ASTM A276.
   d. Ball: 316 stainless steel per ASTM A276.
   e. Support rings: 316 stainless steel per ASTM A276.
   f. Seats:
      1) Metal:
         a) 316 stainless steel per ASTM A276.
      2) Soft:
         a) Teflon, Delrin.
         b) Only utilized on applications where manufacturer's temperature and pressure ratings exceed process design conditions.
3. Design and fabrication:
   a. Either of the following:
      1) Ball valve with 1/4 turn activation.
      2) Free-swiveling ball stem.
   b. Provide body wall thickness sufficient for process design conditions per ASME B31.1.
   c. Temperature: Manufacturer's temperature rating for all components shall exceed process design conditions.

B. Isolation Valves in Copper Instrument Air Tubing:

1. Acceptable manufacturer:
   a. Whitey Co.
2. Materials:
   a. Packing: Graphite or Teflon.
   b. Body: Brass per ASTM B16.
   c. Stem: 316 stainless steel per ASTM A276.
   d. Ball: 316 stainless steel per ASTM A276.
   e. Support rings: 316 stainless steel per ASTM A276.
   f. Seats:
      1) Metal: 316 stainless steel per ASTM A276.
      2) Soft:
         a) Teflon, Delrin.
         b) Only utilized on applications where manufacturer's temperature and pressure ratings exceed process design conditions.
3. Design and fabrication:
   a. Ball valve with 1/4 turn activation.
   b. Provide body wall thickness sufficient for process design conditions per ASME B31.1.

2.9 ACCESSORIES

A. Furnish all mounting brackets, hardware and appurtenances required for mounting primary elements and transmitters.

1. Materials, unless otherwise specified, shall be as follows:
   a. Bolts, nuts, washers, expansion anchors: 316 stainless steel.
   b. Mounting brackets:
      1) Standard: 316 stainless steel.
      2) Highly corrosive areas: Aluminum.
   c. Mounting plates, angles:
      1) Standard: Carbon steel.
      2) Corrosive areas: 316 stainless steel.
   d. Instrument pipe stands:
      1) Standard: Hot-dip galvanized 2 IN schedule 40, ASTM A106, Grade B carbon steel.
      2) Corrosive areas: 316 stainless steel.

B. Tubing Support Angles and Brackets:

1. Any of the following materials are acceptable:
   a. Aluminum support with dielectric material between support and tubing.
   b. Type 316 stainless steel.
   c. Fiberglass.

C. Tubing Tray or Channel:

1. Aluminum.
2. Provide dielectric material between tray or channel and tubing.

D. Provide handheld communicator compatible with all intelligent transmitters furnished.

1. Hand held communicator shall provide capability to check calibration, change transmitter range, and provide diagnostics.

2. If these features are provided with the intelligent transmitter, the hand held communicator is not required.

E. Cable lengths between sensors and transmitters shall be continuous (without splices) and as required to accommodate locations as shown on Drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install instrument mounting pipe stands level and plumb.

C. Instrument Valves:

1. Orient stems for proper operation.
2. Install arrays orderly and neat in appearance with true horizontal and vertical lines.
3. Provide a minimum of 2 IN clearance between valve handle turning radii where there are multiple valve handles appearing in a straight line.
4. Valves shall have bonnets and any soft seals removed during welding or soldering into the line.
    a. When cool, reassemble the valves.
5. Support each valve individually.
    a. The tubing system does not qualify as support for the valve.

D. Locate instrument piping and tubing so as to be free of vibration and interference with other piping, conduit, or equipment.

E. Keep foreign matter out of the system.

F. Remove all oil on piping and tubing with solvent before piping and tubing installation.

G. Plug all open ends and connections to keep out contaminants.

H. Tubing Installation:

1. General:
    a. Install such that tube shows no sign of crumpling, bends of too short a radius, or flattening, etc.
    b. Make tube runs straight and parallel or perpendicular to the floor, equipment and piping runs.
    c. For liquid and steam applications, slope continuously from the process to the instrument with a minimum slope of 0.50 IN per foot.
    d. For gas and air applications, slope continuously from the instrument to the process with a minimum slope of 0.50 IN per foot.
    e. If the sensing line cannot be continuously sloped, install high point vents and low point drains.
    f. Keep instrument tubing clean during all phases of work.
    g. Blow out with clean, dry, oil-free air immediately before final assembly.
    h. Cut by sawing only and debur.
2. Bending:
    a. Make each bend with tube bender of the correct size for the tube.
    b. Make all bends smooth and continuous.
    c. Rebending is not permitted.
    d. Make bends true to angle and radius.
    e. Maintain a true circular cross section of tubing without buckling or undue stretch of tube wall.

f. Allowable tolerance for flattening out of tubing bends: Maximum of 8 percent of the OD for stainless steel tubing.

g. Minimum bending radius for stainless steel tubing:

Tube OD, inches	Minimum Bending Radius, inches
1/4	9/16
3/8	15/16
1/2	1-1/2

h. Minimum bending radius for type L, hard (drawn) copper:

Tube OD, inches	Minimum Bending Radius, inches
3/8	1-3/4
1/2	2-1/2

3. Tubing support:
   a. Intermittently support by clamping to support angle.
   b. Install supports to be self-draining, supported by hangers, or cantilevered from walls or structural beams.
   c. Support at 5 FT-0 IN maximum spans for horizontal or vertical runs.
   d. Use tubing trays in areas where spans between supports are greater than 5 FT and for all signal tubing support.
   e. Support each tubing tray at 10 FT maximum spans.
   f. Align tubing in orderly rows and retain in the tray by bolted clips.
      1) The use of spring or speed clips is not acceptable.
   g. Maintain order of the tubing throughout the length of the tray.
   h. Locate angle, channel and tray installation to protect tubing from spills and mechanical damage.
   i. Locate support members to clear all piping, conduit, equipment, hatchways, monorails, and personnel access ways and allow access for equipment operation and maintenance.
   j. Support trays to prevent torsion, sway or sag.
   k. Permanently attach supports to building steel or other permanent structural members.
   l. Arrange supports and trays so that they do not become a trough or trap.
4. Routing and orientation:
   a. Route to maintain a minimum headroom clearance of 8 FT.
   b. Locate and orient valves and specialties so that they are accessible for operation and maintenance from the operating floor.
      1) Do not route through or over equipment removal areas, below monorails or cranes nor above or below hatches.
5. Expansion and vibration provisions:
   a. Provide horizontal expansion loops at the process connections.
   b. Route tubing parallel to relative motion through sleeved supports that allow linear tube movement.
   c. Cold springing of tubing to compensate for thermal expansion is prohibited.
   d. Utilize flexible hoses to connect pneumatic tubing to air users which may move or vibrate.

I. Air Supply:

1. Connect all instruments requiring air to air supply piping and tubing.
2. Provide connections as follows:
    a. Terminate branch supply line not more than 36 IN from the device with a 1/2 IN isolation valve.
    b. For remaining line, use 1/4 or 3/8 IN tubing of a length to allow for normal equipment movement and vibration.
    c. Use flexible hoses to connect pneumatic tubing to air users which may experience significant movement or vibration.
    d. Make branch connections to individual instruments from the top of the supply header.
    e. Purge instrument air piping of extraneous material by blowing clean, dry, oil-free air through the system prior to final connection.

J. Threaded Connection Seals:

1. Use Tite-Seal or acceptable alternate.
2. Use of lead base pipe dope or Teflon tape is not acceptable.
3. Do not apply Tite-Seal to tubing threads of compression fittings.

K. Capillary Tubing:

1. Route capillary tubing in tubing tray.
2. Install capillary tubing with a 2 IN minimum bend radius which does not kink or pinch the capillaries.
3. Do not cut or disconnect at any point.
4. Coil excess capillary tubing and secure at the instrument.

L. Temperature Elements:

1. Assemble in the following sequence:
    a. Remove temperature sensor sheaths and terminal blocks from the head and nipple assembly.
    b. Connect nipple and head to thermowell installed in the pipe.
    c. Insert sheath and terminal block until it seats in the thermowell.
    d. Connect to the head.

M. Instrument Mounting:

1. Mount all instruments where they will be accessible from fixed ladders, platforms, or grade.
2. Mount all local indicating instruments with face forward toward the normal operating area, within reading distance, and in the line of sight.
3. Mount instruments level, plumb, and support rigidly.
4. Mount to provide:
    a. Protection from heat, shock, and vibrations.
    b. Accessibility for maintenance.
    c. Freedom from interference with piping, conduit and equipment.

N. Instrument Conifguration and setup

1. Instrumentation shall be configured and ready for integration into the SCADA system.
2. All instrumentation configuration shall be completed by the Contractor.

3.2 TRAINING

A. Provide on-site training in accordance with Specification Section 01 79 23.

APPENDIX A: INSTRUMENT SCHEDULE

TAG	DESCRIPTION	RANGE	PROCESS CONNECT	POWER	WIRNG	SIGNAL	MFR	BASIS OF DESIGN
LE/LIT-01-01	INFLUENT LS LEVEL	0-30'	2" MNPT	24VDC	2-WIRE	4-20mA HART, BT	E&H	MICROPILOT FMR50
LSHH-01-01 LSH-01-01 LSH-01-02 LSH-01-03 LSL-01-01	INFLUENT LEVEL SWITCHES	NARROW ANGLE	CABLE TETHERED	24VDC	2-WIRE	DISCRETE	GEMS	SERIES M
FE/FIT-01-01	WOODSIDE LS FLOW	0-3,000GPM	FLANGED	24VDC	CAT6A	ENET/IP	E&H	PROMAG W400
FE/FIT-01-02	RIVERSIDE LS FLOW	0-3,000GPM	FLANGED	24VDC	CAT6A	ENET/IP	E&H	PROMAG W400
LSL-03-01 LSH03-02	BASEMENT SUMP LEVEL SWITCHES	NARROW ANGLE	CABLE TETHERED	24VDC	2-WIRE	DISCRETE	GEMS	SERIES M
LE/LIT-04-01	BATCH TANK LEVEL	0-30'	2" MNPT	24VDC	2-WIRE	4-20mA HART, BT	E&H	MICROPILOT FMR50
LSL-04-01 LSH-04-01 LSH-04-02 LSH-04-03 LSH-04-01	BASEMENT SUMP LEVEL SWITCHES	NARROW ANGLE	CABLE TETHERED	24VDC	2-WIRE	DISCRETE	GEMS	SERIES M
LE/LIT-09-01	UW DAY TANK LEVEL	0-30'	2" MNPT	24VDC	2-WIRE	4-20mA HART, BT	E&H	MICROPILOT FMR50
AIT-201A	SCREENING LEL		REMOTE SENSOR	24VDC	4-WIRE	4-20mA, HART	HONEYWELL	SENSEPOINT XCD
AIT-201B	SCREENING H2S		REMOTE SENSOR	24VDC	4-WIRE	4-20mA, HART	HONEYWELL	SENSEPOINT XCD
FSL-02-01 FSL-02-02	EXHAUST FAN FLOW SWITCHES	ON/OFF	1/2" MNPT	24VDC	3-WIRE	DISCRETE	FCI	

END OF SECTION

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SECTION 40 94 43

PROGRAMMABLE LOGIC CONTROLLER (PLC) CONTROL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Programmable logic controller (PLC) control system(s), including software, programming, and training.

B. Related Sections include but are not necessarily limited to:

1. Division 00 - Procurement and Contracting Requirements.
2. Division 01 - General Requirements.
3. Section 01 61 03 - Equipment: Basic Requirements.
4. Section 10 14 00 - Identification Devices.
5. Section 26 05 19 - Wire and Cable - 600 Volt and Below.
6. Section 40 90 00 - Instrumentation for Process Control: Basic Requirements.
7. Section 40 90 05 – Process Control Descriptions.
8. Section 40 98 00 - Control Panels and Enclosures.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. C37.90.2, Trial-Use Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.
   b. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
2. National Electrical Manufacturers Association (NEMA):
   a. ICS 1, General Standards for Industrial Control and Systems.

B. Qualifications:

1. Installation supervisor shall have had experience in overseeing installation and startup of at least three (3) similar installations.
2. Programmer(s) shall have had experience in programming PLCs for at least two (5) projects of similar size and complexity.

1.3 SUBMITTALS

A. Shop Drawings:

1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. See Specification Section 40 90 00.
3. Product technical data including:
   a. Annotated digital copies of PLC software programs.
      1) Submit annotated PLC program as used for the specific PLC system.
      2) Annotate program listing to include the following:
         a) Written description of each rung's function.
         b) Reference to control loop number for each rung where applicable.
         c) Reference to instrumentation tag number of I/O devices for each rung where applicable.
      3) Provide written descriptions completely defining all function blocks used in program.

4) Provide list of all addresses referenced in logic diagram with description of data associated with each address.

b. Results of factory testing procedures.

c. Drawings containing the following information to be submitted as part of Specification Section 40 98 00 submittals:

1) Arrangement drawings for PLC system components.

2) Panel and enclosure plans, sections and details.

3) Access opening locations and required clearances for each panel and enclosure.

4) Enclosure internal wiring and terminal blocks.

d. Catalog cut sheets containing information on PLC components to be submitted as part of this Specification Section submittals.

4. Certifications:

a. Qualifications of installation supervisor.

b. Qualifications of programmer(s).

B. Contract Closeout Information:

1. Operation and Maintenance Data:

a. See Specification Section 01 33 00 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

2. Submit maintenance procedures available to Owner.

a. Include the location and phone numbers of service centers (including 24 HR "hot lines").

b. Provide specific information including operation and maintenance requirements, programming assistance, troubleshooting guide, parts ordering, field service personnel requests, and service contracts.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Rockwell Automation, Allen-Bradley.

2. No substitution.

B. The existing Process Instrumentation and Control Systems (PICS) design and associated native Ethernet IP network protocol is based on the existing plant Rockwell Automation platform. Network standardization is required to maximize operational efficiency and effectiveness, and minimize network operational costs.

a. All new equipment connected to PICS via Ethernet shall utilize native Ethernet IP protocol. The term “native” used in this context means that the protocol is integral to the equipment—a converter or gateway to convert from one protocol to another (e.g., Modbus Plus to Ethernet IP) is not required. *The use of protocol converters and gateways for substitute equipment is not acceptable.*

b. All proposals for substitute products shall demonstrate equipment compatibility with existing software and hardware systems, replacement parts requirements, and training requirements. The bid price of the proposed substitute products shall include:

1) 8 hours of training (in addition to that specified herein) for Owner operations personnel

2) Spare parts (for each type/size) including control and power boards or modules, operator interface units, and communication and input/output modules

3) PICS modification design, programming, and integration costs required to accommodate the proposed substitute.

2.2 PERFORMANCE AND DESIGN REQUIREMENTS

A. See Specification Section 40 90 00.

B. The PLC system shall accomplish the control requirements of the loop descriptions, Drawings, and Specifications.

C. PLC programming shall be documented and factory tested.

D. The PLC system shall operate in ambient conditions of 32 to 140 DegF temperature and 5 to 95 percent relative humidity without the need for purging or air conditioning.

E. Environmental Controls:

1. Furnish circulation fans in solid state control system enclosures.
2. Over-temperature switches shall be utilized to provide special cooling if required to maintain operating temperatures within the manufacturer's specified range.
3. Air conditioning applications shall include means of preventing moisture condensation.

F. Where the PLC is utilized to control multiple trains of equipment and where the equipment in each train operates as a unit relatively independent of other equipment trains (e.g., facility with multiple boiler units or filter trains), the PLC components (I/O modules, power supplies, etc.) shall be assigned so that the failure of any one (1) component does not affect equipment on all trains.

1. I/O modules shall be segregated on a train basis unless required otherwise for safety reasons.
2. Where several equipment units operate in parallel, but are not considered assigned to a particular equipment train (e.g., multiple raw water pumps or chemical feed pumps all discharging into a common system), the PLC I/O modules associated with each equipment unit shall be assigned so that the failure of any one (1) I/O module does not affect all of the parallel operating equipment units.

G. All PLC control system components shall be capable of meeting or exceeding electromagnetic interference tests per IEEE C37.90.2.

H. Incorporate the following minimum safety measures:

1. Watchdog function to monitor:
    a. Internal processor clock failure.
    b. Processor memory failure.
    c. Loss of communication between processor and I/O modules.
    d. Processor ceases to execute logic program.
2. Safety function wiring: Emergency shutdown switches shall not be wired into the controller.
3. Safe wiring:
    a. Unless otherwise specified, activation of alarms and stopping of equipment shall result from the de-energization of control circuits, rather than the energization of control circuits.
    b. Low voltage control signal wires:
        1) Place in conduit segregated for that purpose only.
        2) Twisted shielded wire pair.
        3) Not located in the same conduit or bundle with power wiring.
4. Initial safety conditions:
    a. Utilize program module to dictate output states in a known and safe manner prior to running of control program.
    b. Utilize program each time PLC is re-initiated and the control program activated.
5. Monitoring of internal faults and display:
    a. Internal PLC system status and faults shall be monitored and displayed.

1) Monitored items shall include:
    a) Memory ok/loss of memory.
    b) Processor ok/processor fault.
    c) Scan time overrun.

6. Control of programs: Protect access to PLC program loading with password protection or with locked, key operated selector switches.
7. Design PLC system with high noise immunity to prevent occurrence of false logic signals resulting from switching transients, relay and circuit breaker noise or conducted and radiated radio frequency interference.
8. Operator intervention:
    a. Logic system failure shall not preclude proper operator intervention.
    b. Safety shutdown of equipment or a system shall require manual operator intervention before the equipment or system operation may be reestablished.

2.3 COMPONENTS

A. PLC System Communications Processor:

1. The Communications Processor shall provide communications with the PLC Central Processor, other control systems, and man-machine interfaces as specified.

B. PLC System Enclosure:

1. In accordance with Specification Section 40 98 00.
2. Wiring and grounding to be in accordance with Specification Section 40 98 00.
3. Termination requirements:
    a. In accordance with Specification Section 40 98 00.
    b. Make connections to I/O subsystem by terminating all field wiring on terminal blocks within the enclosure.
    c. Prewire I/O modules to terminal blocks.
    d. Size terminals to accommodate all active database points and spares.
    e. Provide terminals for individual termination of each signal shield.
    f. Field wiring shall not be disturbed when removing or replacing an I/O module.

C. PLC System Software and Programming:

1. Provide all hardware and programming required to provide communication between the PLC and the man-machine interface.
2. Provide well annotated programming to accomplish all control and monitoring requirements of the Drawings and Specifications.
3. Provide two (2) copies of control logic program on thumb drive.
4. Full documentation capability.
    a. Provide description for each rung.
5. On/off line programming.
6. Offline simulation prior to download.
7. Two-step commands requiring operator verification prior to deletion of any programming.

2.4 ACCESSORIES

A. Provide all accessories required to furnish a complete PLC control system to accomplish the requirements of the Drawings and Specifications.

2.5 SOURCE QUALITY CONTROL

A. Provide a performance test after factory completion and prior to shipment.

1. Conduct a test where the system is operated continuously and checked for correct operation including loop controls, displays, printing, keyboard functions, alarm responses, and on/off sequencing control.
2. Conduct testing with dummy I/O to verify each control loop operation.
3. Allow for Owner and Engineer representatives to witness testing program.
    a. Provide minimum of 15 days notice prior to testing.
4. Do not ship prior to successful completion of this testing program.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install PLC control system in accordance with manufacturer's written instructions.

3.2 FIELD QUALITY CONTROL

A. Employ and pay for services of field service representative(s) to:

1. Inspect equipment covered by these Specifications.
2. Supervise adjustments and installation checks.
3. Maintain and submit an accurate log of all commissioning functions.
    a. All commissioning functions may be witnessed by the Engineer.
    b. All reports shall be cosigned by the Contractor and the Engineer if witnessed.
4. Conduct startup of equipment and perform operational checks.
5. Provide Owner with a written statement that manufacturer's equipment has been installed properly, started up, and is ready for operation by Owner's personnel.

3.3 DEMONSTRATION

A. Demonstrate system in accordance with Specification Section 01 79 23.

END OF SECTION

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SECTION 40 96 52

CONFIGURATION REQUIREMENTS: HUMAN MACHINE INTERFACE (HMI) AND REPORTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Configuration requirements for HMI and reports which includes but is not necessarily limited to.
    a. Specific software functional descriptions.
    b. Graphics requirements.
    c. HMI functionality requirements.
    d. Plant overview screens.
    e. Process overview screens.
    f. Detail displays.
    g. Trend displays.
    h. PLC hardware/HMI status screen.
    i. Alarm monitoring.
    j. Report generation.
    k. Configuration standards and conventions.
    l. Screen configuration review meetings.
    m. Report configuration review meetings.
    n. Coordination.

B. Related Specification Sections include but are not necessarily limited to:

1. Division 00 - Procurement and Contracting Requirements.
2. Division 01 - General Requirements.
3. Section 40 90 00 - Instrumentation for Process Control: Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. ISA 101 – Instrumentation Society of America – Human Machine Interfaces

B. Qualifications:

1. Programmer(s) shall have had experience in software configuration and installation for at least two (2) projects of similar size and complexity.

1.3 DEFINITIONS

A. HMI: Human Machine Interface.

B. I/O: Input/Output.

C. OLE: Object Linking and Embedding, a document standard developed by Microsoft that enables the creation of an object with one application and the linking or embedding of the object in a second application.

D. OPC: "OLE for Process Control"; a software standard utilizing a client/server model that makes interoperability possible between automation/control applications and field systems/devices.

E. PC: Personal Computer.

F. PLC: Programmable Logic Controller.

1.4 SUBMITTALS

A. Shop Drawings:

1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. See Specification Section 40 90 00.
3. Software Configuration Standards and Conventions document.
4. Graphic screen displays; provide in actual colors utilized.
5. Sample reports.
6. Certifications:
    a. Qualifications of programmer(s).

B. Contract Closeout Information:

1. Operation and Maintenance Data:
    a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.
2. Software Configuration Standards and Conventions - final version.

C. Informational Submittals:

1. Results of factory testing procedures.
2. Proposed training agendas and schedule.

1.5 GENERAL FUNCTIONAL REQUIREMENTS

A. Software Functional Requirements:

1. General functional requirements for system configuration are indicated on the Drawings and described in the Specifications.
2. The information presented herein and indicated on the Drawings illustrates the general functional intent of the system and may not be sufficient to fully configure the system.
3. The Contractor is responsible for determining what additional information may be required to complete the configuration tasks, and for obtaining this information from the Owner.

B. Available Process Values:

1. All process alarm, equipment status, and process variable values shall be available at any HMI.
2. If communications to a particular I/O point has failed for any reason, then wherever that data is displayed, the software shall post a visual indication that the point is not valid.

C. Provide comprehensive on-line help for all development functions.

D. Manual Entry of Data:

1. All PC-based HMIs must allow manual entry of surrogate data and other variables, which must then be available for display and use in reports.
    a. Operator-entered commands from any of the operator workstations must be logged by the computer servers.

E. System Failure:

1. Failure of any PLC, remote I/O hardware, or network communication link must be individually alarmed at HMIs.
2. Unless otherwise specified, each alarm must be specific to a single point of failure.

F. Existing software licensing shall remain and a violation in liscensing shall not result with the addition of new plant HMIs.

G. All process related functions, calculations, timers, and numeric manipulations, shall be accomplished in the PLC hardware and not in the HMI.

1. The HMI shall function as a monitoring system, not as a process controller.
2. The HMI shall transfer data to the PLC system and the PLC system shall perform all control algorithms.

1.6 SECURITY

A. Fully integrate security into the SCADA system to allow only users with appropriate security levels access to individual parts of the system.

PART 2 - PRODUCTS

2.1 SPECIFIC SOFTWARE FUNCTIONAL DESCRIPTIONS

A. Specific functional requirements for various software control blocks within the computer system are as follows.

B. Descriptions are general and are not intended to fully indicate the complete functionality of the system.

1. Monitoring of process values:
    a. Process values derived from analog process variable signals must be historically archived.
        1) Store all historical data with time and date of occurrence.
        2) Make values available for use in reports.
        3) Assign high and low alarms to process values as defined below and otherwise deemed appropriate.
    b. Provide capability for computer server(s) to retrieve real-time values from the PLC system at adjustable time periods.
    c. Alarm limits:
        1) Set per direction from the Owner.
        2) An operator having proper security authorization must be able to enable, disable, and adjust the setpoint of any individual alarm.
        3) Alarms shall be available with remote callouts

C. Utilize graphic screen displays at the HMI(s) to provide monitoring and control functionality.

1. Hierarchy of HMI screens is in descending order as follows:
    a. Plant overview screen(s).
    b. Process overview screens.
    c. Process screens.
    d. Pop-up/control screens.

D. HMI operator interface functionality shall include:

1. Indication of process variables.
2. Configuration of control loop parameters (e.g., setpoints, gains, etc.).
3. Adjustment of controller output.
4. Display of real time and historical process trends.
5. Selector switch and pushbutton station controls.
6. System and process status indicators.
7. Graphic representation of plant operations with interactive status and measurement symbols.
8. Annunciation.

E. Graphics:

1. All graphics are t conform with ISA 101 and incorporate “high performance HMI approaches”

2. Utilize dynamic variables with unique tags per graphic.
3. Dragging the mouse over designated process areas of screen shall allow the operator to select predetermined processes or equipment and drill down to site-specific detail screens.
4. Critical "overview" information such as tank levels, flows and pressures shall be indicated through data fields or animation effects such as level fills or color change.
5. All monitored and or controlled process equipment shall indicate status changes.
    a. For example, a pump "running" condition shall be indicated differently than a pump that is “not running.”
6. Tank and vessel levels shall be indicated with a tabular data field and by a scaled analog graphic with a real time trend indicating a rising or falling level within the tank or vessel. The same Graphic shall also include scaled alarm points to provide an understanding of abnormal conditions approaching alarm levels.
7. Provide the ability to "drill down" to detail screens or graphics.
    a. Clicking on a device or process area shall generate a detail graphic or pop-up window to access specific data or control functions.
    b. All operator adjustments (e.g., set point adjustment, mode selection) shall be accomplished via a pop-up display, and shall not be allowed on the process screen.
8. Standard symbol library:
    a. User defined.
    b. Must not require software programming.
9. Single keystroke access from graphic to group display or other custom graphic displays.
10. Capable of being edited by moving, copying, or grouping user defined areas of screen.
11. Utilize a navigation bar.
    a. Navigation bar utilized on every screen.
    b. Navigation bar to include navigation functions, active alarm notification, security functions, current date/time display, "PRINT SCREEN" pushbutton, and other functions as required and as agreed upon at the Screen Configuration Review Meetings.

F. Plant Overview Screens:

1. As a minimum, provide new or modify existing Plant Overview screens as listed below.
    a. This list is meant to serve as an initial guide; final determination of overview screen requirements will be made during the Configuration Conferences.
        1) Plant Overview
        2) Headworks
        3) SBR

G. Process Overview Screens:

1. Provide modifications to existing screens or new screens as required for new equipment and modified processes as part of the project.
    a. This list is meant to serve as an initial guide; final determination of process and equipment screen requirements will be made during the Configuration Conferences.
        1) Plant Overview
        2) Headworks
        3) SBR
2. At a process overview screen, the operator shall be able to select a specific process screen for monitoring/control purposes.
    a. Monitoring and control functions available at the selected process screen include but are not limited to the following:
        1) Select individual equipment items for monitoring and control.
        2) Select a control loop or point for control action.

3) Change control mode of loop selected (manual, automatic, cascade).
4) Change setpoint.
5) Issue commands to start/stop and open/close two-state equipment.
6) For manual loading output stations, the operator shall be able to manipulate analog output values.
7) Select a loop and initiate further display, such as the detail display, trend, or hourly averaging.
8) Display and change ratio and bias values.
9) Control field equipment such as motor-operated valves and switches.

H. Detail Display:

1. Provide separate display for each point.
   a. Representations of each analog and digital point shall be single user configured faceplate.
   b. Display shall include alphanumeric representations of all variables and parameters for single loops including but not limited to:
      1) Alarm points.
      2) Limits.
      3) Constants.
      4) Interconnections to other loops.
      5) Calculating functions.

I. Trend Displays:

1. Real time historical trend displays.
2. Real time on-line trend displays.
3. Capable of displaying multiple points per display.
4. Operator shall be able to select any desired sample time interval.
5. Provide flexibility and easy access to real time and historical trend information for any variable TAG defined within the SCADA application.
   a. As a minimum, provide the following:
      1) Provide capability for the user to define trend scenarios.
      2) Provide a button to open a dialog window to select multiple variable TAGS and save them as a trend scenario for future use.
      3) Provide a pull-down menu to allow the user to open saved trend scenarios.
      4) Provide a button to allow the user to select real-time or historical trends.
      5) Provide a button to save displayed trend info to a file for export to external software applications (such as Microsoft Excel).
      6) Provide a Print Trend button to allow user to print current trend.
6. Utilize Historical Data Server(s) to collect and manage data.

J. PLC Hardware/HMI Status Screen:

1. Provide a status screen to depict status conditions and diagnostic information for all major networked equipment.
2. Depict communication status for all networked communicating devices, such as PLC processors, Ethernet switches, PCs, and radios.

K. Alarm Monitoring:

1. Provide standard alarm screen functionality to ensure flexibility and quick access to live alarms, alarm history and alarm grouping parameters.
   a. Alarms shall be categorized in a numbered system 1-4 using redundant coding for each priority level:

1) 1 = highest priority, color shall be red with a square symbol.
2) 2 = elevated priority, color shall be orange with a triangle symbol.
3) 3 = lower priority, color chall be yellow with a upside down triangle stmbol
4) 4 = diagnostic, color shall be magenta with a 90° rotated square symbol.

b. As a minimum, include the following features and functionality:
1) An Alarm Screen header bar to head all alarm pages and reside below the Navigation Bar.
2) Buttons to dynamically switch between Alarm Summary and Alarm History.
3) A menu to allow user to select and open historical alarm archives.
a) Utilize a time-date stamp file structure.
4) Pull-down menu bar to select operator configured alarm groups.
5) Capability to sort alarms by priority and to define priority for all system alarms.
6) Capability to filter or group alarms.

2. Analog alarms:
a. The SCADA software shall monitor analog and discrete variables and calculated conditions, and determine if the variable is in an alarm condition.
b. For each Analog Tag, an alarm for each of the following conditions shall be assignable:
1) Low-low.
2) Low.
3) High.
4) High-high.
5) Deviation low.
6) Deviation high.
7) Rate of change.
c. Provide adjustable dead bands and delay timers for all analog alarms.

3. Present alarms in order of:
a. Priority.
b. Time of occurrence.
c. Non-acknowledged presented ahead of acknowledged.

4. Utilize single keystroke or pushbutton to:
a. Acknowledge alarms.

5. Alarm list presented to operator shall include:
a. Time of occurrence.
b. Time of acknowledgement.
c. Description.
d. Acknowledgement status.

6. Alarm list printed by either of the following:
a. On command.
b. Periodically.

7. Audible alarming capability for user selected alarms.
8. Remote alarming capability using WIN-911

L. Report Generation:

1. Base bid on the generation of the following reports:
a. Minimum of two formatted reports.
1) Report form and content shall be determined at the Report Configuration Review Meetings.

2) Each report shall contain daily, weekly, and monthly average calculated values.
3) Each report shall contain between three and ten measured parameters.

b. List of all entries initiated by operator including the following:
1) Console key changes.
2) Beginning and final values of setpoint and output changes.
3) Mode changes (i.e., auto to manual).
4) Time change was made.

c. Event list:
1) Description of selected events.
2) Time of event.

2. Custom report capabilities:
a. User configurable.
b. Contain selected information from any log, event, or alarm list.
c. Capable of producing custom log report for periodic and on-demand printing of a list of process or calculated variables.
d. Reports shall not require software programming by the user to setup.

3. Control of programs:
a. Protect access to configuration via password protection.

PART 3 - EXECUTION

3.1 CONFIGURATION REQUIREMENTS

A. Provide all programming modifications and configurations required for all HMI's.

3.2 CONFIGURATION STANDARDS AND CONVENTIONS

A. Prepare and submit a "Software Configuration Standards and Conventions" for the City of Hailey.

1. Submit for review and approval prior to commencing with software configuration.
2. Describe and define such items as:
a. Proposed graphic display process colors/representations.
b. Color standards for "ON," "OFF," and "ALARM" conditions.
c. Font type and size.
d. Alarm handling conventions.
e. Methods for navigation between displays.
f. Address usage/naming conventions.
g. Security setup.
3. Prior to submitting the initial draft document, the Contractor must meet with the Owner to review any of the Owner's existing standards and conventions.
4. In addition to submitting the initial document for review, submit an updated version of the document as part of the Operation and Maintenance Manuals.
a. Revise this document to include any additional standards that are established throughout the configuration process.

B. It is the intent of these specifications to provide the end user with state-of-the-art functionality.

1. Minimum standards are as follows:
a. Depict the actual process equipment configuration as accurately as possible.
2. All overview and site-specific screens shall incorporate a "navigational header bar" similar in function and appearance to *Microsoft Edge* or most current Microsoft browser application.

a. The intention of this Specification is to provide a familiar, user-friendly navigation throughout the graphical displays.

3.3 SCREEN AND REPORT CONFIGURATION REVIEW MEETINGS

A. Conduct a minimum of two eight hour configuration conferences with the Owner to review and discuss system configuration programming and related topics.

1. The purpose of the conferences will be to discuss, in detail, how each I/O point will be handled and the types, quantities, hierarchies, and functioning of display screens.
2. Review of the Owner's existing systems, standards, conventions, file and tag naming requirements, font type and size requirements, and reporting requirements must be part of each conference.
3. Review the navigation bar to be utilized.
4. Review of the Owner's existing systems, standards, conventions, and reporting requirements must be part of each conference.
5. Conferences will be held in Hailey at a site designated by the Owner.
6. Each screen will be reviewed at each conference.
    a. If required, to review all screens, each conference will occur on multiple days.
7. Submit 10 color copies of printed screens via shop drawing submittal process 10 calendar days before each conference.
8. Bring equipment to project screens on wall or provide multiple monitors for viewing by attendees.

B. Proposed graphic screens and report formats must be reviewed with the Owner throughout the configuration process at major milestones (25%, 50%, 75% and 100%).

3.4 COORDINATION

A. Coordinate as required with other contractors and vendors to seamlessly integrate all HMI monitoring and control functions.

1. To the greatest extent possible, integrate graphics presentation for all systems into screens utilizing one common HMI software.

B. Examples of systems that utilize separate application software packages and thus require coordination include, but are not necessarily limited to:

1. Screen Control Systems.

3.5 FIELD QUALITY CONTROL

A. Employ and pay for services of field service representative(s) to:

1. Inspect equipment covered by this Specification Section.
2. Supervise adjustments and installation checks.
3. Maintain and submit an accurate daily or weekly log of all commissioning functions.
    a. All commissioning functions may be witnessed by the Engineer.
    b. All reports shall be cosigned by the Contractor and the Engineer if witnessed.
4. Conduct startup of equipment and perform operational checks.
5. Provide Owner with a written statement that manufacturer's equipment has been installed properly, started up, and is ready for operation by Owner's personnel.

3.6 DEMONSTRATION

A. Demonstrate system in accordance with Specification Section 01 91 14.

1. Provide 3 days of onsite training with Owner Personnel. Training shall include but not be limited to:
    a. HMI screen heirarchy and navigation
    b. Setpoint adjustment

c. Operator overrides
d. Process interlocks
e. Alarm management
f. Process network architecture and IP addressing

END OF SECTION

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SECTION 40 97 00
CONTROL AUXILIARIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Signal modules:
    a. Loop isolator.
    b. Potentiometer transmitter.
    c. Pneumatic/current transducer.
2. Pilot devices:
    a. Selector switches.
    b. Pushbuttons.
    c. Indicating lights.
    d. Combination selector switch/indicator light.
    e. Potentiometer
3. Relays/timers:
    a. Control relay.
    b. Time delay relays.
4. Termination equipment:
    a. Terminal blocks.
    b. Fuse holders.
5. Voltage surge protection devices.
6. Running time indicator.

B. Related Specification Sections include but are not necessarily limited to:

1. Division 00 - Procurement and Contracting Requirements.
2. Division 01 - General Requirements.
3. Section 40 90 00 - Instrumentation for Process Control: Basic Requirements.
4. Section 26 43 13 - Low Voltage Surge Protective Devices (SPD).

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. The International Society of Automation (ISA):
    a. S18.1, Annunciator Sequences and Specifications.
2. National Electrical Manufacturers Association (NEMA):
    a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
    b. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts.
3. Underwriters Laboratories, Inc. (UL).

B. Miscellaneous:

1. Assure units comply with electrical area classifications and NEMA enclosure type shown on Drawings.

1.3 SUBMITTALS

A. Shop Drawings:

1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. See Specification Section 40 90 00.

B. Contract Closeout Information:

1. Operation and Maintenance Data:
   a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the manufacturers listed in the applicable Articles below are acceptable.

B. Provide similar components from the same manufacturer for uniformity of appearance, operations, and maintenance.

C. Submit request for substitution in accordance with Specification Section 01 25 00.

2.2 SIGNAL MODULE

A. Loop Isolators:

1. Acceptable manufacturers:
   a. Moore Industries.
   b. Phoenix Contact
   c. Or approved equal
2. Design and fabrication:
   a. Solid state electronics.
   b. Transmit analog output signal directly proportional to measured input signal.
   c. Power source: 24 Vdc.
   d. Analog input: 4-20 mA DC or 1-5 Vdc.
   e. Output signal: 4-20 mA DC into 1400 ohms.
   f. Impedance:
      1) Voltage input: 10 Meg.
      2) Current input: 50 ohms.
      3) Voltage output: 1 ohm.
      4) Current output: 1650 ohms.
   g. Accuracy: Better than ± 0.10 percent of span.
   h. Isolation: Up to 500 V rms (input, output and case).
   i. Temperature effect: ±0.0025 percent of span per DegF.
   j. Ambient temperature range: 0-140 DegF.
   k. Factory calibrated.

B. Potentiometer Transmitters:

1. Acceptable manufacturers:
   a. Phoenix Contact
   b. Transmation, Inc.
   c. Moore Industries.
   d. AGM Electronics.
   e. Or approved equal
2. Design and fabrication:

a. Solid state electronics.
b. Transmit analog signal directly proportional to measured impedance input.
c. Power source: 24 Vdc.
d. Input: 0-1000 ohms.
e. Output signal: 4-20 mA DC.
f. Accuracy (maximum error): ±o.25 percent.
g. Ambient temperature range: 0-140 DegF.

C. Current/Pneumatic Transducer:

1. Acceptable manufacturer:
   a. Fisher Controls.
   b. Or approved equal.
2. Materials:
   a. Housing: Cast aluminum or fiberglass.
3. Design and fabrication:
   a. Force balance device.
   b. Capable of receiving an electronic signal and converting it to a directly proportional pneumatic signal.
   c. Input signal: 4-20 mA DC.
   d. Output signal: 3-15 psi.
   e. Accuracy (maximum error): +0.50 percent of output span.
   f. Ambient temperature range: 0-140 DegF.

2.3 PILOT DEVICES

A. Selector Switches:

1. Acceptable manufacturers:
   a. Allen-Bradley.
   b. Eaton.
   c. Or approved equal.
2. Design and fabrication:
   a. Heavy-duty type.
   b. NEMA 4/13 or 4/4X/13 as required.
   c. Rotary cam units conforming to NEMA ICS 2-216.22.
   d. Mounting hole: 30.5 mm with key to avoid rotation in hole.
   e. Supply switches having number of positions required with contact blocks to fulfill functions shown and specified.
   f. UL listed.
   g. Maintained contact type with a positive detent to prevent the switch from hanging up between positions.
   h. Knob type operators.
   i. Black colored operators.
   j. Designed with cam and contact block.
   k. Legend plate marked per Contract Documents.
   l. Contact block requirements:
      1) Dry and indoor locations: Standard finger safe contact blocks rated for 10 A continuous current.
      2) Wet or outside locations: Hermetically sealed contact blocks.

B. Pushbuttons:

1. Acceptable manufacturers:
    a. Allen-Bradley.
    b. Eaton.
    c. Or approved equal.
2. Materials:
    a. Backing diaphragm: Buna-N.
3. Design and fabrication:
    a. Heavy-duty type.
    b. NEMA 4/13 or 4/4X/13 as required.
    c. Conforming to NEMA ICS 2-216.22.
    d. Mounting hole: 30.5 mm.
    e. Diaphragm backed.
    f. UL listed.
    g. Emergency stop pushbuttons to have mushroom head operator and maintained contact.
    h. Non-illuminated type:
        1) Momentary contact with necessary contact blocks.
        2) Molded, solid color melamine buttons.
        3) Standard flush operators.
        4) Black colored buttons for START or ON and black color for STOP or OFF.
        5) Appropriate contact blocks to fulfill functions shown or specified.
    i. Contact block requirements:
        1) Dry and indoor locations: Standard finger safe contact blocks rated for 10 A continuous current.
        2) Wet or outside locations: Hermetically sealed contact blocks.
        3) Legend plate marked per Contract Documents.
    j. Illuminating type:
        1) Momentary contact with necessary contact blocks.
        2) Serves as both pushbutton control and indicating light.
        3) Green colored lenses for start or on and red for STOP or OFF.
        4) Resistor-type full voltage light unit with lens and panel gasket.
        5) Legend plate marked per Contract Documents.
        6) Appropriate contact blocks to fulfill functions shown or specified.

C. Indicating Lights:
1. Acceptable manufacturers:
    a. Allen-Bradley.
    b. Eaton.
    c. Or approved equal
2. Design and fabrication:
    a. Heavy duty.
    b. NEMA 4/13 or 4/4X/13 as required.
    c. LED.
    d. UL listed.
    e. Legends marked per Contract Documents.
    f. Mounting hole: 30.5 mm.
    g. Push-to-test indicating lights.

h. Glass lens.
i. Color code lights as follows:
1) Green: ON or running; valve normal.
2) Amber: Standby; auto mode; ready.
3) Red: OFF or stopped; valve abnormal.
j. Legend plate engraved for each light.

D. Combination Selector Switch/Indicator Light:

1. Acceptable manufacturer:
a. Allen Bradley.
b. Eaton.
c. Or approved equal.
2. Design and fabrication:
a. Indicators, pushbuttons, selectors, and selector-push combination units as indicated on Drawings.
1) Contact arrangements and functions as shown on Drawings.
b. Integrally-mounted transformers for each indicating lamp.
1) Lens colors and engravings as shown on Drawings.
c. NEMA 4/13 or 4/4X/13 as required.
d. Cover plate edge bezel: Chrome colored to match existing.
e. Contacts: Heavy-duty rated with easy wiring terminal screws.

E. Potentiometer:

1. Acceptable manufacturers:
a. Allen Bradley.
b. Eaton.
c. Or approved equal
2. Design and fabrication:
a. Heavy-duty, NEMA type.
b. Mounting hole: 30.5 mm.
c. UL listed.
d. Linear adjustment through 0-1000 ohms with 1 percent resolution.
e. 3-wire interface.
f. Dial plate with 0-100 percent scale.
g. Panel mounted.
h. One-turn adjustment knob.

2.4 RELAYS/TIMERS

A. Control Relays:

1. Acceptable manufacturers:
a. Allen-Bradley
b. Phoenix Contact
c. Or approved equal
2. Design and fabrication:
a. Plug-in general purpose relay, tube base.
b. Pin connector type.
c. Switching capacity: 10 A.
d. Contact material: Silver cadmium oxide.

e. Provide relays with a minimum of 3 SPDT contacts.
f. Coil voltage: 120 Vac or 24 Vdc.
g. Relay sockets are DIN rail mounted with guarded terminal.
h. Internal neon or LED indicator is lit when coil is energized.
i. Clear polycarbonate dust cover with clip fastener.
j. Check button.
k. Temperature rise:
1) Coil: 85 DegF max.
2) Contact: 65 DegF max.
l. Insulation resistance: 100 Meg min.
m. Frequency response: 1800 operations/hour.
n. Operating temperature: -20 to +150 DegF.
o. Life expectancy:
1) Electrical: 500,000 operations or more.
2) Mechanical: 50,000,000 operations or more.
p. UL listed or recognized.

B. Time Delay Relays:

1. Acceptable manufacturers:
a. Allen Bradley.
b. Phoenix Contact.
c. Or approved equal
2. Design and fabrication:
a. Melt design test and performance requirements of NEMA ICS 2-218.
b. Heavy-duty.
c. Solid-state construction.
d. External adjusting dial.
e. Auxiliary relays as required to perform functions specified or shown on Drawings.
f. Operates on 117 Vac (±10 percent) power source.
g. Contact rating: A150 per NEMA ICS 2-125.
h. Furnish with "on" and "timing out" indicators.

2.5 TERMINATION EQUIPMENT

A. Terminal Blocks:

1. Acceptable manufacturers:
a. Allen Bradley.
b. Phoenix Contact.
c. Or approved equal
2. Design and fabrication:
a. Modular type with screw compression clamp.
b. Screws: Stainless steel.
c. Current bar: Nickel-plated copper allow.
d. Thermoplastic insulation rated for -40 to +90 DegC.
e. Wire insertion area: Funnel-shaped to guide all conductor strands into terminal.
f. Install end sections and end stops at each end of terminal strip.
g. Install machine-printed terminal markers on both sides of block.
h. Spacing: 6 mm.

i. Wire size: 22-12 AWG.
j. Rated voltage: 600 V.
k. Din rail mounting.
l. UL listed.

3. Standard-type block:
   a. Rated current: 30 A.
   b. Color: Gray body.
4. Bladed-type block:
   a. Terminal block with knife blade disconnect which connects or isolated the two (2) sides of the block.
   b. Rated current: 10 A.
   c. Color:
      1) Panel control voltage leaves enclosure - normal: Gray body, orange switch.
      2) Foreign voltage entering enclosure: Orange body, orange switch.
5. Grounded-type block:
   a. Electrically grounded to mounting rail.
   b. Use to terminal ground wires and analog cable shields.
   c. Color: Green and yellow body.

B. Fuse Holders:

1. Acceptable manufacturers:
   a. Allen Bradley.
   b. Phoenix Contact.
   c. Or approved equal.
2. Design and fabrication:
   a. Modular-type with screw compression clamp.
   b. Screws: Stainless steel.
   c. Current bar: Nickel-plated copper alloy.
   d. Thermoplastic insulation rated for -40 to +105 DegC.
   e. Wire insertion area: Funnel-shaped to guide all conductor strands into terminal.
   f. Blocks can be ganged for multi-pole operation.
   g. Install end sections and end stops at each end of terminal strip.
   h. Install machine-printed terminal markers on both sides of block.
   i. Spacing: 8 mm.
   j. Wire size: 30-12 AWG.
   k. Rated voltage: 300 V.
   l. Rated current: 12 A.
   m. Fuse size: 5 x 20 mm.
   n. Blown fuse indication.
   o. DIN rail mounting.
   p. UL listed.

2.6 RUNNING TIME INDICATORS

A. Acceptable Manufacturer:

1. Eagle Signal Controls.
2. Or approved equal.

B. Design and Fabrication:

1. Six-digit wheels including a 1/10 digit.
2. Non-reset type.
3. Time range in hours.
4. Automatic recycle at zero.
5. Accuracy: 1 percent.
6. Sealed against dirt and moisture.
7. Tamperproof.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

END OF SECTION

SECTION 40 98 00
CONTROL PANELS AND ENCLOSURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Requirements for control panels and enclosures utilized as follows:
    a. Unless noted otherwise, all control panels and enclosures housing control components that are specified in Specification Section 26 29 23, Specification Section 40 91 10 or Specification Section 40 97 00.

B. Related Sections include but are not necessarily limited to:

1. Division 00 - Procurement and Contracting Requirements.
2. Division 01 - General Requirements.
3. Section 10 14 00 - Identification Devices.
4. Section 40 90 00 - Instrumentation for Process Control: Basic Requirements.
5. Section 40 90 05 – Process Control Descriptions.
6. Section 40 91 10 - Primary Elements and Transmitters.
7. Section 40 97 00 - Control Auxiliaries.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. ASTM International (ASTM):
    a. B75, Standard Specification for Seamless Copper Tube.
2. National Electrical Manufacturers Association (NEMA):
    a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
    b. ICS 4, Industrial Control and Systems: Terminal Blocks.
3. National Fire Protection Association (NFPA):
    a. 70, National Electrical Code (NEC):
        1) Article 409, Industrial Control Panels.
4. Underwriters Laboratories, Inc. (UL):
    a. 508A, Standard for Safety Industrial Control Panels.
    b. 698A for Industrial Control Panels Relating to Hazardous Locations.

B. Miscellaneous:

1. Approved supplier of Industrial Control Panels under provisions of UL 508A.
    a. Entire assembly shall be affixed with a UL 508A label "Listed Enclosed Industrial Control Panel" prior to shipment to the jobsite.
    b. Entire assembly shall be affixed with a UL 508A label "Listed Open Industrial Control Panel" prior to shipment to the jobsite.
    c. Control panel(s) without an affixed UL 508A label shall be rejected and sent back to the Contractor’s factory.
    d. At the Owner’s option, UL representatives shall perform a field inspection of the panel and place a UL placard on the panel after it satisfies UL 508A requirements.
    e. All associated costs are to be paid by the Contractor.
2. If detailed panel layouts and schematics suitable for UL508A construction were provided as part of the Contract Documents these documents shall be used by the Contractor for panel construction.

a. Any panel shop modifications or variations are to be provided to the Engineer for approval.
b. Prior to shipping the Contractor is to provide a set of redlined shop drawings to the Engineer at completion of factory acceptance testing to be incorporated into the conformed documents.
c. Conformed documents shall be provided with the panel prior to shipping/delivery to the project site.

1.3 DEFINITIONS

A. Panel: Control panels or enclosures listed in the schedule included in this Specification Section.

B. Foreign Voltages: Voltages that may be present in circuits when the panel main power is disconnected.

C. Intrinsically Safe:

1. A device, instrument or component that will not produce sparks or thermal effects under normal or abnormal conditions that will ignite a specified gas mixture.
2. Designed such that electrical and thermal energy limits inherently are at levels incapable of causing ignition.

D. Cable: Multi-conductor, insulated, with outer sheath containing either building wire or instrumentation wire.

E. Instrumentation Cable:

1. Multiple conductor, insulated, twisted or untwisted, with outer sheath.
2. Instrumentation cable is typically either TSP (twisted-shielded pair) or TST (twisted-shielded triad), and is used for the transmission of low current or low voltage signals.

F. Ground Fault Circuit Interrupter (GFCI): A type of device (e.g., circuit breaker or receptacle) which detects an abnormal current flow to ground and opens the circuit preventing a hazardous situation.

G. Programmable Logic Controller (PLC): A specialized industrial computer using programmed, custom instructions to provide automated monitoring and control functions by interfacing software control strategies to input/output devices.

H. Remote Terminal Unit (RTU): An industrial data collection device designed for location at a remote site, that communicates data to a host system by using telemetry such as radio, dial-up telephone, or leased lines.

I. Input/Output (I/O): Hardware for the moving of control signals into and/or out of a PLC or RTU.

J. Supervisory Control and Data Acquisition (SCADA): Used in process control applications, where programmable logic controllers (PLCs) perform control functions but are monitored and supervised by computer workstations.

K. Highway Addressable Remote Transducer (HART): An open, master-slave protocol for bus addressable field instruments.

L. Digital Signal Cable: Used for the transmission of digital communication signals between computers, PLCs, RTUs, etc.

M. Uninterruptible Power Supply (UPS): A backup power unit that provides continuous power when the normal power supply is interrupted.

N. Loop Calibrator: Portable testing and measurement tool capable of accurately generating and measuring 4-20ma DC analog signals.

1.4 SUBMITTALS

A. Shop Drawings:

1. See Specification Section 01 33 00 for requirements for the mechanics and administration of the submittal process. Panel layout and schematics within contract documents for panels identified in the schedule are to be treated as shop drawings. All other items described below beyond the shop drawings are the responsibility of the Contractor.
2. See Specification Section 40 90 00.
3. According to UL508A requirements.
4. Prepared with computer aided design (CAD) software.
5. Printed on 11 by 17 IN sheets.
6. Drawings shall include a title block containing the following:
    a. Plant or facility name where panel(s) are to be installed.
    b. Drawing title.
    c. Drawing number.
    d. Revision list with revision number and date
    e. Drawing date.
    f. Drawing scale.
    g. Manufacturer name, address, and telephone number.
7. Cover sheet for each drawing set shall indicate the following:
    a. Plant or facility name.
    b. Project name.
    c. Submittal description.
    d. Revision number.
    e. Issue date.
8. Table of contents sheet(s) shall indicate the following for each drawing in the set:
    a. Drawing title.
    b. Drawing number.
9. A panel general data sheet shall indicate the following:
    a. Panel construction notes including enclosure NEMA rating, finish type and color, wire type, wire color strategy, conductor sizes, and wire labeling strategy.
    b. Confirmation that the panel(s) are to be affixed with a UL 508A label prior to shipment from the factory.
    c. Panel materials of construction, dimensions, and total assembled weight.
    d. Nameplate schedule with exact text, letter height and color, and background color.
    e. Cautionary markings.
10. Bill of Materials shall indicate the following:
    a. Where a Bill of Material is included as part of the Contract Documents, only required changes or additions to the Contact Documents to meet design intent shall be submitted.
    b. Where a Bill of Material is required for a panel not included in the Contract Documents it shall include the following component information:
        1) Component item numbers.
        2) Quantity.
        3) Functional name or description.
        4) Manufacturer.
        5) Complete model number.
        6) Size or rating.
11. Panel exterior layout drawings shall indicate the following:

a. Where a Panel Exterior Layout is included as part of the Contract Documents, only required changes or additions to the Contact Documents to meet design intent shall be submitted.
b. Where a Panel Exterior Layout is required for a panel not included in the Contract Documents it shall include the following component information:
1) Panel dimensions and dimensions of components relative to edges and other major components.
2) Panel access openings.
3) Component item numbers referenced to the Bill of Material.
4) Conduit access locations.
5) Front panel device layout.
6) Nameplate location.

12. Panel interior layout drawings shall indicate the following:
a. Where a Panel Interior Layout is included as part of the Contract Documents, only required changes or additions to the Contact Documents to meet design intent shall be submitted.
b. Where a Panel Interior Layout is required for a panel not included in the Contract Documents it shall include the following component information:
1) Interior panel dimensions and dimensions of components relative to edges and other major components.
2) Component item numbers referenced to the Bill of Material.
3) Interior device layouts.
4) Wire-way locations, purpose, and dimensions.
5) Terminal strip designations.
6) Location of lighting fixtures, switches and receptacles.

13. Wiring Schematics shall consist of the following:
a. Where Wiring Schematics are included as part of the Contract Documents. Only required changes or additions to the Contact Documents to meet design intent shall be submitted.
b. Where Wiring Schematics are required for a panel not included in the Contract Documents it shall include the following component information:
1) Panel power distribution diagrams including circuit protection and ratings.
2) Internally wired components and equipment tags.
3) Required field wiring, external components and equipment tags.
4) I/O information:
a) Model number of I/O module.
b) Description of I/O module type and function.
c) Rack and slot number.
d) Terminal number on module.
e) Point or channel number.
f) Programmed point addresses.
g) Signal function and type.
5) Wiring diagrams shall identify each wire as it is to be labeled.

B. Manufacturer catalog cut sheets for enclosure, finish, panel devices, control auxiliaries, and accessories.

C. Electrical load calculations for each panel:
1. Total connected load.
2. Peak electrical demand for each panel.

D. Climate control calculations for each panel.

1. Verify that sufficient dissipation and/or generation of heat is provided to maintain interior panel temperatures within the rated operating temperatures of panel components.

E. Contract Closeout Information:

1. Operation and Maintenance Data:
    a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.
2. See Specification Section 40 90 00.

F. Informational Submittals:

1. Record Drawings:
    a. Contractor shall provide updated panel drawings to the Engineer prior to shipping for record documents and inclusion in the record drawings
    b. Updated panel drawings delivered with the panel(s) from the Contractor's factory.
    c. Drawings shall be enclosed in transparent plastic and firmly secured within each panel.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Enclosures:
    a. Hoffman Engineering Co.
    b. Rittal.
    c. Hammond Manufacturing.
    d. Or approved equal.
2. Panel heaters:
    a. Hoffman Enclosures, Inc.
    b. Rittal.
    c. Hammond Manufacturing.
    d. Or approved equal.
3. Heat exchangers and air conditioners:
    a. Hoffman Enclosures, Inc.
    b. Rittal.
    c. Hammond Manufacturing.
    d. Or approved equal.
4. Cooling fans and exhaust packages:
    a. Hoffman Enclosures, Inc.
    b. Rittal.
    c. Or approved equal.

B. Submit request for substitution in accordance with Specification Section 01 25 00.

2.2 ACCESSORIES

A. Panel Nameplates and Identification:

1. See Section 10 14 00.

2.3 FABRICATION

A. General:

1. Fabricate panels with instrument arrangements and dimensions identified in the Contract Documents. All changes to the contract documents are to be approved by engineer, redlined and provided to the Engineer for as-built record documents.
2. Provide panel(s) with the required enclosure rating per NEMA 250 to meet classifications identified in the Contract Documents.
3. Devices installed in panel openings shall have a NEMA enclosure rating at least equal to the panel enclosure rating.
    a. Devices that cannot be obtained with an adequate NEMA rating shall be installed behind a transparent viewing window.
    b. The window shall maintain the required NEMA rating of the enclosure.
4. Panel(s) shall be completely assembled at the Contractor's factory.
    a. No fabrication other than correction of minor defects or minor transit damage shall be performed on panels at the jobsite.
5. Patching:
    a. Existing enclosures that have been field modified shall be patched where indicated on the Drawings.
    b. Holes in enclosure doors left by removed equipment shall be patched by welding a cover of the same size and shape in the opening. All welding beads on the exterior surface shall be ground smooth.
    c. All patched exterior surfaces shall have the entire surface painted to ensure uniformity of faded existing paint.
    d. Provide final surface treatment with 120 grit abrasives or finer, followed by spot putty to fill all voids.
    e. Utilize solvent or chemical methods to clean panel surfaces.
    f. All bare metal on the interior and exterior surfaces shall be primed and painted.
    g. Paint shall be ANSI #61 gray with flat finish.
6. Painting:
    a. Panels fabricated from steel shall have their internal and external surfaces prepared, cleaned, primed, and painted.
        1) Mechanically abrade all surfaces to remove rust, scale, and surface imperfections.
        2) Provide final surface treatment with 120 grit abrasives or finer, followed by spot putty to fill all voids.
        3) Utilize solvent or chemical methods to clean panel surfaces.
        4) Apply surface conversion of zinc phosphate prior to painting to improve paint adhesion and to increase corrosion resistance.
        5) Electrostatically apply polyester urethane powder coating to all inside and outside surfaces.
        6) Bake powder coating at high temperatures to bond coating to enclosure surface.
            a) Panel interior shall be white with semi-gloss finish.
            b) Panel exterior shall be ANSI #61 gray with flat finish.
        7) Application of alkyd liquid enamel coating shall be allowed in lieu of polyester urethane powder for wall mounted NEMA 1 or NEMA 12 rated panels.
    b. Panels fabricated from stainless steel, aluminum, or fiberglass shall not be painted.
7. Finish opening edges of panel cutouts to smooth and true surface conditions.
    a. Panels fabricated from steel shall have the opening edges finished with the panel exterior paint.
8. Panel shall meet all requirements of UL 508A.
    a. If more than one (1) disconnect switch is required to disconnect all power within a panel or enclosure, provide a cautionary marking with the word "CAUTION" and the following

or equivalent, "Risk of Electric Shock-More than one (1) disconnect switch required to de-energize the equipment before servicing."

9. Provide control panel in accordance with NFPA 70, Article 409.
    a. In the event of any conflict between NFPA 70, Article 409 and UL 508A, the more stringent requirement shall apply.

B. Free-Standing Panels:

1. Welded construction.
2. Completely enclosed, self-supporting, and gasketed dust tight.
3. Rolled lip around all sides of enclosure door opening.
4. Seams and corners welded and ground smooth to touch and smooth in visual appearance.
5. Full height, fully gasketed flush pan doors.
6. Full length piano hinges rated for 1.5 times door plus instrument weight.
7. Doors with keyed alike locking handles and three-point catch.
8. Appropriate conduit, wiring, and instrument openings shall be provided.
9. Lifting eyebolts to allow simple, safe rigging and lifting of panel during installation.

C. Wall Mounted Panels:

1. Seams continuously welded and ground smooth.
2. Rolled lip around all sides of enclosure door opening.
3. Gasketed dust tight.
4. Heavy GA hinge pins on doors.
    a. Hinges rated for 1.5 times door plus instrument weight.
5. Front full opening door.
6. Manufacturer brackets for UL listed wall mounting.

D. Internal Panel Wiring:

1. Panel wire duct shall be installed between each row of components, and adjacent to each terminal strip.
    a. Route wiring within the panel in wire-duct neatly tied and bundled with tie wraps.
    b. Follow wire-duct manufacturer's recommended fill limits.
    c. Wire-duct shall have removable snap-on covers and perforated walls for easy wire entrance.
    d. Wire-duct shall be constructed of nonmetallic materials with rating in excess of the maximum voltage carried therein.
2. Wiring shall be installed such that if wires are removed from one (1) device, source of power will not be disrupted to other devices.
3. Splicing and tapping of wires permitted only at terminal blocks.
4. Wire bunches to doors shall be secured at each end so that bending or twisting will be around longitudinal axis of wire.
    a. Protect bend area with sleeve.
5. Arrange wiring neatly, cut to proper length, with surplus wire removed.
    a. Arrange wiring with sufficient clearance.
    b. Provide abrasion protection for wire bundles that pass through openings or across edges of sheet metal.
6. AC circuits shall be routed separate from analog signal cables and digital signal cables.
    a. Separate by at least 2 IN, except at unavoidable crossover points and at device terminations.
7. Provide at least 6 IN of separation between intrinsically safe devices and circuits and non-intrinsically safe devices and circuits.

8. Wiring to pilot devices or rotary switches shall be individually bundled and installed with a "flexible loop" of sufficient length to permit the component to be removed from panel for maintenance without removing terminations.
9. Conductors for AC and DC circuits shall be type MTW stranded tinned copper listed for operation with 600 V at 90 DegC.
    a. Conductor size shall be as required for load and 16 AWG minimum.
10. Analog signal cables shall be of 600 V insulation, stranded tinned copper, twisted-shielded pairs.
    a. Conductor size: 18 AWG minimum.
    b. Terminate shield drain conductors to ground only at one (1) end of the cable.
11. High precision 250 ohm resistors with 0.25 percent accuracy shall be used where required.
    a. Resistors located at terminal strips.
    b. Resistors terminated using individual terminal blocks and with no other conductors.
    c. Resistor leads shall be un-insulated and of sufficient length to allow test or calibration equipment (e.g., HART communicator, loop calibrator) to be properly attached to the circuit with clamped test leads.
12. Analog signals for devices in separate enclosures shall not be wired in series.
    a. Loop isolators shall be used where analog signals are transmitted between control enclosures.
13. Wire and cable identification:
    a. Wire and cables numbered and tagged at each termination.
    b. Wire tags:
        1) Slip-on, heat shrinkable wire sleeves with legible, machine-printed markings.
        2) Adhesive, snap-on, or adhesive type labels are not acceptable.
    c. Markings as identified in the Shop Drawings.

E. Grounding Requirements:

1. Equipment grounding conductors shall be separated from incoming power conductors at the point of entry.
2. Minimize grounding conductor length within the enclosure by locating the ground reference point as close as practical to the incoming power point of entry.
3. Bond electrical racks, chassis and machine elements to a central ground bus.
    a. Nonconductive materials, such as paint, shall be removed from the area where the equipment contacts the enclosure.
4. Bond the enclosure to the ground bus.
    a. It is imperative that good electrical connections are made at the point of contact between the ground bus and enclosure.
5. Panel-mounted devices shall be bonded to the panel enclosure or the panel grounding system by means of locknuts or pressure mounting methods.
6. Sub-panels and doors shall be bonded to ground.

F. Termination Requirements:

1. Wiring to circuits external to the panel connected to interposing terminal blocks.
2. Terminal blocks rigidly mounted on DIN rail mounting channels.
3. Terminal strips located to provide adequate space for entrance and termination of the field conductors.
4. One (1) side of each strip of terminal blocks reserved exclusively for the termination of field conductors.
5. Terminal block markings:
    a. Marking shall be the same as associated wire marking.

b. Legible, machine-printed markings.
c. Markings as identified in the shop drawings.

6. Terminal block mechanical characteristics, and electrical characteristics shall be in accordance with NEMA ICS 4.
7. Terminal blocks with continuous marking strips.
   a. Each terminal block shall be identified with machine printed labels.
8. Terminals shall facilitate wire sizes as follows:
   a. 120 Vac applications: Conductor size 12 AWG minimum.
   b. Other: Conductor size 14 AWG minimum.
9. Analog signal cable shield drain conductors shall be individually terminated.
10. Install minimum of 20 percent spare terminals.
11. Bladed, knife switch, isolating type terminal blocks where control voltages enter or leave the panel.
12. Fused terminal blocks shall be used in the following circuits:
    a. Control voltage is used to energize a solenoid valve or instruments.
    b. DC power is connected to 2-wire, loop-powered instruments.
13. Fused terminal blocks shall be provided with blown fuse indicators.
14. When control circuits require more than one (1) field conductor connected to a single wiring point, a sufficient number of terminal points shall be connected internally to allow termination of only one (1) field conductor per terminal block.
15. DIN rail mounting channels shall be installed along full length of the terminal strip areas to facilitate future expansion.
16. Connections to devices with screw type terminals shall be made using spade-tongue, insulated, compression terminators.

G. Component Mounting and Placement:

1. Components shall be installed per manufacturer instructions.
2. Control relays and other control auxiliaries shall be mounted on DIN rail mounting channels where practical.
3. Front panel devices shall be mounted within a range of 40 to 70 IN above the finished floor, unless otherwise shown in the Contract Documents.
4. PLC/RTU and I/O rack installation:
   a. Located such that the LED indicators and switches are readily visible with the panel door open.
   b. Located such that repair and/or replacement of component can be accomplished without the need to remove wire terminations or other installed components.
5. Locate power supplies with sufficient spacing for circulation of air.
6. Where components such as magnetic starters, contactors, relays, and other electromagnetic devices are installed within the same enclosure as the PLC/RTU system components, provide a barrier of at least 6 IN of separation between the “power area containing the electromagnetic devices” and the “control area”.
7. Components mounted in the panel interior shall be fastened to an interior sub-panel using machine screws.
   a. Fastening devices shall not project through the outer surface of the panel enclosure.
8. Excess mounting space of at least 20 percent for component types listed below to facilitate future expansion:
   a. I/O Cards and terminal strips
   b. Fuse holders.
   c. Circuit breakers.
   d. Control relays.

e. Time delay relays.
f. Intrinsically safe barriers and relays.

9. Components installed on sub-panels shall be provides with a minimum spacing between component and wire duct of 1 IN.
   a. Minimum of 2 IN separation between terminal strips and wire ducts.
   b. Manufacturers recommended spacing shall take precedence.

H. Power Distribution:

1. Main incoming power circuits shall be protected with a thermal magnetic circuit breaker.
   a. Limit load to maximum of 80 percent of circuit breaker rating.
2. Component types listed below shall be individually fused so that they may be individually de-energized for maintenance:
   a. PLC/RTU power supply modules.
   b. Single-loop controllers.
   c. Recorders.
   d. Alarm annunciators.
3. Equip each panel with necessary power supplies with ratings required for installed equipment and with minimum 25 percent spare capacity.
4. Constant voltage transformers, balancing potentiometers, and rectifiers as necessary for specific instrument requirements.

I. Control Power Requirements:

1. Source power for control panels: Supply all transformers, protection, and power supplies needed to convert the supply voltage to the needed utilization voltage within each control panel.
   a. All control panels shall be supplied with 120 VAC, Single phase, 60 Hz. power, unless otherwise indicated on the Drawings.
   b. The control power shall be terminated within the process control panel at a main circuit breaker rated for the internal and external control loads.
      1) The hot conductor shall terminate on the line side of the main circuit breaker.
      2) The Neutral conductor shall terminate on a pass-through terminal block mounted adjacent to the main circuit breaker.
      3) The ground conductor shall terminate and on a grounding terminal block located at the bottom of the panel. The grounding terminal block will be used for the ground source for all grounding buses within the enclosure.
   c. Surge protective devices shall be installed on the 120 VAC circuit and shall provide line and neutral protection.
      1) The line conductor shall be wired in parallel to the surge protective device on the load side of the main control power circuit breaker.
      2) The neutral conductor shall be wired in parallel to the surge protective device at the incoming neutral pass thru terminal block.
      3) The surge protective devices shall be grounded per the manufacturer’s installation instructions. Grounding terminal blocks shall be used for ground connections.
   d. The control panel shall be powered from a UPS backed source.
      1) The 120 VAC UPS line power shall be sourced from the surge protected 120 VAC process control panel circuit. The cord shall be wired to terminal blocks within the panel.
   e. The Process Control Panel 120V AC control power bus shall be cord and plug connected to the UPS outlet power. The cord shall be wired to terminal blocks within the panel.

2. Where the supply voltage to the control panel is 480 or 240 VAC as indicated on the electrical plans the control panel is to be furnished with a front mounted pad lockable integral disconnect.
3. The Process Control Panel control power shall be the source of power for all control instruments connected to the Process Control Panel, unless otherwise indicated on the Drawings.
    a. All circuits being used to power field devices from the control panel 120 VAC bus are to be connected to a fused terminal block adequately sized for the device it serves.
    b. Terminal blocks shall be provided for all internal and field installed equipment being powered from control panel 120 VAC power bus.
    c. Provide a minimum of 30% spare terminal blocks for future 120 VAC powered equipment.
4. The Process Control Panel shall be the source of power for all 24 VDC control instruments and devices connected to the Process Control Panel, unless otherwise indicated on the Drawings.
    a. All circuits being used to power field devices from the control panel 24VDC bus are to be connected to a fused terminal block adequately sized for the device it serves.
    b. Terminal blocks shall be provided for all internal and field installed equipment being powered from 24 VDC control power.
    c. Provide a minimum of 30% spare terminal blocks for future 24 VDC powered equipment

J. Miniature circuit breakers

1. Miniature circuit breakers shall be thermal-magnetic, current-limiting type. Breaker housing shall satisfy Insulation Group II/RAL 7035, shall have IP20 finger-safe design, shall be suitable for DIN rail mounting and shall include status indicator window and scratch- and solvent-resistant printing.
    a. Miniature circuit breakers shall be Allen-Bradley Bulletin 1489-M or approved equal.
    b. Miniature circuit breakers shall be rated for:
        1) Voltage – Max. 480Y/277 VAC, 48V DC (UL/CSA),
        2) Interrupting capacity – 10 kA (UL/CSA)
2. Miniature circuit breakers shall support reversible line and load connections and shall have dual terminals that:
    a. Connect up to 4 wires, or 2 wires and a bus bar.
    b. Clamp conductors from both the top side and bottom side.
3. Miniature circuit breakers shall be compatible with UL 508 Listed bus bars, auxiliary contacts, signal contacts, shunt trips and toggle-mount lockout attachments.

K. Surge protector

1. Surge protectors shall use an MOV to clamp high voltage surges. The surge protective device shall provide visual indication, internal thermal disconnecting as well as remote monitoring of event and end of life failure. The surge protector shall be UL 1449 certified.

L. Uninterruptable Power Supply:

1. Furnish and install 1000VA double online conversion UPS.
    a. The UPS shall be installed within the enclosure in front of the panel mounted components.
    b. Provide with IO card with relay outputs. Outputs shall include the following:
        1) Battery Fail
        2) Utility Fail
        3) UPS Fault

M. Control Relays - Miniature

1. Miniature relays shall be, 2-pole, plug-in type with blade-style terminals and ON/OFF flag indicators. Miniature relays shall have an electrical schematic on the faceplate and a clear cover for visual inspection.
    a. Miniature relays shall be Allen Bradley Bulletin 700-HK or approved equal.
    b. Shall be furnished with a plug-in, latching, finger safe, DIN rail mounted type socket with coil and contact separation.
    c. Coils shall be rated for the voltage applied.

N. Wire terminating components

1. Feed-through and fused terminal blocks for control wiring shall be molded type, screw compression clamp, DIN rail mounted with barriers rated not less than 300V, 25A, suitable for conductor ranging between No. 22 and No. 14.
    a. Terminal blocks shall be Allen Bradley Bulletin 1492-J4 or approved equal.
    b. Grounding terminal blocks shall provide DIN rail grounding clamp. Grounding terminal blocks shall be Allen Bradly 1492-JG4 or approved equal.
    c. Fuse blocks shall be Allen Bradley 1492-WFB4 or approved equal
    d. All fuse holders shall be populated with fuses and 100% spare fuses shall be supplied.
    e. Fuses shall be appropriately sized for the application and power requirements of the load.
2. Terminal block end anchors shall be used to secure all components onto the DIN rail at both ends of the DIN rail.

O. Internal Panel Lighting and Service Receptacles:

1. Panels less than or equal to 3 FT wide:
    a. One (1) electrical GFCI duplex receptacle.
    b. One (1) compact LED light fixture with motion sensor).
2. Panels or panel faces greater than 4 FT wide:
    a. One (1) duplex electrical GFCI receptacle per 6 FT of length.
    b. Continuous LED lighting strip with motion sensor(s).

P. Environmental Controls:

1. Indoor panels located in a designated electrical room or control room:
    a. Thermostat controlled cooling fans with exhaust louvers if required to maintain temperature inside panel(s) below the maximum operating temperature rating of the internal components.
    b. Internal corrosion inhibitors.
2. Indoor panels not located within a designated electrical room or control room:
    a. Thermostat controlled heaters to maintain temperature approximately 10 DegF above ambient for condensation prevention inside the panels.
    b. Automatically controlled, closed-loop heat exchangers or closed-loop air conditioners where required to maintain temperature inside each enclosure below the maximum operating temperature rating of the components inside the panel(s).
    c. Internal corrosion inhibitors.
3. Outdoor panels:
    a. Outdoor temperature range of 0 DegF through 120 DegF.
    b. Thermostat controlled heaters to maintain temperature approximately 10 DegF above ambient for condensation prevention inside the panels.
    c. Outdoor temperature range of 0 DegF through 120 DegF.

d. Thermostat controlled closed-loop heat exchangers or closed-loop air conditioners if required to maintain temperature inside each enclosure below the maximum operating temperature rating of the components inside the panel.

4. Environmental control components:
   a. Panel heaters:
      1) Thermostat controlled.
      2) Fan driven.
      3) Components mounted in an anodized aluminum housing.
      4) Designed for sub-panel mounting.
      5) Powered from 120 Vac and protected with a dedicated circuit breaker.
   b. Cooling fans and exhaust packages:
      1) Cooling fan with louver or grill and replaceable filter.
      2) Designed to be mounted within a panel cutout to provide positive airflow through the panel.
      3) Cooling fan and exhaust louvers shall be designed and listed to maintain a NEMA 12 enclosure rating.
      4) Fitted with replaceable, high-density foam or synthetic fiber.
      5) Cooling fan controlled with a separately mounted thermostat with bi-metal sensor and adjustable dial for temperature setting.
      6) Powered from 120 Vac and protected with a dedicated circuit breaker.
   c. Heat exchangers and air conditioners:
      1) Dual-loop design to isolate panel interior air from exterior air.
      2) Thermostat controlled.
      3) Operate from 120 Vac and protected with a dedicated circuit breaker.

2.4 MAINTENANCE MATERIALS

A. Extra Materials:

1. Minimum 12 replacement filters for each type installed.
2. 50% spare fuse quantities.

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. Scope: Inspect and test entire panel assembly to verify readiness for shipment. Provide record drawings prior to shipment as specified.

B. Location: Contractor's factory.

C. Factory Tests:

1. Tests shall be fully documented and signed by the Contractor's factory supervisor.
2. The panel shop shall fully test the control panel for correct wiring consistent with contract documents.
   a. Each I/O point shall be checked by measuring or connecting circuits at the field terminal blocks.
3. Burn-in test: Panel(s) shall be fully energized for a minimum period of 24 HRS.
4. A PLC Central Processing Unit (CPU) shall be obtained and connected to the panel(s) if necessary for testing purposes.
5. Testing equipment (such as digital multi-meters, analog loop calibrators, and laptop computers with PLC programming software) shall be used as required for testing.
6. The following functions shall be tested as a minimum:
   a. Demonstrate functions of the panel(s) required by the Contract Documents.

b. Correctness of wiring from all panel field terminals to all I/O points and to all panel components.
c. Simulate and test each discrete signal at the field terminal strips.
d. Simulate and test each analog signal using loop calibrators.
e. Correct operation of communications between PLC system Central Processing Units (CPUs) and Remote I/O bases.
f. Correct operation of single-loop controllers (including digital communication to microprocessor based devices).
g. Correct operation of all digital communication devices.
h. Demonstrate online and offline diagnostic tests and procedures.
i. The Contractor shall notify the Engineer in writing a minimum of 15 calendar days prior to the Factory Tests.
    1) Engineer and Owner's Representative has the option to witness all required tests.

7. Make following documentation available to the Engineer at test site during the tests:
    a. Contract Documents.
    b. Factory Demonstration Testing procedures.
    c. List of equipment to be testing including make, model, and serial number.
    d. Shop Drawing submittal data for equipment being tested.
8. Deficiencies shall be corrected prior to shipment from the Contractor's factory.

3.2 INSTALLATION

A. Anchor panels in a manner to prevent the enclosure from racking, which may cause the access doors to become misaligned.

B. Obtain approved panel layouts prior to installation of conduits.

C. Install products in accordance with manufacturer's instructions.

D. Contractor shall provide redlined as-built drawings to engineer at project completion to be included in shop drawing record documents.

END OF SECTION

DIVISION 41

MATERIAL PROCESSING AND HANDLING EQUIPMENT

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SECTION 41 22 23
HOISTS, TROLLEYS, AND MONORAILS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hoists, trolleys, and monorails.

B. Related Sections include but are not necessarily limited to:

1. Section 01 61 03 - Equipment - Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Bearing Manufacturers Association (ABMA).
2. American Society of Mechanical Engineers (ASME):
   a. B30.11, Safety Code for Underhung Cranes and Monorail Systems.
   b. B30.16, Safety Code for Overhead Hoists.
3. ASTM International (ASTM):
   a. A36, Standard Specification for Carbon Structural Steel.
4. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).

B. Comply with ASME B30.11 and ASME B30.16.

1.3 DEFINITIONS

A. Hook Height: The minimum acceptable distance in feet from bottom of hook in full raised position to the nearest floor surface.

B. Lift Height: The distance in feet from the bottom of the hook in full raised position to the surface of the lowest floor from which items may be hoisted.

C. Total Trolley Capacity: The ultimate load-carrying capacity of the trolley based on the ultimate strength of the material used (with a 5:1 safety factor) and the bearing life.

D. Ultimate Load-Carrying Capacity: Live load, weights of all equipment and an allowance for impact.

1.4 SUBMITTALS

A. Shop Drawings:

1. See Section 01 61 03.
2. Product technical data including:
   a. Acknowledgement that products submitted meet requirements of standards referenced.
   b. Short Circuit Current Rating (SCCR) nameplate marking per NFPA 70. Include any required calculations per Section 01 61 03.
3. Fabrication and/or layout drawings.
   a. Track layout including supports, splices, connections, switches, and end trucks.
4. Test reports verifying strength of inserts and rail.
5. Load test results.

B. Contract Closeout Information:

1. Operation and Maintenance Data:

a. See Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Hoists:
   a. Yale.
   b. Acco and Wright.
   c. The David Round Company.
2. Trolleys:
   a. Yale.
   b. Acco and Wright.
   c. The David Round Company.
3. Monorails:
   a. Spanmaster.
   b. Twin City Monorail.

2.2 MANUFACTURED UNITS

A. Trolleys:

1. Hand-geared.
2. Completely compatible with hoists, cranes, and monorails specified.
3. Meet NEC standards according to classifications shown on Drawings.
4. Capable of maneuvering curves without binding or scraping the track.
5. Minimum ABMA L-10 bearing life of 5000 hours based on 75% of the wheel load, excluding impact.
6. Motor Driven:
   a. Operate at a single speed as scheduled.
   b. Enclose internal gears in oil tight housing.
   c. Design motors to operate with 460 V, 3 PH, 60 cycle power supply.
7. Plain trolleys:
   a. Frame consisting of thick rolled steel sections extending beyond wheel flanges to protect wheels.
   b. Alloy steel hardened axles, ball-bearings and pressed steel wheels.
      1) Carburized and hardened ball tread wheels.
      2) Factory lubricated requiring no additional lubrication.

B. Hoists:

1. Hand chain hoists:
   a. Spur-geared.
   b. Design load-carrying parts so that the calculated static stress in the material, based on rated capacity, does not exceed 25% of the average ultimate strength of the material.
   c. For all hand chain hoists, provide hook-type mounting.
   d. Load chain and wheels:
      1) Close link coil or roller-type chain.
      2) Links of uniform size and shape and free from scale.

3) Manufacture load chain wheels from steel, pearlitic malleable iron or modular cat-iron.
    a) Form load and idler sheaves to fit chain.

e. Hand chain and wheels:
    1) Hand chain of the endless coil-type with a drop that is about 2 feet less than the specified lift of the hoist.
    2) Chain yield point at least three times the required hand chain pull for rated load.
    3) Manufacture hand chain wheels from steel, malleable iron, high strength cast iron, or aluminum alloy.
    4) Equip hand wheel with suitable chain guard to prevent the hand chain from slipping or jumping the wheel rim.

f. Hooks:
    1) Forged steel.
    2) Bottom hook free to swivel in the loaded condition without twisting the chain.
    3) Gate or swing type latch hooks.

g. Automatic mechanical load brake which will prevent lowering of the load unless manual power is applied to the hand chain.

h. Sleeve or antifriction type bearings.

i. Enclose gearing in sealed construction and provide life-time lubrication.

j. Load limit clutch to automatically prevent hoist from lifting loads greater than rated capacity.

2. For Class I, Division 1 or 2, Group D locations, provide spark and corrosion-resistant models with stainless steel hooks, load chains, hand chain, and trolley wheels.

3. Mark each hoist with the following information:
    a. Name and address of manufacturer.
    b. Manufacturer's unit identification number.
    c. Rated load.

C. Monorails:

1. Straight track: ASTM A36 steel I beams.
2. Where track curves are required, supply straight track and curves which are standard items of monorail manufacturer.
3. Design track to support hoist capacity plus 25% for impact load plus the weight of hoist and accessories without exceeding allowable working stress of track material with maximum deflection of 1/450 of span.
4. Brace track to prevent sideways movement under full load conditions.
5. Provide end stops at all track ends.
6. Assure that track splices have been designed by track supplier and are located at support points.

2.3 ACCESSORIES

A. Trolley stops design to engage the trolley frame rather than trolley wheels.

B. Furnish chain containers for hand hoists.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Support track as shown on Drawings.

B. Arrange supports for easy removal of track for repair or replacement.

C. Align track true and level.

D. Warning Signs:

1. Affix to the hoist or the lower load block or the controls in a readable position a durable label or labels displaying the following information concerning safe operating procedures:
   a. The word WARNING or other legend designed to bring the label to the attention of an operator.
   b. Cautionary language against:
      1) Lifting more than rated load.
      2) Operating hoist when hook is not centered under hoist.
      3) Operating hoist with twisted, kinked or damaged rope or chain.
      4) Operating damaged or malfunctioning hoist.
      5) Operating hoist with a rope that is not properly seated in its groove (if applicable).
      6) Lifting people or lifting loads over people.
      7) Removing or obscuring warning label.

3.2 FIELD QUALITY CONTROL

A. Test each hoist, trolley, and monorail using 110% rated load.

B. Employ and pay for services of equipment manufacturer's field service representative(s) to:

1. Inspect equipment covered by this Specification Section.
2. Supervise pre-start-up adjustments, installation checks and all field tests.
3. Conduct initial start-up of equipment and perform operational checks.
4. Provide a written statement that manufacturer's equipment has been installed properly, started up and is ready for operation by Owner's personnel.
5. Instruct Owner's personnel for 8 hours at jobsite on operation and maintenance of the hoist, trolley, monorail and crane equipment.

3.3 SCHEDULE

A. Hoist, trolley, and monorail systems include but are not necessarily limited to the following:

TAG NUMBER	LOADING (TONS)	HOIST	TROLLEY	HOOK HEIGHT (FT)*	LIFTING HEIGHT (FT)*	HP	OPERATING SPEED FPM
HST-03-01	0.75**	C	HG	18.50	15.67	N/A	N/A

* Distances listed are approximate as they will vary depending on hoist and trolley selection.
** Verify hoist, trolley, and monorail system loading requirement with Grit Pump (P-03-01) pump submittals.

C = Chain
HG = Hand Geared
WR = Wire Rope
NA = Not Applicable

END OF SECTION

DIVISION 43

PROCESS GAS AND LIQUID HANDLING, PURIFICATION, AND STORAGE EQUIPMENT

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SECTION 43 05 21

COMMON MOTOR REQUIREMENTS FOR EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Squirrel cage type, AC induction motors, up to 500 HP, for up to 4 poles (3600 or 1800 rpm nominal), or up to 250 HP for over 6 poles (1200 rpm or slower) shall be per NEMA MG1, Small or Medium.
2. Special purpose motors with features or ratings which are not specified herein, are specified in the particular equipment specifications.

1.2 RELATED SECTIONS

A. This section contains specific references to the following related sections. Additional related sections may apply that are not specifically listed below.

1. Section 26 29 23 – Low Voltage Adjustable Frequency Drives

1.3 REFERENCES

A. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Reference	Title
ABMA 9	Load Ratings and Fatigue Life for Ball Bearings
ABMA 11	Load Ratings and Fatigue Life for Roller Bearings
IEEE 112	Standard Test Procedures for Polyphase Induction Motors and Generators
IEEE 841	Standard for Petroleum and Chemical Industry- Premium-Efficiency, Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 500 HP
NEMA ICS 2	Industrial Control and Systems Controllers, Contactors and Overload Relays Rated Not More Than 2000 Volts AC or 750 Volts DC
NEMA 250	Enclosures for Electrical Equipment (1000 volts maximum)
NEMA MG 1	Motors and Generators
Department of Energy	Energy Policy and Conservation Act, Final Rules EERE-2010-BT-STD-0027-0117
UL 674	Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations
UL 1004	Electric Motors

1.4 DEFINITIONS

A. Terminology used in this Section conforms with NEMA MG-1. Motors covered in this specification are those defined in NEMA MG1 as Small (Fractional) and Medium (Integral) AC induction motors.

1.5 ADMINISTRATIVE REQUIREMENTS

A. Unit Responsibility: Where Unit Responsibility is specified in the driven equipment sections of these specifications, the motor supplier shall coordinate with the provider of the driven

equipment to verify that the motor provided under this section is fully compatible with and meets the specified performance requirements for that equipment.

1.6 SUBMITTALS

A. Action Submittals:

1. Procedures:
   a. Copy of this Section, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.
   b. Check-marks (✓) to denote full compliance with a paragraph as a whole. Underline deviations and denote by a number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance. Include a detailed, written justification for each deviation.
   c. Failure to include a copy of the marked-up specification sections with justification(s) for any requested deviation will cause rejection of the entire submittal with no further consideration.
2. Routine Factory test data for polyphase motors.
   a. High-potential test.
3. Factory test data, from required dynamometer tests, where specified.
4. Vibration level when measured in accordance with NEMA MG 1, for all IEEE 841 motors, and where elsewhere specified.
5. Motor heating curve, where specified,
6. Motor mounting, outline, dimensions, and weight.
7. Motor bearing and winding RTDs (resistance temperature detector), where specified.
8. Motor winding thermostat or thermistor, where specified.
9. Motor winding space heaters, where specified.
10. Motor nameplate data.
11. Inverter duty motors:
    a. Motor winding voltage rating.
    b. Variable or constant torque application.
    c. Operating speed range.
12. Conduit box dimensions, usable volume as defined in NEMA MG1 and NFPA 70, and conductor termination details.

B. Informational Submittals:

1. Submittal requirements for operation and maintenance manuals as per requirements of Division 1.

1.7 QUALITY ASSURANCE

A. Factory Testing:

1. All polyphase motors shall be factory tested in conformance with routine tests per NEMA MG1 and IEEE 112. Provide the following tests:
   a. Measurement of winding resistance.
   b. No-load readings of current and speed at normal voltage and frequency.
   c. Current input at rated frequency with rotor at standstill.
   d. High potential test.

1.8 DELIVERY, STORAGE AND HANDLING

A. Procedures shall be in accordance with Division 01.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The following candidate manufacturers are capable of producing equipment and/or products that will satisfy the requirements of this Section. The manufacturer's standard product may require modification to conform to specified requirements:

1. Baldor.
2. General Electric.
3. Siemens.
4. US Motors.
5. WEG.
6. Approved Equal.

2.2 PERFORMANCE/DESIGN CRITERIA

A. Service Conditions:

1. Temperature: -25-degree C to +40-degree C.
2. Site Elevation: Approximately 5,250 feet above sea level minimum.
3. Derate motors for higher ambient temperature and for higher altitude with motor size based on brake-horsepower.

B. Design Requirements:

1. Operation: Continuous.
2. Compliance: Energy Policy Act of 1992 (EPAct), Final Rule 2014.
3. Tolerance: +/- 10-percent of rated voltage at rated frequency; +/- 5-percent of rated frequency at rated voltage.
4. Standard design: NEMA Design B.

C. Service Factor (percent of additional horsepower):

1. 1.15 for Sine-wave motors.
2. Dual rating: 1.15 Sine-wave and 1.0 Inverter Duty for Inverter Duty motors.

D. Motor Efficiency:

1. NEMA Premium™ efficiency electric motor, single-speed, polyphase, 1-500 horsepower, 3600-rpm 2-pole, 1800-rpm 4-pole, and 1200-rpm 6-pole (1-250 HP), squirrel cage induction motors, NEMA Design B, continuous rated. NEMA Standards Publication MG 1 2011, in Table 12-12.

Table 12-12 Full-Load Efficiencies for 60 HZ Premium Efficiency Electric Motors Rated 600 Volts or Less (Random Wound)								
Open Motors								
HP	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
1	77.0	74.0	85.5	82.5	82.5	80.0	75.5	72.0
1.5	84	81.5	86.5	84.0	86.5	84.0	77.0	74.0
2	85.5	82.5	86.5	84.0	87.5	85.5	86.5	84.0
3	85.5	82.5	89.5	87.5	88.5	86.5	87.5	85.5
5	86.5	84.0	89.5	87.5	89.5	87.5	88.5	86.5
7.5	88.5	86.5	91.0	89.5	90.2	88.5	89.5	87.5
10	89.5	87.5	91.7	90.2	91.7	90.2	90.2	88.5
15	90.2	88.5	93.0	91.7	91.7	90.2	90.2	88.5
20	91.0	89.5	93.0	91.7	92.4	91.0	91.0	89.5
25	91.7	90.2	93.6	92.4	93.0	91.7	91.0	89.5

Table 12-12 Full-Load Efficiencies for 60 HZ Premium Efficiency Electric Motors Rated 600 Volts or Less (Random Wound)								
Enclosed Motors								
HP	2 Pole		4 Pole		6 Pole		8 Pole	
	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency	Nominal Efficiency	Minimum Efficiency
1	77.0	74.0	85.5	82.5	82.5	80.0	75.5	72.0
1.5	84.0	81.5	86.5	84.0	87.5	85.5	78.5	75.5
2	85.5	82.5	86.5	84.0	88.5	86.5	84.0	81.5
3	86.5	84.0	89.5	87.5	89.5	87.5	85.5	82.5
5	88.5	86.5	89.5	87.5	89.5	87.5	86.5	84.0
7.5	89.5	87.5	91.7	90.2	91.0	89.5	86.5	84.0
10	90.2	88.5	91.7	90.2	91.0	89.5	89.5	87.5
15	91.0	89.5	92.4	91.0	91.7	90.2	89.5	87.5
20	91.0	89.5	93.0	91.7	91.7	90.2	90.2	88.5
25	91.7	90.2	93.6	92.4	93.0	91.7	90.2	88.5

2.3 MATERIALS

A. Motor frames:

1. TEFC motors shall be cast iron.
2. Aluminum frame motors are not permitted.

B. Stator windings:

1. Shall be copper with Class F minimum insulation not to exceed Class B temperature rise of 80-degree C at rated load and with Design B torque /current characteristics for all Medium (Integral) motors.
2. Small (fractional) motors shall be supplied with Class F insulation where available.

C. Rotor material shall be aluminum or copper.

D. Fans shall be non-sparking fan blades.

E. Motor leads shall be non-hygroscopic.

2.4 MOTOR TYPES

A. General Requirements for motors 1/2 horsepower through 500 horsepower:

1. Three phase, squirrel cage, with copper windings.
2. Rated for full voltage starting and continuous duty.
3. Rating shall be:
    a. 460/230 volts, three-phase, 60-Hertz, as shown on the contract drawings.
4. General Purpose Type motors, which may also be called Type 1 per the project equipment specifications shall be:
    a. Open Drip Proof Motors, shall be as defined per NEMA MG1, self-cooled by convection air.
    b. Weather-Protected Type I Motors (WP-I), shall be as defined per NEMA MG1, similar to ODP construction with addition of screens to prevent entry of rain, snow, and particles, or objects into the motor. Suitable for clean indoor and protected outdoor installations.
    c. Weather Protected Type II Motors (WP-II) shall be as defined per NEMA MG1, with maximum protection from entry of airborne particles, moisture and high velocity air. Suitable for unprotected outdoor installations.
5. Severe Duty Type Motors, which may also be called Type 2 per the project equipment specifications, shall be in accordance with IEEE 841.
    a. Totally Enclosed Fan-Cooled Motors (TEFC) shall be defined per NEMA MG1.
    b. Enclosure: totally enclosed, fan cooled, with external fan blowing air to the motor frame cooling fins for cooling.
    c. Applications: severe duty and most outdoor installations.
6. Explosion Proof Type Motors, which may also be called Type 3 per the project equipment specifications.
    a. Enclosures: UL listed explosion proof
    b. Applications: hazardous locations including Class I and Class II (Division 1 and 2), and Class III classified areas.

B. Motors Less Than 1/2 Horsepower:

1. Type shall be:
    a. Squirrel cage, capacitor start with Class F insulation and copper windings.
    b. Fan motors rated 1/8 horsepower or less: split-phase or shaded-pole type.
2. Rating shall be:
    a. 115Volts, single phase, 60 Hz.
    b. 208 Volts, single phase, 60 Hz.
    c. 230 Volts, single phase, 60 Hz.

2.5 COMPONENTS

A. Inverter-Fed Polyphase Motors per NEMA MG1 Part 31:

1. Applications: variable torque or constant torque loads, for vertical or horizontal motors with variable frequency drive controllers (VFD).
2. Features shall include:
    a. Insulation design to meet 2000-Volt peak at a minimum of 0.1 micro-second rise time.
    b. Built-in motor winding protection as specified.
    c. Electrically insulated bearings or,

d. Provide Electro Static Technology's AEGIS Shaft Grounding Ring for Bearing Protection or equal. The shaft grounding ring shall be solidly bonded per manufacturer's recommendations.

B. Thermal Protection:

1. Inverter duty motors:
   a. Motors up to 50 horsepower:
      1) Protection to be NEMA Type 2 bi-metallic thermal switch (Klixon) type.
      2) Motor Nameplate: Marked "OVER TEMP PROT 2" in accordance with NEMA MG 1 12.43.

C. Motor Nameplates:

1. Materials: Engraved or stamped stainless steel.
2. Features shall be as follows:
   a. NEMA Standard MG 1 motor data.
   b. Permanently fastened to the motor frame.
   c. ABMA bearing identification number for motors meeting IEEE 841.
   d. NEMA nominal efficiency for all motors.
   e. NEMA nominal and minimum efficiency for motors meeting IEEE 841.
   f. UL frame temperature limit code for explosion proof motors.
   g. Space heater data.
   h. Over Temperature Protection Type Number.
   i. Temperature device rating and alarm and shutdown setpoint.
   j. Provide motor nameplates for motors with space heaters located in Class I, Division 2, Groups C, and D areas in accordance with NEC 501.125(B).

D. Conduit Boxes:

1. Provide oversized boxes, with split construction with threaded hubs and petroleum-resistant gaskets.
2. Conduit boxes can be rotated in order to permit installation in any of four positions 90 degrees apart.
3. Provide grounding lug located within the conduit box for ground connection.
4. Provide separate conduit boxes for temperature devices and space heaters.
5. Separate terminal box for any signal leads (RTD, thermistor, vibration transmitter, etc.).
6. Provide with terminal block for conductor connections via Burndy YAV compression ring terminals on leads.

E. Bearings:

1. Provide oil or grease lubricated ball bearings, angle contact roller bearings for axial thrust loads, and cylindrical bearings for radial-only loads.
2. Rated for a minimum L-10 life of 50,000 hours for direct-connected loads.
3. Cartridge type bearings will not be accepted.
4. Fitted with lubricant fill and drain or relief fittings.
5. Belt loads not to exceed forces calculated from NEMA MG 1 Table 14-1 and 14-1A.

F. Bearing lubrication shall be either grease or oil as per the requirements in either 1 or 2:

1. Grease lubricated bearings:
   a. Shall be for electric motor use only.
   b. Grease shall be capable of higher temperatures associated with electric motors and shall be compatible with Polyurea-based greases.
   c. Provide grease fittings, similar to Alemite™ type (or equivalent).

d. Shielded bearings with regreasable provisions are permissible.

2. Provide oil lubricated bearings with externally visible sight glass to view oil level.

G. Lifting Eyes:

1. Provide lifting eyes with a safety factor of 5.
2. Provide one lifting eye for motors more than 50 pounds.
3. Provide two lifting eyes for motors over 150 pounds.

H. Winding Space Heaters when specified or shown:

1. Provide winding space heaters to prevent condensation.
2. Rating: 120 volts, single phase, 60 Hertz.
3. Motor nameplate to show space heater rating in watts and volts.
4. Provide terminal block in motor conduit box for heater leads termination.

2.6 FINISHES

A. Paint Finish:

1. Provide standard manufacturer paint finish.
2. Provide motors with semi-gloss finish, scratch and heat resistance electric motor paint.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Delivery Inspection:

1. Inspect driven equipment-motor assembly and components immediately upon delivery and unloading at the job site for damages.
2. Take photos of damage(s) if any, to substantiate the delivery inspection report.

3.2 INSTALLATION

A. Grounding of Motors:

1. Connect the motor feeder ground cable (green) to the grounding lug terminal in the conduit terminal box.

B. Supplemental Grounding of Motors: Provide for motors fed from VFDs, all motors above 100 horsepower, and all motors in classified areas, where feasible.

1. Bond the motor frame to the grounding grid/electrode system to provide supplemental grounding.

C. Field Coating of Motors:

1. Refer to the driven equipment specification section and Section 09 96 00 for coating requirements.

3.3 FIELD QUALITY CONTROL

A. Field Testing:

1. Measure winding insulation resistance of motors to no less than 10-megohm with a 1000-Vac megohmmeter.
2. Test motors for proper rotation prior to connection to the driven equipment.

B. Field Inspection:

1. Compare equipment nameplate data with drawings and specifications.
2. Inspect physical and mechanical condition.
3. Inspect anchorage, alignment, and grounding.
4. Verify the installation of breather/drain fittings as specified herein.

5. Check for proper connections of space heaters, winding and RTDs and or thermostats.
6. Visually check for correct phase and ground connections:

C. Manufacturer Services: Provide where specified or shown on the drawings.

1. Provide services to the driven equipment manufacturer for the inspection and certification of the installation of the motor driven equipment.
2. Provide assistance in the startup and operational testing of the motor driven equipment.

3.4 SYSTEM START UP

A. Commissioning Test: Provide where specified or shown on the drawings.

1. Provide assistance during the commissioning test of the motor driven equipment.

3.5 CLOSEOUT ACTIVITIES

A. Operation and Maintenance:

1. Provide the operation and maintenance manual of the motor(s). Include testing result information in the O&M manual.

END OF SECTION

SECTION 43 21 00
PUMPING EQUIPMENT - BASIC REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pumping equipment.

B. Related Specification Sections include but are not necessarily limited to:

1. Section 01 61 03 - Equipment - Basic Requirements.
2. Section 03 15 19 - Anchorage to Concrete
3. Section 09 96 00 - High Performance Industrial Coatings.
4. Section 43 25 13 - Pumping Equipment - Submersible End-Suction Sewage Pumps.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. ANSI/Hydraulic Institute (ANSI/HI):
   a. 9.6.3, Rotodynamic (Centrifugal and Vertical) Pumps – Guideline for Allowable Operating Region.
   b. 9.6.4, Rotodynamic Pumps for Vibration Measurements and Allowable Values.
   c. 9.6.6, Rotodynamic Pumps for Pump Piping.
   d. 11.6, Rotodynamic Submersible Pump for Hydraulic Performance, Hydrostatic Pressure, Mechanical, and Electrical Acceptance Tests.
   e. 14.6, Rotodynamic Pumps for Hydraulic Performance Acceptance Tests.

B. Coordinate all mechanical seal systems specified to ensure pump and seal compatibility.

C. Pump/motor and VFD coordination: See Specification Section 01 61 03.

1.3 DEFINITIONS

A. The abbreviations used in this section are defined as follows:

1. AOR: Allowable Operating Range.
2. BEP: Best Efficiency Point.
3. IPS: Iron Pipe Size.
4. NPSH3: Net Positive Suction Head for 3% head loss.
5. POR: Preferred Operating Range.
6. TDH: Total Dynamic Head.
7. TEFC: Totally Enclosed Fan Cooled.
8. VFD: Variable Frequency Drive.

B. Pump Service Category: Pump or pumps having identical names (not tag numbers) used for specific pumping service.

1.4 SUBMITTALS

A. Shop Drawings:

1. See Specification Section 01 61 03.
2. Product technical data including:
   a. Performance data and curves with flow (GPM), head (FT), horsepower, hydraulic efficiency, rotating speed (RPM), AOR, BEP, POR, NPSH3 requirements, minimum bowl submergence requirements for vertical mixed flow, axial and turbine pumps.

b. Pump accessory data.
c. Bearing supports, shafting details and lubrication provisions.
1) Bearing life calculations.
2) Critical speed calculations.
d. Solids passage information.
e. Anchor design information required by Section 03 15 19.
3. Certifications:
a. Certified pump performance curves as described in the SOURCE QUALITY CONTROL Article.
b. Verification of Primary and Secondary conditions in POR and AOR.
4. Test reports:
a. Factory hydrostatic test.

B. Contract Closeout Information:

1. Operation and Maintenance Data:
a. See Specification Section 01 78 23 for requirements for the mechanics, administration, and the content of Operation and Maintenance Manual submittals.

C. Informational Submittals:

1. Certifications:
a. Provide a written statement that manufacturer's equipment has been installed properly, started up and is ready for operation by Owner's personnel.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Pumps:
a. See individual pump Specification Sections.
2. Mechanical seals:
a. Chesterton.
b. John Crane.
c. Garlock.
d. Or as noted in the individual pump Specification Sections.

2.2 CENTRIFUGAL PUMP DESIGN

A. Provide units with increasing head characteristics from the end run out portion of the curve to:

1. Shut-off condition.
2. For Mixed flow, Axial Flow and Propeller pumps to the right hand edge of the AOR.

2.3 ACCESSORIES

A. See Specification Section 01 61 03.

B. Each Unit:

1. Lifting eye bolts or lugs.
2. Plugged gage cock connection at suction and discharge nozzles.
3. Tapped and plugged openings for casing and bearing housing vents and drains.
4. Fittings for properly adding flushing lubricant.
5. Pressure relief fittings for grease lubrication.

C. Packing Seal:

1. Provide packing unless mechanical seal is specified in narrow-scope pump sections.
2. Minimum of five rings graphite impregnated synthetic packing.
3. Provide minimum 1/4 inches diameter supply tap and 1/2 inches diameter minimum drain tap.
4. Provide split Teflon or bronze water seal ring.
5. Adjustable split follower cast iron or bronze gland.

D. Mechanical Seals:

1. Provide as specified in the narrow-scope pump sections.
2. Provide rotating balanced O-ring type.
3. Provide water lubrication - cooling.
4. Materials:
   a. Metal parts except springs: 316 stainless steel.
   b. Springs: Hastelloy C.
   c. Seal faces: Unfilled carbon graphite versus silica-free Grade 99.5 ceramic.
   d. Elastomers: Viton.

2.4 FABRICATION

A. Pump Support:

1. Design base to support weight of drive, shafting and pump.
2. Comply with HI vibration limitations.
3. Mount horizontal pump, motor and coupling on single piece drip lip type machine base.
4. Mount vertical pumps on single piece pedestal machine base.
5. Mount vertical turbine/propeller/can pumps on a rigid machined base plate attached to the discharge elbow. Base plate to be bolted to the pump can or an independent rigid machined sole plate grouted to the concrete substructure with anchor rods and leveled with jackscrews.
6. Fabricate to withstand all operating loads transmitted from the pump and drive.
7. On vertically configured end suction centrifugal pumps when supplied with a fabricated steel mounting frame and suction elbow, the suction elbow shall be a long radius reducing elbow with greater than 50% area reduction to comply with Table 9.6.6.3.2 of ANSI/HI 9.6.6 standard for straight pipe lengths.

2.5 SOURCE QUALITY CONTROL

A. Verification primary design condition in POR.

B. Verification secondary design condition in AOR.

C. Factory hydrostatic test all pumps at 150% of shut-off head for a minimum of five minutes.

D. If specifically required in the individual pump specification sections, provide factory tests:

1. All units:
   a. Conduct tests in accordance with HI.
      1) Shut-off head and design condition: Positive unilateral performance tolerance meeting Grade 1U per ANSI/HI 14.6 for Rotodynamic Pumps.
      2) Shut-off head and design conditions: Positive unilateral performance tolerances meeting Grade 1U per ANSI/HI 11.6 for Rotodynamic Submersible Pumps.
2. All pumps:
   a. Head (FT) versus flow (GPM) pump curves:
      1) Efficiencies along curve.

2) Brake horsepower along each curve.

3. Results certified by a registered professional engineer.

E. Statically and dynamically balance each pump per ANSI/HI standards.

1. If specifically required in the individual pump specification sections or in Specification Section 01 61 03, field vibration test pumps:
   a. To meet requirements of ANSI/HI 9.6.4 for Rotodynamic Pumps at any point on the pumps and motor.

F. To meet requirements of ANSI/HI 11.6 for Submersible Pumps.

PART 3 - EXECUTION

3.1 INSTALLATION

A. See Specification Section 01 61 03.

B. Floor or Pad-Mounted Units (Non-Submersible):

1. Align vertically and horizontally level, wedge and plumb units to match piping interfaces.
2. Assure no unnecessary stresses are transmitted to equipment flanges.
3. Tighten flange bolts at uniform rate and manufacturer's recommended torque for uniform gasket compression.
4. Support and match flange faces to uniform contact over entire face area prior to bolting pipe flange and equipment.
5. Permit piping connecting to equipment to freely move in directions parallel to longitudinal centerline when and while bolts in connection flange are tightened.
6. Grout equipment into place prior to final bolting of piping but not before initial fitting and alignment.
7. Assemble connecting piping with gaskets in place and minimum of four bolts per joint installed and tightened.
   a. Test alignment by loosening flange bolts to see if there is any change in relationship of piping flange with equipment connecting flange.
   b. Realign as necessary, install flange bolts and make equipment connection.
8. Field paint units as defined in Specification Section 09 96 00.
9. Provide pressure gage, visible from grade or operating floor, on discharge of all pumps and on suction and discharge of all non-submersible units.

C. Submersible Units:

1. Assemble connecting piping with gaskets in place and minimum of four bolts per joint installed and tightened.
   a. Test alignment by loosening flange bolts to see if there is any change in relationship of piping flange with equipment connecting flange.
   b. Realign as necessary, install flange bolts and make equipment connection.
2. Field paint units as defined in Specification Section 09 96 00.
3. Provide discharge pressure gage visible from grade or operating floor.

3.2 FIELD QUALITY CONTROL

A. Provide services of equipment manufacturer's field service representative(s) to:

1. Inspect equipment covered by this Specification Section.
2. Supervise pre-start adjustments and installation checks.
3. Conduct initial start-up of equipment and perform operational checks.
4. Instruct Owner's personnel for the specified minimum number of hours at jobsite per Specification Section 01 79 23 - Instruction of Operation and Maintenance Personnel on operation and maintenance of each of the specified pumping equipment.

END OF SECTION

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SECTION 43 25 13

PUMPING EQUIPMENT - SUBMERSIBLE END-SUCTION SEWAGE PUMPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Submersible sewage pumps in a wet pit application for pumping of unscreened wastewater (Woodside Influent pumps) and underflow from the grit chamber (Grit pump).
2. Bid Alternate - Batch Tank Pumping: submersible sewage pumps in a wet pit application for pumping of screened and degritted wastewater (Batch Tank pumps).

B. Related Specification Sections include but are not necessarily limited to:

1. Section 09 96 00 - High Performance Industrial Coatings.
2. Section 26 05 00 - Electrical - Basic Requirements.
3. Section 26 05 19 - Wire and Cable - 600 Volt and Below.
4. Section 26 29 23 - Variable Frequency Drives - Low Voltage.
5. Section 43 05 21 - Common Motor Requirements for Equipment.
6. Section 43 21 00 - Pumping Equipment - Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Bearing Manufacturers Association (ABMA).
2. American National Standards Institute (ANSI).
3. ASTM International (ASTM):
    a. A48, Standard Specification for Gray Iron Castings.
    b. A890, Standard Specification for Castings, Iron-Chromium-Nickel-Molybdenum Corrosion-Resistant, Duplex (Austenitic/Ferritic) for General Application.
4. FM Global (FM).
5. Hydraulic Institute (HI):
    a. Standards for Centrifugal, Rotary and Reciprocating Pumps.
6. National Electrical Manufacturers Association (NEMA):
    a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
7. National Fire Protection Agency (NFPA):
    a. 70, National Electrical Code (NEC):
        1) Article 500, Hazardous (Classified) Locations, Classes I, II, and III, Divisions 1 and 2.
8. Underwriters Laboratories, Inc. (UL).
    a. 62, Flexible Cord and Fixture Wire.

1.3 SYSTEM DESCRIPTION

A. Woodside Influent Pumps (P-01-01, P-01-02, P-01-03): The pumps operate in a triplex configuration to lift raw influent wastewater into the Headworks Building.

B. Grit Pump (P-03-01): The pump operates in a simplex configuration to lift grit slurry from the grit chamber into the grit classifier.

C. Batch Tank Pumps (P-04-01, P-04-02, P-04-03): The pumps operate in a triplex configuration to distribute screened and degritted wastewater from the batch tank into one of two sequencing batch reactors.

D. Motor control equipment furnished and installed under Division 26 – Electrical.

E. Provide single source coordination responsibility through the pump manufacturer for the entire system including but not limited to the following:

1. Pumps.
2. Motors.
3. Pump accessories, including discharge elbow, rails, lifting chain, power cables.
4. Winch, hoist, jib crane, etc.

1.4 SUBMITTALS

A. Shop Drawings:

1. Requirements in Specification Section 01 61 03.
2. Requirements in Specification Section 26 29 23.
3. Requirements in Specification Section 43 21 00.

B. Operation and Maintenance Manuals:

1. See Specification Section 01 78 23 for requirements for:
   a. The mechanics and administration of the submittal process.
   b. The content of Operation and Maintenance Manuals.

C. Project Information:

1. Executed Manufacturer's Installation Certification Form.

D. Refer to Section 01 81 33 – Cyber Security Requirements for required cyber security related submittals.

1.5 SHIPPING

A. Per Section 01 61 03.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. Flygt.
2. Ebara.
3. Sulzer – ABS.

2.2 PERFORMANCE AND DESIGN REQUIREMENTS

A. Woodside Influent Pumps (P-01-01, P-01-02, P-01-03):

1. Shutoff Head (range): 70 feet to 75 feet.
2. Design Condition:
   a. Flow: 950 GPM.
   b. Head: 42.4 feet.
   c. Minimum Hydraulic Efficiency: 70%.
   d. Flow Relative to BEP (PCT range): 70% to 120%.
   e. Maximum NPSH3: 17.8 feet.
3. Runout Condition:
   a. Minimum Flow: 1,420 GPM.
   b. Maximum Head: 33 feet.
   c. Minimum Hydraulic Efficiency: 60%.

d. Flow Relative to BEP (PCT): <163%.
e. Maximum NPSH3: 18.6 feet.

4. Secondary Condition:
   a. Maximum Flow: 700 GPM.
   b. Minimum Head: 29.4 feet.
   c. Minimum Hydraulic Efficiency: 69.5%.
   d. Flow Relative to BEP (PCT): >75%.
   e. Maximum NPSH3: 17.4 feet.
5. Maximum Suction Diameter: 6 inches.
6. Discharge Diameter: 6 inches.
7. Pump Rotation: Per Drawings.
   a. Motor requirements:
      1) Maximum Operating Speed: 1,800 RPM.
      2) Minimum Operating Speed: 750 RPM.
      3) Service factor: 1.3.
      4) Minimum motor efficiency at the Design Condition: 92%.
      5) Minimum power factor: 75%.
      6) Maximum nameplate horsepower: 25.
   b. Drive type: Variable speed.
   c. Ambient conditions:
      1) Wastewater maximum temperature: 70 DEGF.
      2) Air maximum temperature: 105 DEGF.

B. Grit Pump (P-03-01):
1. Shutoff Head (range): 45 feet to 55 feet.
2. Design Condition:
   a. Flow: 200 GPM.
   b. Head: 33.1 feet.
   c. Minimum Hydraulic Efficiency: 35%.
   d. Flow Relative to BEP (PCT range): 60% to 120%.
   e. Maximum NPSH3: 26.5 feet.
3. Runout Condition:
   a. Minimum Flow: 620 GPM.
   b. Maximum Head: 15.0 feet.
   c. Minimum Hydraulic Efficiency: 25%.
   d. Flow Relative to BEP (PCT): <170%.
   e. Maximum NPSH3: 20.0 feet.
4. Maximum Suction Diameter: 4 inches.
5. Discharge Diameter: 4 inches.
6. Minimum Solids Passage: 3 inches.
7. Pump Rotation: Per Drawings.
   a. Motor requirements:
      1) Maximum Operating Speed: 1,800 RPM.
      2) Minimum Operating Speed: 750 RPM.
      3) Service factor: 1.3.
      4) Minimum motor efficiency at the Design Condition: 90%.
      5) Minimum power factor: 75%.

6) Maximum nameplate horsepower: 10.1.
b. Drive type: Constant speed.
c. Ambient conditions:
1) Wastewater maximum temperature: 70 DEGF.
2) Air maximum temperature: 105 DEGF.

C. Batch Tank Pumps (P-04-01, P-04-02, P-04-03):
1. Shutoff Head (range): 50 feet to 55 feet.
2. Design Condition:
a. Flow: 1,415 GPM.
b. Head: 6.0 feet.
c. Minimum Hydraulic Efficiency: 70%.
d. Flow Relative to BEP (PCT range): 80% to 120%.
e. Maximum NPSH3: 16.2 feet.
3. Runout Condition:
a. Minimum Flow: 2,150 GPM.
b. Maximum Head: 9.2 feet.
c. Minimum Hydraulic Efficiency: 60%.
d. Flow Relative to BEP (PCT): <180%.
e. Maximum NPSH3: 25.0 feet.
4. Secondary Condition:
a. Maximum Flow: 1,110 GPM.
b. Minimum Head: 12.5 feet.
c. Minimum Hydraulic Efficiency: 65%.
d. Flow Relative to BEP (PCT): >90%.
e. Maximum NPSH3: 17.4 feet.
5. Maximum Suction Diameter: 8 inches.
6. Discharge Diameter: 8 inches.
7. Pump Rotation: Per Drawings.
a. Motor requirements:
1) Maximum Operating Speed: 900 RPM.
2) Minimum Operating Speed: 450 RPM.
3) Service factor: 1.3.
4) Minimum motor efficiency at the Design Condition: 88%.
5) Minimum power factor: 70%.
6) Maximum nameplate horsepower: 16.
b. Drive type: Variable speed.
c. Ambient conditions:
1) Wastewater maximum temperature: 70 DEGF.
2) Air maximum temperature: 105 DEGF.

2.3 MATERIALS

A. Woodside Influent Pumps (P-01-01, P-01-02, P-01-03):
1. Pump case: Cast iron, ASTM A48, Class 35.
2. Motor housing: Cast iron, ASTM A48, Class 25 or Class 30.
3. Impeller: Cast Iron, ASTM A-532 Class III, Type A.
4. Shaft: Stainless Steel, Series 300 or 400.

5. Suction cover: Cast Iron, ASTM A-532 Class III, Type A.
6. O-rings: Nitrile (Buna-N) or fluorocarbon (Viton).
7. Fasteners: Stainless steel.
8. Lower ring seal: Tungsten-carbide both faces or Silicon Carbide both faces.
9. Upper ring seal: Tungsten-carbide both faces or carbon and ceramic or carbon and Ni-resist.
10. Seal metal parts: Stainless steel.

B. Grit Pump (P-03-01):

1. Pump case: Cast iron, ASTM A48, Class 35.
2. Motor housing: Cast iron, ASTM A48, Class 35.
3. Impeller: Duplex stainless steel, ASTM A890, Grade 4A.
4. Shaft: Stainless Steel, Series 300 or 400.
5. Suction cover: Cast Iron, ASTM A-532 Class III, Type A.
6. O-rings: Nitrile (Buna-N) or fluorocarbon (Viton).
7. Fasteners: Stainless steel.
8. Lower ring seal: Tungsten-carbide both faces or Silicon Carbide both faces.
9. Upper ring seal: Tungsten-carbide both faces or carbon and ceramic or carbon and Ni-resist.
10. Seal metal parts: Stainless steel.

C. Batch Tank Pumps (P-04-01, P-04-02, P-04-03):

1. Pump case: Cast iron, ASTM A48, Class 35.
2. Motor housing: Cast iron, ASTM A48, Class 25 or Class 30.
3. Impeller: Cast Iron, ASTM A-532 Class III, Type A.
4. Shaft: Stainless Steel, Series 300 or 400.
5. Suction cover: Cast Iron, ASTM A-532 Class III, Type A.
6. O-rings: Nitrile (Buna-N) or fluorocarbon (Viton).
7. Fasteners: Stainless steel.
8. Lower ring seal: Tungsten-carbide both faces or Silicon Carbide both faces.
9. Upper ring seal: Tungsten-carbide both faces or carbon and ceramic or carbon and Ni-resist.
10. Seal metal parts: Stainless steel.

D. Wet Pit Applications:

1. Guide rails: Type 316 Stainless steel.
2. Lifting chains and cables: Type 316 Stainless steel.
3. Base elbow: Cast iron, ASTM A48, Class 35.

2.4 COMPONENTS

A. General:

1. Provide pumps capable of handling various wastewater conditions as identified in Article 1.3..
2. Where watertight sealing is required, machine and fit mating surfaces with O-rings.
3. Provide with heavy duty lift lugs or hoisting bail designed for lifting the entire pump and motor assembly.

B. Impeller:

1. Woodside Influent Pumps:

a. Provide semi-open solids-handling type dynamically balanced impeller in accordance with HI standards.
b. Provide adjustable impeller that will provide effective sealing between the suction cover and impeller.

2. Grit Pumps:
   a. Provide 6-vane vortex solids-handling type dynamically balanced impeller in accordance with HI standards.
   b. Provide adjustable impeller that will provide effective sealing between the suction cover and impeller.
3. Batch Tank Pumps:
   a. Provide semi-open solids-handling type dynamically balanced impeller in accordance with HI standards.
   b. Provide adjustable impeller that will provide effective sealing between the suction cover and impeller.

C. Shaft:

1. Design shaft for a maximum deflection of 0.004 inches at the stuffing box as calculated at the design condition.

D. Mechanical Seal:

1. Seal shaft with double mechanical seal running in an oil filled chamber.
2. Provide seals requiring neither routine maintenance nor adjustment, but capable of being easily inspected and replaced.
3. Hold interface in contact by its own spring system.

E. Bearings:

1. Support shaft on upper and lower permanently lubricated bearings with a minimum ABMA L-10 life of 50,000 hours.

F. Motors:

1. Provide pump with FM, UL, or CSA listed motor approved for explosion-proof atmospheres.
2. Provide induction type motor with a squirrel cage rotor, of totally submersible design without loss of watertight integrity to a depth of at least 65 feet, constructed with epoxy or poly-seal encapsulated windings, air-filled or dielectric oil filled, with Class H insulation rated for 180 degrees C and rated for continuous duty operation.
3. Motor shall be 3 PH, 60 cycle, 480 V.
4. Motor shall be capable of running continuously in an unsubmerged condition while pumping under load without damage to motor or seal.
5. The motor horsepower provided shall be adequate so that the pump is non-overloading throughout the entire pump performance curve from shut-off through runout.
6. The motor shall be designed and assembled by the same manufacturer as the pump.
7. Cooling Jackets (Woodside Influent and Batch Tank pumps):
   a. The motor shall be equipped with a closed loop cooling system where the cooling medium is circulated through the pump motor cooling jacket. The pumped fluid shall not be circulated through the cooling jacket. An impeller in the lower motor coolant reservoir will circulate coolant around the motor housing. The cooling system shall provide sufficient cooling for continuous operation whether the pump is submerged in the pumped media or surrounded by air in liquid or ambient temperatures of up to 40 degrees C.
   b. Cooling system will provide sufficient cooling for the entire range of pump operating speeds.

G. Power and Control Cables:

1. Provide power and control cables which are listed per NEC requirements and approved for the installation types indicated on the drawings. As a minimum the cable shall be suitable for installation in conduit and for submersible applications.
2. Size cables in accordance with applicable NFPA 70 specifications.
    a. Power cable for VFD controlled pumps shall be shielded and suitable for VFD applications.
3. Provide 49 feet power cable and control cable for each pump.
4. Provide each cable with a strain relief, cord grip, and explosion proof seal installed in accordance with NFPA 70, Article 500.
5. Minimum acceptable cable type: "SO-Water Resistant" per UL 62.

H. Pump Protection:

1. Temperature Monitor:
    a. Furnish each phase of the motor with thermal switches embedded in the motor windings for monitoring by pump supplier provided monitoring relay for pumps with variable speed drives and as shown on Drawings.
    b. Should the thermal switches sense high temperature in the windings, the monitoring relay will provide a dry contact that allows the motor controller to shut the pump down, and provide an alarm. Should any one of the thermal switches detect high temperature, the monitoring relay will require manual reset once the stator temperature returns to normal.
    c. Set temperature of the temperature monitors not higher than 90% of insulation temperature rating.
2. Leak Detection:
    a. Provide sensors inside the terminal board and the stator chamber to detect water intrusion and is monitored by pump supplier provided monitoring relay for all submersible pumps.
    b. If water is detected inside the terminal board or the stator chamber, the monitoring relay will provide a dry contact that allows the motor controller to stop the pump and provide an alarm.
3. Provide monitoring relay that provides protection for submersible pump high temperature and leakage as specified above. Monitoring relays will be installed under Division 26 in the motor control center.

I. Coatings:

1. Apply two-component oxirane ester or polyamidoamine epoxy system to the exterior of the pump casing and motor housing as specified in Specification Section 09 96 00.

J. Wet Pit Applications:

1. Provide sliding guide bracket integral to pump unit which properly aligns the pump discharge with the discharge connection elbow for watertight seal during pumping.
2. Guide the entire weight of the pumping unit to the base discharge elbow by guide rail(s).
3. The guide rail(s) shall not support any portion of the weight of the pump.
4. Provide chains or cable of sufficient strength to lift pumps from sump.
5. Furnish guiding rail assembly and the discharge flange assembly of nonsparking components.
6. Design pump to allow for removal without entering the wet well and without removal of bolts, nuts or other fastenings.
7. Provide pump unit connecting to discharge connection with a simple downward motion without rotation. The entire weight of the pumping unit shall wedge tightly against the discharge elbow flange forming a seal without the use of bolts, gaskets, or o-rings.

8. Provide necessary sliding guide bracket and discharge connection which, when bolted to the floor of the sump and to the discharge line, will receive the pump discharge connecting flange without need of adjustment, fasteners, clamp, or similar devices.
9. No portion of the pump shall bear directly on the floor.

2.5 ACCESSORIES

A. See Specification Section 43 21 00 - Pumping Equipment: Basic Requirements.

B. Controls:

1. See Electrical and Instrument and Controls Designs for controls requirements.

C. Winch for Wet Pit Applications:

1. Secure a manually operated, cable-type winch capable of lifting the pumps for the Woodside Influent and Batch Tank pumping systems.
   a. One portable winch capable of lifting both the Woodside Influent and Batch Tank pumps with two davit bases.
      1) Alternatively, Owner may provide use of its hoisting equipment for installation. See Section 01 14 19 for additional requirements.
   b. Grit Pump may be installed by new monorail and hoist as specified in Section 41 22 23. See Section 01 14 19 for additional requirements.
2. Provide winch with a fabricated steel support frame and with a minimum capacity of 1.5 times pump weight.
3. Fit cable end with a grab hook to properly link up with the lifting chain.
4. Provide davit base for portable steel support frame.

2.6 SOURCE QUALITY CONTROL

A. Secure from the pump manufacturer the following inspections and tests on each pump before shipment from factory:

1. Check impeller, motor rating and electrical connections for compliance with this Specification Section.
2. Test motor and cable insulation for moisture content or insulation defects.
3. Prior to submergence, run pump dry to establish correct rotation and mechanical integrity.
4. Run pump submerged for 30 minutes.
5. After operational test #4, perform insulation test (#2) again.

B. Factory test of head (FT) versus flow (GPM) for all pumps being provided as specified in Specification Section 43 21 00.

PART 3 - EXECUTION

3.1 INSTALLATION

A. See Specification Section 43 21 00.

B. For wet pit pumps, permanently install discharge connection elbow in wet well along with discharge piping.

C. Seal pump cable end with a high quality protective covering, to make it impervious to moisture or water seepage prior to electrical installation.

3.2 FIELD QUALITY CONTROL

A. See Specification Section 43 21 00.

3.3 CLOSEOUT ACTIVITIES

A. Refer to Section 01 81 33 – Cyber-Security Requirements for cyber security related closeout requirements.

END OF SECTION

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DIVISION 46

WATER AND WASTEWATER EQUIPMENT

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SECTION 46 12 22
GRIT CLASSIFIER WITH CYCLONE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Grit dewatering system, consisting of one (1) screw type dewatering classifier, one (1) grit cyclone, for removing grit material pumped from the primary grit removal devices.

B. Related Sections include but are not necessarily limited to:

1. Division 00 - Procurement and Contracting Requirements.
2. Division 01 - General Requirements.
3. Section 01 61 03 – Equipment - Basic Requirements.
4. Section 40 05 00 – Pipe and Pipe Fittings – Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:

1. American Gear Manufacturers Association (AGMA).
2. American Iron and Steel Institute (AISI):
   a. Steel Products Manual.
3. ASTM International (ASTM):
   a. A276, Standard Specification for Stainless Steel Bars and Shapes.
4. International Electrotechnical Commission (IEC).

B. Qualifications:

1. Supplied by a single manufacturer or supplier.
2. Manufacturer shall provide evidence of at least ten (10) installations in which identically sized equipment has been provided satisfactory performance for a minimum of five (5) years.

1.3 SUBMITTALS

A. Shop Drawings:

1. See Section 01 33 00 for requirements for the mechanics and administration of the submittal process.
2. Scaled floor plan and sections showing dimensions, weights, structural supports, embedments and clearances.
3. Materials of construction of all components.
4. Provide cyclone losses for apex and vortex finder.

B. Operation and Maintenance Manuals:

1. See Section 01 33 00 for requirements for:
   a. The mechanics and administration of the submittal process.
2. See Section 01 78 23 for requirements for:
   a. The content of Operation and Maintenance Manuals.

1.4 PERFORMANCE

A. The grit dewatering system performance requirements:

GRIT SLURRY FEED RATE	PARTICLE SIZE	REMOVAL %
200 GPM	150 Mesh	> 95%

1.5 ENVIRONMENTAL CONDITIONS

A. The grit classifier and cyclone will be installed indoors in the Headworks Building as shown on the Drawings.

B. Equipment Environment Application Rating: Class 1 Division 1 Groups C & D.

1.6 DELIVERY, STORAGE, AND HANDLING

A. The system shall be delivered to the site in fully assembled units to the extent possible.

B. Refer to Section 01 65 00 for additional delivery requirements and 01 66 00 for additional storage and handling requirements.

1.7 WARRANTY

A. A two (2)-year equipment warranty shall be provided. The manufacturer will warrant against any defects in material or workmanship to the classifier, cyclone and framework. The warranty date will be from the time of Substantial Completion, as defined in the Supplementary Conditions, for the Construction Contractor and will be one (1) date for all equipment.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:

1. WEMCO (Hydrogritter Series).
2. Smith & Loveless, Inc. (Schloss Series).
3. Kusters Water (ProTechtor® Series).
4. Hydro International (SpiraSnail® with OpTeaCup® concentrator).
5. Or engineer approved equal.

2.2 MATERIALS

A. Cyclone (WEMCO and Kusters Water):

1. Cone housing: Aluminum.
2. Cone lining: Neoprene or soft gum rubber.
   a. Cone shall be designed to allow each liner section to be replaced independently.
3. Flanged inlet, overflow ports: Cast iron, ANSI 125 LB FF flanges.
4. Inlet head housing: Cast iron.
5. Inlet head liner: Neoprene or soft gum rubber.
6. Vortex finder: Ni-hard, Brinell hardness of 500.
7. Apex housing: Steel.
8. Apex liner: Neoprene or soft gum rubber.
9. Cylinder housing: Steel.
10. Cylinder lining: Neoprene or soft gum rubber.
11. Retainer ring: Steel.
12. Support: 316 stainless steel.
13. Hardware: 316 stainless steel.

B. Cyclone (Smith & Loveless):

1. Cone housing (upper): Ni-Hard, Brinell hardness of 500.
2. Cone housing (lower): PISTA® Duralyte®.

3. Flanged inlet, overflow ports: Cast iron, ANSI 125 LB FF flanges.
4. Vortex finder: Ni-hard, Brinell hardness of 500.
5. Support: 316 stainless steel.
6. Hardware: 316 stainless steel.

C. Cyclone (Hydro International):

1. Material: 316 stainless steel.
2. Diameter: 24 inches.
3. Flanged inlet, overflow ports: Cast iron, ANSI 125 LB FF flanges.
4. Hardware: 316 stainless steel.

D. Grit Classifier (GC-03-01):

1. Tank: 316 stainless steel.
2. Tank cover: 316 stainless steel.
3. Tank support: 316 stainless steel.
4. Feed box: 316 stainless steel.
5. Screw conveyor: 316 stainless steel.
6. Auger tube/trough: 316 stainless steel.
7. Hollow shaft screw: 316 stainless steel.
8. Flights: 316 stainless steel.
9. Hardware: 316 stainless steel.

2.3 PERFORMANCE AND DESIGN REQUIREMENTS

A. Cyclone:

1. Number of units: 1.
2. Inlet flow rate: 200 GPM.
3. Inlet pressure:
   a. WEMCO, Smith & Loveless, Kusters: 5 to 10 PSI.
   b. Hydro International: 27 inches.
4. Underflow rate: sized for proper hydraulic loading to grit classifier.
5. Inlet port size: 4 IN.
6. Overflow port size: 6 IN.
7. Apex diameter: 2 IN.
8. Vortex finder diameter: 4 IN.

B. Grit Classifier (GC-03-01):

1. Number of units: 1.
2. Maximum overflow rate: 3.2 GPM/SQ FT.
3. Minimum pool surface: 8.3 SQ FT.
4. Minimum removal capacity: 60 LB/HR
5. Screw speed: 12 RPM maximum.
6. Motor: 1 HP maximum.

2.4 CYCLONE

A. The cyclone inlet diameter shall be 4 IN, the overflow 6 IN. Inlet and overflow connections shall be flanged, 150 LBS ANSI cast iron. The cyclone shall be installed on the classifier for horizontal piping configurations for the inlet and overflow connections..

B. The cyclone vortex finder shall be 4 IN DIA and made of an abrasion-resistant alloy with an approximate hardness of 500 Brinell.

C. Each cyclone inlet shall be tapped for a 1 IN NPT gage connection and a diaphragm-protected pressure gage shall be provided by the cyclone manufacturer.

D. The cyclone underflow shall feed into the classifier for washing and dewatering and be sized so that the proper hydraulic loading is provided to the classifier.

E. The cyclone overflow will feed to piping furnished by the contractor which must be properly and adequately vented to prevent siphoning.

F. The cyclone manufacturer shall supply a fabricated steel support to mount the cyclone.

1. The cyclone shall be attached to a 3/8 IN stainless steel mounting plate, designed such that the cyclone is properly oriented into the classifier feedboxes.
2. The cyclone mounting plate shall be independently supported with two structural steel supports, designed for attachment to the floor with anchor bolts.
3. The discharges of the cyclone shall feed into a hopper supplied by the cyclone manufacturer.

2.5 GRIT CLASSIFIER

A. The grit classifier shall comprise a complete assembly including drive, screw conveyor, fabricated trough with supports and necessary anchorage parts.

B. Classifier Tank:

1. The grit settling tank shall be constructed of 1/4 IN plate, suitably reinforced and mounted on 1/4 IN minimum thickness supports. The tank shall be designed to provide a settling compartment where grit separation takes place.
2. Weir overflow shall discharge into a launder box equipped with a 6 IN DIA flanged pipe stub for connection to drain.
3. The tank shall be provided with a 2 IN DIA NPT half coupling with pipe plug to allow the tank to be drained.
4. The grit classifier shall be provided with an 11 GA minimum thick split cover.
   a. Cover shall be bolted to the classifier tank with a hinged cover section.
   b. The cover and access hatches shall be fitted with adhesive backed neoprene rubber gaskets that will provide a gas tight seal.
   c. Mounting clamps, hinges and hardware shall be in sufficient number to form a gas tight seal.

C. Classifier Feed Box:

1. The classifier tank shall be supplied complete with one fabricated feed box to facilitate the introduction of underflow from the cyclone into the classifier.
2. The feed box shall be reinforced minimum 12 GA plate.
3. The feed boxes shall be designed and located by the manufacturer to minimize short-circuiting to the overflow weir of the classifier, and to handle maximum cyclone underflow discharge.
4. The classifier manufacturer shall be responsible for ensuring that the feed boxes are designed to dissipate energy generated from the head drop of the cyclone underflow, to minimize disruption of the classifier pool.

D. Shafted Screw Conveyor:

1. The grit shall be removed from the bottom of the settling compartment and discharged by means of a helical shafted screw conveyor.
2. Screw conveyor trough/tube thickness: 1/4 IN minimum.
3. Screw diameter: 3 IN minimum.
4. Angle: As recommended by Manufacturer.
5. Screw overall length: constructed to discharge at location on the Drawings.
6. Stress: 3,000 PSI maximum.

7. Fatigue: 98 PCT of 20 years minimum.
8. Flight thickness: 12 gage minimum.
9. Flight height: 4 1/8 IN minimum.
10. Wearing shoes: minimum 10 gage thick by 4 IN high.
11. The shafted screw conveyor shall be rigidly supported at both the upper and lower ends, so that the screw conveyor is mounted above the classifier tank.
    a. Lower bearing: Internal, attached to manually operated hand wheel and screw-type lifting device designed to allow the entire assembly to be lifted above the maximum water level inside the classifier body.
        1) Lower bearing designs incorporating conventional packing, requiring external flushing or bearings located outside the grit tank will not be acceptable.
    b. Upper bearing: Rigidly connected to and supported by the drive unit.
    c. Shaftless screws will not be acceptable.
12. Wearing shoes shall be abrasion-resistant and mounted on the flights by means of bolts and nuts. The abrasion-resistant wearing shoes shall be a minimum of 500 Brinell steel.
13. Grit shall discharge directly into the receiving dumpster. An extension such as a grit chute or pan used to direct discharged grit into the receiving dumpster is not allowed.
14. The upper end of the grit classifier dewatering screw conveyor housing shall be provided with a fabricated support that shall be mounted from grade as shown on the Drawings. Support shall be fabricated of structural shapes with a minimum 1/4 IN thickness.

E. Drive System:

1. Shaft mounted gear motor assembly.
    a. High-thrust in-line speed reducer design for a maximum output speed of 12 RPM.
    b. Speed reducer minimum torque rating: 7,240 IN/LB.
    c. Speed reducer minimum thrust rating: 8,300 LB_f.
2. Motor:
    a. Maximum horsepower: 1 HP.
    b. Voltage: 460 V, 3 phase, 60 Hz.
    c. Single speed: 1,800 RPM nominal.
    d. Drive type: Direct.
    e. Explosion proof, approved for Class I, Division 1.

2.6 CONTROL SYSTEM

A. The grit dewatering system shall be controlled by the Plant PLC with a local control station provided by the equipment supplier. The motor controller is in an MCC furnished and installed under Division 26 – Electrical.

1. Local control station shall include:
    a. FORWARD/OFF switch for hand operation.
    b. EMERGENCY STOP pushbutton.
    c. NEMA 7 enclosure.

2.7 MAINTENANCE MATERIALS

A. Extra Material:

1. Furnish the Owner the following extra parts:
    a. One (1) complete set of cyclone liners and seals.
    b. One (1) grit classifier lower bearing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. See Section 01 61 03.

B. Install the grit dewatering system in accordance with the manufacturer’s instructions.

3.2 FIELD QUALITY CONTROL

A. Provide services of equipment manufacturer's field service representative(s) to:

1. Attend pre-installation conference.
2. Inspect equipment covered by this Specification Section.
3. Supervise pre-start adjustments and installation checks.
4. Conduct initial startup of equipment and perform operational checks.
5. Instruct Owner's personnel at jobsite on operation and maintenance of the equipment.
6. Provide for a minimum of 8 HRS of field services in a minimum of one site visit.

END OF SECTION

SECTION 46 21 00
GRIT REMOVAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Free or forced vortex type grit removal equipment.
    a. Contract Drawings provide general layout of units, based on free vortex type grit removal equipment. Contractor to provide detailed drawings for units to meet the performance requirements of this specification.

B. Related Sections include but are not necessarily limited to:

1. Division 00 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
2. Division 01 - General Requirements.
3. 01 61 03 - Equipment - Basic Requirements.
4. Section 01 75 00 - Checkout and Start-up Procedures.
5. Section 05 50 00 - Metal Fabrications.
6. Section 09 96 00 - High Performance Industrial Coatings.

1.2 QUALITY ASSURANCE

A. See Section 01 61 03 - Equipment - Basic Requirements.

B. Referenced Standards:

1. Anti-Friction Bearing Manufacturers Association (AFBMA).
2. American Iron and Steel Institute (AISI).
3. American Society for Testing and Materials (ASTM):
    a. A36, Specification for Structural Steel.
    b. A890, Standard Specification for Castings, Iron-Chromium-Nickel-Molybdenum Corrosion-Resistant, Duplex (Austenitic/Ferritic) for General Application.
4. American Society of Mechanical Engineers (ASME).
5. American Gear Manufacturer's Association (AGMA).
6. National Electrical Manufacturers Association (NEMA).
7. American National Standards Institute (ANSI).

1.3 SUBMITTALS

A. See Section 01 33 00 - Submittal Procedures.

B. Operation and Maintenance Manuals:

1. See Section 01 33 00 for requirements for:
    a. The mechanics and administration of the submittal process.
    b. The content of Operation and Maintenance Manuals.
2. Equipment shall not be started until a manufacturer Operation and maintenance manual has been submitted and approved.

C. Shop Drawings:

1. Product technical data including:
    a. Acknowledgement that products submitted meet the requirements of the standards referenced.
    b. Sufficient data to verify compliance with specifications and to illustrate construction or assembly of the components and materials. Manufacturer, model, and type.

c. Overall dimensions and total weights of equipment.
d. Material specifications.
e. Electrical wiring diagrams.
f. Installation drawings and layouts to scale customized for this installation.
g. Full scale test results from installations of similar size and peak design flow rates showing performance equal to that specified in Part 2 of this specification and conforming with testing requirements included in Part 3 of this specification.
h. Contractor's instruction for storage, handling and installation.
i. Paint product data.

D. Maintenance materials.

E. Certification of proper installation and satisfactory operation form manufacturer.

F. Manufacturer's field service report.

G. Operation and Maintenance Manuals:

1. See Section 01 33 00.

1.4 JOB CONDITIONS

A. Equipment will be located inside the new Headworks Building.

B. Layout is based on free vortex type grit removal system.

1. Contractor shall adjust layout of equipment, piping, and penetrations as necessary if a forced vortex grit removal system is selected until accepted by Engineer.
2. Alternatively, the Contractor may request redesign by Engineer with Owner's costs for such assigned as a credit to the contract by Change Order.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Hydro International (HeadCell®).

B. Veolia (Mectan V®).

C. Smith & Loveless (PISTA® VIO™).

D. Or Equal.

2.2 PERFORMANCE REQUIREMENTS

A. The following requirements apply to the grit removal unit:

Parameter	Design Flow Rate (MGD)	Influent Grit (CF/MG)	Maximum Head Loss (inches)	Grit Removal Performance
Average Annual Flow	1.19	5.0	1.5	95% removal of all grit with SES ≥75 µm
Peak Month Flow	1.46	5.0	2	95% removal of all grit with SES ≥105 µm
Peak Day Flow	1.83	5.0	3	95% removal of all grit with SES ≥105 µm
Peak Hour Flow	3.20	5.0	5	95% removal of all grit with SES ≥125 µm

2.3 MATERIALS

A. Grit Removal Equipment (Hydro International):

1. Steel components (influent duct, frame, grit hopper): 316L stainless steel.
2. Trays: Low-density polyethylene (LDPE).

3. Hardware: 316L stainless steel.

B. Grit Removal Equipment (Veolia and Smith & Loveless):

1. Housing: Cast Iron, ASTM A48, Class 25 or better.
2. Impellers or propellers: 316L stainless steel.
3. Gears and pinions: Alloy steel, heat treated, machined, and hardened in accordance with AGMA standards.
4. Bolts and fasteners: Stainless steel, IFI-104, Grade 303 or 305.
5. Anchor bolts: Stainless steel, IFI-104, Grade 303 or 305.
6. Torque tube: 316L stainless steel.
7. Influent baffle plate: 316L stainless steel.
8. Two piece floor plate assembly: 316L stainless steel.

2.4 EQUIPMENT

A. Design Requirements:

1. Equipment Manufacturer shall verify modification requirements with Shop Drawings.
2. Grit Chamber Dimensions (Hydro International):
   a. Chamber width: 12 FT - 0 IN.
   b. Chamber length: 12 FT - 0 IN.
   c. Chamber depth from channel inlet invert: 9 FT - 9 IN.
   d. Grit chamber elevations:
      1) Operating walkway: 5255.50.
      2) Grit chamber floor: 5240.75.
      3) Inlet channel invert: 5250.50.
      4) Outlet weir top of concrete: 5251.29.
      5) Water level in grit chamber: See Hydraulic Profile in Drawings.
   e. Influent duct opening size: 2-foot height by 1.5-foot width.
3. Grit Chamber Dimensions (Veolia and Smith & Loveless)::
   a. Upper chamber diameter (minimum): 8 FT - 6 IN.
   b. Upper chamber depth: 4 FT - 9-1/2 IN.
   c. Upper chamber sidewater depth: 2 FT - 11-2/3 IN.
   d. Grit storage chamber diameter: 3 FT - 2 IN.
   e. Grit storage chamber depth: 5 FT - 0 IN.
   f. Grit chamber elevations:
      1) Operating walkway: 5255.50.
      2) Grit storage chamber floor: 5245.71.
      3) Inlet channel invert: 5250.50.
      4) Outlet channel invert: As recommended by manufacturer.
      5) Water level in grit chamber: See Hydraulic Profile in Drawings.
      6) Inlet opening size: as recommended by Manufacturer.
   g. Drive horsepower: 1.0 HP.
   h. Provide all baffles and other appurtenances required for proper operation of equipment, including low-flow inlet baffling.

B. Grit fluidizing system:

1. Hydro International:
   a. 1-1/2” NPT utility water system requiring an intermittent 32 GPM of utility water supplied at 50 PSIG.

b. Manufacturer shall provide all components required within tankage, including, but not limited to fluidizing ring.

2. Veolia:
   a. Manufacturer shall include a fluidizing water system to maintain a fluidized grit bed in the storage chamber.
      1) Manufacturer shall include all equipment, devices, valves, and other appurtenances necessary for an automatically controlled fluidizing water system not shown in Drawings.
3. Smith & Loveless:
   a. Manufacturer shall include a fluidizing vane system to maintain a fluidized grit bed in the storage chamber.
      1) Fluidizing vanes shall attach to bottom of torque tube to provide mechanical agitation of grit storage chamber.

C. Self-Priming Grit Pump (Veolia and Smith & Loveless):

1. Provide self-priming centrifugal pump in lieu of the submersible Grit Pump (P-03-01) as specified in Section 43 25 13.
2. Two-vane, semi open, non-clog type impeller with integral pump out vanes on back shroud.
   a. Material: ASTM A890, Grade 4A.
3. Provide for external adjustment of impeller to the wear plate.

2.5 FABRICATION

A. General:

1. Welding: Fully or partially submerged joints shall be sealed watertight by continuous welds.
2. Edge grinding: Round over sharp edges and corners with a file or power grinder.
3. See Section 09 96 00 - High Performance Industrial Coatings.
4. Shop painting:
   a. Prepare, prime and finish coat all ferrous surfaces in accordance with Section 09 96 00. Exception: Stainless steel.
   b. Requirements for additional field painting are specified in Section 09 96 00.
5. Field connections to be bolted. No field welding will be allowed.
6. All components designed for heavy-duty 24 hour per day service.

B. Influent Duct (Hydro International):

1. Distributes screened wastewater tangentially into each tray of the grit chamber.
2. Minimum 3-inch clear openings.

C. Settling Trays and Frame (Hydro International):

1. Each grit settling tray consists of 6 trays, each with a 9-foot diameter, providing an overall surface area of 343 square feet. The interior portion of the trays will have sufficient size to install a submersible grit pump in the grit sump at the bottom of the chamber.
2. Trays are supported by a 316L stainless steel frame.
3. The frame consists of a base unit designed to be grouted into place in the lower portion of the grit chamber (grouting by Contractor).

D. Impeller or Propeller Assembly (Veolia and Smith & Loveless):

1. Impeller or propeller connected to drive tube driven by mechanical drive turntable bearing. Four (4) blades per unit minimum, affixed to drive tube by means of a two piece collar allowing adjustment in either an upward or downward position to assure maximum grit removal and organics separation.
2. Pitch of each impeller or propeller blade set.
3. Drive tube: 3/8-IN thick, minimum.

4. Impeller or propeller blades: ¼-IN thick, minimum.

E. Gear Motor (Veolia and Smith & Loveless):

1. Helical gear type motor, 480 V, 3 phase, 60 Hz, TEFC with normal starting torque and low starting current.
2. Gear reducer to include antifriction bearings with high overhung load properties, and double lip temperature oil seals riding on precision ground shafts.
3. Gear motor designed for heavy-duty 24-hour service and not to overload under any normal operating conditions.
4. Oil lubrication for helical gearing.
5. B-10 bearing life: 100,000 hours minimum.
6. Service factor: 2.0 or greater.
7. Motor controller will be located in an MCC furnished and installed under Division 26 – Electrical.

F. Mechanical Drive (Veolia and Smith & Loveless):

1. Combination spur gear and minimum 21 IN diameter turntable bearing, totally enclosed in heavy cast iron case, and driven by pinion on output shaft of gear motor.
2. Output speed: 21 rpm, maximum.
3. Mechanical drive assembly specifically designed for this service and installation, including any additional weight from the stainless steel drive tube and impeller or propeller assembly compared with manufacturers standard steel components. Clarifier drives modified to meet the higher impeller or propeller speeds are not acceptable.
4. Gear box to be sealed with bottom opening for drive tube protected by air bell, 1/8- IN thick minimum, to prevent water from entering the gearbox in the event of flooding.
5. Gear box oil or grease lubricated.
6. Service factor: 5.0 minimum, at standard operating speeds.
7. B-10 bearing life for turntable assembly: 175,000 hours, minimum.
8. B-10 bearing life for other drive assembly bearings: 100,000 hours, minimum.

G. Baffle Plate (Veolia and Smith & Loveless):

1. If required by manufacturer provide baffle assembly at inlet channel to optimize grit removal performance across the design flow rate ranges listed in Article 2.2.

H. Floor Plate (Veolia and Smith & Loveless):

1. Provide removable floor plate assembly over grit storage chamber to minimize the possibility of organic capture.
2. Provide 3 IN opening for grit to pass through to storage chamber.
3. Design plate in two sections with lifting loops to allow access to the grit storage chamber.
4. Plate to be 1/4 IN minimum and must support a 200 pound per square foot live load.

I. Straightening Vanes (Veolia and Smith & Loveless):

1. If required by manufacturer, provide stainless steel straightening vanes in approach channel.

2.6 SPARE PARTS (VEOLIA AND SMITH & LOVELESS):

A. Replacement lubricant for two drive gear assemblies.

B. One spare gear motor.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Shop assemble each gear motor, mechanical drive, and impeller or propeller assembly prior to shipment and test run to assure proper operation of all components.

B. Install equipment in strict accordance with the Manufacturer's instructions and recommendations in the location shown on the Drawings.

C. Furnish manufacturer's recommended grades of oil and grease required for operation.

D. Set anchor bolts in accordance with the Manufacturer's recommendations.

E. Installation Supervision:

1. The grit removal equipment manufacturer shall provide one factory-trained representative to be on-site for two consecutive 8-hour periods during the installation of the equipment to supervise installation and adjustment of all components. The equipment shall be aligned, connected, and installed at the location shown and in accordance with the manufacturer's recommendations.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Services:

1. See Section 01 61 03 and 01 75 00.
2. Manufacturer's representative shall:
   a. Inspect equipment covered by this Section.
   b. Supervise adjustment and installation checks.
   c. Conduct startup of equipment and perform operational checks.
   d. Provide Owner with a written statement that manufacturer's equipment has been installed properly, started up and is ready for operation by Owner's personnel.

B. Operation Test:

1. Fill grit basins with water to its operating level and operate mechanism continuously for a period of not less than 12 HRS.
2. At no time during the operating tests shall the equipment exceed the rated torque or exhibit indications of binding or uneven operation. Record torque values as registered on the drive mechanism torque indicator and motor amperage (all three phases) at 3 hour intervals.
3. If the mechanism should exceed rated torque or, in the opinion of the Owner, the mechanism should exhibit indications of binding or improper adjustment, the contractor shall immediately halt the tests and remedy the problem. After completion of necessary repairs or adjustments, the tests shall be repeated. Failure to successfully complete the test in six attempts shall be considered sufficient cause for rejection.

C. Field Acceptance Tests

1. After the equipment is installed and the complete grit removal system is operational, testing of the system by the Contractor is required in accordance with Section 01 75 00.
2. As a condition precedent to final acceptance of the work, the manufacturer's representative shall demonstrate to the Engineer that the equipment has been properly installed, aligned, and tested and meets all requirements for satisfactory performance under the conditions specified herein. Should the Engineer determine during the testing that the equipment does not perform to or meet the requirements as specified herein, the Contactor shall cause the necessary modifications or replacements to be made.
3. The Contractor shall be subject to all costs for removal of the defective equipment and replacing, restoring, start-up and testing of the equipment as required for a satisfactory installation as specified.

3.3 OPERATOR TRAINING

A. The grit removal equipment manufacturer shall provide two 4-hour instruction sessions during start-up conforming to the requirements specified in this Section 01 79 23. The training sessions shall include preventative maintenance requirements, overhaul and troubleshooting instructions, and normal operating practices.

END OF SECTION

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