SECTION 07 92 01

CAULKING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General**. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 1, and all related specification sections, apply to this section.

1.2 DESCRIPTION OF WORK

A. **Scope of Work**. The Contractor shall provide the labor, tools, equipment, and materials necessary to furnish and install the caulking in accordance with the drawings and as specified herein.

1.3 QUALITY ASSURANCE

A. **Codes and Regulatory Agencies**. Perform all work in compliance with all federal, state, and local codes and regulatory agencies.

B. **Standards**. Materials and workmanship shall be in accordance with the following standards referenced herein.

1. ASTM – American Society for Testing and Materials.
2. FS – Federal Specification.
3. NSF – National Sanitation Foundation.

1.4 SUBMITTALS

A. **Product Data**. Submit manufacturer's specifications, including manufacturer's published data indicating that material complies with the specifications and is intended for the applications shown, recommendations and installation instructions for caulking compound and associated miscellaneous material required.

B. **Color Chart**. Submit manufacturer's standard color chart for color selection by the Owner.

1.5 JOB CONDITIONS

A. **Environmental Conditions**

1. Proceed with installation of caulking under weather conditions when temperatures are within manufacturer's recommended limitations for installation.
2. Proceed with the work only when forecasted weather conditions are favorable for proper care and development of high early bond strength.
3. Wherever joint width is affected by ambient temperature variations, install caulking only when temperatures are in the lower third of the

manufacturer's recommended installation temperature range, so that sealant will not be subjected to excessive elongation and bond stress at subsequent low temperatures.

4. Avoid mixing sealants in direct sunlight when high temperatures prevail.

B. **Protection**

1. Allow no caulking to overflow or spill onto adjoining surfaces, or to migrate into the voids of adjoining surfaces including rough textured materials.
2. Use masking tape or other precautionary devices to prevent staining of adjoining surfaces by either the primer/sealer or caulking materials.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **Delivery**

1. Each unit shall be labeled with the following:

a. Name of material and supplier.
b. Formula or specification number, lot number, color, and date of manufacture.
c. Mixing instructions, shelf life, and curing time when applicable.

B. **Storage**

1. Store or expose no materials to temperatures above 90 degrees Fahrenheit (° F.) or in direct sunshine.
2. Use no materials which are outdated as indicated by shelf life.
3. Store sealant tape in a manner which will retain shape.
4. Store containers where temperature is approximately 75° F. for 16 hours before using.

C. **Handling**. Open no containers or mix components until necessary preparatory work and priming have been completed.

1.7 SPECIAL WARRANTY

Not used.

PART 2 - PRODUCTS

2.1 CAULKING

A. **Type**. Two component, premium grade, polyurethane base, elastomeric sealant formulated for total immersion with a nonsag and self-leveling consistency.

B. **Color**. As selected by the Owner.

C. **Requirements**

1. Meet ASTM C920 and FS TT-S-00227E.
2. Type. M.
3. Grade. NS.
4. Class. 25.
5. Use. NT, M, G, A.
6. Elasticity. Minimum 50 percent at 0 degrees Fahrenheit (° F.).
7. NSF "Approved for Contact with Potable Water."

2.2 MISCELLANEOUS

A. **Joint Cleaner**. Provide the type of joint cleaning compound recommended by the caulking manufacturer for all joint surfaces.

B. **Joint Primer/Sealer**. Provide the type of joint primer/sealer recommended by the caulking manufacturer for all joint surfaces.

C. **Bond Breaker Type**. Polyethylene tape or other plastic tape as recommended by the caulking manufacturer to be applied to sealant contact surfaces where bond to the substrate or joint filler must be avoided for proper performance of caulking. Provide self-adhesive tape wherever applicable.

D. **Sealant Backer Rod**. Compressible rod stock polyethylene foam, polyethylene jacketed polyurethane foam, butyl rubber foam, neoprene foam or other flexible, permanent, durable nonabsorptive material as recommended for compatibility with caulking by the manufacturer. Provide size and shape of rod which will control the joint depth.

2.3 PRODUCTS AND MANUFACTURERS

A. **Products**. Provide one of the following:

1. Sikaflex 2cNs, two-component by Sika Chemical Company.
2. Or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. **General**. Comply with caulking manufacturer's written instructions except where more stringent requirements are shown or specified.

B. **Areas to Be Caulked**

1. Interior and exterior perimeter of all door and window frames.
2. Interior and exterior perimeter of all louvers and wall openings.
3. Interior and exterior joints formed by the junction of masonry work, concrete, and precast decking.
4. All ceiling joints of precast concrete slabs.
5. Wall panel, fascia, soffit, and coping joints.
6. All reglets and expansion joints.

7. Where else shown on the drawings and as required by the Engineer/Architect.

C. **Surface Preparation**

1. Remove dirt, moisture, loose material, and other substances that would interfere with bond.
2. Clean joint surface with oil free pressurized air immediately before installation of primer/sealer.

D. **Mixing**

1. Two Component. Follow manufacturer's written instructions.

   a. Thoroughly mix components before use.
   b. Add entire contents of activator and color components to base material. Do not mix partial units.
   c. Mix contents for 3 to 5 minutes as recommended by manufacturer and until color and consistency are uniform.
   d. Do not use mixture after pot life has expired.

E. **Priming**. Prime all joint surfaces.

1. Allow no primer or sealer to spill or migrate onto adjoining surfaces.
2. Allow primer to dry prior to application of sealants.

F. **Isolation Joint**

1. Apply masking tape before installation of primer in continuous strips in alignment with the joint edge to produce sharp, clean interface with adjoining materials. Remove tape immediately after joints have been sealed and tooled as directed.
2. Install no sealants without backer rods or bond breaker tape, unless shown otherwise.
3. Roll the back-up rod stock into the joint to avoid lengthwise stretching. Do not twist, braid, puncture, or prime backer rods.

G. **Placement**

1. Caulking shall be by gun method. Select gun nozzle to suit conditions and provide a full bead of caulking throughout the joint.
2. Use installation techniques that will ensure caulking to be deposited in a uniform, continuous ribbon without skip marks, pin holes, air pockets, and uniform bond on opposite sides, produced by a complete "wetting" of the joint bond surfaces equally on the opposite sides.
3. Follow with hand tool in finished areas for a uniform neat appearance.

3.2 CLEANING AND PROTECTION

A. **Cleaning**. Clean adjacent surfaces of sealant or soiling resulting from the work.

1. Use solvent or cleaning agent recommended by the caulking manufacturer.
2. Leave all finish work in a neat clean condition.

B. **Curing Time**. Allow the minimum curing time as recommended by the manufacturer, but in no case shall the curing time be less than 72 hours.

C. **Protection**. Protect the caulking during the construction period so that it will be without deterioration, soiling, discoloration, or damage at the time of final acceptance.

END OF SECTION

SECTION 09 29 00

GYPSUM DRYWALL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General.** Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 1, and all related specification sections, apply to this section.

1.2 DESCRIPTION OF WORK

A. **Scope of Work.** The Contractor shall provide the labor, tools, equipment, and materials necessary to furnish and install metal support systems and gypsum drywall finish systems in accordance with the drawings and as specified herein.

1.3 QUALITY ASSURANCE

A. **Codes and Regulatory Agencies**. Perform all work in compliance with all federal, state, and local codes and regulatory agencies.

B. **Standards.** All material, testing, and workmanship shall be in conformance with the following standards as referenced herein:

1. ASTM - American Society for Testing and Materials.

1.4 SUBMITTALS

A. **Product Data.** Furnish manufacturer's published product data for each product specified.

B. **Samples.** Submit the following:

1. Drywall - 4" x 4" x full thickness, one of each type specified.
2. Framing – 12-inch-long section of each size and of each gauge specified.
3. Trim – 6-inch-long section of each shape called for and/or required.
4. Fasteners - One of each type and size.

1.5 PROJECT CONDITIONS

A. **Environmental Conditions.** Establish and maintain environmental conditions for application and finishing gypsum board to comply with ASTM C 840 and with gypsum board manufacturer's recommendations.

B. **Minimum Room Temperatures.** For gypsum board to framing, maintain not less than 50 degrees Fahrenheit (° F.) (10 degrees Celsius [° C.]) for 48 hours prior to application and continuously thereafter until drying is complete.

C. **Ventilation.** Ventilate building spaces to remove water not required for drying joint treatment materials. Avoid drafts during dry, hot weather to prevent materials from drying too rapidly.

1.6 **DELIVERY, STORAGE, AND HANDLING**

A. **Delivery.** Deliver materials in original packages, containers, or bundles bearing brand name and identification of manufacturer or supplier.

B. **Storage.** Store materials inside under cover and keep them dry and protected against damage from weather, direct sunlight, surface contamination, corrosion, construction traffic, and other causes. Neatly stack gypsum boards flat to prevent sagging.

C. **Handling.** Handle gypsum boards to prevent damage to edges, ends, and surfaces. Do not bend or otherwise damage metal corner beads and trim.

1.7 **SPECIAL WARRANTY**

Not used.

PART 2 - PRODUCTS

2.1 **STEEL FRAMING COMPONENTS FOR SUSPENDED AND FURRED CEILINGS**

A. **General.** Provide components which comply with ASTM C 754 for materials and sizes, unless otherwise indicated on the drawings.

B. **Concrete Inserts.** Inserts designed for attachment to concrete forms and for embedment in concrete, fabricated from corrosion resistant materials, with holes or loops for attachment of hanger wires and capability to sustain, without failure, a load equal to three times that imposed by ceiling construction, as determined from testing per ASTM E 488.

C. **Wire for Hangers and Ties.** ASTM A 641, Class 1 zinc coating, soft temper.

D. **Hanger Rods.** Mild steel, zinc coated, or protected with rust inhibitive paint.

E. **Channels.** Cold rolled steel, 0.0598 inch minimum thickness of base (uncoated) metal and 7/16 inch wide flanges, protected with galvanizing complying with ASTM A 525 for G60 coating designation, and as follows:

1. Carrying Channels. 1-1/2 inches deep, 508 pounds per 1,000 feet, unless otherwise indicated on the drawings.
2. Furring Channels. 3/4 inch deep, 316 pounds per 1,000 feet, unless otherwise indicated on the drawings.

F. **Steel Resilient Furring Channels.** Manufacturer's standard product designed to reduce sound transmission, complying with ASTM C 645 for material, finish, and widths of face and fastening flange, fabricated to form 1/2 inch deep channel of the following configuration:

1. Single-Leg Configuration. Asymmetric shaped channel with face connected to a single flange by a single slotted leg (web).
2. Double-Leg Configuration. Hat shaped channel, with 1-1/2-inch-wide face connected to flanges by double slotted or expanded metal legs (webs).

2.2 STEEL FRAMING FOR WALLS AND PARTITIONS

A. **Steel Studs and Runners.** ASTM C 645, with flange edges of studs bent back 90 degrees and doubled over to form 3/16-inch-minimum lip (return) and complying with the following requirements for minimum thickness of base (uncoated) metal and for depth:

1. Thickness. 0.0329 inch unless otherwise indicated on the drawings.
2. Depth. 3-5/8 inches, unless otherwise indicated on the drawings.
3. Galvanized.

B. **Steel Rigid Furring Channels.** ASTM C 645, hat shaped, depth and minimum thickness of base (uncoated) metal as follows:

1. Depth. 7/8 inch.
2. Thickness. 0.0329 inch, unless otherwise indicated on the drawings.
3. Galvanized.

C. **Furring Brackets.** Serrated arm type, adjustable, fabricated from corrosion resistant steel sheet complying with ASTM C 645, minimum thickness of base (uncoated) metal of 0.0329 inch, designed for screw attachment to steel studs and steel rigid furring channels used for furring.

D. **Steel Resilient Furring Channels.** Manufacturer's standard product designed to reduce sound transmission, complying with ASTM C 645 for base metal, finish and widths of face and fastening flange, fabricated to form 1/2-inch-deep channel of the following configuration:

1. Single Leg Configuration. Asymmetric shaped channel with face connected to a single flange by a single slotted leg (web).
2. Double Leg Configuration. Hat shaped channel, with 1-1/2-inch-wide face connected to flanges by double slotted or expanded metal legs (webs).

E. **Z Furring Members.** Manufacturer's standard Z-shaped furring members with slotted or nonslotted web, fabricated from hot dip galvanized steel sheet complying with ASTM A 525, Coating Designation G60; with a minimum base metal (uncoated) thickness of 0.0179 inch, face flange of 1-1/4 inches, wall attachment flange of 7/8 inch, and of depth required to fit insulation thickness indicated.

F. **Fasteners.** Fasteners shall be of type, size, corrosion resistance material, holding power, and other properties required to fasten steel framing and furring members securely to substrates involved, complying with the recommendations of gypsum drywall manufacturers for applications indicated.

2.3 GYPSUM BOARD

A. **General.** Provide gypsum board of types indicated in maximum lengths available to minimize end-to-end joints.

1. Thickness. Provide gypsum board in thicknesses indicated, or if not otherwise indicated, in 5/8-inch thicknesses to comply with ASTM C 840 for application system and support spacing indicated.

B. **Gypsum Wallboard**

1. Type. Moisture resistant.
2. Type. Foil backed unless otherwise indicated.
3. Edges. Tapered and featured (rounded or beveled) for prefilling.

2.4 GLASS MESH MORTAR UNITS

A. **General.** Proprietary backing units with glass fiber mesh reinforcing and water resistant coating on both faces, complying with the following requirements:

1. Coated Gypsum Panels. Gypsum core with glass fiber mesh surface mats and manufacturer's proprietary water and vapor retarding coating on both faces, fabricated in panels 1/2 inch thick by 48 inches wide by 96 inches long, and weighing 2.0 pounds per square foot (sf).
2. Cement Coated Portland Cement Panels. High density Portland cement surface coating on both faces and lightweight concrete core composed of Portland cement and expanded ceramic aggregate; fabricated in panels 7/16 inch thick by 36 inches wide by 36, 48, 60, 64, or 72 inches long; and weighing 3.2 to 3.8 pounds per sf.
3. Vinyl Coated Portland Cement Panels. Core formed in a continuous process from aggregated Portland cement slurry and reinforced with vinyl coated woven glass fiber mesh embedded in both surfaces, with one face smooth and other textured; fabricated in panels 1/2 inch thick and by 36 inches wide by 48, 60, and 72 inches long; and weighing 3 pounds per sf.

B. **Available Products.** Subject to compliance with requirements, glass mesh mortar units which may be incorporated in the work include, but are not limited to, the following:

1. Dens Shield; Georgia Pacific Corp.
2. Wonder Board; Modulars, Inc.
3. Durock Tile Backer Board; Durabond Div., USG Industries, Inc.

2.5 TRIM ACCESSORIES

A. **Corner Bead and Edge Trim for Interior Installation.** Corner beads, edge trim, and control joints shall comply with ASTM C 1047 and requirements indicated below:

1. Material. Formed metal complying with the following requirement:

   a. Sheet steel coated with zinc by hot dip or electrolytic processes, or with aluminum.

2. Edge trim shapes indicated below by reference to designations of Figure 1 in ASTM C 1047:

   a. "LC" bead, unless otherwise indicated.
   b. "LK" bead with square nose for use with kerfed jambs.
   c. "U" bead where indicated.

3. One Piece Control Joint. Formed with V-shaped slot per Figure 1 in ASTM C 1047, with slot opening covered with removable strip.

2.6 GYPSUM BOARD JOINT TREATMENT MATERIALS

A. **General.** Provide materials complying with ASTM C 475, ASTM C 840, and recommendations of manufacturer of both gypsum board and joint treatment materials for the application indicated.

B. **Joint Tape.** Paper reinforcing tape, unless otherwise indicated on the drawings.

1. Use pressure-sensitive or staple-attached open-weave glass-fiber reinforcing tape with compatible joint compound where recommended by manufacturer of gypsum board and joint treatment materials for application indicated.

C. **Setting-Type Joint Compounds.** Factory prepackaged, job mixed, chemical hardening powder products formulated for uses indicated.

1. Where setting type joint compounds are indicated for use as taping and topping compounds, use formulation for each which develops greatest bond strength and crack resistance and is compatible with other joint compounds applied over it.
2. For prefilling gypsum board joints, use formulation recommended by gypsum board manufacturer for this purpose.

D. **Drying Type Joint Compounds.** Factory prepackaged vinyl based products complying with the following requirements for formulation and intended use.

1. Ready Mix Formulation. Factory-premixed product.
2. Topping compound formulated for finish (third) coats.
3. All-purpose compound formulated for use as topping compound.

2.7 MISCELLANEOUS MATERIALS

A. **General.** Provide auxiliary materials for gypsum drywall construction which comply with referenced standards and the recommendations of the manufacturer of the gypsum board.

B. **Fastening Adhesive for Metal.** Special adhesive recommended for laminating gypsum boards to steel framing.

C. **Gypsum Board Screws.** ASTM C 1002.

D. **Asphalt Felt.** ASTM D 226, Type I (No. 15).

E. **Concealed Acoustical Sealant.** ASTM C 919, nondrying, nonhardening, nonskinning, nonstaining, nonbleeding, gunnable sealant.

F. **Sound-Attenuation Blankets.** Unfaced mineral-fiber blanket insulation produced by combining mineral fibers manufactured from glass or slag with thermosetting resins to comply with ASTM C 665 for Type I (blankets without membrane facing).

G. **Glass Mesh Mortar Unit Finishing Materials.** Tape and joint compounds as recommended by glass mesh mortar unit manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. **General.** Examine substrates to which drywall construction attaches or abuts, preset hollow metal frames, cast-in anchors, and structural framing, with installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of drywall construction. Do not proceed with the installation until unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. **Ceiling Anchorages.** Coordinate installation of ceiling suspension system with installation of overhead structural systems to ensure that inserts and other structural anchorage provisions have been installed to receive ceiling anchors in a manner that will develop their full strength and at spacing required to support ceiling.

1. Furnish concrete inserts and other devices indicated, to other trades for installation well in advance of time needed for coordination with other construction.

3.3 INSTALLATION OF STEEL FRAMING, GENERAL

A. **Steel Framing Installation Standard.** Install steel framing to comply with ASTM C 754 and with ASTM C 840 requirements that apply to framing installation.

1. Install supplementary framing, blocking, and bracing at terminations in the work and for support of fixtures, equipment services, heavy trim, grab bars, toilet accessories, furnishings, and similar construction to comply with details indicated and with recommendations of gypsum board manufacturer, or if none available, with "Gypsum Construction Handbook" published by United States Gypsum Company.

3.4 INSTALLATION OF STEEL FRAMING FOR SUSPENDED AND FURRED CEILINGS

A. **Installation.** Secure hangers to structural support by connecting directly to structure where possible; otherwise connect to cast-in concrete inserts or other anchorage devices or fasteners as indicated.

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

2. Keep hangers and braces 2 inches clear of ducts, pipes, and conduits.

3. Sway brace suspended steel framing with hangers used for support.

4. Install suspended steel framing components in sizes and at spacings indicated but not less than that required by referenced steel framing installation standard.

   a. Wire Hangers. 0.1620-inch diameter (8 gauge), 4 feet on center.
   b. Carrying Channels (Main Runners). 1-1/2 inches, 4 feet on center.
   c. Rigid Furring Channels (Furring Members). 16 inches on center.

5. Installation Tolerances. Install steel framing components for suspended ceilings so that cross furring members or grid suspension members are level to within 1/8 inch in 12 feet as measured both lengthwise on each member and transversely between parallel members.

6. Wire tie or clip furring members to main runners and to other structural supports as indicated.

3.5 INSTALLATION OF STEEL FRAMING FOR WALLS AND PARTITIONS

A. **Installation**

1. Install runners (tracks) at floors, ceilings, and structural walls and columns where gypsum drywall stud system abuts other construction.

   a. Where studs are installed directly against exterior walls, install asphalt felt strips between studs and wall.

2. Installation Tolerances. Install each steel framing and furring member so that fastening surfaces do not vary more than 1/8 inch from plane of faces of adjacent framing.

3. Extend partition framing full height to structural supports or substrates above suspended ceilings. Continue framing over frames for doors and openings and frame around ducts penetrating partitions above ceiling to provide support for gypsum board.

4. Install steel studs and furring in sizes and at spacings indicated but not less than that required by referenced steel framing installation standard.

   a. For single- and double-layer construction. 16 inches on center.

5. Frame door openings to comply with details indicated, with GA-219, and with applicable published recommendations of gypsum board manufacturer. Attach vertical studs at jambs with screws either directly to frames or to jamb anchor clips on door frames; install runner track section (for cripple studs) at head and secure to jamb studs.

6. Frame openings other than door openings to comply with details indicated, or if none indicated, in same manner as required for door openings; and install framing below sills of openings to match framing required above door heads.

7. Install thermal insulation as follows:

   a. Erect insulation vertically and hold in place with Z furring members spaced 24 inches on center.
   b. Except at exterior corners, securely attach narrow flanges of furring members to wall with concrete stub nails, screws designed for masonry attachment, or powder driven fasteners spaced 24 inches on center.
   c. At exterior corners, attach wide flange of furring members to wall with short flange extending beyond corner; on adjacent wall surface, screw attach short flange of furring channel to web of attached channel. Start from this furring channel with standard width insulation panel and continue in regular manner. At interior corners, space second member no more than 12 inches from corner and cut insulation to fit.
   d. Until gypsum board is installed, hold insulation in place with 10 inch staples fabricated from 0.0625-inch- (16-gauge-) diameter tie wire and inserted through slot in web of member.

3.6 APPLICATION AND FINISHING OF GYPSUM BOARD, GENERAL

A. **Gypsum Board Application and Finishing Standard.** Install and finish gypsum board to comply with ASTM C 840.

1. Install sound attenuation blankets where indicated, prior to gypsum board unless readily installed after board has been installed.

2. Locate exposed end butt joints as far from center of walls and ceilings as possible, and stagger not less than 24 inches in alternate courses of board.

3. Install ceiling boards across framing with no joints, except at walls.

4. Install wall/partition boards with no end butt joints.

5. Install exposed gypsum board with face side out. Do not install imperfect, damaged, or damp boards. Butt boards together for a light contact at edges and ends with not more than 1/16 inch open space between boards. Do not force into place.

6. Locate either edge or end joints over supports, except in horizontal applications where intermediate supports or gypsum board back blocking is provided behind end joints. Position boards so that like edges abut, tapered edges against tapered edges, and mill cut or field cut ends against mill cut or field cut ends. Do not place tapered edges against cut edges or ends. Stagger vertical joints over different studs on opposite sides of partitions.

7. Attach gypsum board to steel studs so that leading edge or end of each board is attached to open (unsupported) edge of stud flange first.

8. Attach gypsum board to supplementary framing and blocking provided for additional support at openings and cutouts.

9. Spot grout door frames for solid core wood doors and doors over 32 inches wide. Apply spot grout at each jamb anchor clip just before inserting board into frame.

10. Form control joints and expansion joints at locations indicated, with space between edges of boards prepared to receive trim accessories.

11. Cover both faces of steel stud partition framing with gypsum board.

    a. Fit gypsum board around ducts, pipes, and conduits.
    b. Where partitions intersect open concrete coffers, cut gypsum board to fit profile of coffers and allow 1/4- to 1/2-inch-wide joint for sealant.

11. Isolate perimeter of nonload bearing drywall partitions at structural abutments. Provide 1/4-inch to 1/2-inch space and trim edge with "U" bead edge trim. Seal joints with acoustical sealant.

12. Space fasteners in gypsum boards in accordance with referenced gypsum board application and finishing standard and manufacturer's recommendations.

3.7 METHODS OF GYPSUM BOARD APPLICATION

A. **Single-Layer Application.** Install gypsum wallboard as follows:

1. On ceilings apply gypsum board prior to wall/partition board application to the greatest extent possible.

2. On partitions/walls apply gypsum board vertically (parallel to framing), unless otherwise indicated, and provide sheet lengths which will minimize end joints.
3. On partitions/walls 8'-1" or less in height apply gypsum board horizontally (perpendicular to framing); use maximum length sheets possible to minimize end joints.
4. On Z furring members apply gypsum board vertically (parallel to framing) with no end joints. Locate edge joints over furring members.

B. **Wall Tile Base.** In areas where drywall is base for ceramic tile or other rigid wall finishes, utilize the following:

1. "Wet" areas glass mesh mortar units with joints treated to comply with manufacturer's recommendations.

C. **Fastening Methods.** Apply gypsum boards to steel framing with adhesive and supplementary screws.

D. **Direct Bonding to Substrate.** Where gypsum board is indicated to be directly adhered to a substrate (other than studs, joists, furring members, or base layer of gypsum board), comply with gypsum board manufacturer's recommendations, and temporarily brace or fasten gypsum board until fastening adhesive has set.

3.8 INSTALLATION OF DRYWALL TRIM ACCESSORIES

A. **General.** Where feasible, use the same fasteners to anchor trim accessory flanges as required to fasten gypsum board to the supports. Otherwise, fastening flanges shall comply with manufacturer's recommendations.

B. **Corner Beads**. Install corner beads at external corners.

C. **Edge Trim**. Install metal edge trim whenever edge of gypsum board would otherwise be exposed or semiexposed, and except where plastic trim is indicated. Provide type with face flange to receive joint compound except where "U" bead (semifinishing type) is indicated.

1. Install "LC" bead where drywall construction is tightly abutted to other construction and back flange can be attached to framing or supporting substrate.
2. Install "LK" bead where substrate is kerfed to receive long flange of trim.
3. Install U type trim where edge is exposed, revealed, gasketed, or sealant filled (including expansion joints).

D. **Control Joints.** Install control joints at locations indicated, or if not indicated, at spacings and locations required by referenced gypsum board application and finish standard, and approved by the Engineer/Architect for visual effect.

3.9 FINISHING OF DRYWALL

A. **General.** Apply joint treatment at gypsum board joints (both directions); flanges of corner bead, edge trim, and control joints; penetrations; fastener heads, surface defects, and elsewhere as required to prepare work for decoration.

1. Prefill open joints and rounded or beveled edges, if any, using setting type joint compound.

2. Apply joint tape at joints between gypsum boards, except where trim accessories are indicated.

3. Finish interior gypsum wallboard by applying the following joint compounds in three coats (not including prefill of openings in base), and sand between coats and after last coat:

   a. Embedding and First Coat. Setting type joint compound.
   b. Fill (Second) Coat. Setting type joint compound.
   c. Finish (Third) Coat. Ready mix drying type all purpose or topping compound.

4. Glass Mesh Mortar Unit Base for Ceramic Tile. Comply with ASTM C 840 and manufacturer's recommendations for treatment of joints behind tile.

3.10 PROTECTION

A. **Protection.** Provide final protection and maintain conditions, in a manner suitable to installer, which ensures gypsum drywall construction being without damage or deterioration at time of substantial completion.

END OF SECTION

SECTION 09 90 00

PAINTING

PART 1 - GENERAL

1.1 RELATED DOCUMENT

A. **General**. Drawings and general provisions of Contract, including General and Supplementary Conditions, Division 1, and all related specification sections, apply to this section.

1.2 DESCRIPTION OF WORK

A. **Scope of Work**. This section includes surface preparation, painting, and finishing of exposed interior and exterior surfaces. Surface preparation, priming, and finish coats specified in this section are in addition to shop priming and surface treatment specified under other sections.

B. **Definitions**. "Paint" includes coating systems materials, primers, emulsions, enamels, stains, sealers and fillers, and other applied materials whether used as prime, intermediate, or finish coats.

1.3 QUALITY ASSURANCE

A. **Standards**. Ensure that material and workmanship are in accordance with the following standards as referenced herein:

1. SSPC – The Society for Protective Coatings.
2. Corps of Engineers.
3. NSF – NSF International.
4. ICRI – International Concrete Repair Institute.
5. ASTM – American Society for Testing and Materials.
6. NACE – National Association of Corrosion Engineering.
7. NAPF – National Association of Pipe Fabricators, Inc.

B. **Single Source Responsibility**. Provide primers, coats, and finish coats from the same manufacturer.

C. **Compatibility of Work**

1. Review other sections in which primers are provided to ensure compatibility of the total systems for various substrates.
2. On request, furnish information on characteristics of finish materials to ensure use of compatible primers.
3. Notify the Engineer/Architect of problems anticipated using the materials specified.

1.4 SUBMITTALS

A. General

1. Submit all submittals in accordance with the Division 1 Submittal Requirements and this specification section.

B. Submittal Package No. 1 – Product Data

1. Product Data.

   a. Submit manufacturer's technical information, label analysis, and application instructions for each material proposed for use.
   b. List each material and cross-reference the specific coating, finish system, and application.
   c. Identify each material by the manufacturer's catalog number and general classification.

C. Submittal Package No. 2 – Color Charts

1. Samples. Submit manufacturer's color charts for Owner's use.

1.5 JOB CONDITIONS

A. Environmental Conditions

1. Climatic.

   a. Apply water-based paints only when the temperature of surfaces to be painted and surrounding air temperatures are between 40 degrees Fahrenheit (° F.) and 90° F.

   b. Apply solvent thinned paints only when the temperature of surfaces to be painted and surrounding air temperatures are between 45° F. and 95° F.

   c. Do not apply paint:

      1) In precipitation or fog of any kind.
      2) When the relative humidity exceeds 85 percent.
      3) At surface temperatures less than 5° F. above the dew point.
      4) To damp or wet surfaces.

   d. When approved, continue painting during inclement weather if surfaces and areas to be painted are enclosed and heated within temperature limits specified by the manufacturer during application and drying periods.

2. Ventilation.

a. Be responsible for maintaining adequate ventilation, temperature, and humidity control in all areas where paint is being applied, drying, or curing.

1) "Adequate" ventilation, temperature, and humidity levels are considered to be those required by regulatory agencies and guidelines, the paint manufacturer's product application data, the requirements of this section, and the Owner's Representative.

B. **Warning Signs**

1. Provide and display prominent warning signs indicating "WARNING - PAINTING AND ABRASIVE BLASTING WORK UNDERWAY" throughout the job site wherever surface preparation or painting operations are being performed.

a. These signs shall be no less than 3' x 3' in size, and placed at clearly visible locations near all points of access by person or vehicle to the work area(s).

1.6 DELIVERY, STORAGE, AND HANDLING

A. **Delivery**. Deliver materials to the job site in the manufacturer's original, unopened containers bearing a label from the manufacturer that includes the following:

1. Product name or title of material.
2. Product description (generic classification or binder type).
3. Federal Specification number, if applicable.
4. Manufacturer's stock number and date of manufacture.
5. Contents by volume, for pigment and vehicle constituents.
6. Thinning and application instructions.
7. Color name and number.
8. Manufacturer's name.

B. **Storage**

1. Store materials not in use in tightly covered containers in a well ventilated area at a minimum ambient temperature of 45° F.
2. Keep storage area in a clean condition, free of foreign materials and residue.
3. Store clean rags in a metal container with a tight-fitting cover.
4. Remove oily rags and waste daily.

C. **Handling**. Take necessary measures to ensure that workers and work areas are protected from fire and health hazards resulting from handling, mixing, and application.

1.7 **SPECIAL WARRANTY**

Not used.

PART 2 - PRODUCTS

2.1 **MANUFACTURERS.** Use products of the manufacturers listed in the painting schedule. No "Or Equals" will be considered for this project. Submit any potential substitutes according to Section 00 70 00, "General Conditions."

2.2 **PIPE BANDING TAPE, LABELING, AND DIRECTIONAL ARROWS**

A. **Minimum 2 inches wide**, self-sticking.

B. **Meets ASTM** B 946.

C. **5-mil minimum** thickness.

D. **Label text heights** shall be sized as follows:

Under 3/4"	Arrows only
3/4" to 1-1/4"	1/2"
1-1/2" to 2"	3/4"
2-1/2" to 6"	1-1/4"
8" to 10"	2-1/2"
10" and over	3-1/2"

E. **Approved Manufacturers**

1. W. H. Brady Company.
2. Seton Identification Products.
3. Or equal.

2.3 **THINNERS.** Use only the recommended products of the manufacturer furnishing the paint.

2.4 **COLORS.** All colors not specified will be selected by the Owner. Where multiple coats are specified, shade-tint each coat of paint for visual inspection of the number of coats applied.

2.5 **POTABLE WATER CONTACT.** Coatings in contact with potable water shall meet NSF Standard 61 and shall be listed by NSF.

PART 3 - EXECUTION

3.1 **EXAMINATION**

A. **Compliance**

1. Examine substrates and conditions for compliance with paint application requirements.
2. Correct unsatisfactory conditions before painting.

3. Start of painting will be construed as the Applicator's acceptance of surfaces and conditions within a particular area.
4. If any surface to be finished cannot be put in proper condition, notify the Engineer/Architect immediately in writing or assume full responsibility for failure to do so and correct any unsatisfactory work.

3.2 PREPARATION

A. General Procedures

1. Remove hardware and hardware accessories, plates, machined surfaces, lighting fixtures, and similar items in place that are not to be painted, or protect them before surface preparation and painting.
2. Remove these items if necessary for complete painting of the items and adjacent surfaces.
3. Following completion of painting operations in each space or area, reinstall items by workers skilled in the trades involved.
4. All surfaces must be clean, dry, and free of oil, grease, chalk, and other containments.
5. Schedule cleaning and painting so that dust and other contaminants from the cleaning process will not fall on wet paint.

B. **Surface Preparation**. Clean and prepare surfaces to be painted in accordance with the manufacturer's instructions for each particular substrate condition and as specified.

1. Provide barrier coats over incompatible primers or remove and reprime.

2. Cementitious Materials. Prepare concrete, concrete masonry block, cement plaster, and mineral fiber reinforced cement panel surfaces to be painted.

   a. Remove efflorescence, chalk, dust, dirt, grease, oils, and release agents.

   b. Roughen as required to remove glaze.

   c. If hardeners or sealers have been used to improve curing, use mechanical methods of surface preparation.

   d. Use abrasive blast cleaning methods according to SSPC-SP13/NACE 6, ICRI CSP 2-3 to prepare concrete unless an alternate method is approved.

   e. Prepare all concrete surfaces designated chemical resistant per ICRI CSP 3-5 minimum with all bugholes opened and filled with an epoxy surfacer (Paint Code F in the Schedule).

   f. Determine alkalinity and moisture content of surfaces by performing appropriate tests.

1) If surfaces are sufficiently alkaline to cause blistering and burning of finish paint, correct this condition before application.
2) Do not paint surfaces where moisture content exceeds the manufacturer's recommendations.

3. Wood.

a. Clean surfaces of dirt, oil, and other foreign substances with scrapers, mineral spirits, and sandpaper, as required.
b. Sand surfaces smooth which are exposed to view and remove dust when finished.
c. Scrape and clean small, dry, seasoned knots and apply a thin coat of white shellac or other recommended knot sealer before application of primer.
d. After priming, fill holes and imperfections in finish surfaces with putty or plastic wood filler. Sand smooth when dried.

4. Ferrous Metals. Clean nongalvanized ferrous metal surfaces; remove oil, grease, dirt, loose mill scale, and other foreign substances. Use solvent or mechanical cleaning methods that comply with SSPC-SP1/SP2/SP3.

a. Blast steel surfaces that will be submerged in accordance with requirements of SSPC Specification SSPC-SP 10, near white blast cleaning. Maintain a minimum 2-mil profile.
b. Abrasive-blast-clean nonsubmerged steel per SSPC-SP 6, Commercial Blast Cleaning creating a minimum 1.5-mil profile.
c. Brush off blast cleaned (SSPC-SP 7, Brush-Off Blast Cleaning) epoxy shop-primed surfaces that will be submerged and have not been painted for 60 days or longer before application of the intermediate and finish coats.
d. Blast ductile iron surfaces in accordance with requirements of NAPF 500 Abrasive Blast Cleaning.
e. Touch up bare areas and prime coats that have been damaged. Surface preparation shall be the same as the original surface preparation. Touch up with the same primer as the shop coat.
f. Prime all surfaces blast-cleaned on the same day or before rusting or soiling occurs.

5. Plastic. Clean surface and sand uniformly to resemble 80-100 grit sandpaper.

6. Existing Epoxy Finishes. Thoroughly and uniformly sand or otherwise abrade prior to recoating.

C. **Materials Preparation**. Carefully mix and prepare paint materials in accordance with manufacturer's directions.

1. Maintain containers used in mixing and application of paint in a clean condition, free of foreign materials and residue.

2. Stir material before application to produce a mixture of uniform density; stir as required during application.
3. Do not stir surface film into material. Remove film and, if necessary, strain material before using.
4. Use only thinners approved by the paint manufacturer, and only within recommended limits.

3.3 APPLICATION

A. Requirements

1. Apply paint in accordance with manufacturer's directions. Use applicators and techniques best suited for substrate and type of material being applied.

2. Do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions detrimental to formation of a durable paint film.

   a. Paint colors, surface treatments, and finishes are indicated in Part 4 of this section.
   b. Provide finish coats that are compatible with primers used.
   c. Apply additional coats when undercoats, stains, or other conditions show through final coat of paint until paint film is of uniform finish, color, and appearance. Give special attention to ensure that surfaces, including edges, corners, crevices, welds, and exposed fasteners, receive a dry film thickness equivalent to that of flat surfaces.
   d. Grind all 90-degree angles of carbon steel and apply a stripe coat of the specified primer.

B. Special Techniques/Requirements

1. Do not permit spraying unless approved in writing.
2. Ensure that the application, drying time between coats, and mixing are in accordance with the recommendations of the manufacturer.
3. Protect all areas from damage by equipment, materials, spatterings, drippings, and overspray. Take particular care to prevent staining of concrete. Immediately remove all spattering, dripping, and overspray. Paint or repaint any area discolored or stained as directed.
4. Prior to installation, finish-paint all surfaces inaccessible after installation.

3.4 MARKING

A. **Color Coding**. Paint and mark according to function all exposed piping as specified in Part 4 of this section.

B. **Banding**. Band all exposed piping as specified in Part 4 of this section. Space banding as directed, but not greater than 10 feet apart with a minimum of one group of bands between fittings.

C. **Flow Arrows**. Provide arrows indicating flow direction on all exposed piping.

D. **Labeling**. Label all exposed piping with the function of the pipe. Apply labeling on any single run of pipe before any tees or elbows, but not greater than 20 feet on center.

3.5 FIELD QUALITY CONTROL

A. **The Owner reserves the right** to invoke the following test procedure at any time and as often as desired during the period when paint is being applied.

1. The Owner will engage the services of an independent testing agency to sample the paint material being used. Samples of material delivered to the project will be taken, identified, sealed, and certified in the presence of the Contractor.

2. If test results show material being used does not comply with the published manufacturer's specifications for that paint system:

   a. Stop painting.
   b. Remove noncomplying paint.
   c. Pay for testing.
   d. Repaint surfaces coated with rejected paint.
   e. Remove rejected paint from previously painted surfaces if, upon repainting with specified paint, the two coatings are incompatible.

B. **The Owner reserves the right** to check the minimum dry mil thickness per coat (MDMTPC) at any time following application. Repaint areas not meeting minimum requirements.

C. **Provide a 10' x 10' mock-up** of each specified system, including surface preparation and finish color. The mock-up may remain as part of the completed project. Proceed with the rest of the paint application when authorized to proceed in writing.

3.6 PROTECTION

A. **Cover**. Protect work of other trades, whether to be painted or not, against damage by painting. Correct damage in an acceptable manner by cleaning, repairing or replacing, and repainting.

B. **Signs**

1. Provide "wet paint" signs to protect newly painted finishes.
2. Remove temporary protective wrappings provided by others for protection of their work after completion of painting operations.
3. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.
4. Remove all "Wet Paint" signs and other warning signs utilized during installation and curing.

3.7 DEMONSTRATION

A. **Visual.** The Contractor, Owner, and Engineer/Architect will visually review the painting for completion, colors, finish, and uniformity before acceptance by Owner.

PART 4 - SCHEDULE

4.1 GENERAL

A. **Dry Film Thickness Per Coat.** DFT is the acronym for this term in the following schedules. Do not exceed the manufacturer's recommended maximum dry film thickness per coat.

B. **New Work.** Paint all new surfaces according to paragraph 4.2.

C. **Existing Areas**

1. Compatibility Test. Before painting, patch test all areas for compatibility of new paint with existing and notify the Engineer/Architect of any incompatibility.

2. Adhesion Test. Before painting, perform the tests per ASTM D 3359, Methods A and/or B, followed by a report detailing the system tested, their results, and any recommended changes to the specified system.

3. Disturbed Areas.

   a. Paint all surfaces of existing areas disturbed due to tie-ins, closing of openings, cutting new openings, rerouting of pipe, relocating or removal of equipment, and other related work as specified herein.
   b. Color match existing surface and paint to lap existing by not less than 3 inches.

D. **Coding and Banding.** When exposed, color code and band the following piping, fittings, and valves with the specified colors:

Material	Tnemec	PPG	Carboline	International	ICI/Devoe
Water					
Raw	Spring Water	Fiberoptics	Blue Ice	Light Blue	Seafoam Breeze
Settled	Aqua Sky	Water Garden	Skyward	Mint Green	Cascading Water
Filtered	Delft Blue	Cavern Ice	Open Sky	Sky Blue	Car Blue
Softened	Clear Sky	Cooling Tower	Atomic Blue	Mid-Ocean Blue	Light Blue
Finished or Potable	Safety Blue	Safety Blue	Safety Blue	Safety Blue	Safety Blue
Backwash Supply	Purple Haze	Cyprus Blue	National Blue	Blue	National Blue
Nonpotable	Safety Purple	Safety Purple	Safety Purple	Safety Purple	Safety Purple
Wastewater					
Raw	Deep Space	Dark Gray	Machine Gray	Aluminum Gray	Machine Gray
Primary	Gray	Light Gray	Gull Gray	Light Gray	Haze Gray
Secondary	Light Gray	ASA No. 70	Light Gray	Gray	Light Gray
Filtered	Slate Gray	Mountain Mist	Sterling Gray	Platinum Gray	Mist Gray
Effluent	White	Porcelain White	Safety White	Blued White	White on White
Backwash Waste/ Supernatant	Aluminum	Conveyor Gray	Granite Gray	Steel Gray	Swordplay
Filter to Waste/Drain	Black	Black Gold	Black	Black	Black
Sludge					
Primary	Clay	Weathered Marble	Basket Weave	Dark Ivory Beige	Water Chestnut
WAS	Muley	Desert Brown	Blush	Medium Brown	Clay Pot
RAS	Amber Canyon	Beechnut	Alpaca	Cream Tan Brown	Tuscan Tan
Digested	Tiki Wood	Tantone	Dunes Tan	Medium Brown	Sand Motif
Thickened	Weathered Bark	Telegraph	Falcon Brown	Bark	Warm Brown
Flammable/Explosive					
Natural and Propane Gas	Safety Red	Safety Red	Safety Red	Safety Red	Safety Red
Liquid Fuel Oil/Diesel	Chilean Red	Caution Red	Tile Red	Red	Oxide Red
Methane/Digester Gas	Safety Orange	Safety Orange	Safety Orange	Safety Orange	Safety Orange
Odor Control Foul Air	International Orange	Caution Orange	Coppers Smith	International Orange	Kessy's Bark
Air					
Low Pressure (≤ 90 psi)	Hunter Green	Caution Green	Vernal Green	Signal Green	Medium Green
High Pressure (> 90 psi)	Safety Green	Safety Green	Safety Green	Safety Green	Safety Green

Material	All Manufacturers
Storm	Match ceilings and walls.
Electrical Conduit	Match ceilings and walls.
Chemicals	
Chlorine/Sodium Hypochlorite	Safety Yellow with no bands
Oxidants (Ozone, Permanganates, Ammonia)	Safety Yellow with purple bands
Phosphates	Safety Yellow with brown bands
Coagulants (Alum, Ferric Chloride, Polymers)	Safety Yellow with orange bands
Carbon Slurry	Safety Yellow with black bands
Bases (Lime Slurry, Caustic, Soda Ash)	Safety Yellow with green bands
Fluoride	Safety Yellow with blue bands.
Acids (Sulfuric, etc.)	Safety Yellow with red bands
Sodium Bisulfite	Safety Yellow with white bands
Brine	Safety Yellow with gray bands

4.2 PAINT SCHEDULE

Surface Substrate	Surface Location	Immersed or Below Grade	Exterior Only	Interior Only	Exterior / Interior	Required Coats	DFT	Paint Codes
Concrete Block or Masonry • Paint Interior of all new Exposed Concrete Block • Paint all other Masonry Where Noted in the Plans or Specifications	Walls			X		1 Primer/Block Filler 1 Intermediate 1 Finish	12 4 4	A B B
	Walls		X			1 Primer/Block Filler 1 Intermediate 1 Finish	12 6 6	A M M
Precast Concrete and Cast-in-Place Concrete • Paint the interior of all exposed precast concrete ceilings. • Paint all other Concrete Where Noted in the Plans or Specifications.	Walls and Ceilings			X		1 Primer/ Surfacer 1 Finish	12 4	F B
	Walls and Ceilings		X			1 Primer/ Surfacer 1 Intermediate 1 Finish	12 6 6	F M M
	Walls, Ceilings, and Floors, In Contact with Potable Water	X			X	1 Primer/Surfacer 1 Intermediate 1 Finish	- 4 4	F C C
	Walls, Ceilings, and Floors, In Contact with Nonpotable Water or Sewage	X			X	1 Primer/Surfacer 1 Intermediate 1 Finish	- 10 10	F D D
	Walls and Floors, Chemical Resistant				X	1 Primer/ Surfacer 1 Intermediate 1 Finish	12 9 9	F H H
	Floors			X		1 Primer/ Surfacer 1 Intermediate 1 Finish	12 9 9	F E E

For paint codes see paragraph 4.3 at the end of this Section.

Surface Substrate	Surface Location	Immersed or Below Grade	Exterior Only	Interior Only	Exterior / Interior	Required Coats	DFT	Paint Codes
Ferrous Metal Products • Paint all Ferrous Metal Products including Piping, Valves, Fittings, Equipment, and Miscellaneous Metals Installed during Project. • Paint existing Ferrous Metal Products Where Noted in the Plans or Specifications. • Metal Siding, Fascia, and Coping shall be prefinished by the manufacturer. • Paint all exposed galvanized conduit and pipe in painted finished areas. • Paint all damaged and disturbed areas of any galvanized products such as threading or field–welds. • Do not paint stainless steel, aluminum, galvanized steel or similar corrosion resistant materials unless noted otherwise in the drawings or the specifications.	Submerged, In Contact with Potable Water	X			X	1 Shop/Primer 1 Touch Up 1 Intermediate 1 Finish	4 4 4 4	C C C C
	Submerged, In Contact with Nonpotable Water or Sewage	X			X	1 Shop/Primer 1 Finish	10 10	D D
	High Temperature(<450 °F)				X	1 Shop/Primer 1 Intermediate 1 Finish	1.6 1 1	J L L
	Very High Temperature (450 °F to 750 °F)				X	1 Shop/Primer 1 Intermediate 1 Finish	1.6 1 1	K K K
	Galvanized Product Touch-ups				X	1 Primer 1 Finish	2 2	P P
	Exterior		X			1 Shop/Primer 1 Touch Up 1 Intermediate 1 Finish	4 4 4 4	B B B G
	Interior			X		1 Shop/Primer 1 Touch Up 1 Intermediate 1 Finish	4 4 4 4	B B B B

For paint code details, see paragraph 4.3 at the end of this Section.

Surface Substrate	Surface Location	Immersed or Below Grade	Exterior Only	Interior Only	Exterior / Interior	Required Coats	DFT	Paint Codes
Plastic Products • Paint all exposed interior Plastic Pipe, Fittings, and Valves installed in this project or where noted in the plans or specifications.			X			1 Primer 1 Intermediate 1 Finish	4 4 4	B B G
				X		1 Primer 1 Finish	2 3	B B
Wood Products • Paint all exposed Wood installed in this project or where noted in the plans and specifications except for Prefinished, Redwood, or Pressure-Treated Products.					X	1 Primer 1 Intermediate 1 Finish	2 2 2	N O O
Foam Piping Insulation • Paint all Foam Piping Insulation Where Noted in the Plans or Specifications.					X	1 Primer 1 Finish	2 4	N O
Drywall and Plaster • Paint all exposed Drywall and Plaster installed in this project or where noted in the plans or specifications.				X		1 Primer 1 Intermediate 1 Finish	2 4 4	N O O
Pipe Coverings and Pipe Drains	Match walls and ceilings							

For paint code details, see paragraph 4.3 at the end of this Section.

4.3 MANUFACTURERS AND PAINT CODES

Generic Name	Code	Tnemec	PPG	Carboline	ICI/Devoe	International
Cementitious Acrylic or Polyamide Epoxy Block Filler	A	Series 130-6602 Envirofill	Aquapon 97-685 Series	Sanitile 600	Bloxfill 4000 Block Filler	Intercryl 320
Polyamide Epoxy	B	Series N69-H.B. Epoxoline II	Aquapon HB 97-130	Carboguard 893 SG	Devran 224 HS	Intergard 251
Polyamide Epoxy NSF 61 Approved	C	Series N140 Pota-Pox Plus	Aquapon 95-132	Carboguard 561	Bar-Rust 233H	Interseal 670HS
Coal Tar Epoxy/Ultra High Build Epoxy	D	Series 46H-413 Black HB Tneme-Tar	Coal Cat 97-650	Bitumastic 300M	Devtar 5A	Interzone 954
Self-Leveling/ Polyamide Epoxy	E	Series 281 Tneme-Glaze	Megaseal SL 99-6680	Sanitile 945	DevFloor 525 with DevFloor 571	Intergard 345
Filler and Surfacer	F	Series 218 MortarClad	Megaseal CF 99-6672 or -6675	Sanitile 600 TG	DevFloor 574 / Bloxfill 4000	Ceilcote 610 / Corocrete SF
Polyurethane	G	Series 1074 H.B. Endura-Shield II	Pitthane Ultra 95-812	Carbothane 134 HG	Devthane 379	Interthane 870
Novolac Epoxy	H	Series 282 Tneme-Glaze	Megaseal SC/HSN	Semstone 145	Devran 124	Ceilcote 2000 w/ Ceilcote 680
Not Used	I					
High Temperature Primer	J	Series 90E-92 Tneme-Zinc	Silicone-Acrylic Red	Carbozinc 11	HT-8	Interzinc 22
High Temperature Silicone (Resists at least 450 °F)	K	Series 39	Speedhide 6-230	Thermaline 4900 R	HT-8	Intertherm 875
Very High Temperature Silicone (resists at least 1000 °F and requires a bake cure)	L	Series 39	Speedhide 6-220	Thermaline 4700	HT-10 Aluminum	Intertherm 50 Aluminum
Elastomeric Acrylic	M	Series 156/157 Envirocrete	Permacrete 4-110	Flexxide Elastomer	#2200 Decra-Flex Elastomeric	N/A
Acrylic Primer	N	Series 10-10-99W	Seal Grip 17-921	Carbocrylic 120	Devflex 4020	Intercryl 520
Acrylic	O	Series 6 Tneme-Cryl	Pitt Tech 90-474	Carbocrylic 3359	Devflex 4208	Intercryl 530
Cold Galvanizing Compound	P	Minimum 95% Zinc. Approved Manufacturers: Rust-Oleum, ZRC, or Chesterton 752.				

END OF SECTION

SECTION 26 00 01

BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General**. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this section.

B. **Related Sections**. The following sections contain requirements that relate to this section:

1. Section 01 31 19.01, "Project Meetings."
2. Section 01 32 16, "Schedules."
3. Section 01 33 00, "Submittals."
4. Section 01 60 00, "Materials and Equipment."
5. Section 01 79 00, "Startup, Demonstration and Training."
6. Section 26 00 02, "Basic Electrical Materials and Methods."

1.2 DESCRIPTION OF WORK

A. **Scope of Work**. The Contractor shall provide the labor, tools, equipment, and materials necessary to implement the following general administrative and procedural requirements in accordance with the plans and as specified herein.

B. **Extent of Work**. Work under this Contract consists of furnishing, installing, testing, and guaranteeing of complete electrical systems as shown on the drawings and as specified in Division 26. The Contractor shall connect and place all wired equipment in proper working order. Refer to the plans and specifications for work included in this Contract. Some general guidelines to coordinating work between Division 26 and Divisions 23, 40, 43, and 44 are as follows:

1. Division 26 includes all power wiring and raceways for Division 23 equipment. Division 26 is responsible to furnish and install motor starters and disconnect switches for Division 23 equipment. Remote two-wire control logic will be extended to the motor starters as work of Division 23. Where combined line voltage power/control is used for Division 23 equipment, the wiring and raceways are treated as power wiring and are work of Division 26. All Division 26 work for Division 23 equipment is shown on the plans.
2. Division 26 includes all 3-phase power for plant equipment provided under Divisions 40, 43, and 44. The instrumentation and control system as specified in Division 40 wiring and interior raceways is not work of Division 26. Exterior raceways for the instrumentation and control system are part of Division 26 work to the extent shown on the drawings.

Field wiring for plant equipment is work of Division 26. All Division 26 work for Division 40, 43, and 44 equipment is shown on the plans.

3. No generalities regarding the coordination of work with the work of Divisions other than 40, 43, and 44 can be made. See the plans for the extent of these requirements for Division 26 work.

C. **Temporary Utilities.** Temporary utilities and connections include the following:

1. Engage the local utility company for temporary electric service.
2. Temporary telephones for the Engineer/Architect's field office.
3. Temporary lighting to provide adequate illumination of work areas and security.
4. Temporary power and connections to maintain existing equipment in operation and to permit operation of new equipment as construction progresses.
5. The monthly construction power cost shall be borne by the Electrical Contractor.

1.3 QUALITY ASSURANCE

A. **Codes and Standards.** Perform all work in compliance with applicable requirements of governing agencies having jurisdiction and in accordance with these plans and as specified herein.

1. All work shall be installed in full accordance with the latest edition of the National Electrical Code (NEC) as prepared and published by the National Fire Protection Association (NFPA) and any applicable local or state codes. All electrical equipment shall be listed and labeled by Underwriters' Laboratories, Inc. (UL) or any approved independent nationally recognized electrical testing laboratory where such standards exist. Optionally, in lieu of such listing and labeling, equipment preapproved by the Electrical Inspector may be supplied. Wherever UL compliance is mentioned in the specifications, the above alternatives shall be understood to apply to all listing and labeling requirements. This does not preempt or replace the specifications or replace the approval process. All service switches/circuit breakers shall be labeled as outlined above for service entrance duty.
2. Comply with the requirements of NFPA Code 241 "Standards for Safeguarding Construction, Alteration, and Demolition Operations," the American National Standards Institute (ANSI) A10 Series standards for "Safety Requirements for Construction and Demolition," and the National Electrical Contractors Association (NECA) National Joint Guideline NJG-6 "Temporary Job Utilities and Services."

B. **Permits and Regulations.** The Contractor shall obtain all permits and inspections required by laws, ordinances, rules, regulations, and public authority having jurisdiction and shall obtain certificates of such inspections and shall submit same to the Engineer/Architect and shall pay all fees, charges, and expenses in connection therewith. The Contractor shall furnish to the Owner a certificate of final inspection from the proper authority prior to final payment.

Obtain and pay for easements required to bring temporary utilities to the site, where the Owner's easement cannot be utilized for that purpose.

1.4 SUBMITTALS

A. **General.** Follow the procedures specified in Section 01 33 00, "Submittals," and in addition, the Contractor shall prepare and submit a complete submittal list to the Engineer/Architect. The submittal list shall include all submittal items covered in the Division 26 specification sections. In addition, the submittal list shall contain dates for all items to be submitted and shall accompany the first submittal. The submittal list shall be coordinated with the construction schedule and shall clearly show such coordination.

B. **Shop Drawings.** Shop drawings shall be submitted to the Engineer/Architect for review for compliance with the Contract Documents. Shop drawings shall identify the specific equipment and material being supplied; the location on the project where it is to be used; the quantity being supplied; and all accessories, dimensions, descriptions, mounting and connection details, wiring diagrams, elementary control diagrams, equipment interface diagrams, and any other information necessary to determine compliance with the plans and specifications. Typical shop drawing review will require 10 working days following receipt of all information necessary to determine compliance with the plans and specifications. If the submittal schedule or actual submittal contains too large a quantity to allow a 10-day turnaround, the Contractor will be as informed as early as possible. The added number of days required for review will be determined at that time. Fabrication and installation shall be in accordance with the approved shop drawings. Products submitted as substitutions shall be clearly marked as such in the submittal. Please see general and supplemental conditions for further requirements for substitutions.

1. Increase, by the quantity listed below, the number of electrical related shop drawings, product data, and samples submitted, to allow for distribution plus two copies of each submittal which will be retained by the Engineer/Architect.

    a. Shop Drawings - Initial Submittal. One additional blue or black line print.
    b. Shop Drawings - Final Submittal. One additional blue or black line print.
    c. Product Data. One additional copy of each item.
    d. Samples. One additional for each item.

    Additional copies may be required by individual sections of these specifications.

C. **Permits and Easements.** Submit copies of reports, permits, and easements necessary for installation, use, and operation.

D. **Test Reports.** Submit copies of reports of tests, inspections, and meter readings as specified. Tests, inspections, and meter readings shall be performed using the Contractor's temporary power source unless otherwise specified.

E. **Record Documents**

1. Prepare record documents in accordance with the requirements in Section 01 33 00, "Submittals". In addition to the requirements specified in Division 1, indicate installed conditions for:

   a. Major raceway systems, size and location, for both exterior and interior; locations of control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
   b. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
   c. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

2. Engage the services of a Land Surveyor or Professional Engineer registered in the state in which the project is located to record the locations and invert elevations of underground installations.

F. **Operation and Maintenance Manuals**

1. Prepare maintenance manuals in accordance with Section 01 33 00, "Submittals" and Section 01 79 00, " Start-Up, Demonstration and Training". Compile and assemble the operation and maintenance data of equipment specified in Division 26 into a separate set of vinyl covered three ring binders, tabulated and indexed for easy reference. Data shall clearly indicate only provided options and accessories.

2. In addition to the requirements specified in Division 1, include the following information for equipment items:

   a. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
   b. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
   c. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
   d. Servicing instructions and lubrication charts and schedules.
   e. Spare parts list as required by individual Division 26 sections.

1.5 JOB CONDITIONS

A. **Coordination.** Coordinate with other trades to prevent delays, omissions, or errors.

B. **Scheduling.** It is mandatory that the facility be maintained in operation during construction and that periods of shutdown due to "line changeovers," etc., are held to a minimum. These outages must be scheduled with and have the concurrence of the Engineer/Architect and the Owner. Further, it is mandatory that the completion of various stages of the electrical work coincide with the other phases of construction to maintain present and permit operation of new installations as construction progresses.

C. **Controls and Wiring.** Controls and wiring shall be furnished and installed as specified under the electrical contract based on the ratings and horsepowers shown on the plans. The general, heating, ventilating, and air conditioning (HVAC), and plumbing contractors shall verify the rating and horsepower of the equipment they propose to furnish and shall provide for any necessary electrical changes to accommodate the equipment furnished at no change in contract price.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **Delivery.** Deliver products to the project identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

1.7 SPECIAL WARRANTY

A. **General.** Compile and assemble the warranties specified in Division 26 into a separate set of vinyl covered three ring binders, tabulated and indexed for easy reference.

1. Provide complete warranty information for each item. Information to include:

   a. Product or equipment list.
   b. Date of beginning of warranty or bond.
   c. Duration of warranty or bond.
   d. Names, addresses, and telephone numbers and procedures for filing a claim and obtaining warranty services.

1.8 DEFINITIONS

A. **Finished Areas.** In general, areas with carpet or tile floors, lay-in or fixed ceiling tile, special architectural ceiling treatment, or tiled, plastered, or paneled walls shall be considered finished areas.

B. **Interior.** For the purposes of this specification, interior is any area within the boundaries of the foundation of any building or within the superstructure of other structures not classified as a building.

PART 2 - PRODUCTS

2.1 TEMPORARY ELECTRICAL EQUIPMENT

A. **General.** Provide new materials and equipment for temporary services and facilities; if acceptable to the Engineer/Architect, used materials and equipment that are undamaged may be used. Provide materials and equipment that are suitable for the intended use.

1. Provide weathertight, grounded temporary electrical distribution system, with ground fault circuit interrupters and ground fault interrupter features of proper types, sizes, electrical ratings, and characteristics to fulfill project requirements. Provide overcurrent protective devices at main distribution panel for power and light circuitry. Provide disconnects for equipment circuits.
2. Provide circuits of proper sizes, characteristics, and ratings for each use indicated. Provide rigid steel conduit to protect wiring on grade, floors, decks, or other areas exposed to possible damage. Provide 20 ampere, four gang receptacle outlets, equipped with ground fault circuit interrupters, reset button and pilot light, spaced so that a 100 foot extension cord can reach each area of work. Use only grounded extension cords; use "hard service" cords where exposed to abrasion and traffic. Provide warning signs at power outlets that are other than 120 volt. Provide outlets of proper National Electrical Manufacturers Association (NEMA) configuration to prevent insertion of 120 volt plugs into higher voltage outlets.
3. Provide general service incandescent lamps of wattage required for adequate illumination. Protect lamps with guard cages or tempered glass enclosures, where exposed to breakage. Provide exterior type fixtures where exposed to weather or moisture. Provide local switching to allow lights to be turned off in patterns to conserve energy.

PART 3 - EXECUTION

3.1 EXAMINATION

A. **General.** Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate electrical systems, equipment, and materials installation with other building components.
2. Verify all dimensions by field measurements.
3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.

3.2 PREPARATION

A. Rough-In

1. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
2. Refer to equipment specifications specified elsewhere for rough-in requirements.

B. Coordination

1. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete or supported from or on other structural components, as they are constructed.
2. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service and place each in proper operating order.
3. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the work. Give particular attention to large equipment requiring positioning prior to closing in the building and equipment which must be placed in service before further construction can take place.

C. **Clearance.** Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.

3.3 INSTALLATION

A. **General.** Install systems, materials, and equipment to conform with submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Engineer/Architect before final placement.

1. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
2. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.
3. Install access panel or doors where units are concealed behind finished surfaces. Access panels and doors are specified in Section 08 31 00, "Access Doors."
4. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

B. **Temporary Electric.** Provide temporary electric. Use qualified tradesman for installation. Locate temporary services and facilities where they will serve the project adequately and result in minimum interference with the work. Connect the service to the local utility company's temporary power source in the manner directed by the utility company officials. Install temporary lighting to fulfill security and protection requirements, without having to operate the entire temporary lighting system. Inspect and test the temporary electric service before placing in use. Arrange for inspections and test and obtain permits for use. Provide temporary electrical connections when first needed to avoid delay in the work. Maintain, expand, and modify temporary connections as needed. Remove temporary electrical service and connections promptly when need has ended, or when replaced by use of a permanent facility. Complete, or if necessary, restore permanent work delayed because of interference with the temporary service or facility. Repair damaged work, clean exposed surfaces, and replace work which cannot be repaired. At substantial completion, clean and renovate permanent services and facilities that have been used to provide temporary services and facilities during the construction period.

3.4 CUTTING AND PATCHING

A. **General**. Perform cutting and patching in accordance with the General Conditions and the following requirements:

1. Perform cutting, fitting, and patching of electrical equipment and materials required to:

   a. Uncover work to provide for installation of ill-timed work.
   b. Remove and replace defective work.
   c. Remove and replace work not conforming to requirements of the Contract Documents.
   d. Remove samples of installed work as specified for testing.
   e. Install equipment and materials in existing structures.
   f. Upon written instructions from the Engineer/Architect, uncover and restore work to provide for the Engineer/Architect observation of concealed work.

2. Cut, remove, and legally dispose of selected electrical equipment, components, and materials as indicated, including, but not limited to, removal of electrical items indicated to be removed and items made obsolete by the new work. Existing electrical items not indicated to be reused are to be removed.

3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

4. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

5. Patch new or existing finished surfaces or building components which are disturbed by electrical installations. Use new matching materials.

B. **Openings, Penetrations, and Inserts**. Provide all openings required for the work. Make penetrations through walls and floors by core drilling. Seal openings after the installation of raceways, wire, or cable as specified in Section 26 05 29.

1. Core drill with the required size drill. Visually inspect the opposite side of the wall or the floor prior to drilling to verify that utilities and other in-place items will not be damaged by drilling operations. Rope off areas on the floor below the drilling location and post required warning signs.
2. Drilled penetrations shall be of adequate size to permit installation of seals in the space between penetrating items and core sides, and the spaces between penetrating items.
3. All chases, sleeves, inserts for hangers, supports, and fastenings should be located in advance of new construction in order to minimize interferences.

3.5 ELECTRICAL DEMOLITION

A. **Existing Conduit Location**

1. In existing structures at this project, there is electrical conduit embedded in concrete. It shall be the responsibility of the Contractor, under this section, to attempt to locate and mark the existence of any conduit embedded in areas where, as part of this Contract, the concrete is to be drilled or cut into for any purpose.
2. Contractor shall use every available means possible to attempt to locate existing conduit. Whenever a hole is to be cut into an existing slab, wall, or other structural concrete, that area shall be X-rayed prior to drilling to show the locations of conduits and steel rebar.

B. **Removal and Relocation of Existing Electrical Apparatus**

1. The Contractor, under this section, shall remove and store or relocate all existing electrical apparatus as shown on the drawings, as specified herein, or as necessary for the completion of this Contract except where specifically called for to be included under another section of the Contract. The Contractor shall be responsible for verifying existing conditions, dimensions, locations, quantities, etc., associated with the removal and relocation of electrical apparatus. In addition, the Contractor shall be responsible for verifying and identifying the existing circuits associated with the removal and relocation of electrical apparatus. Failure of the Contractor to review the Contract Documents and verify the existing conditions shall not be sufficient cause to warrant a change in contract after contract award.

2. Where existing electrical equipment, including lighting fixtures, is shown to be removed, the Contractor shall also remove the existing branch wiring.

a. Wiring removal shall extend to the branch disconnect or to the next piece of utilization equipment.
b. Where new or existing equipment is to be reinstalled, the wiring shall be temporarily terminated.

3. Where part of the existing equipment on a branch circuit is to be disconnected, the circuit shall be de-energized only long enough to disconnect the equipment and terminate the wiring that is to remain.

4. All equipment and major lengths of wiring retired and removed shall remain the property of the Owner unless shown or directed otherwise and shall be placed in storage on the site by the Contractor where ordered.

5. When pumps, motors, or other apparatus are being removed under other sections of this Contract, all electrical wiring, conduit, boxes, and related equipment shall be completely removed under Division 26.

6. Removal of all equipment shall include the removal of all accessories incidental to the major units. Where wiring is removed from conduit and boxes, the accessible conduit and boxes shall also be removed.

7. When the Contract is complete, no piece of electrical equipment shall remain installed that is not in service unless otherwise ordered.

8. Where electrical conduit, boxes, or appurtenances are embedded in walls or slabs, and wires, wiring devices, fixtures, or other apparatus is removed from these embedded items, the conduits shall be cut off flush with the surface and plugged with masonry to a smooth surface and the boxes and other appurtenances covered with suitable approved stainless steel cover plates. The cover plates shall have stainless steel fasteners.

9. Electrical equipment or components, supported by materials or equipment being removed under this or other Divisions in this Contract, shall be temporarily supported during the demolition process and then properly and permanently resupported prior to the conclusion of this Contract. All supports shall meet all the applicable requirements of this Division.

10. Any electrical equipment or components damaged during the performance of this Contract shall be replaced or repaired to a "like new" condition in accordance with the requirements of this Division.

3.6 CLEANING

A. **General**. When all work is completed and has been tested and accepted by the Engineer/Architect, the Contractor shall clean all light fixtures, equipment, and exposed surfaces that have been directly affected by this work. The Contractor, insofar as the work is concerned, shall at all times keep the premises in a neat and orderly condition and at the completion of the work shall properly clean up and remove from the site any excess materials.

3.7 DEMONSTRATION

A. **General**. The Contractor shall perform a 30-day operational demonstration of the complete electrical system. The 30-day operational demonstration shall not begin until all field tests are completed and all problems and defects encountered during the field test have been corrected.

B. **System Acceptance.** System acceptance shall not occur until the entire electrical system has performed as a functioning unit continuously for 30 consecutive days. Failure of any component or required feature shall require a restart of the 30-day operational demonstration until 30 consecutive days of continuous operation have been completed.

C. **Staffing**. Provide the services of qualified service technician for the duration of the 30-day operational demonstration. The service technician shall be on call 24 hours per day, 7 days a week.

END OF SECTION

SECTION 26 00 02

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General**. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this section.

B. **Related Sections.** The following sections contain requirements that relate to this section:

1. Section 02 41 00, "Demolition."
2. Section 03 30 00, "Cast-in-Place Concrete."
3. Section 26 00 01, "Basic Electrical Requirements."
4. Section 31 23 00, "Excavation Backfill and Embankment."

1.2 DESCRIPTION OF WORK

A. **General.** The Contractor shall provide the labor, tools, equipment, and materials necessary to provide basic electrical materials in accordance with the plans and as specified herein.

B. **Applications.** This section includes limited scope general construction materials and methods for application with electrical installations as follows:

1. Excavation for underground utilities and services, including underground raceways, vaults, and equipment.
2. Miscellaneous metals for support of electrical materials and equipment.
3. Wood grounds, nailers, blocking, fasteners, and anchorage for support of electrical materials and equipment.
4. Concrete used for outdoor equipment pads, pole base foundations, pipe supports, and housekeeping pads for all floor-mounted equipment including but not limited to motor control centers, switchboards, and transformers, and freestanding motor controllers, switches, circuit breakers, and custom panels.

1.3 QUALITY ASSURANCE

A. **Codes and Standards**. Perform all work associated with basic electrical materials in compliance with applicable requirements of governing agencies having jurisdiction and in accordance with these plans and as specified herein. Where provisions of the pertinent codes and standards conflict with this specification, the more stringent provision shall govern.

1. American Institute of Steel Construction (AISC) "Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings."

2. American Welding Society (AWS) D1.1 "Structural Welding Code - Steel."
3. National Electrical Code (NEC).

B. **Qualifications**

1. Installer Qualifications. Engage an experienced installer for the installation.

2. Qualify welding processes and welding operators in accordance with AWS D1.1 "Structural Welding Code - Steel."

a. Certify that each welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

1.4 SUBMITTALS

A. **Shop Drawings.** Shop drawings detailing fabrication and installation for metal fabrications and wood supports, and anchorage for electrical materials and equipment.

B. **Certificates.** Welder certificates, signed by Contractor, certifying that welders comply with requirements specified under "Quality Assurance" article of this section.

1.5 JOB CONDITIONS

A. **Coordination.** Coordinate with other trades to prevent delays, omissions, or errors.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **Storage and Handling.** Store and handle materials in compliance with the manufacturer's recommendations to prevent their deterioration and damage.

1.7 SPECIAL WARRANTY

Not used.

PART 2 - PRODUCTS

2.1 MATERIALS

A. **Miscellaneous Metals and Reinforcing Materials**

1. Provide steel plates, shapes, bars, and bar grating conforming to American Society for Testing and Materials (ASTM) A 36.
2. Provide cold formed steel tubing conforming to ASTM A 500.
3. Provide hot rolled steel tubing conforming to ASTM A 501.
4. Provide steel pipe conforming to ASTM A 53, Schedule 40, welded.

5. Provide nonshrink, nonmetallic grout which is premixed, factory packaged, nonstaining, noncorrosive, nongaseous grout, recommended for interior and exterior applications.
6. Provide fasteners which are zinc-coated, type, grade, and class as required.
7. Provide deformed reinforcing bars conforming to ASTM A 615, Grade 40 or 60, unless otherwise indicated.
8. Provide reinforcing materials with size and placement as shown on the plans.
9. Provide welded wire fabric conforming to ASTM A 185.

B. **Miscellaneous Lumber**

1. Provide framing materials which are Standard Grade, light framing size lumber of any species. Number 3 Common or Standard Grade boards complying with West Coast Lumber Inspection Bureau (WCLIB) or American Wood Preservers Association (AWPA) rules, or Number 3 boards complying with Southern Pine Inspection Bureau (SPIB) rules. Lumber shall be preservative treated in accordance with AWPA LP-2 and kiln dried to a moisture content of not more than 19 percent.
2. Provide construction panels which are plywood panels; American Plywood Association (APA) C-D PLUGGED INT, with exterior glue; thickness as indicated, or if not indicated, not less than 15/32 inch.

C. **Concrete**

1. Provide concrete as specified in Section 03 30 00, "Cast-in-Place Concrete."

PART 3 - EXECUTION

3.1 EXAMINATION

A. **General.** Prior to all work of this section, carefully inspect the installed work of all other trades and verify that all such work is complete to the point where this installation may properly commence.

1. Field-verify all locations and dimensions to ensure that the equipment will be properly located, readily accessible, and installed in accordance with all pertinent codes and regulations, the Contract Documents, and the referenced standards.
2. The work shall be carefully laid out in advance, and where cutting, drilling, etc., of floors, walls, ceilings, or other surfaces is necessary for the proper installation, this work shall be carefully done, and any damage to building, piping, or equipment shall be repaired by skilled mechanics of the trades involved at no additional cost to the Owner.
3. In the event any discrepancies are discovered, immediately notify the Engineer/Architect in writing. Do not proceed with installation in areas of discrepancy until all such discrepancies have been fully resolved.

3.2 EXCAVATION

A. **General.** Perform excavation in accordance with Section 31 23 00, "Excavation and Backfill," and in accordance with any local codes and ordinances.

3.3 ERECTION

A. **Erection of Metal Supports and Anchorage**

1. Cut, fit, and place miscellaneous metal fabrications accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
2. Provide field welding which complies with AWS "Structural Welding Code."

B. **Erection of Wood Supports and Anchorage**

1. Cut, fit, and place wood grounds, nailers, blocking, and anchorage accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
2. Select fastener sizes that will not penetrate members where opposite side will be exposed to view or will receive finish materials. Make tight connections between members. Install fasteners without splitting wood members.
3. Attach to substrates as required to support applied loads.

3.4 INSTALLATION

A. **Concrete**. Install concrete in accordance with Section 03 30 00, "Cast-in-Place Concrete," and in accordance with the plans and as specified herein.

1. Strength, Spacing, and Placement of Equipment Housekeeping Pads. Provide a housekeeping pad for all floor mounted equipment unless noted otherwise. Fabricate pad as follows:

   a. Coordinate size of housekeeping pad with actual equipment provided. Fabricate base 4 inches larger in both directions than the overall dimensions of the supported equipment.
   b. Form concrete pads with framing lumber with form release compounds. Provide 1-inch chamfer on top edge and corners of pad.
   c. Install reinforcing bars and place anchor bolts and sleeves to facilitate securing equipment.

END OF SECTION

SECTION 26 05 12

WIRE, CABLES, AND CONNECTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this section.

B. **Related Sections.** The following sections contain requirements that relate to this section:

1. Section 26 00 01, "Basic Electrical Requirements."
2. Section 26 00 02, "Basic Electrical Materials and Methods."
3. Section 26 05 23, "Communication and Signal Cables."
4. Section 26 05 34, "Cabinets, Boxes, and Fittings."

1.2 DESCRIPTION OF WORK

A. **General.** The Contractor shall provide the labor, tools, equipment, and materials necessary to install wires, cables, and connectors in accordance with the plans and as specified herein.

B. **Miscellaneous.** This section includes wires, cables, and connectors for power, lighting, signal, control, and related systems rated 600 volts and less.

1.3 QUALITY ASSURANCE

A. **Codes and Standards.** Perform all work associated with wires, cables, and connectors in compliance with applicable requirements of governing agencies having jurisdiction and in accordance with these plans and as specified herein.

1. National Fire Protection Association (NFPA) 70, "National Electrical Code (NEC)."

2. Underwriters' Laboratories, Inc. (UL) Compliance. Provide components which are listed and labeled by UL under the following standards.

a.	UL Standard 83	Thermoplastic Insulated Wires and Cables.
b.	UL Standard 486A	Wire Connectors and Soldering Lugs for Use with Copper Conductors.
d.	UL Standard 854	Service Entrance Cable.

3. National Electrical Manufacturers Association/Insulated Cable Engineers Association (NEMA/ICEA) Compliance. Provide components which comply with the following standards:

a. WC-70 Nonshielded 0-2 kV Cables.

4. Institute of Electrical and Electronics Engineers (IEEE) Compliance. Provide components which comply with the following standards:

a. Standard 82 Test Procedure for Impulse Voltage Tests on Insulated Conductors.

1.4 SUBMITTALS

A. **General.** Furnish manufacturer's product data, test reports, and materials certifications as required.

B. **Submittals.** Submit the following in accordance with Conditions of Contract and Division 1 specification sections:

1. Product data for electrical wires, cables, and connectors.
2. Product data for Megger insulation testing instrument.
3. Report sheets for Megger testing.

1.5 JOB CONDITIONS

Not used.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **Deliver wire and cable properly packaged** in factory-fabricated-type containers, or wound on NEMA specified type wire and cable reels.

B. **Store wire and cable in clean dry space** in original containers. Protect products from weather, damaging fumes, construction debris, and traffic.

C. **Handle wire and cable carefully** to avoid abrading, puncturing, and tearing wire and cable insulation and sheathing. Ensure that dielectric resistance integrity of wires/cables is maintained.

1.7 SPECIAL WARRANTY

Not used.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Wires and Cables

1. Provide electrical wires and cables of manufacturer's standard materials as indicated by published product information designed and constructed as recommended by manufacturer for a complete installation, and for application indicated. Except as otherwise indicated, provide copper conductors with conductivity of not less than 98 percent at 20 degrees Celsius (° C.) (68 degrees Fahrenheit° F.).

2. Provide factory fabricated wires of sizes, ampacity ratings, and materials for applications and services indicated. Where not indicated, provide proper wire selection as determined by Installer to comply with project's installation requirements, and NEC and NEMA standards. Select from the following UL types those wires with construction features which fulfill project requirements:

   a. Provide Type XHHW for dry locations, maximum operating temperature 90° C. (194° F.). Insulation, flame retardant, cross linked polyethylene; conductor, annealed copper.
   b. Provide Type THWN/THHN for dry and wet/damp locations; maximum operating temperature 75° C. (167° F.)/90° C. (194° F.). Insulation flame retardant moisture and heat resistant thermoplastic; conductor annealed copper.

3. Provide color coding for phase identification in accordance with requirements in Section 26 05 53, "Electrical Identification."

   a. Wiring and identification for emergency systems shall be in compliance with NEC Article 700-9.

4. Conductor stranding shall be as follows:

AWG kcmil	Strands (RHW/THW)	Strands (XHHW)	Strands (THWN/THHN)
No. 14 to No. 10	1	7	1
No. 8 to No. 2	7	7	19
No. 1 to No. 4/0	19	19	19
250 to 500	37	37	37
600 and above	61	61	61

B. **Variable-Frequency Drive (VFD) Cables**

1. Material. Conductors shall be annealed copper, conforming to American Society for Testing and Materials (ASTM) B 3 and B 8 and have cross-linked polyethylene (XLPE) insulation, meeting the requirements of UL Standard 44, suitable for use in wet and dry locations at a conductor temperature not exceeding 90° C. Conductors shall be listed as either RHW-2 or XHHW-2.
2. Conductor insulation thickness shall be at least 0.045 inches for No. 12 and No. 10 AWG conductors and 0.060 inches for No. 8 through No. 2 AWG conductors.
3. Ground conductors shall be cabled with either one full-size insulated conductor or three bare conductors. Where three conductors are used, the sum of the cross sectional areas of the ground conductors shall be equal to, or greater than, that of an equipment ground conductor sized according to NEC Table 250.122 for the overcurrent device as shown on the contract drawings protecting the VFD cable.

4. Conductors shall be provided with either an overall aluminum foil 100 percent shield covered by a tinned copper braid shield or a 5-mil-thick copper tape corrugated and longitudinally applied with a minimum overlap of 15 percent to form a 100 percent shield.
5. The cable shall be provided with an overall polyvinyl chloride (PVC) jacket, UL 1277 listed as Type TC, Tray Cable.

C. **Connectors and Terminals**

1. General. Provide UL-type factory-fabricated metal connectors and terminals of sizes, ampacity ratings, materials, types, and classes indicated.
2. Twist-on Connectors. Conforming to UL 486 C consisting of a tapered spring with insulated outer covering.
3. Compression Connectors. Tin plated copper. Configuration shall be tee, in-line, etc., as required.
4. Terminals. Tin plated copper, compression locking fork tongue with insulated barrel.
5. Compression Lugs. Tin-plated copper, standard barrel, one hole or two hole as required.
6. Pin Terminators. Tin plated copper, compression, for wire sizes No. 18 American Wire Gauge (AWG) to No. 8 AWG.
7. Heat-Shrink Insulation. Heat-shrinkable polyolefin with an internally applied adhesive watertight sealant.
8. Motor Connection Kit. Consisting of compression lugs bolted together, cloth tape cover, and heat shrink insulation.
9. Splice Kit. Consisting of compression connector and heat-shrink insulation.

2.2 MANUFACTURERS

A. **Manufacturers**. Subject to compliance with requirements, provide products by one of the following:

1. Wire and Cable.

   a. American Insulated Wire Corp.
   b. General Cable Co
   c. The Okonite Co.
   d. Rome Cable Corp.
   e. Southwire Company.

2. VFD Cable.

   a. Belden.
   b. Tamaqua Cable Products Corp.
   c. Or equal.

3. Connectors and Terminals for Wires and Cable Conductors.

   a. AMP.
   b. Burndy Corporation.
   c. Grafoplast Wiremarkers, Inc.
   d. Ideal Industries, Inc.
   e. 3M Company
   f. O-Z/Gedney Co.
   g. Raychem.
   h. Square D Company.
   i. Thomas and Betts Corp.

PART 3 - EXECUTION

3.1 WIRE AND CABLE INSTALLATION

A. **Uses Permitted**

1. Install UL-Type XHHW wiring in conduit for service entrance, power feeders, motor branch circuits, panelboard feeder circuits, and below grade or exterior control and metering circuits.
2. Install UL-Type THWN/THHN wiring in conduit for branch circuits for lighting, receptacles, and interior control and metering circuits.
3. Install VFD cables between VFDs and motors unless shown otherwise on the contract drawings.

B. **Install electrical cables**, wires, and connectors in compliance with NEC.

C. **Coordinate cable installation** with other work.

D. **Pull conductors simultaneously** where more than one is being installed in same raceway. Use UL listed pulling compound or lubricant, where necessary.

E. **Use pulling means** including, fish tape, cable, rope, and basket weave wire/cable grips which will not damage cables or raceways. Do not use rope hitches for pulling attachment to wire or cable.

F. **Conceal all cable** in finished spaces.

G. **Install exposed cable** parallel and perpendicular to surfaces or exposed structural members, and follow surface contours, where possible.

H. **Power conductors shall be** No. 12 AWG minimum. Control conductors may be No. 14 AWG where circuit amperes and the NEC allow and when length does not pose a voltage drop problem.

I. **Conductors shall be sized** such that voltage drop does not exceed 3 percent for branch circuits or 5 percent for feeder/branch circuit combination.

J. **Provide adequate length of conductors** within electrical enclosures and train the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than No. 10 AWG cabled in individual circuits. Make terminations so there is no bare conductor at the terminal.

K. **Install a maximum of three lighting circuits** or three 20-ampere, 120-volt general-use receptacle circuits per conduit. Install all other branch circuits and feeders in separate conduits unless otherwise noted.

L. **Provide a separate neutral** for every branch circuit.

3.2 CONNECTOR, TERMINAL, AND SPLICE INSTALLATION

A. **Uses Permitted**

1. Install twist-on connectors for lighting, communication, and receptacle branch circuits and utilization equipment only in size No. 8 AWG and smaller and only in finished areas.
2. Install fork tongue terminals on control and metering conductors which connect to terminal blocks.
3. Install motor connection kits on all polyphase induction motors.
4. Install compression connectors and lugs for all other connections.

B. **Service entrance conductors shall** be installed without splices. Electrical equipment feeders shall be spliced only where shown or specifically approved. Control and metering conductors shall be installed without splices.

C. **Install all compression connectors**, splices, and lugs with a racheting tool which will not release until proper compression is achieved.

D. **Splices where permitted** shall possess equivalent-or-better mechanical strength and insulation ratings than conductors being spliced. Use splice and tap connectors which are compatible with conductor material.

E. **Tighten electrical connectors** and terminals in accordance with manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and 486B.

3.3 FIELD QUALITY CONTROL

A. **The Contractor shall test** each electrical circuit after permanent cables are in place with terminators installed, but before cable or wire is connected to equipment or devices to demonstrate that each circuit is free from improper grounds and short circuits.

B. **The Contractor shall test** by Megger test, the insulation resistance between phases and from each phase to ground for each of the following feeder and motor branch circuits:

1. Motor control centers.
2. Panelboards.
3. Motors.

C. **The Megger testing shall be witnessed** by the Engineer/Architect. The Engineer/Architect shall be notified at least 48 hours in advance of testing.

D. **Measure the insulation resistance** at 500 volts direct current (dc) with a hand cranked or motor driven "Megger" insulation testing instrument. Battery operated test instruments are not permitted. All test instruments are to be provided by the Contractor.

E. **If any insulation resistance measures** less than 50 megohms, the cable shall be considered faulty with the cable failing the insulation test. In moist environments, bag the ends of the cable to prevent a faulty Megger test.

F. **Any cable which fails** the insulation tests or which fails when tested under full load conditions shall be replaced with new cable for the full length and retested. Corrective action and repeated tests shall be accomplished at the Contractor's own expense.

G. **Maintain testing report sheets** identifying each cable tested, what each feeder or motor branch circuit will be connected to, and the level of insulation resistance measured. Test reports shall be signed by the tester, initialized by the Engineer/Architect and sent to the Engineer/Architect within 48 hours.

H. **Every belowgrade service or feeder splice shall** be water-immersion Megger tested in the presence of the Engineer/Architect. Each splice shall be immersed in a grounded water immersion bath for 24 continuous hours prior to and during the test. Criteria for failure shall be as described for cable above.

END OF SECTION

SECTION 26 05 23

COMMUNICATION AND SIGNAL CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General**. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this section.

B. **Related Sections**. The following sections contain requirements that relate to this section:

1. Section 26 00 01, "Basic Electrical Requirements."
2. Section 26 00 02, "Basic Electrical Materials and Methods."
3. Section 26 05 12, "Wires, Cables, and Connectors," for ordinary building wire that may sometimes be used for control or signal circuits.

1.2 DESCRIPTION OF WORK

A. **General**. The Contractor shall provide the labor, tools, equipment, and materials necessary to furnish and install communication and signal cables in accordance with the plans and as specified herein.

B. **Cables and Accessories**. This section includes cables and connectors designed for and used in communication, control, data, and signal circuits including:

1. Shielded twisted pair cable.
2. Unshielded twisted pair cable.
3. Coaxial cable connectors.

1.3 QUALITY ASSURANCE

A. **Codes and Standards**. Perform all work in compliance with applicable requirements of governing agencies having jurisdiction and in accordance with these plans and as specified herein.

B. **Connected Equipment Manufacturer Approval**. Where cables specified in this section are used to provide signal paths for systems specified in other sections of these specifications or for systems furnished under other contracts, obtain review of the cable characteristics and approval for use with the connected system equipment by the connected equipment manufacturers.

C. **Electrical Component Standard**. Provide work complying with applicable requirements of National Fire Protection Association (NFPA) 70, "National Electrical Code (NEC)," and NFPA 262, "Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces."

D. **Toxicity**. Comply with applicable codes and regulations regarding toxicity of combustion products of materials used in communication and signal cables.

E. **National Electrical Manufacturer's Association/Insulated Cable Engineers Association (NEMA/ICEA) Compliance.** Comply with NEMA/ICEA Standard Publication WC 70, "Nonshielded 0-2 kV Cables"; and WC 63.2, "Performance Standard for Coaxial Premise Data Communications Cables".

F. **American Society for Testing and Materials (ASTM) Compliance.** Comply with applicable requirements of ASTM B 1, B 2, B 3, B 8, B 33, D 2219, and D 2220. Provide copper conductors with conductivity of not less than 98 percent at 20 degrees Celsius (° C.) (68 degrees Fahrenheit ° F.).

G. **Underwriters' Laboratories, Inc. (UL) Compliance**. Comply with applicable requirements of UL Standard 83, "Thermoplastic-Insulated Wires and Cables"; and UL 486 A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors." Provide products that are UL listed and labeled.

1.4 SUBMITTALS

A. **General**. Furnish manufacturer's product data, test reports, and material certifications as required.

1.5 JOB CONDITIONS

Not used.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **Deliver wire and cable properly packaged** in factory-fabricated-type containers, or wound on NEMA-specified-type wire and cable reels.

B. **Store wire and cable in clean dry space** in original containers. Protect products from weather, damaging fumes, construction debris, and traffic.

C. **Handle wire and cable carefully** to avoid abrasing, puncturing, and tearing wire, cable insulation, and sheathing. Ensure that dielectric resistance and characteristic impedance integrity of the cable are maintained.

1.7 SPECIAL WARRANTY

Not used.

PART 2- PRODUCTS

2.1 MATERIALS

A. **General**. Provide communication and signal cables of manufacturer's standard materials as indicated by published product information, designed and constructed as recommended by manufacturer, for a complete installation and for applications indicated.

2.2 SIGNAL CABLES

A. **300-Volt Rated Single Pair.** Shielded twisted pair cable, 18 American Wire Gauge (AWG), stranded- (tinned-) copper conductors, polyvinyl chloride (PVC) insulation, aluminum type shield, tinned copper drain wire, ultraviolet (UV) stabilized PVC jacket, 300-volt rated. UL listed as power limited tray cable. 100 percent shield coverage.

B. **300-Volt Rated Multiple Pair.** Multiple shielded twisted pairs as described above with an overall shield and UV stabilized PVC jacket, 300 volt rated. UL-listed as power limited tray cable.

C. **600-Volt Rated Single Pair.** Shielded twisted pair cable, 18 AWG, stranded (tinned) copper conductors, PVC insulation, aluminum type shield, tinned copper drain wire, UV stabilized PVC jacket, 600 volt rated. UL listed as tray cable. 100 percent shield coverage. Suitable for direct burial.

2.3 COAXIAL CABLES

A. **RG-59/U.** Coaxial single conductor, 75-ohm characteristic impedance, with polyethylene low-density dielectric core, constructed in compliance with MIL-C-17/29, and 100 percent sweep tested 5-300 megahertz (MHz).

B. **RG-6A/U.** Coaxial single conductor, 75-ohm characteristic impedance, with solid polyethylene core, 97 percent copper braid shield coverage, with polyethylene jacket, 100 percent sweep-tested 5-450 MHz.

C. **RG-8/U.** Coaxial single conductor, 50-ohm characteristic impedance, with solid polyethylene core, 60 percent tin coated copper braid shield coverage, with PVC jacket.

D. **RG-58/U.** Coaxial single conductor, 50-ohm characteristic impedance, with cellular polyethylene core, 97 percent bare copper braid shield coverage, with PVC jacket.

E. **Aerial Cables**. Coaxial single conductor cable, 75-ohm characteristic impedance; with center conductor 18-gauge copper-clad steel; dielectric, cellular expanded polyethylene; outer conductor 34-gauge bare copper braid, 95 percent coverage; with UV-resistant PVC jacket; 100 percent sweep tested.

2.4 CONNECTORS AND TERMINALS

A. **Coaxial Cable Connectors.** Provide radio frequency, Type F cable connectors for RG-59/U flexible coaxial video cable.

B. **Provide terminals** for signal cable as specified in Section 26 05 12, "Wires, Cables, and Connectors."

2.5 MANUFACTURERS

A. **Manufacturers.** Subject to compliance with requirements, provide products of one of the following:

1. Cables.

a. Alpha Communications.
b. American Insulated Wire Corp.
c. Belden Communication Division.
d. Berk-Tek Company.
e. General Cable Corporation.
f. Mohawk CDT.
g. Phelps Dodge Corp.
h. Pirelli Cable Corp.

2. Connectors.

a. Thomas & Betts Corporation.
b. 3M Company.

PART 3 - EXECUTION

3.1 **INSPECTION.** Examine areas and conditions under which communication and signal cables are to be installed. Notify Engineer/Architect in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer/Architect.

3.2 **COORDINATION.** Coordinate with other work, including wires/cables, boxes, and raceways, as necessary to interface installations of communication and signal cables with other work.

3.3 APPLICATIONS

A. **Use 300-volt rated single- or multiple-pair** signal cables for analog direct current (dc) signals (4-20 milliampere [mA], 1-5 volt, etc.) interior to buildings and in control panels where no circuit voltage exceeds 300 volts.

B. **Use 600-volt rated single or multiple pair** signal cables in all exterior or underground conduits, and in all pull boxes, control panels, or motor control centers where circuit voltages exceed 300 volts.

3.4 INSTALLATION

A. **General.** Install communication and signal cables in accordance with manufacturer's written instructions, in compliance with NEC, and in accordance with standard industry practice.

B. **Coordinate installation** with other work.

C. **Install communication and signal cables** without damaging conductors, shield, or jacket. Do not either in handling or installation bend cable to smaller radii than minimum recommended by manufacturer. Ensure that medium manufacturer's recommended pulling tensions are not exceeded. Pull conductors simultaneously where more than one is being installed in same raceway. Use pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Use pulling means, including fish tape, cable, rope, and basket weave wire/cable grips that will not damage cable or raceway.

D. **Install all cables** in conduit.

E. **Cables shall be installed** without splices.

F. **Tighten connectors and terminals**, including screws and bolts, in accordance with manufacturer's published instructions for torque tightening values.

G. **Cable Terminations.** Terminate cables on numbered terminal blocks where cable terminations are made on backboards and in cabinets and outlet boxes.

H. **Wiring at Backboards and Cabinets.** Install conductors parallel to and at right angles to walls. Bundle, lace, and train the conductors to terminal points with no excess. Use wire distribution spools at points where cables are fanned or conductors turned. Label each terminal.

I. **Conductor Terminations**. Terminate conductors of cables on terminal blocks using tools recommended by terminal block manufacturer.

3.5 GROUNDING

A. **Provide equipment grounding connections** for telephone systems as indicated. Tighten connections to comply with tightening torques specified in UL Standard 486A to ensure permanent and effective grounding.

3.6 FIELD QUALITY CONTROL

A. **Prior to usage, test communication** and signal cables for electrical continuity and for short circuits. In addition, test the cable installation with a time domain reflectometer with strip chart recording capability and anomaly resolution to within 1 foot in runs up to 1,000 feet in length. Test all cable segments for faulty connectors, splices, terminations, and the integrity of the cable and its component parts. Replace malfunctioning cable with new materials, then retest until satisfactory performance is achieved.

3.7 COMMISSIONING

A. **Subsequent to hookups of communication and signal cables**, operate communication and signal systems to demonstrate proper functioning. Replace malfunctioning cable with new materials, and then retest until satisfactory performance is achieved.

B. **Documentation.** Use the above time domain reflectometer to make a strip chart recording of transmission characteristics, wave form, and performance of all segments of the installation at the time of commissioning. Bind the recordings in a cable record book indexed for easy reference during future maintenance operations and turn book over to the Owner's authorized representative.

END OF SECTION

SECTION 26 05 26

GROUNDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this section.

B. **Related Sections.** The following sections contain requirements that relate to this section:

1. Section 26 00 01, "Basic Electrical Requirements."
2. Section 26 00 02, "Basic Electrical Materials and Methods."
3. Section 26 05 12, "Wires, Cables, and Connectors."
4. Section 26 05 53, "Electrical Identification."

1.2 DESCRIPTION OF WORK

A. **General.** The Contractor shall provide the labor, tools, equipment, and materials necessary to furnish and install grounding materials in accordance with the plans and as specified herein.

B. **Grounding.** This section includes solid grounding of electrical systems and equipment. It includes basic requirements for grounding for protection of life, equipment, circuits, and systems. Grounding requirements specified in this section may be supplemented in other sections of these specifications.

C. **Applications of electrical grounding** and bonding work in this section include the following:

1. Underground metal piping.
2. Underground metal water piping.
3. Underground metal and steel reinforced concrete structures.
4. Metal building frames.
5. Electrical power systems.
6. Grounding electrodes.
7. Separately derived systems.
8. Raceways.
9. Service equipment.
10. Enclosures.
11. Equipment.
12. Lighting standards.
13. Low level signal ground systems.

1.3 QUALITY ASSURANCE

A. **Codes and Standards.** Perform all work to furnish and install grounding in compliance with applicable requirements of governing agencies having jurisdiction and in accordance with these plans and as specified herein.

1. Electrical Code Compliance. Comply with applicable local electrical code requirements of the authority having jurisdiction, and American National Standards Institute/National Fire Protection Association (ANSI/NFPA) 70, "National Electrical Code" (NEC), as applicable to electrical grounding and bonding, pertaining to systems, circuits, and equipment. Comply with the latest edition of the codes listed above.

2. Underwriters' Laboratories, Inc. (UL). All grounding system components and materials for which UL maintains a testing and listing service shall be UL listed. Comply with the applicable requirements of the following UL standards:

   a. 467, "Electrical Grounding and Bonding Equipment."
   b. 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors."
   c. 486B, "Wire Connectors for Use with Aluminum Conductors."
   d. 486C, "Splicing Wire Connectors."
   e. 869, "Electrical Service Equipment."

3. ANSI/Institute of Electrical and Electronics Engineers (IEEE). Comply with applicable provisions and recommended installation and testing practices of the following ANSI/IEEE standards:

   a. 80-1986, "IEEE Guide for Safety in AC Substation Grounding."
   b. 81-1983, "IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounded System (Part 1)."
   c. 81.2-1991, "IEEE Guide for Measurement of Impedance and Safety Characteristics of Large, Extended, or Interconnected Grounding Systems (Part 2)."
   d. 141-1993, "IEEE Recommended Practice for Electric Power Distribution for Industrial Plants."
   e. 142-1991, "IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems."

4. ANSI Standard C2-1993, "National Electrical Safety Code" (NESC).

1.4 SUBMITTALS

A. **Submit the following** in accordance with Conditions of Contract and Division 1 specification sections:

1. Product data for each type of product specified.

1.5 JOB CONDITIONS

Not used.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **Deliver ground wire properly packaged** in factory-fabricated-type containers, or wound on National Electrical Manufacturers Association (NEMA) specified type wire reels.

B. **Store grounding materials** and ground wire in clean dry space in original containers. Protect products from weather, damaging fumes, construction debris, and traffic.

C. **Handle grounding wire carefully** to avoid abrading, puncturing and/or tearing wire insulation. Ensure that dielectric resistance of the cable insulation is maintained.

1.7 SPECIAL WARRANTY

Not used.

PART 2 - PRODUCTS

2.1 GROUNDING CONDUCTORS

A. **General**. Provide types indicated. Where types, sizes, ratings, and quantities indicated are in excess of NEC requirements, the more stringent requirements and the greater size, rating, and quantity indications govern.

B. **Bare Conductors**

1. Copper Conductors. Conform to the following:

   a. Solid Conductors. American Society for Testing and Materials (ASTM) B 3.
   b. Assembly of Stranded Conductors. ASTM B 8.
   c. Tinned Conductors. ASTM B 33.

C. **Insulated Conductors**. Refer to Section 26 05 12, "Wires, Cables, and Connectors."

D. **Ground Bus**. Bare (tin-plated), annealed, 98 percent conductivity copper bars of rectangular cross section, 1/4" x 3" x length as required. Cable lug hole spacing 2 inches center to center minimum.

E. **Braided Bonding Jumpers**. Flexible, 153,700-circular-mil braid, formed with 30 AWG tin-plated copper wire and terminated with crimp-type copper connectors or ground connector for copper braid to rod or tube.

F. **Bonding Strap.** Soft copper, 0.05 inch thick and 2 inches wide, except as indicated.

2.2 GROUNDING ELECTRODES

A. **Ground Rods.** One piece, copper clad steel with high strength steel core and electrolytic grade copper cladding 3/4" x 10".

2.3 CONNECTORS

A. **General.** Listed and labeled as grounding connectors for the materials used.

B. **Pressure Connectors.** High-conductivity plated units.

C. **Bolted Clamps.** Heavy-duty units listed for the application.

D. **Exothermic Welded Connections.** Provided in kit form and selected for the specific types, sizes, and combinations of conductors and other items to be connected.

2.4 ACCESSORIES

A. **Ground Staple.** Square shank, barbed, hot dipped galvanized.

B. **Ground Wire Guards.** 1" x 8'-0" molded, ultraviolet-light-stabilized plastic.

2.5 MANUFACTURERS

A. **Manufacturers.** Subject to compliance with requirements, provide products by the following:

1. Anixter Bros., Inc.
2. Burndy Corporation.
3. A.B. Chance Co.
4. Erico Products, Inc.
5. Ideal Industries, Inc.
6. Joslyn Manufacturing Co.
7. Thomas and Betts.

PART 3 - EXECUTION

3.1 INSTALLATION

A. **General**

1. Ground electrical systems and equipment in accordance with NEC requirements except where the Contract Documents exceed NEC requirements.
2. Comply with NEC Article 250 for sizes and quantities of equipment grounding conductors and grounding electrode conductors, except that larger sizes indicated or shown on the Contract Documents shall take precedence.

3. Connect the grounded service conductor to a grounding electrode at each service disconnect.

B. **Grounding Electrodes**

1. Ground Rods. Provide at least one ground rod at each building. Locate ground rods a minimum of one rod length from each other and at least the same distance from any other grounding electrode. Connect ground conductors to ground rods by means of exothermic welds except at test wells and as otherwise indicated. Make these connections without damaging the copper coating or exposing the steel of the rod. Drive rods until tops are 24 inches below finished floor or final grade except as otherwise indicated.

C. **Conductors**

1. Grounding Electrode Conductors.

   a. Interconnect all grounding electrodes with a grounding electrode conductor sized as shown on the plans or as required by the NEC.
   b. Route grounding electrode conductors along the shortest and straightest paths possible without obstructing access or placing conductors where they may be subjected to strain, impact, or damage, except as indicated.
   c. Bury exterior grounding electrode conductors at least 30 inches below grade.
   d. Use bare, tinned, stranded copper except as otherwise indicated.

2. Equipment Grounding Conductors.

   a. Provide equipment grounding conductors in all conduits containing power, control, or instrumentation conductors on the load side of the service equipment or on the load side of a separately derived system.
   b. Use insulated copper conductors up to No. 6 AWG. Use bare stranded copper for sizes No. 4 AWG and larger.

D. **Grounding Connections**

1. General. Make connections in such a manner as to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

   a. Use electroplated or hot tin coated materials to ensure high conductivity and make contact points closer in order of galvanic series.
   b. Make connections with clean bare metal at points of contact.

2. Exothermic Welded Connections. Use for connections to structural steel and for all underground connections. Install at connections to ground rods. Comply with manufacturer's written recommendations. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

3. Terminate insulated equipment grounding conductors for feeders and branch circuits with pressure type grounding lugs. Where metallic raceways terminate at metallic housings without mechanical and electrical connection to the housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a grounding conductor to a ground bus or stud in the housing. Bond electrically noncontinuous conduits at both entrances and exits with grounding bushings and grounding conductors. Size bonding conductors per NEC 250.122 based upon the largest overcurrent protection device trip setting for any contained conductor.

4. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torquing requirements are not indicated, tighten connections to comply with torque tightening values specified in UL 486A and UL 486B.

5. Compression Type Connections. Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by manufacturer of connectors. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

6. Moisture Protection. Where insulated grounding conductors are connected to ground rods or ground buses, insulate the entire area of the connection and seal against moisture penetration of the insulation and cable.

7. Ensure that grounding electrode conductor connections to interior piping, structural members, and the like are accessible for periodic inspection during the life of the structure.

E. **Equipment Grounding**

1. Separately derived systems required by NEC to be grounded shall be grounded in accordance with NEC 250.30. In addition, bond the grounded conductor of the separately derived system to the nearest available point on the interior metal water piping system, per NEC 250.104(A), and wherever available to a line side feeder ground conductor.

2. Building Steel. Exposed structural steel building framework shall be bonded to the grounding electrode conductor with a conductor of the

same size as the service entrance grounding electrode conductor, per NEC 250.104(C).

3. Utilization Equipment.

   a. Bond interior metal piping systems and metal air ducts to equipment ground conductors of pumps, fans, electric heaters, and air cleaners serving individual systems.

4. Underground Distribution System Grounding.

   a. Manholes and Handholes. Provide a driven ground rod close to the wall and set the rod depth such that 4 inches will extend above the finished floor. Where necessary, install ground rod before the manhole is placed and provide a 1/0 AWG bare tinned copper conductor from the ground rod into the manhole through a sleeve in the manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure sensitive tape or heat shrunk insulating sleeve from 2 inches above to 6 inches below the concrete.

   b. Connections. Ground all non-current-carrying exposed metal parts associated with manholes, substations, and pad-mounted equipment to the ground rod or ground conductor. Make connections with minimum No. 4 AWG stranded copper wire. Train conductors plumb or level around corners and fasten to manhole walls. Connect to cable armor and cable shields by means of tinned terminals soldered to the armor or shield, or as recommended by manufacturer of splicing and termination kits. Interconnect bare grounding conductors carried with incoming or outgoing circuits with the manhole grounding system.

   c. Grounding System. Ground non-current-carrying metallic items associated with manholes, substations, and pad-mounted equipment by connecting them to bare underground cable and grounding electrodes arranged as indicated.

5. Metal Light Poles. Provide each light pole with a driven ground rod. Provide a grounding electrode conductor for connecting the rod to the pole and to the branch circuit ground conductor.

F. **Direct-Current Low-Level-Signal Ground System**

1. Provide a separate grounding system consisting of insulated ground wires interconnected and increasing in size based upon conductor length. Powered equipment using low-level direct-current (dc) signals shall be connected by a minimum No. 10 AWG wire to the low-level dc ground system. Ground system conductor size shall increase one standard conductor size (based upon NEC ampacity tables for copper conductors in conduit) for each four pieces of equipment served; e.g., five units each connected to a No. 10 AWG copper ground must be connected to a No. 8

AWG ground wire. Nine units with No. 10 AWG must be fed from a No. 6 AWG, etc. Wire shall be distinctly identified at every point at which it is accessible to distinguish it from equipment or isolated grounding conductors.

2. The dc signal grounding system shall be connected to the facility grounding electrode conductor at the service equipment.
3. Instrumentation, Digital Control. Install separate insulated equipment ground conductor in all instrumentation, digital control circuits.

3.2 FIELD QUALITY CONTROL

A. **Tests**. Subject the completed grounding system to a ground resistance test at each location where a maximum ground resistance level is specified and at service disconnect enclosure ground terminal. Measure ground resistance without the soil being moistened by any means other than natural precipitation or natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests by the fall-of-potential method.

B. **Ground/resistance maximum values** shall be as follows:

1. Equipment Rated 500 Kilovolt Amperes (kVA) and Less. 10 ohms.
2. Equipment Rated 500 kVA to 1000 kVA. 5 ohms.
3. Equipment Rated over 1000 kVA. 3 ohms.
4. Unfenced Substations and Pad Mounted Equipment. 5 ohms.
5. Manhole Grounds. 10 ohms.
6. Fence Grounds. 10 ohms.
7. Structure Grounds. 25 ohms.

C. **Deficiencies**. Where ground resistances exceed specified values, and if directed, modify the grounding system to reduce resistance values. Where measures are directed that exceed those indicated, the provisions of the Contract covering change orders will be applied.

D. **Report**. Prepare test reports, certified by the testing organization, of the ground resistance at each test location. Include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

3.3 CLEANING AND ADJUSTING

A. **Restore surface features** at areas disturbed by excavation and reestablish original grades except as otherwise indicated. Where sod has been removed, replace it as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work to their original condition. Include necessary topsoil, fertilizing, liming, seeding, sodding, sprigging, or mulching. Perform such work in accordance with Division 32 section "Landscape Work." Maintain disturbed surfaces. Restore vegetation in accordance with section "Landscape Work." Restore disturbed paving as indicated.

3.4 LABELING

A. **Provide labeling for the grounding system** as specified in Section 26 05 53, "Electrical Identification."

3.5 DEMONSTRATION

A. **Provide a verification tour** of all grounding electrode conductor connections for the Engineer/Architect and the Owner. Review test reports which verify compliance of ground system with Contract requirements.

END OF SECTION

SECTION 26 05 29

SUPPORTING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General**. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this section.

B. **Related Sections**. The following sections contain requirements that relate to this section:

1. Section 05 10 00, "Structural Steel," for steel shapes used to fabricate assemblies employed in the support of electrical conduits and equipment.
2. Section 26 00 01, "Basic Electrical Requirements."
3. Section 26 00 02, "Basic Electrical Materials and Methods."

1.2 DESCRIPTION OF THE WORK

A. **Scope of Work**. The Contractor shall provide the labor, tools, equipment, and materials necessary to furnish and install supporting materials and assemblies, sleeves, and seals in accordance with the plans and as specified herein.

1.3 QUALITY ASSURANCE

A. **Codes and Standards**. Perform all work to furnish and install supporting devices in compliance with applicable requirements of governing agencies having jurisdiction and in accordance with these plans and as specified herein.

1. National Electrical Code (NEC) Compliance. Components and installation shall comply with National Fire Protection Association (NFPA) 70 (NEC).
2. Certification. Manufactured electrical components shall be listed and labeled by either Underwriters' Laboratories, Inc. (UL), Electrical Testing Laboratories, Inc. (ETL), Canadian Standards Association (CSA), or other approved, nationally recognized testing and listing agency that provides third party certification follow-up services.
3. Manufacturers Standardization Society (MSS) Compliance. Comply with applicable MSS standard requirements pertaining to fabrication and installation practices for pipe hangers and supports.
4. National Electrical Contractors Association (NECA) Compliance. Comply with NECA's "Standard of Installation" pertaining to anchors, fasteners, hangers, supports, and equipment mounting.
5. Federal Specification (FS) Compliance. Comply with FS FF-S-760 pertaining to retaining straps for conduit, pipe, and cable.

6. Metal Framing Manufacturers Association Standard Publication (MFMA)-1.
7. American Institute of Steel Construction "Specifications for Design, Fabrication, and Erection of Structural Steel for Buildings," including "Commentary" of supplements thereto, as issued.
8. The Aluminum Association "Specifications for Aluminum Structures."

B. **Supports, anchors, sleeves, and seals** furnished as part of factory fabricated equipment are specified as part of that equipment assembly in other divisions and Division 26 sections.

1.4 SUBMITTALS

A. **Submit the following** in accordance with Conditions of Contract and Division 1 specification sections:

1. Product data for each type of product specified.

2. Hanger and support schedule showing manufacturer's figure, number, size, spacing, features, and application for each required type of hanger, support, sleeve, seal, and fastener to be used.

3. Shop drawings indicating details of fabricated support assemblies.

1.5 JOB CONDITIONS

Not used.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **Deliver supporting materials** and assemblies properly packaged in sturdy factory fabricated containers.

B. **Store supporting materials** and assemblies in clean, dry spaces in original containers. Protect from weather, damaging fumes, debris, and construction operations.

C. **Handle supporting materials** carefully to avoid damage.

1.7 SPECIAL WARRANTY

Not used.

PART 2 - PRODUCTS

2.1 MANUFACTURED SUPPORTS

A. **General**. Provide manufactured support devices which are listed and labeled. In the event that more than one type of supporting device meets the requirements of the project, and none is specifically indicated on the drawings, device selection is the Contractor's option.

B. **Materials**

1. U-channel and clamps/hangers for supporting aluminum, steel, or stainless steel conduit, boxes or equipment shall be fabricated from cold rolled steel ASTM A 570, Grade 33, or malleable iron, and finished by a hot dip galvanizing process after fabrication in accordance with ASTM A 123. Parts, screws, nuts, and rod shall be electrolytically coated with zinc to ASTM B 633, Type III SC1 standards. Field cuts shall be thoroughly wire brushed and refinished with brush applied cold process galvanizing in accordance with ASTM A 780.
2. U-channel, clamps, and hangers for supporting conduit and equipment shall be Type 316 stainless steel. Parts, screws, nuts, and rod shall be Type 316 stainless steel. Strut extruded from aluminum alloy 6036-T6 may be substituted for stainless steel where it will not be in contact with concrete or grout and when its strength is sufficient for the application.
3. Provide fittings and accessories made from aluminum alloy 5052-H32 for aluminum strut.
4. Malleable iron fittings and accessories shall be high tensile strength and ductility, ASTM A 47 or ASTM A 48, Class 30A, zinc electroplated, with aluminum lacquer or powder paint finish.

C. **Products shall include** but are not limited to the following:

1. Clevis Hangers. Steel for supporting rigid metal conduit, with 3/8-inch hanger rod through 2-inch conduit size; 1/2-inch hanger, 2-1/2-inch and larger conduit size.

2. Round Steel Rod. Zinc plated, threaded at ends only, 1/2-inch minimum size except as stated in 1 above, with zinc plated hexagon nuts.

3. Beam Clamp. Malleable iron with 1/4-inch tapped side and back holes for attachment of conduit clamps.

4. Swivel Beam Clamp. Malleable iron for use with hanger rod. Clamp to have swivel eye hook, closed in the installed position, and malleable iron swivel eye tapped for the hanger rod to which it is attached. Provide jamb nut.

5. I-Beam Clamps. Steel, 1-1/2-inch-x-3/16-inch stock, 1/2-inch hook rod in 8-, 11-, or 14-inch lengths, as required, with double eye swing connector threaded for 1/2-inch rod. Provide jamb nut for support rod.

6. Conduit Straps. Malleable iron, one hole.

7. Clamp Backs. Malleable iron, for use with one hole conduit strap to support conduit away from wall or ceiling surface.

8. Two-Hole Conduit Straps. Steel, minimum 1/8-inch-thick heavy-duty, zinc electroplated.

9. Conduit Hangers. Steel, zinc electroplated, for hanging conduit from beam clamps. With 1/4-inch, 20-thread, zinc electroplated closure bolt and square nut. Provide 1/4-inch, 20-thread zinc-electroplated stove bolt to secure hanger to beam clamp.

10. Duct Bank Conduit Spacers. Nonmetallic spacers to support conduit and maintain spacing during concrete pours.

11. Riser Clamps. Two cold rolled steel bars, formed to fit the conduit to be supported, 8-1/2-inch-plus-conduit trade diameter long by 1-inch tall (2 inches for 5 inch and larger trade size conduit) by 3/16-inch-thick (1/2 inch through 1-1/2-inch trade size; 1/4 inch thick, 2- through 6-inch trade size), with zinc-electroplated finish. Bars shall be secured around conduit with two electroplated hexhead cap screws and hex nuts.

12. Fasteners and Anchors. Provide fasteners and anchors to assemble supports and to secure supports to structures. Fasteners, including bolts, nuts, washers, self-tapping anchors, and expansion anchors to be installed out-of-doors, below grade level, or in corrosive atmospheres or process areas shall be stainless steel.

    a. Anchors for securing 3/4- or 1-inch conduit straps and device boxes to sound concrete walls and ceilings shall be self-tapping anchors, similar and equal to Hilti Kwik-Con II or ITW Buildex Blue Max, 3/16 inch by minimum 1-1/4 inches long, in areas not requiring stainless steel.
    b. For anchors for use in securing conduit larger than 1 inch, heavier equipment than device boxes, and all fasteners to be used in areas enumerated above as requiring stainless steel fasteners, provide stud type expansion anchors, drop-in two-piece expansion anchors, or adhesive stud anchors, similar and equal to Hilti Kwik-Bolt II, Hilti HDI Drop-in, or Hilti HVA Adhesive Anchor System.
    c. Fasteners for securing conduit or equipment to metal plate or metal structural members shall be welded studs applied by the electric arc method. Studs for stainless steel or aluminum shall be of the same material as the base metal. Studs for use in damp or wet environments or out-of-doors shall be stainless steel for use on low carbon steel or stainless steel. Studs shall be similar and equal to TRW Nelson Stud Welding Division low carbon or mild steel or Type 304 or 305 stainless steel, applied with a Nelson stud welder.

13. U-Channel. 1-1/2" x 1-1/2" 12-gauge cold rolled steel, 12-gauge stainless steel, or 0.1046-inch-thick extruded aluminum, with solid base or bolt-hole base as required. Provide spring nuts or spring studs and related hardware of material specified hereinbefore appropriate to the U-channel material.

14. Lightweight U-Channel. 5/16" x 1/2" nominal, 18-gauge cold rolled steel, pregalvanized, for support of surface lighting fixtures mounted on the underside of suspended ceiling systems or outlets flush in suspended ceiling systems. Provide 1/4-inch threaded rod and square nuts, box mounting studs, and channel fasteners as appropriate.

15. Perforated Sheet Steel. Provide perforated 11-gauge Type 316 stainless steel sheet. Sheet shall have 1/4-inch holes on 3/8-inch centers. Provide sizes as shown on the contract documents.

2.2 STRUCTURAL SHAPE SUPPORTS

A. **General**. Provide structural shape supports in the form of individual structural steel angles, channels, or W-shapes as shown on the drawings or required to support equipment or systems.

B. **Supports**

1. Materials.

a. Steel shapes, such as angle, channel, or W-shapes, shall be fabricated from ASTM A 36 cold-rolled steel.

2. Finishes.

a. Shapes shall be cleaned and finished by a hot dip galvanizing process in accordance with ASTM A 123.
b. Field cuts shall be thoroughly wire brushed and finished with brush applied cold process galvanizing in accordance with ASTM A 780.

2.3 STRUCTURAL SHAPE SUPPORTS

A. **General**. Provide structural shape supports in the form of individual structural aluminum channel or W-shapes fabricated from aluminum alloy 6061-T6. Support members shall be sized to perform their support functions without deflection of more than one half percent of total height for vertical members and 1 percent of total span for other than vertical members.

B. **Protection**. Aluminum members in contact with concrete or the earth shall be thoroughly coated with alkali resistant bituminous paint.

2.4 FABRICATED SUPPORTS

A. **General**. Provide fabricated support assemblies constructed of structural shapes welded together to form a complete, secure, and durable assembly and finished appropriately to withstand the environment in which they are to be employed.

B. **Materials**. Provide structural steel angles, channels, and W-shapes hereinbefore specified, cleaned, but without other finish.

C. **Fabrication**

1. Steel shapes shall be assembled by full penetration welded connections. Welding shall be performed by a welder who has successfully passed the American Welding Society (AWS) welding qualification tests for AWS D1.1 "Structural Welding Code-Steel."
2. Welds shall be ground smooth and flush so as to present a noninterferring surface for equipment mounting. Disturbed areas around welds shall be wire brushed (ground, if necessary) to remove slag and spall.
3. Entire assembly shall be cleaned and finished by a hot dip galvanizing process in accordance with ASTM A 123. Finish damaged during installation shall be wire brushed and refinished with a brush applied cold process galvanizing in accordance with ASTM A 780.

D. **Materials**. Provide structural aluminum angles, channels, and W-shapes hereinbefore specified in natural aluminum finish.

E. **Fabrication**

1. Aluminum shapes shall be assembled by gas metal-arc welding, using ER4043 filler metal for maximum crack resistance. Welding shall be performed by a welder who has successfully passed the American Welding Society (AWS) welding qualification test for AWS D1.2 "Structural Welding Code-Aluminum."
2. Welds shall be ground smooth and flush so as to present a noninterferring surface for equipment mounting.

2.5 CONDUIT SEALS

A. **General**. Provide seals around conductors inside conduits and between conduits and sleeves/bored holes through which conduits penetrate concrete walls and floors.

B. **Materials**

1. Expanding Foam Seals. Provide two part silicone sealant which foams in place to fill voids between cables and conduits.
   a. Foam shall be UL listed as a fire barrier and shall be similar and equal to 3M 2001 RTV Foam. Prior to using this product, ensure that it will not adversely react with conductor insulation or sheath material.
   b. Provide a foam depth of at least one conduit trade size.
2. Mechanical Seals. Provide conduit internal sealing bushings composed of two brass or bronze pressure discs, three stainless steel socket head cap screws, and a neoprene gasket. Pressure discs and gasket shall be factory predrilled to match size and number of cables in the conduit to be sealed. Seals shall be similar and equal to O-Z/Gedney CSB series, and

shall be rated to withstand 50 pounds per square inch gauge (psig) water or gas pressure.

2.6 WALL/FLOOR SEALS

A. General

1. Provide seals around sleeves or conduits penetrating concrete walls which are below grade or water-bearing walls and concrete floors through which conduits pass from below grade.

B. Materials

1. Provide high strength malleable or ductile iron body and pressure clamp, hot dip galvanized, with Type 316 stainless steel hex head tightening bolts. Body shall include fins designed to prevent water from creeping along the outside of the body. The body shall fit over and seat against a sleeve of high strength, high impact plastic pipe or steel pipe with high organic zinc conductive epoxy coating. A neoprene O-ring shall be included between the body and sleeve to provide a seal between them. Two close fitting pressure rings of polyvinyl chloride (PVC) coated steel shall be located on each side of a neoprene grommet through which the entering conduit passes, which grommet is compressed by the pressure clamp as the tightening bolts are screwed into the body. Assembly shall be similar and equal to O-Z/Gedney FSK series.

2.7 SLEEVES

A. General

1. Provide sleeves in interior, nonwater-bearing, cast-in-place concrete construction and in masonry construction to permit the passage of electrical raceways, through walls and floors, ceilings and roofs.
2. Sleeves shall be fabricated of substantial materials to retain their shape through the construction process and to be compatible with seals or fire-stops required.

B. Material

1. Sleeves for conduit penetrating cast-in-place concrete shall be galvanized sheet steel, rigid galvanized conduit, or Schedule 80 PVC conduit as follows:

    a. Provide heavy wall rigid galvanized steel conduit or sleeves fabricated from galvanized sheet steel having the same thickness as equivalent heavywall rigid conduit and with welded seams ground smooth. Cut ends of sleeves and seams of fabricated sleeves shall be coated with cold process galvanizing after cutting/fabrication. Use metal sleeves only in locations exposed

to the air on both sides after construction is complete and in dry locations.

2. Provide heavywall PVC conduit sleeves (Schedule 80) for damp locations such as basement areas and out-of-doors in locations where there will be no requirement for sealing the sleeve, as from groundwater, or for fire-stopping the sleeve.

2.8 MANUFACTURERS

A. **Manufacturers**. Subject to compliance with requirements, provide products by the following:

1. Slotted Metal Angle and U-Channel Systems.

   a. B-Line (Cooper).
   b. Thomas & Betts.
   c. American Electric (Steel City).
   d. Unistrut Diversified Products.

2. Conduit Supports.

   a. Appleton.
   b. Cantex, Inc.
   c. Carlon.
   d. Crouse-Hinds.
   e. Killark.
   f. Thomas & Betts Corp.

3. Fasteners and Anchors.

   a. Hilti.
   b. ITW Buildex.
   c. Ideal Industries, Inc.
   d. Rawlplug Co.

4. Seals and Fire-Stops.

   a. CSD Sealing Systems.
   b. Dow Corning.
   c. 3M.

5. Conductor and Cable Supports.

   a. B-Line Systems.
   b. Condux International, Inc.
   c. Kellems, Division of Hubbell, Inc.
   d. O-Z/Gedney.
   e. Pass & Seymour/Legrand.
   f. Red Seal Electric Co.

PART 3 - EXECUTION

3.1 INSTALLATION

A. **Install supporting devices** to fasten electrical components securely and permanently in accordance with NEC requirements.

B. **Coordinate with the building structural system** and with other electrical installations.

C. **For raceway supports comply with the NEC** and the following requirements:

1. Conform to manufacturer's recommendations for selection and installation of supports.
2. Supports shall be secured to the surface upon which they are mounted with fasteners adequate to carry the present and any indicated future working loads by a safety factor of four times the total working load, defined as the ultimate load. When the ultimate load calculation, either in tension or shear of any fastener is less than 200 pounds, provide fasteners which will develop an ultimate strength of at least 200 pounds in either tension or shear, as applicable, for each support.
3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
4. Support parallel runs of horizontal raceways together on trapeze type hangers.
5. Support individual suspended horizontal conduit runs on pipe hangers suspended on 3/8 inch steel rod from swivel type supports securely anchored to structure. Do not use spring steel clips or other attachments to suspended ceiling supports.
6. Secure conduit clamps to concrete or masonry walls with concrete screw anchors, stud type expansion anchors, drop-in two-piece anchors, or adhesive stud anchors as strength requirements dictate. Provide stainless steel anchors in damp or wet areas, areas subject to hose down, or out-of-doors. Provide clamp backs for conduit installed on damp or wet walls and for all aluminum conduit on concrete or masonry walls.
7. Holes cut to depth of more than 1-1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete shall not cut the main reinforcing bars. Fill holes that are not used.
8. Support exposed and concealed raceway within 1 foot of an unsupported box and access fittings. In horizontal runs, support at the box and access fittings may be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples or threadless box connectors.
9. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals.

10. In all-steel construction, where through fasteners are not appropriate, provide welded threaded studs. In damp or wet areas or out-of-doors, studs shall be stainless steel or, for aluminum base material, aluminum as specified.
11. Raceway supports shall be provided as required by the NEC and installed as recommended by NECA.
12. Support conduits in concrete duct banks with nonmetallic spacer to maintain conduit spacing during concrete pour.

D. **Install vertical conductor supports** simultaneously with installation of conductors.

E. **Miscellaneous Supports.** Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.

F. **In open overhead spaces**, cast boxes with hubs threaded to raceways need not be supported separately except where used for fixture support; support sheet metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an approved type of fastener not more than 2 feet from the box.

G. **Support duct banks entering building**, manholes, handholes, and other structures as shown on the drawings.

H. **Install sleeves in concrete slabs** and walls and all fire-rated assemblies.

I. **Seal all sleeves penetrating concrete** water-bearing walls or exterior walls below grade with mechanical seals. In new construction, cast seals into walls or floors. Provide surface mounted mechanical seals over holes cut in existing below grade walls.

J. **Seal the interior of all conduits** entering from below grade with seals as specified. Provide similar seals for conduits in existing water-bearing walls.

K. **Do not use wood screws** except in construction made of wood. Wood screws shall be round head or lag type with electrogalvanized or hot dip galvanized finish.

L. **Provide No. 8 or larger sheet metal screws** into metal studs in drywall construction. Do not use toggle bolts in drywall ceilings or walls.

M. **Provide fire-stops as specified around electrical work** penetrating fire rated assemblies. Install in accordance with the standard UL drawing for the greater fire resistance at the barrier.

N. **Provide supports fabricated from structural steel** or aluminum shapes as detailed on the drawings or as required to support equipment.

O. **Provide supports for luminaires mounted** on the bottom of suspended ceilings. Supports shall be constructed of lightweight U-channel spanning at least two lathers channels or main grid rails with 1/4-inch threaded rod through the ceiling system into the four corners of fluorescent or high intensity discharge (HID) fixtures. Provide a minimum of two 1/4-inch threaded rods to support smaller ceiling surface mounted incandescent or parallel lamp (PL) fluorescent fixtures. Provide fixture stud and carrier to support flush outlet boxes in the ceiling treatment or tile from the U-channel.

P. **Provide stainless mounting hardware** for securing electrical equipment to perforated sheet steel.

Q. **The following supports and support methods** are specifically prohibited:

1. Strap iron.
2. Wire of any type.
3. Welding other than stud welding as specified.
4. Plastic ties.
5. Piggyback clamps (one conduit supported from another conduit or pipe).
6. Devices which depend upon spring tension to support conduit or to remain in place.
7. Power driven anchors.
8. Clip type devices to secure lighting fixtures to the bottom of lay-in style suspended ceiling grids.

3.2 TESTS

A. **Test pull-out resistance of one of each** type, size, and anchorage material for the following fastener types:

1. Concrete screw anchors.
2. Expansion anchors.
3. Toggle bolts.

B. **Provide all jacks, jigs, fixtures, and calibrated indicating scales** required for reliable testing. Obtain the Engineer/Architect approval before transmitting loads to the structure. Test to 90 percent of rated proof load for fastener. If fastening fails test, revise all similar fastener installations and retest until satisfactory results are achieved.

END OF SECTION

SECTION 26 05 33

RACEWAY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this section.

B. **Related Sections.** The following sections contain requirements that relate to this section:

1. Section 26 00 01, "Basic Electrical Requirements."
2. Section 26 00 02, "Basic Electrical Materials and Methods."
3. Section 26 05 12, "Wires, Cables, and Connectors."
4. Section 26 05 29, "Supporting Devices."
5. Section 26 05 34, "Cabinets, Boxes, and Fittings."
6. Section 26 05 53, "Electrical Identification."

1.2 DESCRIPTION OF WORK

A. **General.** The Contractor shall provide the labor, tools, equipment, and materials necessary to install raceways in accordance with the plans and as specified herein.

B. **Types.** Types of raceways specified in this section include the following:

1. Flexible metal conduit.
2. Liquidtight flexible metal conduit.
3. Underground plastic utilities duct.
4. Rigid metal conduit.
5. Rigid nonmetallic conduit.
6. Liquidtight flexible nonmetallic conduit.
7. Surface raceways.
8. Wireways.

1.3 QUALITY ASSURANCE

A. **Codes and Standards.** Perform all work associated with raceways in compliance with applicable requirements of governing agencies having jurisdiction and in accordance with these plans and as specified herein.

1. National Electrical Code (NEC). Components and installation shall comply with National Fire Protection Association (NFPA) 70 "National Electrical Code."
2. National Electrical Manufacturers Association (NEMA) Compliance. Comply with applicable requirements of NEMA standards pertaining to raceways.

3. Underwriters' Laboratories, Inc. (UL) Compliance and Labeling. Comply with applicable requirements of UL standards pertaining to electrical raceway systems. Provide raceway products and components listed and labeled by UL, Electrical Testing Laboratories (ETL), or Canadian Standards Association (CSA).

1.4 SUBMITTALS

A. **General**. Furnish manufacturer's product data, test reports, and materials certifications as required.

B. **Instructions**. Provide manufacturer's written installation instructions for wireway, metallic raceway, and nonmetallic raceway products.

1.5 JOB CONDITIONS

Not used.

1.6 DELIVERY, STORAGE, AND HANDLING

Not used.

1.7 SPECIAL WARRANTY

Not used.

1.8 SEQUENCING AND SCHEDULING

A. **Coordinate with other work**, including metal and concrete deck installation, wires/cables, boxes, and panels, as necessary to interface installation of electrical raceways and components with other work.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. **Rigid Steel Conduit**. Rigid steel, hot dip galvanized, threaded type conforming to Federal Specification (FS) WW-C-581E, ANSI C80.1 and UL 6.

B. **Rigid Aluminum Conduit**. Rigid aluminum conduit conforming to ANSI C80.5.

C. **Flexible Metal Conduit**. FS WW-C-566 and UL 1. Continuous, spirally wound, interlocked aluminum.

D. **Liquidtight Flexible Metal Conduit**. Single strip, flexible, continuous, interlocked, and double wrapped steel; galvanized inside and outside; covered with liquidtight jacket of flexible PVC conforming to UL 360.

E. **Available Manufacturers**. Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:

1. AFC.
2. Alflex Corp.
3. Allied Tube and Conduit.
4. Electri-Flex Company.
5. LTV Copperweld.
6. Perma-Cote Industries.
7. Robroy Industries, Inc.
8. Wheatland Tube Co.

2.2 NONMETALLIC CONDUIT

A. **Rigid Nonmetallic Conduit**. PVC, Schedule 40, 90 degrees Celsius (° C.), conforming to NEMA TC-2, UL 651, and NEC Article 347.

B. **Rigid Nonmetallic Conduit (Heavy Wall)**. PVC, Schedule 80, 90° C., conforming to NEMA TC-2, UL 651, and NEC Article 347.

C. **Liquidtight Flexible Nonmetallic Conduit**. Continuous spiral of hard PVC encapsulated with flexible PVC conforming to UL 1660.

D. **Electrical Nonmetallic Tubing**. PVC conforming to NEMA TC-13.

E. **Available Manufacturers**. Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following:

1. Alflex.
2. Cantex Industries.
3. Carlon.
4. Electric-Flex.

2.3 CONDUIT FITTINGS AND ACCESSORIES

A. **General**. Provide conduit accessories of types, sizes, and materials, complying with manufacturer's published product information, which mate and match conduit and tubing.

B. **Conduit Bodies**

1. General. Provide conduit bodies of types, shapes, and sizes as required to suit individual applications and NEC requirements. Provide matching gasketed covers secured with corrosion resistant screws.
2. Rigid Metal. Threaded galvanized cast iron or aluminum conforming to UL 514B and FS W-C-586D.
3. Nonmetallic. PVC, molded solvent weld connector conforming to UL 514B.

C. **Locknuts**. Construct locknuts with sharp edge for digging into metal and ridged outside circumference for proper fastening.

D. **Bushings**. Metal, flared bottom, ribbed sides, set screw type grounding terminal and smooth rounded inner circumference.

E. **Conduit Hubs**. Threaded hub, metal, locknut/bushing, gasket.

F. **Rigid Metal Conduit Fittings**. Threaded cast malleable iron galvanized or aluminum, fittings conforming to FS W-F-408.

G. **Flexible Metal Conduit Fittings**. Provide conduit fittings for use with flexible steel conduit of threadless hinged-clamp type.

1. Straight Terminal Connectors. One piece body, female end with clamp and deep slotted machine screw for securing conduit, and male threaded end provided with locknut.
2. 45-Degree or 90-Degree Terminal Angle Connectors. Two-piece body construction with removable upper section, female end with clamp and deep slotted machine screw for securing conduit, and male threaded end provided with locknut.

H. **Liquidtight Flexible Metal Conduit Fittings**. FS W-F-406, Type 1, Class 3, Style G. Galvanized malleable iron fittings with compression type steel ferrule and neoprene gasket sealing rings, with insulated or noninsulated throat.

I. **Rigid Nonmetallic Conduit Fittings**. NEMA TC 3, mate and match to conduit type and material.

J. **Liquidtight Flexible Nonmetallic Conduit Fittings**. PVC, one piece body with PVC ferrule and neoprene gasket.

K. **Sealing Fittings and Products**

1. Mechanical Pipe Seals. See Section 26 05 29, "Supporting Devices."
2. Joint Sealants. Refer to Section 26 05 29, "Supporting Devices."
3. Provide gland type sealing bushings for interior conduit seals. See Section 26 05 29, "Supporting Devices."

L. **Escutcheon Plates**. Chrome plated, stamped steel, hinged, split-ring escutcheon, with set screw. Inside diameter shall closely fit conduit outside diameter. Outside diameter shall completely cover the opening in floors, walls, or ceilings.

M. **Available Manufacturers**. Subject to compliance with requirements, manufacturers offering conduit fittings which may be incorporated in the work include, but are not limited to, the following:

1. Fittings.

   a. Appleton Electric.
   b. Carlon.
   c. Condux International, Inc.
   d. Crouse-Hinds.
   e. Electri-Flex Company.
   f. Killark Electric Mfg. Co.
   g. O.Z. Gedney.
   h. Raco (Hubbell).
   i. Robroy Industries.

2. Escutcheon Plates.

   a. Chicago Specialty Mfg. Co.
   b. Sanitary-Dash Mfg. Co.

2.4 WIREWAYS

A. **General**. Provide electrical wireways of types, grades, sizes, and number of channels for each type of service as indicated. Provide complete assembly of raceway including, but not limited to, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other components and accessories as required for complete system.

B. **General Purpose Wireways**. NEMA 1 steel, front accessible, totally enclosed with bolted covers. Finish with rust-inhibiting coating and gray baked enamel finish. Protect screws installed toward inside of wireway with spring nuts to prevent wire insulation damage.

C. **Oiltight Wireways**. NEMA 12, oiltight and dusttight steel with hinged gasketed cover, external latches, and flanged gasketed joints. Finished with gray enamel paint inside and outside.

D. **Watertight Wireways**. NEMA 4X, watertight, corrosion resistant stainless steel with hinged gasketed cover, screw clamps, and flanged gasketed joints.

E. **Available Manufacturers**. Subject to compliance with requirements, manufacturers offering wireways which may be incorporated in the work include, but are not limited to, the following:

   1. American Electric.
   2. B-Line Systems, Inc. (Copper).
   3. Cross Brothers, Inc.
   4. Erickson Electric Equipment Co.
   5. GS Metals Corp.
   6. Hoffman (Enclosures).
   7. Square D Company.

2.5 SURFACE RACEWAYS

A. **General.** For surface raceways provide sizes and channels as indicated. Provide fittings that match and mate with raceway.

B. **Metal Raceways.** Provide surface metal raceway constructed of (aluminum) (galvanized steel) with snap-on covers, with 1/8-inch mounting screw knockouts in base approximately 8 inches on center. Finish with manufacturer's standard prime coating suitable for painting. Provide raceways of types suitable for each application required.

C. **Nonmetallic Raceways.** Provide surface nonmetallic raceway with two piece construction, manufactured of rigid PVC compound with matte texture and manufacturer's standard color. Raceway and system components shall meet UL 94 requirements for nonflammable, self-extinguishing characteristics.

D. **Available Manufacturers.** Subject to compliance with requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:

E. **Manufacturers.** Subject to compliance with requirements, provide products by the following:

1. Surface Metal Raceway.

   a. Allied Tube & Conduit.
   b. American Electric.
   c. B-Line Systems, Inc.
   d. Erickson Electrical Equipment Co.
   e. GS Metals Corp.
   f. Hoffman Co.
   g. Square D Co.
   h. The Wiremold Co.

2. Surface Nonmetallic Raceway.

   a. Anixter, Inc.
   b. Hoffman Co.
   c. Hubbell, Inc.
   d. Panduit Corp.
   e. Gardner Bender.
   f. The Wiremold Co.

PART 3 - EXECUTION

3.1 **EXAMINATION.** Examine areas and conditions under which raceways are to be installed, and substrate which will support raceways. Notify Engineer/Architect in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer/Architect.

3.2 PREPARATION

A. **General.** Field-bend conduit with benders designed for the purpose so as not to distort or vary the internal diameter. Cut conduits straight and properly ream to remove burrs.

B. **Metal Conduits.** Cut conduit threads deep and clean. Use of running threads at conduit joints and terminations is prohibited. Conduits installed underground, in slabs, or exterior shall have threads painted with a corrosion inhibiting compound before couplings are assembled. Aluminum conduits in contact with reinforced concrete shall be isolated by a bitumastic coating.

C. **Nonmetallic Conduits.** All PVC conduit joints shall be solvent welded to provide a watertight seal capable of sustaining an internal or external pressure of 25 pounds per square inch (psi) for 1 hour. PVC conduit shall be installed in a sand bed except PVC conduit encased in concrete.

D. **Install joint sealers** as specified in Section 26 05 29, "Supporting Devices."

E. **Install mechanical pipe seals** as specified in Section 26 05 29, "Supporting Devices."

3.3 INSTALLATION - GENERAL

A. **Complete the installation of raceways** before starting installation of cables and wires in raceways. All spare raceways shall be capped or plugged and include a pull wire. All metallic raceways shall be grounded.

B. **Install raceways as indicated** in accordance with manufacturer's written installation instructions, and in compliance with NEC and National Electrical Contractors Association (NECA) "Standards of Installation." Use roughing-in dimensions furnished by the supplier for all electrically operated units. Set raceways and boxes for connection to units only after the dimensions and locations clear with other trades. Install units plumb and level, and maintain manufacturer's recommended clearances.

C. **Mechanically assemble metal raceways** for conductors to form continuous electrical conductor, and make connections to electrical boxes, fittings, and cabinets to provide effective electrical continuity and a rigid mechanical assembly. Avoid the use of dissimilar metals throughout the system to eliminate the possibility of electrolysis. Where dissimilar metals are in contact, coat all surfaces with corrosion inhibiting compound before assembling.

D. **Size conduits to meet the NEC** requirements, except no conduit shall be smaller than 3/4 inch for interior applications or 1 inch for exterior applications. The diameter of embedded conduits shall not exceed one-third of the slab or wall thickness.

3.4 INSTALLATION - CONDUITS

A. Uses Permitted

1. Use flexible metal conduit in finished areas only and only from boxes to recessed lighting fixtures (6-foot maximum length) or for concealed work in existing walls.
2. Use liquidtight flexible metal conduit for the final 24 inches of connections to motors or equipment subject to movement or vibration.
3. Use PVC coated rigid steel conduit in areas exposed to severe moisture or corrosive conditions as designated on the plans.
4. Use rigid metal conduit (RMC) for all other interior installations not exposed to severe moisture or corrosive conditions.
5. Use Schedule 40 PVC for conduits located in slabs or under slabs.
6. Use concrete-encased Schedule 40 PVC conduit for all exterior underground installations. The transition from concrete encasement to riser shall be PVC-coated rigid steel conduit.
7. Use RMC for all exterior aboveground installations.

B. Routing

1. General. Install exposed conduits and conduits above suspended ceilings, parallel or perpendicular to walls, ceilings, or structural members. Do not run through structural members. Avoid horizontal runs within partitions or side walls. Avoid ceiling inserts, lights, or ventilation ducts or outlets. Do not run conduits across pipe shafts or ventilation duct openings and keep conduits a minimum of 6 inches from parallel runs of flues, hot water pipes, or other sources of heat. Wherever possible, install horizontal raceway runs above water and steam piping.
2. Finished Areas. Conduits installed in finished areas of new construction shall be concealed in walls, in slabs, or above suspended ceilings. New conduits installed in existing finished areas shall be concealed where practical.
3. Concrete Slabs or Floors. Conduits in concrete slabs or floors shall be placed between the bottom and top reinforcing steel. Separate conduits by not less than the diameter of the largest conduit to ensure proper concrete bond. Conduits crossing in the slab or floor must be reviewed by the Engineer/Architect for proper cover.
4. Other Interior Areas. Where possible, conduits to motors or equipment more than 3 feet from walls shall be run under the slab or floor and stubbed up to the equipment. For all other interior applications, conduits shall be exposed.
5. Exterior. Do not run conduits exposed on the exterior surface of buildings.
6. Underground. Install underground conduits a minimum of 24 inches below finished grade for circuits 600 volts or less and 36 inches for circuits above 600 volts. Concrete encased conduits shall have a minimum of 3 inches of concrete cover for circuits 600 volts and less and 4 inches for circuits above 600 volts. Wherever possible, make changes of direction with long sweep bends having a minimum radius of 2.5 feet.

Conduits shall slope toward manholes or pull boxes and away from building with a pitch of not less than 3 inches in 100 feet. Provide a marker tape over all conduit runs as specified in Section 26 05 53, "Electrical Identification."

C. **Penetrations**

1. Exterior Walls. Conduits penetrating exterior walls of any structure (other than handholes, manholes, or pull boxes) below grade, at grade floors, or below grade floors shall be sealed to prevent moisture migration as specified in Section 26 05 29, "Supporting Devices." As close as practical to the penetration, install a junction box to allow for the installation of the interior conduit seal.
2. Slabs and Floors. Where PVC conduits are installed in slabs or floors, the transition from embedded to exposed shall be RMC or IMC. The metal conduit shall extend a minimum of 1 inch into the concrete. Where PVC conduits are installed below on-grade slabs or floors, the penetration shall be made with RMC or IMC.
3. Roofs. Conduits shall penetrate roofs only where specifically shown on the plans. Roof penetrations shall meet the requirements of Section 07 51 17, "Roofing and Sheet Metal."
4. Finished Walls, Floors, and Ceilings. Where conduits pass through finished walls and ceilings, install escutcheons.

D. **Supports.** All conduits shall be supported as specified in Section 26 05 29, "Supporting Devices." Support all conduits entering structures as shown on the plans and as specified in Section 26 05 29. Provide reinforcing for concrete duct banks passing through backfilled area. Reinforcing shall extend a minimum of 5 feet beyond excavation.

E. **Fittings.** Install miscellaneous fittings such as reducers, chase nipples, three piece unions, split couplings, and plugs that have been specifically designed and manufactured for their particular application. Use threaded fittings and conduit bodies for RMC and IMC. Install grounding type expansion fittings in raceways every 200 feet of linear run or wherever structural joints are crossed to allow for expansion and contraction. Draw up couplings and conduit sufficiently tight to ensure watertightness. Terminate RMC at NEMA 1 and NEMA 12 boxes with two locknuts, one inside and one outside, and a bushing. Terminate RMC and IMC at NEMA 3R, NEMA 4, and NEMA 4X enclosures and weatherproof equipment enclosures with conduit hub assemblies.

F. **Conduit Seals.** Provide explosionproof conduit seals where required by the NEC. Install approved sealing compound after conductor installation. Follow all manufacturer's installation practices.

3.5 INSTALLATION - WIREWAYS

A. **Uses Permitted**

1. Use watertight wireways in damp or wet interior areas and for all exterior areas.
2. Use oiltight wireways in dry process areas.
3. Use general purpose wireways in nonprocess areas.

B. **Routing**. Install wireways parallel or perpendicular to wall, floors, ceilings, or structural members.

C. **Supports.** All wireways shall be supported as specified in Section 26 05 29, "Supporting Devices."

D. **Fittings.** Install fittings that have been specifically designed and manufactured for their particular application.

3.6 **CLEANING**. During construction, protect partially completed raceway runs from entrance of dirt, moisture, and debris by means of suitable factory made duct plugs. After completion of installation, pull a mandrel through every conduit to check for alignment and clear passage. Use an iron shot mandrel with a diameter of 1/4 inch less than the nominal size of the conduit and with a length equal to the conduit diameter. The mandrel shall have a leather or rubber gasket slightly larger than the conduit opening. After testing the conduits with the mandrel, pull a stiff brush through each duct until it is clear of any particles of earth, sand, or gravel, then install plugs until wire is to be pulled. Clean existing ducts to be used for new cable in the same manner as noted above.

END OF SECTION

SECTION 26 05 34

CABINETS, BOXES, AND FITTINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General**. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this section.

B. **Related Sections.** The following sections contain requirements that relate to this section:

1. Section 26 00 01, "Basic Electrical Requirements."
2. Section 26 00 02, "Basic Electrical Materials and Methods."
3. Section 26 05 26, "Grounding."
4. Section 26 05 29, "Supporting Devices."
5. Section 26 05 33, "Raceways."

1.2 DESCRIPTION OF WORK

A. **General**. The Contractor shall provide the labor, tools, equipment, and materials necessary to furnish and install cabinets, boxes, and fittings in accordance with the plans and as specified herein.

B. **Types of cabinets, boxes, and fittings** specified in this section include the following:

1. Outlet and device boxes.
2. Pull and junction boxes.
3. Cabinets.
4. Hinged door enclosures.

1.3 QUALITY ASSURANCE

A. **Codes and Standards**. Perform all work to furnish and install cabinets, boxes, and fittings in compliance with applicable requirements of governing agencies having jurisdiction and in accordance with these plans and as specified herein.

B. **Underwriters' Laboratories, Inc. (UL) Listing and Labeling**. Items provided under this section shall be listed and labeled by UL.

C. **Nationally Recognized Testing Laboratory (NRTL) Listing and Labeling.** Items provided under this section shall be listed and labeled by an NRTL. The term "NRTL" shall be as defined in Occupational Safety and Health Administration (OSHA) Regulation 1910.7.

D. **National Electrical Code (NEC) Compliance**. Components and installation shall comply with National Fire Protection Association (NFPA) 70 "National Electrical Code."

E. **National Electrical Manufacturers Association (NEMA) Compliance**. Comply with NEMA Standard 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)."

1.4 SUBMITTALS

A. **General**. Furnish manufacturer's product data, test reports, and material certifications.

B. **Shop Drawings**. For shop fabricated junction and pull boxes, show accurately scaled views and spatial relationships to adjacent equipment. Show box types, dimensions, and finishes.

1.5 JOB CONDITIONS

Not used.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **Store cabinets, boxes, and fittings** in clean dry space. Protect products from weather, damaging fumes, construction debris, and traffic.

1.7 SPECIAL WARRANTY

Not used.

1.8 DEFINITIONS

A. **Cabinets.** An enclosure designed either for surface or for flush mounting having a frame, or trim in which a door or doors may be mounted.

B. **Device Box**. A box designed to house a receptacle or a switch.

C. **Enclosure**. A box, case, cabinet, or housing for electrical wiring or components.

D. **Hinged Door Enclosure**. An enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with the walls of the box.

E. **Outlet Box**. A wiring enclosure where current is taken from a wiring system to supply utilization equipment.

F. **Wiring Box**. An enclosure designed to provide access to wiring systems or for the mounting of indicating devices or of switches for controlling electrical circuits.

PART 2 - PRODUCTS

2.1 OUTLET, DEVICE, AND WIRING BOXES

A. **Metal Outlet, Device, and Wiring Boxes**

1. Conform to UL 541A, "Metallic Outlet Boxes, Electrical," and UL 514B, "Fittings for Conduit and Outlet Boxes." Boxes shall be of type, shape, size, and depth to suit each location and application.
2. Conform to NEMA OS 1, "Sheet Steel Outlet Boxes, Device Boxes, Covers, and Box Supports." Boxes shall be flat-rolled code gauge galvanized steel with stamped knockouts, threaded screw holes, and accessories suitable for each location including mounting brackets and straps, cable clamps, exterior rings, and fixture studs. Device boxes shall be minimum of 3-1/2 inches deep.
3. Provide cast aluminum boxes with threaded raceway entries, and features and accessories suitable for each location including mounting ears, threaded screw holes for devices, and closure plugs. Boxes shall be made from copper free aluminum. Device boxes shall be minimum of 2-1/2 inches deep. Outlet boxes shall be minimum of 1-1/2 inches deep.
4. Provide cast iron boxes of iron alloy, waterproof, with threaded raceway entries and features and accessories suitable for each location, including mounting ears, threaded screw holes for devices, and closure plugs. Device boxes shall be minimum of 2-1/2 inches deep. Outlet boxes shall be minimum of 1-1/2 inches deep.

2.2 PULL AND JUNCTION BOXES

A. **General**. Comply with UL 50, "Electrical Cabinets and Boxes," for boxes over 100 cubic inches volume. Boxes shall have screwed or bolted on covers of material same as box and shall be of size and shape to suit application.

B. **General Purposes Boxes**. Hot-dip galvanized sheet steel without knockouts and with welded seams. Where necessary to provide a rigid assembly, construct with internal structural steel bracing.

C. **Dusttight and Oiltight Boxes**. (Painted) (Hot-dip galvanized) sheet steel without knockouts and with welded seams and oil-resistant gasket. Rated NEMA 12.

D. **Raintight Boxes**. Painted galvanized steel, drip shield, with stamped knockouts in bottom only. Rated NEMA 3R.

E. **Weatherproof Boxes**. Type 316 stainless steel, welded seams, without knockouts. Stainless steel hardware, seamless gasket, cover clamps on all four sides. Rated NEMA 4X.

F. **Cast Aluminum Boxes**. Molded of copper-free aluminum, with gasketed cover and integral threaded conduit entrances.

2.3 HINGED DOOR ENCLOSURES

A. **General**. Comply with UL 50, "Cabinets and Enclosures," and NEMA ICS6, "Enclosures for Industrial Control and Systems."

B. **General Purpose Enclosures**. Constructed of 14-gauge sheet steel with continuous welded seams. Doors shall be hinged directly to cabinet and removable, with 3/4-inch flange around all edges, shaped to cover edge of boxes. Provide three-point handle-operated latch with key lock. Enclosure greater than 36 inches in width shall have two doors. Provide a painted removable internal mounting panel for component installation. Enclosure shall be rated NEMA 1 and shall be painted American National Standards Institute (ANSI) 61 gray.

C. **Dusttight and Oiltight Enclosures**. Constructed of 14-gauge sheet steel with continuous welded seams. Doors shall be hinged directly to cabinet and shall be removable, with 3/4-inch flange around all edges, shaped to cover edge of box. Oil resistant gasket. Provide three-point handle-operated latch with key lock. Enclosures greater than 36 inches in width shall have two doors. Provide a painted removable internal mounting panel for component installation. Enclosure shall be rated NEMA 12 and shall be painted ANSI 61 gray unless otherwise noted.

D. **Weatherproof Enclosures**. Constructed of 14-gauge Type 316 stainless steel with continuous welded seams. Doors shall be hinged directly to cabinet and shall be removable. Rolled lip around door and cabinet. Watertight seamless gasket. Stainless steel door clamps. Provide three-point handle-operated latch with key lock. Enclosures greater than 36 inches in width shall have two doors. Provide a painted, removable internal mounting panel for component installation. Enclosure shall be rated NEMA 4X.

2.4 CABINETS

A. **General**. Comply with UL 50, "Electrical Cabinets and Boxes."

B. **Cabinet shall be constructed of sheet steel,** NEMA 1 class except as otherwise indicated. Cabinet shall consist of a box and a front consisting of a one piece frame and a hinged door. Arrange door to close against a rabbet placed all around the inside edge of the frame, with a uniformly close fit between door and frame. Provide concealed fasteners, not over 24 inches apart, to hold fronts to cabinet boxes and provide for adjustment. Provide flush or concealed door hinges not over 24 inches apart and not over 6 inches from top and bottom of door. For flush cabinets, make the front approximately 3/4 inch larger than the box all around. For surface mounted cabinets make front same height and width as box.

C. **Provide double doors for cabinets** wider than 24 inches. Telephone cabinets wider than 48 inches may have sliding or removable doors.

D. **Provide combination spring catch** and key lock, with all locks for cabinets of the same system keyed alike. Locks may be omitted on signal, power, and lighting cabinets located within wire closets and mechanical-electrical rooms. Locks shall be of a type to permit doors to latch closed without locking.

2.5 ACCESSORIES

A. **Corrosion Inhibitors**. All enclosures containing equipment, terminals, or splices shall have a vapor phase corrosion inhibitor. Provide two spares for each one installed.

2.6 MANUFACTURERS

A. **Manufacturers**. Subject to compliance with requirements, provide products by the following:

1. Adalet Enclosure Systems.
2. American Electric.
3. Carlon Divison of Lamson & Sessions.
4. Crouse Hinds.
5. Erickson Electrical Equipment Co.
6. Hoffman Enclosures.
7. Killark Electric Mfg. Co.
8. O.Z. Gedney.
9. Spring City Electrical Mfg. Co.
10. Square D Co.
11. Steel City/Thomas & Betts.

PART 3- EXECUTION

3.1 COORDINATION

A. **Coordinate installation of electrical cabinets**, boxes, and fittings with wire/cable, wiring devices, and raceway installation work.

3.2 INSTALLATION

A. **Uses Permitted**

1. Outlet Boxes.

   a. Use galvanized flat rolled sheet steel boxes in finished areas with framed construction.
   b. Use cast metal boxes in all other locations. Each box with associated covers and fittings shall have a NEMA rating suitable for each location installed.

2. Pull and Junction Boxes.

   a. Use general purpose boxes in finished areas with framed construction.
   b. Use dusttight and oiltight boxes in other dry interior areas.
   c. Use weatherproof boxes for all other locations.

3. Hinged Door Enclosures.

a. Use dusttight and oiltight enclosures to house electrical equipment and controls in dry interior locations.
b. Use weatherproof enclosures to house electrical equipment and controls in all other locations.

4. Cabinets.

a. Install enclosures and associated materials and NEMA types suitable for each location and in conformance with the drawings.

B. **General**

1. Cap unused knockout holes where blanks have been removed and plug unused conduit hubs.
2. Support and fasten items securely in accordance with Section 26 05 29, "Supporting Devices."
3. Sizes shall be adequate to meet NEC volume requirements, but in no case smaller than size indicated.
4. Remove sharp edges where they may come in contact with wiring or personnel.
5. Install boxes in locations which ensure ready accessibility to enclosed electrical wiring and avoid installing boxes back to back in walls where there would be less than 6 inches (150 millimeters [mm]) separation. Fasten boxes firmly and rigidly to substrates or structural surfaces to which attached, or solidly embed electrical boxes in concrete or masonry. Aluminum boxes in contact with reinforced concrete shall be isolated by a bitumastic coating.
6. Provide electrical connections for installed boxes.

C. **Outlet, Device, and Wiring Boxes**

1. For outlets at windows and doors, locate close to window trim. For outlets indicated above doors, refer to plans for mounting height above finished floor and center outlets above the door opening except as otherwise indicated.
2. For column and pilaster locations, locate outlet boxes for switches and receptacles on columns or pilasters so the centers of the columns are clear for future installation of partitions.
3. For outlet boxes for locations in special finish materials for receptacles and switches mounted in desks or furniture cabinets or in glazed tile, concrete block, marble, brick, stone, or wood walls, use rectangular shaped boxes with square corners and straight sides. Install such boxes without plaster rings. Saw cut all recesses for outlet boxes in exposed masonry walls.

4. Mount outlet boxes for switches and receptacles with the long axis vertical or as indicated. Three or more gang boxes shall be mounted with the long axis horizontal. Locate box covers or device plates so they will not span different types of building finishes either vertically or horizontally. Locate boxes for switches near doors on the side opposite the hinges and close to door trim, even though electrical floor plans may show them on hinge side.
5. For outlet locations on exterior face of exterior walls, all outlet boxes shall be recessed in the wall.
6. For ceiling outlets for fixtures, where wiring is concealed, use 4-inch round or octagon boxes 1-1/2 inches deep, minimum.
7. For cover plates for surface boxes, use plates sized to box front without overlap.
8. Protect outlet boxes to prevent entrance of plaster and debris.
9. For concrete boxes use extra deep boxes to permit side conduit entrance without interfering with reinforcing, but do not use such boxes with over 6 inch depth.
10. Install floor boxes in concrete floor slabs so they are completely enveloped in concrete except for the top. Where normal slab thickness will not envelop box as specified above, provide increased thickness of the slab. Provide each compartment of each floor box with grounding terminal consisting of a washer-in-head machine screw, not smaller than No. 10-32, screwed into a tapped hole in the box. Adjust covers of floor boxes flush with finished floor.

D. **Pull and Junction Boxes**

1. Install clamps, grips, or devices to which cables may be secured. Arrange cables so they may be readily identified. Support cable at least every 30 inches inside boxes.
2. Mount pull boxes in inaccessible ceilings with the covers flush with the finished ceiling.
3. Provide pull and junction boxes for telephone, signal, and other systems at least 50 percent larger than would be required by Article 314 of NEC, or as indicated. Locate boxes strategically and provide shapes to permit easy pulling of future wires or cables of types normal for such systems.

E. **Cabinets and Hinged Door Enclosures**

1. Mount with fronts straight and plumb.
2. Install with tops 78 inches above floor.
3. Set cabinets in finished spaces flush with walls.
4. Use spacers to maintain 1/4-inch clearance from wall.

3.3 GROUNDING

A. **Electrically ground metallic cabinets**, boxes, and enclosures. Where wiring to item includes a grounding conductor, provide a grounding terminal in the interior of the cabinet, box, or enclosure.

3.4 CLEANING AND FINISH REPAIR

A. **Upon completion of installation** and before devices and wiring are installed, remove burrs, dirt, and construction debris and repair damaged finish including chips, scratches, abrasions, and weld marks.

B. **For galvanized finish**, repair damage using a zinc-rich paint recommended by the manufacturer.

C. **For painted finish**, repair damage using matching corrosion-inhibiting touch-up coating.

END OF SECTION

SECTION 26 05 44

MANHOLES AND HANDHOLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General**. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this section.

B. **Related Sections**. The following sections contain requirements that relate to this section:

1. Section 03 30 00, "Cast-In-Place Concrete," for cast-in-place concrete requirements except as modified herein.
2. Section 26 00 01, "Basic Electrical Requirements."
3. Section 26 00 02, "Basic Electrical Materials and Methods."
4. Section 26 05 26, "Grounding."
5. Section 26 05 29, "Supporting Devices."
6. Section 31 23 00, "Excavation, Backfill, and Embankment," for general requirements for excavation, backfill, and related items for manholes and handholes.

1.2 DESCRIPTION OF WORK

A. **General**. The Contractor shall provide the labor, tools, equipment, and materials necessary to install manholes and handholes in accordance with the plans and as specified herein.

B. **Underground Work**. This section includes underground electrical work including the following:

1. Manholes.
2. Handholes.

1.3 QUALITY ASSURANCE

A. **Codes and Standards**. Perform all work associated with manholes and handholes in compliance with applicable requirements of governing agencies having jurisdiction and in accordance with these plans and as specified herein.

B. **Manufacturer Qualifications**. Manufacturers of precast manholes and handholes shall be firms regularly engaged in manufacturing factory fabricated manholes and handholes, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 3 years.

1.4 SUBMITTALS

A. **General.** Furnish manufacturer's product data, test reports, and material certification as required.

B. **Submittals.** Submit the following in accordance with Conditions of Contract and Division 1 specification sections.

1. Product data for accessories for manholes and handholes and miscellaneous components. Include:

   a. Frames and covers.
   b. Pulling eye assemblies.
   c. Pulling and lifting hardware.
   d. Bolting inserts.
   e. Cable stanchions, arms, and insulators.
   f. Sump frames and cover.
   g. Manhole ladder.

C. **Detail drawings and design calculations** for precast manholes and handholes including reinforcing steel. Calculations shall reflect the conditions of this project and shall conform to the latest edition of the applicable codes. Drawings shall bear the stamp of a registered professional structural engineer in the state of Ohio.

1.5 JOB CONDITIONS

Not used.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **Store precast concrete units** at site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

B. **Lift and support precast concrete units** only at designated lifting or supporting points.

1.7 SPECIAL WARRANTY

Not used.

1.8 DEFINITIONS

A. **Manhole.** A below the surface enclosure or chamber, large enough for a person to enter, connecting with ducts, and affording facilities for installing, operating, and maintaining equipment or wiring.

B. **Handhole.** A below the surface enclosure in connection with ducts into which people reach, but do not enter, for the purpose of installing, operating, or maintaining equipment or wiring.

1.9 SEQUENCING AND SCHEDULING

A. **Coordination of the Work**. Coordinate layout and installation of manholes and handholes with final arrangement of ducts as influenced by actual final location of other utilities in the field. Coordinate elevations of duct and raceway entrances into manholes and handholes with final profiles of conduits as determined by coordination with other utilities and underground obstructions. Revise locations and elevations from those indicated as required to suit field conditions and ensure duct runs drain to manholes and handholes and as approved by the Engineer/Architect.

PART 2 - PRODUCTS

2.1 MATERIALS

A. **Manhole/Handhole Hardware and Accessories**

1. Frames and covers shall be cast iron conforming to American National Standards Institute (ANSI) C2, "National Electrical Safety Code," Rule 323. Furnish with cast in legend, "Electric" or "Signal" as appropriate. Cover to frame bearing surfaces machined.
2. Sump frame and grate shall comply with Federal Specification (FS) RR-F 621, Type VII for frame, Type I for cover. Locate sump at center of manhole or handhole directly below the cover.
3. Pulling eyes in walls shall be eyebolt with rebar fastening insert. Two inch diameter eye, 1" x 4" long bolt. Working load embedded in 6 inch, 4,000 pounds per square inch (psi) concrete: 13,000 pounds minimum tension.
4. Pulling and lifting irons in floor shall be 7/8-inch diameter hot dipped galvanized, bent steel rod, stress relieved after forming, and fastened to reinforced rod. Exposed triangular shaped opening. Ultimate yield strength, 40,000 pounds shear, 60,000 pounds tension.
5. Bolting inserts for cable stanchions shall be flared, threaded inserts of noncorrosive, chemical resistant, nonconductive thermoplastic material. One-half inch internal diameter by 2-3/4 inches deep, flared to 1-1/4-inch minimum at base. Tested ultimate pull-out strength: 12,000 pounds, minimum.
6. Expansion anchors for installation after concrete is cast shall be zinc plated carbon steel wedge type with stainless steel expander clip 1/2-inch bolt size, 5,300-pound rated pull-out strength, and 6,800-pound rated shear strength, minimum.
7. Barriers shall be provided for voltage separation of electrical, telephone, and instrumentations cables.
8. Cable stanchions shall be hot rolled, hot dipped galvanized "T" section steel, 2-1/4-inch size, punched with 14 holes on 1-1/2-inch centers for cable arm attachment.
9. Cable arms shall be 3/16-gauge hot rolled, hot dipped galvanized sheet steel pressed to channel shape, approximately two 12 inches wide by 14 inches long and arranged for secure mounting in horizontal position at any position on cable stanchions.

10. Cable support insulators shall be high glaze, wet process porcelain arranged for mounting on cable arms.

B. **Manhole and Handhole Moistureproofing**

1. Conform to Section 07 10 00, "Waterproofing."

C. **Precast Manholes and Handholes**

1. Factory-fabricated of reinforced concrete and in conformance with ANSI C 2, "National Electrical Safety Code (NESC)" and applicable requirements of ASTM C 478, "Specifications for Precast, Reinforced Concrete Manhole Sections." Manhole structure shall be designed in accordance with requirements of the American Concrete Institute (ACI) 318, "Building Code Requirements for Reinforced Concrete," and the American Association of State Highway and Transportation Officials (AASHTO) publication "Standard Specifications for Highway Bridges." AASHTO H20 highway loading shall apply with 30 percent loading added for impact.
2. Handholes, unless otherwise indicated, shall be 4' W x 4' L x 4' D and shall be constructed of precast concrete in two sections. The reinforced concrete shall utilize Grade 60 reinforcing bars and Type II cement with a concrete strength equal to 4,500 psi. Reinforcing shall be tied unless evidence of compliance with ASTM A 184, "Fabricated Deformed Steel Bar Mats for Concrete Reinforcement," is approved by Engineer/Architect prior to fabrication.
3. Precast units consisting of interlocking, mating sections, complete with accessory items, hardware, and features as indicated including concrete knockout panels for conduit entrance and sleeve for ground rod.
4. Joint sealant for joints between precast sections shall be continuous extrusion of asphaltic butyl material compounded for the adhesion, cohesion, flexibility, and durability properties required for a permanent seal against the maximum hydrostatic pressures theoretically attainable at the installation location with the ground water level at grade.

D. **Extra Materials**

1. Furnish the following extra materials matching products installed, packaged with protective covering for storage and with identification labels clearly describing contents.

   a. Cable stanchions, support arms, insulators, and associated fasteners in the quantity of 10 percent of those installed for actual use in this project.

2.2 MANUFACTURERS

A. **Manufacturers.** Subject to compliance with requirements, provide products by one of the following:

1. Precast Manholes and Handholes.

   a. CDR Systems Corporation.
   b. Christy Concrete Products, Inc.
   c. Hartford Concrete Products, Inc.
   d. Norwalk Concrete Industries.
   e. Strongwell.
   f. Oldcastle Precast.
   g. Smith-Midland Corp.

2. Frames and Covers.

   a. East Jordan Iron Works, Inc.
   b. Campbell Foundry Co.
   c. Neenah Foundry Co.

PART 3 - EXECUTION

3.1 INSTALLATION

A. **Duct Entrances to Manholes and Handholes**. End bells spaced approximately 10 inches center to center for 5-inch ducts and varied proportionately for other duct sizes. The change from regular spacing to end bell spacing shall start 10 feet from the end bell and shall be made without reducing duct line slope and without forming a trap in the line. Grout end bells into manhole walls from both sides to provide watertight entrances.

B. **General**. Provide manholes/handholes of sizes, shapes, and locations as indicated. Determine final grading of ducts as influenced by possible adjustments in other utilities and surface features and discovery of underground obstructions before installing manholes/handholes. Obtain Engineer/Architect's approval for manhole/handhole installation adjustments necessitated by the above. Install units plumb and level and with orientation and depth coordinated with arrangement of connecting ducts to minimize bends and deflections required for proper entrances.

C. **Elevation**. Install manholes with rooftop 15 inches below finished grade, minimum. Install handholes with depth as indicated. Where indicated, cast handhole cover frame directly into roof of handhole and set roof surface 1 inch above grade.

D. **Drainage**. Install drains in bottom of units where indicated. Arrange to coordinate with drainage provisions indicated or specified.

E. **Precast Access**. Install access to manhole/handhole through cast iron frame and cover. For manholes, use 30-inch-diameter cover except as indicated. Use 30-inch-diameter cover for handholes except use 24-inch-diameter covers for 2' x 2' handholes. Install precast concrete rings and seal with joint sealant as described in Part 2 of this specification. In addition, caulk all seams and joints inside and

out. Set frames in paved areas and traffic ways flush with finished grade. Set other frames 1 inch above finished grade.

F. **Waterproofing**. Apply waterproofing to exterior surfaces of units after concrete has cured at least 3 days. Apply in accordance with requirements of Section 07 10 00, "Waterproofing." After ducts have been connected and grouted in, and prior to backfilling, waterproof joints and connections and touch up abrasions and scars. Waterproof exterior of manhole/handhole chimneys after brick mortar has cured at least 3 days.

G. **Hardware.** Install removable hardware including pulling eyes, cable stanchions, cable arms, and insulators as required for installation and support of cable and conductors and as indicated.

H. **Hardware**. Furnish removable hardware including pulling eyes, cable stanchions, cable arms, and insulators for installation under another contract. For each manhole/handhole furnish one stanchion for each 2.5 lineal feet of interior floor perimeter. In addition, furnish one arm for each stanchion, three insulators for each arm, and a total of three pulling eyes. Furnish materials complete with associated fasteners, packaged with protective covering for storage and with identification labels clearly describing contents.

I. **Field Installed Bolting Anchors**. Do not drill deeper than 3-7/8 inches for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

J. **Install barriers for voltage separation** of electrical, telephone, and instrumentation cables.

K. **Grounding.** Provide grounding as specified in Section 26 05 26, "Grounding."

3.2 INSTALLATION OF PRECAST MANHOLES/HANDHOLES

A. **Install in accordance with ASTM C 891**, "Practice for Installation of Underground Precast Concrete Utility Structures," and manufacturer's instructions.

B. **Support units on a level bed of crushed stone** or gravel, graded from the 1 inch sieve to the No. 4 sieve and compacted to same density as adjacent undisturbed earth.

C. **Compact backfill as required** to set units securely in place. Backfill and grading shall be sloped to drain surface water away from access covers.

3.3 FIELD TESTING

A. **Grounding**. Test manhole grounding provisions to ensure electrical continuity of bonding and grounding connections. Make ground resistance test at each ground rod and submit a report of the results. Use an instrument specifically designed for ground resistance measurements.

B. **Watertightness**. Make internal inspection of manholes/handholes 3 months after completion of construction for indications of water ingress. Where leakage is noted, remove any water found and seal leakage sources. Reinspect after 2 months and reseal any remaining leakage sources. Repeat process at 2 month intervals until leakage is corrected.

3.4 CLEANING AND RESTORATION

A. **Clean Manholes**. Clean all internal surfaces of manholes including sump. Remove all foreign material.

B. **Restoration**. Restore surface features at areas disturbed by excavation and reestablish original grades except as otherwise indicated. Where sod has been removed, replace it as soon as possible after backfilling is completed. Restore all areas disturbed by trenching, storing of dirt, cable laying, and other work to their original condition. The restoration shall include all necessary topsoil, fertilizing, liming, seeding, sodding, sprigging, or mulching. All such work shall be performed in accordance with section "Grading and Seeding." Maintain disturbed surfaces. Restore vegetation in accordance with section "Grading and Seeding." Restore disturbed paving as indicated.

END OF SECTION

SECTION 26 05 53

ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General**. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this section.

B. **Related Sections**. The following sections contain requirements that relate to this section:

1. Section 09 90 00, "Painting," for related identification requirements.
2. Section 26 00 01, "Basic Electrical Requirements."
3. Section 26 00 02, "Basic Electrical Materials and Methods."

1.2 DESCRIPTION OF WORK

A. **General**. The Contractor shall provide the labor, tools, equipment, and materials necessary to perform the work in accordance with the plans and as specified herein.

B. **This section includes identification** of electrical materials, equipment, and installations. It includes requirements for electrical identification components including, but not limited to, the following:

1. Buried electrical line warnings.
2. Identification labeling for raceways, cables, and conductors.
3. Operational instruction signs.
4. Warning and caution signs.
5. Equipment labels and signs.

1.3 QUALITY ASSURANCE

A. **Codes and Standards**. Perform all work associated with electrical identification in compliance with applicable requirements of governing agencies having jurisdiction, in accordance with these plans, and as specified herein.

B. **National Electrical Code**. Provide warning signs where required by National Fire Protection Association (NFPA) 70 "National Electrical Code (NEC)."

C. **American National Standards Institute (ANSI) Compliance**. Comply with requirements of ANSI Standard A13.1, "Scheme for the Identification of Piping Systems," with regard to type and size of lettering for raceway and cable labels.

1.4 SUBMITTALS

A. **Transmittals.** Furnish manufacturer's product data, test reports, and materials certifications as required.

B. **Submit the following** in accordance with Conditions of Contract and Division 1 specification sections:

1. Product data for each type of product specified.

1.5 JOB CONDITIONS

Not used.

1.6 DELIVERY, STORAGE, AND HANDLING

Not used.

1.7 SPECIAL WARRANTY

Not used.

PART 2 - PRODUCTS

2.1 MATERIALS

A. **Box, Conduit, and Raceway Identification**

1. Adhesive Labels. Preprinted, flexible, self-adhesive orange vinyl labels with black legend. Legend covered with clear weather and chemical resistant coating.
2. Plastic Sleeves. Preprinted, pretensioned, snap-on, flexible, wraparound plastic sleeves with black legend. Sized to fit conduit diameter.
3. Plasticized Card Stock Tags. Vinyl cloth with preprinted and field printed legends. Orange background, except as otherwise indicated, with eyelet for fastener.
4. Buried Line Warning Tape. Permanent, bright colored (orange), continuous printed, plastic warning tape not less than 6 inches wide by 4 mils thick with continuous metallic strip or core. Printed legend indicative of general type of underground line below.

B. **Wire and Cable Identification**

1. Colored Marking Tape. Self-adhesive vinyl tape not less than 7 mils thick and 3/4 inch wide.
2. Wire Labels. Self-adhesive wraparound labels with clear heat shrinkable jacket or permanent plastic heat shrinkable labels. Preprinted legends.
3. Aluminum Face Card Stock Tags. Weather resistant, 18 point minimum card stock faced on both sides with embossable aluminum sheet, 0.002 inch thick, and laminated with moisture resistant acrylic adhesive. Preprint legend to suit the application and punch for tie fastener.

4. Aluminum Wraparound Marker Bands. Bands with stamped or embossed legend and slots or ears for permanently securing around wires, cables, or groups of wires. Four millimeter (mm) thick sheet aluminum.

C. **Nameplates and Signs**

1. Laminated Plastic. Engraving stock plastic laminate, 1/16 inch minimum thick for signs up to 20 square inches, or 8 inches in length; 1/8 inch thick for larger sizes. Engrave legend in black letters on white face unless otherwise noted and punched for mechanical fasteners.
2. Metal Backed Butyrate. Weather-resistant, nonfading, preprinted cellulose acetate butyrate signs with 20-gauge, galvanized steel backing, with colors, legend, and size appropriate to the location. Provide 1/4-inch grommets in corners for mounting.
3. Brass or Aluminum Tags. Metal tags with stamped legend, punched for fasteners. Dimensions: 2 inches by 2 inches by 19 gauge.

D. **Accessories**

1. Fasteners. Self-tapping stainless steel screws or number 10/32 stainless steel machine screws with nuts and flat and lock washers.
2. Cable Ties. Fungus inert, self-extinguishing, one piece, self-locking nylon cable ties, 0.18-inch minimum width, 50-pound minimum tensile strength, and suitable for a temperature range from minus 40 degrees Fahrenheit (° F.) to 185 ° F. Provide ties in specified colors when used for color coding.

2.2 MANUFACTURERS

A. **Manufacturers**. Subject to compliance with requirements, provide products by the following:

1. American Labelmark Co.; Labelmaster Subsidiary
2. Brady Corp.
3. Carlton Industries, Inc.
4. Champion American, Inc.
5. Ideal Industries, Inc.
6. Markal Corp.
7. National Band and Tag Co.
8. Panduit Corp.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. **Conduits**

1. Underground Lines. Identify with warning tape in trench above conduits.

B. **Boxes**

1. Code Required Caution Signs. Self-adhesive labels indicating system voltage. Install on outside of box cover.
2. Circuit Identification. Self-adhesive labels indicating contained circuits.

C. **Wires and Cables**

1. Color Coding. Color code service, feeder, and branch circuit conductors as follows:

208/120 Volts	Phase	480/277 Volts
Black	A	Brown
Red	B	Orange*
Blue	C	Yellow
White	Neutral	White
Green	Ground	Green

*Where not permitted by inspecting authority, use purple.

   a. Use conductors with colored insulation or use colored marking tape for sizes 8 American Wire Gauge (AWG) and smaller.
   b. Use colored marking tape for sizes larger than No. 8 AWG. Apply for a distance of 6 inches from terminal points and in boxes where splices or taps are made.

2. Circuit Identification. Use aluminum wraparound marker bands to identify feeders and branch circuits in manholes, handholes, and pull boxes.

3. Conductor Labeling. Use wire labels to identify conductors as follows:

   a. Conductors indicated to be for future connection or connection under another contract with identification indicating source and circuit numbers.
   b. Where multiple branch circuits or control wiring or communications/signal conductors are present in the same box or enclosure (except for three circuit, four wire home runs), label each conductor or cable. Provide legend indicating source, voltage, circuit number, and phase for branch circuit wiring. Phase and voltage of branch circuit wiring may be indicated by means of coded color of conductor insulation. For control and communications/signal wiring, use color coding for wire/cable marking tape at terminations and at intermediate locations where conductors appear in wiring boxes, troughs, and control cabinets. Use consistent letter/number conductor designations throughout on wire/cable marking tapes.
   c. Match identification markings with designations used in panelboards, shop drawings, Contract Documents, and similar

previously established identification schemes for the facility's electrical installations.

d. Provide securely attached nameplates identifying all ground buses. Provide securely attached nametags to each accessible termination, attachment, or bonding location for each equipment grounding conductor, grounding electrode conductor, and bonding conductor.

D. **Signs**

1. Install warning, caution, or instruction signs where required by NEC, where indicated, or where reasonably required to ensure safe operation and maintenance of electrical systems and of the items to which they connect. Install engraved plastic laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install butyrate signs with metal backing for outdoor items.
2. For emergency operating signs, install engraved laminate signs with white legend on red background with minimum 3/8 inch high lettering for emergency instructions on power transfer, load shedding, or other emergency operations.
3. Provide code required signs for multiple main switches, for standby power systems, and, where required, for generator ground connection.

E. **Nameplates**

1. General. Provide equipment identification nameplates for each major unit of electrical equipment, including central or master units of each electrical system. This includes communication/signal/alarm systems unless unit is specified with its own self-explanatory identification. Text shall match terminology and numbering of the contract documents and shop drawings.

2. Provide 1-1/2-inch high engraved plastic laminated nameplates (2 inches high where two lines of text are required) with 1/2-inch lettering for the following:

   a. Panelboards, electrical cabinets, and enclosures.
   b. Motor control centers.
   c. Motor starters.
   d. Power transfer equipment.
   e. Transformers.
   f. Battery racks.
   g. Power generating units.
   h. Enclosed circuit breakers.
   i. Disconnect switches.
   j. Control panels.

3. Provide 5/8-inch-high engraved plastic laminated nameplates (1-inch high where two lines of text are required) with 1/4-inch high lettering for individual compartments of the following:

   a. Motor control centers.

4. Provide 5/8-inch-high engraved plastic laminated namplates (1-inch high where two lines of text are required) with 1/4-inch high lettering for the following:

   a. Push-button stations.
   b. Remote controlled switches.
   c. Dimmers.
   d. Control devices.
   e. Light switches.
   f. Downstream receptacles protected by an upstream Ground Fault Interrupter (GFI) receptacle. The nameplate shall indicate that the receptacle is supplied through a GFI receptacle and the location of the GFI receptacle.

5. Install labels at locations indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment. All code requirements for signage shall be met.

3.2 INSTALLATION

A. General

1. Lettering and Graphics. Coordinate names, abbreviations, colors, and other designations used for electrical identification with corresponding designations specified or indicated. Install numbers, lettering, and colors as approved in submittals and as required by code.
2. Install identification devices in accordance with manufacturer's written instructions and requirements of NEC. Clean surfaces of dust, loose material, and oily films before applying.
3. Sequence of Work. Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.
4. Install labels where indicated or at locations for best viewing without interference with operation and maintenance of equipment.

B. Painting

1. Clean surface of dust, loose material, and oily films before painting.
2. For galvanized metal, use single component acrylic vehicle coating formulated for galvanized surfaces. For concrete masonry units, use heavy-duty, acrylic-resin block filler. For concrete surfaces, use clear, alkali-resistant, alkyd binder-type sealer.
3. Apply one intermediate and one finish coat of orange silicone alkyd enamel.

4. Apply primer and finish materials in accordance with manufacturer's instructions.

C. **Buried Line Warning Tape**. During trench backfilling, for exterior underground power, control, signal, and communications cables and conduits, install continuous underground plastic line marker, located directly above line at 6 to 8 inches below finished grade. Where multiple lines are installed in a common trench or concrete envelope, do not exceed an overall width of 16 inches; install a single line marker.

D. **Tape**. Apply colored, pressure sensitive plastic tape in half-lapped turns. Apply the last two turns of tape with no tension to prevent possible unwinding. Do not obliterate cable identification markings by taping. Tape locations may be adjusted slightly to prevent such obliteration.

E. **Metal Tags**. Attach metal tags with one piece self-locking nylon cable ties.

F. **Cable Ties**. Apply cable ties with a special tool or pliers; tighten for snug fit and cut off excess length.

END OF SECTION

SECTION 26 24 19

MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General**. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this section.

B. **Related Sections**. The following sections contain requirements that relate to this section:

1. Section 26 00 01, "Basic Electrical Requirements."
2. Section 26 00 02, "Basic Electrical Materials and Methods."
3. Section 26 05 26, "Grounding."
4. Section 26 05 53, "Electrical Identification," for identification labels and warning signs for motor control centers (MCCs) and their components.
5. Section 26 29 00, Motor Controllers," for motor control devices installed in MCCs.

1.2 DESCRIPTION OF WORK

A. **Scope of Work**. The Contractor shall provide the labor, tools, equipment, and materials necessary to furnish and install MCCs in accordance with the plans and as specified herein.

1. This section includes MCCs for use on alternating current (ac) circuits rated 600 volts (V) or less. Extent of MCC work is indicated by drawings and schedules.

2. Types of MCC components specified in this section include the following:

a. MCC supporting structures.
b. Bus systems.
c. Unit compartments.
d. Motor controller units.
e. Feeder units.
f. Overload protection.
g. Overcurrent protection.
h. Control components.

1.3 QUALITY ASSURANCE

A. **Codes and Standards.** Perform all work to furnish and install MCCs in compliance with applicable requirements of governing agencies having jurisdiction and in accordance with these plans and as specified herein.

1. Listing and Labeling. Provide MCCs that are listed and labeled.

   a. The Terms "Listed" and "Labeled." As defined in the National Electrical Code (NEC), Article 100.

2. Electrical Component Standard. National Fire Protection Association (NFPA) 70, "NEC," for components and installation.

3. National Electrical Manufacturers Association (NEMA) Standard. NEMA ICS 2, "Standards for Industrial Control Devices, Controllers and Assemblies."

4. Underwriters' Laboratories, Inc. (UL) Standard. UL 845, "Motor Control Centers."

1.4 SUBMITTALS

A. **Product Data.** Submit manufacturer's technical product data on MCC. Application data to include, but not be limited to, the following:

1. Voltage.
2. Phase.
3. Frequency.
4. Horizontal bus capacity.
5. Vertical bus capacity.
6. Short circuit ratings.
7. Main and branch circuit breaker ratings.
8. Types of motor controllers.
9. Types of wiring (NEMA type wiring).
10. Enclosures.
11. Sections.
12. Motor size and overload heaters.
13. Panels and transformers.
14. Control components.
15. Overcurrent protective devices.
16. Metering components.

B. **Shop Drawings.** Submit layout drawings of MCCs showing accurate scaled basic equipment sections including, but not limited to, motor controllers, device panels, and circuit breakers. Show spatial relationships of MCC components to proximate electrical equipment. Submit unit wiring diagrams and elementary control wiring diagrams which show all external devices connected to the motor control circuit. Control wiring diagrams shall be in ladder logic form. Clearly differentiate on wiring diagrams those conductors which are factory installed and

those which are field installed. Provide terminal and wire numbers on control diagrams.

C. **Maintenance Data.** Submit maintenance data and parts list for each MCC, including "troubleshooting" maintenance guide. Include that data, product data, and shop drawings in a maintenance manual.

1.5 **JOB CONDITIONS**

A. **Coordination.** Coordinate with other trades to prevent delays, omissions, or errors.

1.6 **DELIVERY, STORAGE, AND HANDLING**

A. **Delivery.** Deliver in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.

B. **Storage.** Store so condensation will not occur on or in MCCs. During storage, provide temporary heaters to prevent condensation from occurring.

C. **Handling.** Handle MCCs in accordance with NEMA ICS 2.3, "Instructions for Handling, Installation, Operation, and Maintenance of Motor Control Centers." Use factory installed lifting provisions.

1.7 **SPECIAL WARRANTY**

Not used.

PART 2 - PRODUCTS

2.1 **GENERAL**

A. **Provide MCCs** and ancillary components which comply with manufacturer's standard design, materials, components, and construction in accordance with published product information.

B. **Main Entrance.** Provide MCCs for top or bottom main entry as shown on the drawings. All MCCs installed above accessible spaces shall utilize Type 304 stainless steel underfloor pull boxes with angle iron frames. Boxes shall be dusttight. Conduit entrance shall be via a grounding, threaded fitting.

C. **Ratings.** Voltage and current rating of MCCs shall be as shown on the drawings. Unless otherwise shown, the short circuit withstand rating of MCCs shall be 22,000 amperes RMS symmetrical.

2.2 **CONSTRUCTION**

A. **General.** Provide MCCs consisting of one or more vertical sections, each with groupings of unit compartments containing motor controllers, feeder, and auxiliary devices as indicated.

B. **Wiring.** Provide MCC with NEMA Class 2, Type B wiring. All wiring shall be identified by a permanent plastic heat shrink label at each termination.

C. **Supporting Structures.** Provide factory-assembled, deadfront, vertical MCC sections, as shown on the plans, fastened together to form rigid freestanding assembly. Construct each section 90 inches high, 20 inches wide, and a minimum of 15 inches deep. Provide NEMA Type 1 enclosure. Construct each section with 6-inch-minimum horizontal wireways at top and bottom and a 4-inch-wide, 6-inch-deep, 72-inch-high vertical wireway on the right. The vertical wireway shall be accessible through hinged doors, and with supports at proper intervals within for fastening wires/cables. Form supporting members of not less than 13-gauge hot rolled steel. Construct structure doors with removable pin hinges and secure with quarter turn indicating type fasteners. Provide removable lifting angle full length of MCC. Design lifting angle to support entire weight of MCC section. Design bottom channels to be removable; provide holes for bolting MCC units to floor. Provide shipping splits in MCC lineup to allow for shipment of maximum 60-inch-long units. Design MCCs so matching vertical sections of same current rating and manufacturer can be added later at either end of lineup without use of transition sections. Provide removable end and top plates to close off openings.

D. **Bus System.** Provide tin-plated copper bus bars. Provide main horizontal bus with an ampere rating as shown on the drawings. Provide vertical bus rated for 300 amperes unless otherwise noted on the drawings. Construct vertical bus bar barriers with automatic shutters to cover bus stab openings when units are removed. Provide tin-plated copper ground bus running full width of MCC at bottom of lineup. Drill ground bus and furnish lugs for each unit compartment.

E. **Equipment/System Identification.** Provide equipment/system identification nameplates complying with Section 26 05 53, "Electrical Identification," in accordance with the drawings.

F. **Finishes.** Thoroughly clean interior and exterior of supporting structures and unit compartments prior to coating of MCC, including bolted joints, with rust inhibiting prime coat. Provide two finish coats of manufacturer's standard color baked-on enamel or electrostatically applied powder paint.

2.3 UNIT COMPARTMENTS

A. **General.** Provide draw-out-type unit compartments with doors, unit support pans, saddles, and disconnect operators. Enclose and isolate each unit from adjacent units. Provide draw-out units with a de-energized position where the unit is still supported by the structure, but no electrical connection is made. Provide a method of locking the unit in the de-energized position. Design plug-in units of the same type and size to be interchangeable with each other. Provide plug-on connections for each electrical power phase. Design the contact fingers to be floating and self-aligning. Tin-plate the contacts for low resistance connections. Interiors shall be painted white or off-white. Units shall have pull-apart terminal strips.

B. **Unit Doors.** Provide unit doors securely mounted with a minimum of two rugged concealed type hinges which allow doors to swing open a minimum of 115 degrees for ease of unit maintenance and withdrawal. Fasten doors to structure so that they remain in place when unit is withdrawn. Closed door must cover unit space when unit has been temporarily removed. Provide interlock for each unit door with associated disconnect mechanism to prevent door from opening when unit is energized.

C. **Disconnect Operators.** Provide external operator handles for controllers, switches, and circuit breakers. Design handle with up-down motion and with down position indicating OFF. Construct handles which permit locking handle in OFF position with three padlocks.

D. **Circuit Breakers.** Provide thermal magnetic molded case circuit breakers as specified in Section 26 28 00, "Overcurrent Protective Devices." Sizes shall be as shown on the drawings.

F. **Main Circuit Breakers.** Provide solid-state trip circuit breakers as specified in Section 26 28 00, "Overcurrent Protective Devices." See plans for size. The main service for every building shall have a service equipment label.

H. **Motor Controller Units.** Provide combination type motor controller units, types as specified in Section 26 29 00, "Motor Controllers," with thermal magnetic circuit breaker or fused switch as indicated. Provide a 120-volt control power transformer for each motor controller unit with two primary fuses and one secondary fuse. The transformer secondary shall be grounded. Units shall be NEMA rated.

2.4 ACCESSORIES

A. **Control Components.** Provide quantity and type of control components and auxiliary contacts indicated in the drawings and/or schedules. Control devices shall be as specified in Section 40 93 13, "Control Devices." All control equipment conductors shall be landed with vinyl insulated locking fork terminals.

2.5 MANUFACTURERS

B. **Manufacturers.** Subject to compliance with requirements, provide products by the following:

1. Allen-Bradley Co.
2. Cutler Hammer Products.
3. General Electric Co.
4. Siemens Energy & Automation, Inc.
5. Square D Co.

PART 3 - EXECUTION

3.1 EXAMINATION

A. **Inspection**. Examine areas and conditions under which MCCs are to be installed, and substrate which will support MCCs. Notify Engineer/Architect in writing of conditions detrimental to proper completion of the work. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Engineer/Architect.

3.2 INSTALLATION

A. **General.** Install MCCs as indicated, in accordance with equipment manufacturer's written instructions and with recognized industry practices, complying with applicable requirements of NEC, NEMA's Standard Pub/No. ICS-2, and NEC "Standard of Installation."

1. Provide and install housekeeping pads for all MCCs.
2. Coordinate with other electrical work including wiring/cabling and raceway work, as necessary to interface installation of MCCs with other work. Install control wiring from master terminal blocks in top and bottom horizontal wireways to all associated unit compartment terminal blocks.
3. Install fuses, if any, in MCC units.
4. Seal all conduit and cable tray entrances to MCCs, after wire installation, with silicone foam.
5. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standard 486A and B.
6. Provide equipment grounding connections for MCCs as indicated. Tighten connections to comply with tightening torques specified in UL Standard 486A to ensure permanent and effective grounds.

3.3 FIELD QUALITY CONTROL

A. **Prior to energization of MCCs**, check with insulation resistance tester for proper values of phase-to-phase and phase-to-ground insulation resistances. Log that data, and submit to Engineer/Architect.

B. **Prior to energization of circuitry**, check control center electrical circuits for continuity and for short circuits.

C. **Subsequent to wire/cable and raceway hookups**, energize MCC circuitry and check each motor for proper phase rotation.

D. **Install approved overloads** after all wiring is checked.

3.4 ADJUSTING

A. **Adjust operating mechanisms** for free mechanical movement.

3.5 CLEANING

A. **Touch up scratched or marred surfaces** to match original finishes.

3.6 DEMONSTRATION

A. **Schedule an operational demonstration** with the Engineer/Architect and Owner with at least 7 days' advance notification. Demonstrate capability and compliance of MCCs and all associated controls with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace malfunctioning units with new units and proceed with retesting.

3.7 EXTRA MATERIALS

A. **Spare Fuses.** Furnish six spares of each type and rating of fuse and fusible devices required. Include spares for:

1. Control power fuses.
2. Fuses and fusible devices for fused circuit breakers.
3. Fuses for fusible switches.

B. **Spare Indicating Lights.** Furnish six of each type required.

C. **Touch-Up Paint.** Furnish three 1/2-pint containers.

END OF SECTION

SECTION 26 27 26

WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General**. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this section.

B. **Related Sections**. The following sections contain requirements that relate to this section:

1. Section 26 00 01, "Basic Electrical Requirements."
2. Section 26 00 02, "Basic Electrical Materials and Methods."
3. Section 26 05 53, "Electrical Identification," for requirements for legends to be engraved on wall plates.
4. Section 26 28 16, "Circuit and Motor Disconnects," for devices other than snap switches and plug/receptacle sets used as disconnects for motors.

1.2 DESCRIPTION OF WORK

A. **General**. The Contractor shall provide the labor, tools, equipment, and materials necessary to furnish and install wiring devices in accordance with the plans and as specified herein.

1. This section includes the following:

a. Receptacles.
b. Ground fault circuit interrupter (GFCI) receptacles.
c. Plugs.
d. Plug connectors.
e. Snap switches.
f. Wall plates.

1.3 QUALITY ASSURANCE

A. **Codes and Standards**. Perform all work to furnish and install wiring devices in compliance with applicable requirements of governing agencies having jurisdiction and in accordance with these plans and as specified herein.

1. Regulatory Requirements. Comply with provisions of the following codes.
2. National Fire Protection Association (NFPA) 70, "National Electrical Code (NEC)."
3. Underwriters' Laboratories, Inc. (UL) and National Electrical Manufacturers Association (NEMA) Compliance. Provide wiring

devices which are listed and labeled by UL and comply with applicable UL and NEMA standards.

1.4 SUBMITTALS

A. **Transmittals.** Furnish manufacturer's product data, test reports, and materials certifications as required.

B. **Submit the following** in accordance with Conditions of Contract and Division 1 specifications sections:

1. Product data for each type of product specified.
2. Samples of those products indicated for sample submission in Owner's Representative comments on product data submittal. Include color and finish samples of device plates and other items per Owner's Representative.

1.5 JOB CONDITIONS

A. **Sequence and Scheduling**. Schedule installation of finish plates after the surface upon which they are installed has received final finish.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **Deliver wiring devices and components** properly packaged in factory fabricated type containers.

B. **Store wiring devices and components** in original packaging and in a clean, dry space; protect from weather and construction traffic.

C. **Handle wiring devices and components** carefully to avoid breakages, impacts, denting, and scouring finishes. Do not install damaged equipment; replace/return damaged units to equipment manufacturer.

1.7 SPECIAL WARRANTY

Not used.

PART 2 - PRODUCTS

2.1 MATERIALS

A. **Manufacturers**

1. Manufacturers. Subject to compliance with requirements, provide products by one of the following:

a. Wiring Devices.

1) Bryant Electric Co.
2) Hubbell, Inc.

3) Pass & Seymour/Legrand.

B. **Wiring Devices**

1. General. Provide wiring devices, in types, characteristics, grades, colors, and electrical ratings for applications indicated which are UL listed and which comply with NEMA WD 1 and other applicable UL and NEMA standards. Provide ivory color devices and wall plates except as otherwise indicated. Verify color selections with Engineer/Architect.

2. Receptacles.

   a. As scheduled in Table 1 in Part 3 below. Comply with UL 498 and NEMA WD 1.
   b. Receptacles, Industrial Heavy-Duty. Provide pin and sleeve design receptacles conforming to UL 498. Provide features indicated.
   c. Ground Fault Interrupter (GFI) Receptacles. As indicated in Table 1 in Part 3 below; provide "feed through" type ground fault circuit interrupter, with integral heavy duty NEMA 5-20R duplex receptacles arranged to protect connected downstream receptacles on same circuit. Provide unit designed for installation in a 2 3/4 inch deep outlet box without adapter, grounding type, Class A, Group 1, per UL Standard 943.

3. Plugs. 20 amperes, 125 volts, 3 wire, grounding, armored cap plugs, parallel blades with cord clamp, and 0.4-inch cord hole; match NEMA configuration with power sources.

4. Plug Connectors. 20 amperes, 125 volts, nylon body armored connectors, 3 wire, grounding, parallel blades, double wipe contact, with cord clamp, and 0.4-inch cord hole, match NEMA configuration to mating plugs. Arrange as indicated.

5. Switches.

   a. Snap Switches. Quiet-type alternating current (ac) switches as indicated in Table 2 in Part 3 below. Comply with Federal Specification (FS) W-S-896, UL 20, and NEMA WD1.

C. **Wiring Device Accessories**

1. Wall Plates. Single and combination, of types and sizes, and with ganging and cutouts as indicated. Provide plates which mate and match with wiring devices to which attached. Provide metal screws for securing plates to devices with screw heads colored to match finish of plates. Provide wall plate color to match wiring devices except as otherwise indicated. Provide wall plates with engraved legend where indicated. Provide an engraved legend plate labeled "GFI" for all receptacles protected by an upstream GFI receptacle or GFI circuit

breaker. Conform to requirements of Section 26 05 53, "Electrical Identification." Provide plates possessing the following additional construction features:

a. Material and Finish. Steel plate with wrinkled finish, baked-on white insulating enamel.
b. Material and Finish. 0.04-inch thick, Type 302 satin finished stainless steel.
c. Material and Finish. 0.05-inch thick aluminum, anodized.

2. Weatherproof Covers. Weatherproof receptacle covers shall be rainproof while in use and shall be in full compliance with NEC Article 406.8. There shall be a neoprene gasket between the enclosure and the mounting surface and between the cover and base to ensure a proper seal. Switch covers shall be Crouse-Hinds DS185 or equal. Receptacle covers shall be Crouse-Hinds WLRD/WLRS or equal.

3. Weatherproof GFCI Receptacle Covers. Weatherproof covers for GFCI receptacles shall be rainproof while in use and shall be in full compliance with NEC Article 406.8. The covers shall be constructed of clear polycarbonate. The covers shall be hinged allowing them to swing open and closed. Provide molded polycarbonate inserts to plug unused cord openings in the cover and stainless steel mounting hardware. Provide standard box or FS box mounting provisions as necessary.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Installation of Wiring Devices and Accessories

1. Install wiring devices and accessories as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC, and in accordance with recognized industry practices to fulfill project requirements.
2. Coordinate with other work, including painting, electrical boxes, and wiring installations, as necessary to interface installation of wiring devices with other work.
3. Mount all wall switches at 4'-0" above finished floor and all receptacles at 1'-6" above the finished floor unless otherwise noted.
4. Install wiring devices only in electrical boxes which are clean, free from building materials, dirt, and debris.
5. Install galvanized steel wall plates in unfinished spaces.
6. Install wiring devices after wiring work is completed.
7. Install wall plates after painting work is completed.
8. Install telephone/power service poles in accordance with final furnishings arrangement plan, plumb, true, and secure.
9. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for wiring devices. Where manufacturer's torquing requirements

are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standard 486A. Use properly scaled torque-indicating hand tool.

3.2 PROTECTION

A. **General.** Protect installed components from damage. Replace damaged items prior to final acceptance.

3.3 FIELD QUALITY CONTROL

A. **Testing.** Prior to energizing circuits, test wiring for electrical continuity, and for short circuits. Ensure that proper polarity of connections is maintained. Subsequent to energizing, test wiring devices and demonstrate compliance with requirements, operating each operable device at least six times.

1. Test ground fault interruptor operation with both local and remote fault simulations in accordance with manufacturer recommendations.

3.4 TABLES

A. **Receptacles**

Type	Amperes	Volts		Hubble Catalog Number	Leviton Catalog Number	Bryant Catalog Number
Duplex receptacles	20	125	NEMA 5-20R	5362	5362	5362
Duplex GFCI receptacles	20	125	NEMA 5-20R	GF5362		
Duplex receptacle plates, flush or surface-mounted		Standard	S8	84003-40		
250-volt receptacles	30	250	NEMA 6-30R	9330	5372	9630FR
250-volt receptacle plates				S723	84028	

B. **Switches**

Type	Amperes	Volts	Hubble Catalog Number	Leviton Catalog Number	Bryant Catalog Number
Single-pole switch	20	120-277	1221	1221	4901
Double-pole switch	20	120-277	1222	1222	4902
Three-way switch	20	120-277	1223	1223	4903
Four-way switch	20	120-277	1224	1224	4904
Switch plates, flush or surface-mounted			S-1	84001-40	

END OF SECTION

SECTION 26 28 00

OVERCURRENT PROTECTIVE DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this section.

B. **Related Sections.** The following sections contain requirements that relate to this section:

1. Section 26 00 01, "Basic Electrical Requirements."
2. Section 26 00 02, "Basic Electrical Materials and Methods."
3. Section 26 05 53, "Electrical Identification."

1.2 DESCRIPTION OF WORK

A. **General.** The Contractor shall provide the labor, tools, equipment, and materials necessary to install overcurrent protective devices (OCPDs) in accordance with the plans and as specified herein.

B. **Miscellaneous.** This section includes OCPDs rated 600 volts and below and switching devices commonly used with them.

C. **Panelboards, Switchboards, and Motor Control Centers**. Application, installation, and other related requirements for OCPD installations in distribution equipment are specified in other Division 26 sections.

1.3 QUALITY ASSURANCE

A. **Codes and Standards**. Perform all work associated with OCPDs in compliance with applicable requirements of governing agencies having jurisdiction and in accordance with these plans and as specified herein.

1. Electrical Component Standard. Components and installation shall comply with National Fire Protection Association (NFPA) 70, "National Electrical Code (NEC)."

2. Listing and Labeling. Provide products specified in this section that are listed and labeled.

a. The terms "listed" and "labeled" shall be defined as they are in the NEC, Article 100.

B. **Single-Source Responsibility**. Obtain similar OCPDs from a single manufacturer.

1.4 SUBMITTALS

A. **General.** Furnish manufacturer's product data, test reports, and materials certifications as required.

B. **Submittals.** Submit the following in accordance with Conditions of Contract and Division 1 specification sections:

1. Product data for fuses, circuit breakers, and OCPD accessories specified in this section, including descriptive data and time-current curves for all protective devices and let-through current curves for those with current limiting characteristics. Include coordination charts and tables and related data.

1.5 JOB CONDITIONS

Not used.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **Deliver OCPDs and components** in factory-fabricated-type containers or wrappings, which properly protect devices from damage.

B. **Store OCPDs in original packaging** and protect from weather and construction traffic. Wherever possible, store indoors; where necessary to store outdoors, store above grade and enclose with watertight wrapping.

C. **Handle OCPDs carefully** to prevent physical damage to circuit breakers and components. Do not install damaged circuit breakers; remove from site and replace damaged devices with new.

1.7 SPECIAL WARRANTY

Not used.

1.8 DEFINITIONS

A. **OCPD.** A device operative on excessive current that causes and maintains the interruption of power in the circuit it protects.

B. **Ampere Squared Seconds.** An expression of available thermal energy resulting from current flow. With regard to current limiting fuses and circuit breakers, the ampere squared seconds during fault current interruption represents the energy allowed to flow before the fuse or breaker interrupts the fault current within its current limiting range.

PART 2 - PRODUCTS

2.1 MATERIALS

A. **General**

1. Provide OCPDs in indicated types, as integral components of panelboards, switchboards, and motor control centers; and also as individually enclosed and mounted single units.
2. Enclosures. National Electrical Manufacturers Association (NEMA) 250, "Enclosures for Electrical Equipment (1000 volts Maximum)."

B. **Cartridge Fuses**

1. NEMA Standard FU1, "Low Voltage Cartridge Fuses." Unless indicated otherwise, provide nonrenewable cartridge fuses of indicated types, classes, and current ratings that have voltage ratings consistent with the circuits on which used.
2. Class RK1 and RK5 Dual Element Time Delay Fuses. UL 198E, "Class R Fuses."
3. Class RK1 Fast Acting Fuses. UL 198E, "Class R Fuses."

C. **Molded Case Circuit Breakers**

1. General. UL 489, "Molded Case Circuit Breakers and Circuit Breaker Enclosures," and NEMA AB 1, "Molded Case Circuit Breakers."

2. Construction. Bolt-in type, except breakers 225-ampere frame size and larger may be plug-in type if held in place by positive locking device requiring mechanical release for removal.

3. Characteristics. Frame size, trip rating, and number of poles shall be as indicated on the drawings. The short circuit interrupting capacity shall be 22,000 amperes symmetrical for 480Y/277 volt systems and 10,000 amperes symmetrical for 208Y/120 volt and 120/240 volt systems, unless a greater rating is indicated.

4. Tripping Device. Quick-make, quick-break toggle mechanism with inverse time delay and instantaneous overcurrent trip protection for each pole.

5. Adjustable Instantaneous Trip Devices. Factory-adjusted to low trip setting current values.

6. Enclosure for Switchboard or Panelboard Mounting. Suitable for panel mounting in switchboard or panelboards where indicated.

7. Enclosure for Switchboard or Motor Control Center Mounting. Provide individual mounting where indicated.

8. Enclosure for Independent Mounting. NEMA Type 1 enclosure, except as otherwise indicated or required to suit environment where located.

9. Circuit Breakers with Solid-State Trip Devices. Provide indicated circuit breakers with solid-state trip devices having the following features:

a. Ambient Compensation. Trip device insensitive to temperature changes between 20 degrees Celsius (° C.) and +55° C.
b. Adjustability. Breaker ratings and trip settings shall be changeable by operation of controls on front panel of breaker, by change of plug-in element without removing breaker from mounting, or by a combination of the two methods.
c. Ground Fault Tripping. Adjustable for pickup and time delay values. Provide for indicated units. Include labeled light or indicator to indicate cause of trip.

D. **OCPD Accessories**

1. Key Interlocks. Arrange interlocking so keys are held captive at devices indicated. Where future key interlocking provisions are indicated, provide necessary mountings and hardware as required for the future installation.
2. Labels. Install label inside enclosure identifying the type of OCPD installed, its overcurrent rating, its interrupt rating, and UL class. Where applicable, trip settings and time delays should be provided on permanent labels.
3. Instantaneous Undervoltage Trip Device. For indicated OCPDs.
4. Adjustable Time Delay Undervoltage Trip Devices. For indicated OCPDs.

E. **Extra Materials**

1. For types and ratings required, furnish spare fuses, amounting to one fuse for every five installed fuses, but not less than one set of three of each type of fuse.

2.2 MANUFACTURERS

A. **Manufacturers**. Subject to compliance with requirements, provide products by the following:

1. Cartridge Fuses.

a. Bussmann Div., Cooper Industries, Inc.
b. Eagle Electric Mfg. Co., Inc.
c. Ferraz Shawmut.
d. General Electric Co.
e. Littelfuse Inc.

2. Molded-Case Circuit Breakers.

a. ABB Power Distribution, Inc.
b. Cutler Hammer Products.
c. General Electric Co.

d. Eaton Commercial Controls Division.
e. Siemens Energy & Automation, Inc.
f. Square D Co.

3. Molded-Case Circuit Breakers with Solid-State Trip Devices.

a. Cutler Hammer Products.
b. General Electric Co.
c. Siemens Energy & Automation, Inc.
d. Square D Co.

PART 3 - EXECUTION

3.1 INSTALLATION

A. **Independently Mounted OCPDs.** Locate as indicated and install in accordance with manufacturer's written installation instructions.

B. **OCPDs in distribution equipment** shall be factory-installed.

3.2 IDENTIFICATION

A. **Identify components** in accordance with Section 26 05 53, "Electrical Identification."

3.3 CONTROL WIRING INSTALLATION

A. **Install wiring between OCPDs** and control/indication devices as specified in Section 26 05 12, "Wires, Cables, and Connectors," for hard wired connections.

3.4 CONNECTIONS

A. **Check connectors, terminals, bus joints**, and mountings for tightness. Tighten field connected connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and 486B.

3.5 GROUNDING

A. **Provide equipment grounding connections** for individually mounted OCPD units as indicated and as required by NEC. Tighten connectors to comply with tightening torques specified in UL Standard 486A to ensure permanent and effective grounding.

3.6 FIELD QUALITY CONTROL

A. **Visual and Mechanical Inspection**. Include the following inspections and related work.

1. OCPD Ratings and Settings. Verify indicated ratings and settings to be appropriate for final system arrangement and parameters. Where discrepancies are found, test organization shall recommend final protective device ratings and settings. Use accepted revised ratings or settings to make the final system adjustments.
2. Inspect for defects and physical damage, NRTL labeling, and nameplate compliance with current single line diagram.
3. Exercise and perform operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.
4. Check tightness of electrical connections of OCPDs with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
5. Clean OCPDs using manufacturer's approved methods and materials.
6. Verify installation of proper fuse types and ratings in fusible OCPDs.

B. **Electrical Tests**. Include the following items performed in accordance with manufacturer's instructions:

1. Insulation resistance test of OCPD conducting parts. Insulation resistance less than 100 megohms is not acceptable.
2. Contact resistance test or measurement of millivolt drop across contacts of drawout circuit breakers and fused power circuit devices at rated current. Compare contact resistance or millivolt drop values of adjacent poles and of similar breakers. Deviations of more than 50 percent are not acceptable.
3. Make adjustments for final settings of adjustable trip devices.
4. Activate auxiliary protective devices such as ground fault or undervoltage relays, to verify operation of shunt trip devices.
5. Check key and other interlock and safety devices for operation and sequence. Make closing attempts on locked open and opening attempts on locked closed devices including moveable barriers and shutters.

C. **Retest**. Correct deficiencies identified by tests and observations and provide retesting of OCPDs by testing organization. Verify by the system tests that specified requirements are met.

3.7 CLEANING

A. **Upon completion of installation**, inspect OCPDs. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish.

3.8 DEMONSTRATION

A. **Training**. Arrange and pay for the services of factory authorized service representatives to demonstrate OCPDs and train Owner's maintenance personnel.

B. **Conduct a minimum** of one-half day of training in operation and maintenance as specified under "Instructions to Owner Employees" in the "Project Closeout"

section of these specifications. Include both classroom training and hands-on equipment operation and maintenance procedures.

C. **Schedule training** with at least 7 days' advance notification.

END OF SECTION

SECTION 26 28 13

FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this section.

B. **Related Sections.** The following sections contain requirements that relate to this section:

1. Section 26 00 01, "Basic Electrical Requirements."
2. Section 26 00 02, "Basic Electrical Materials and Methods."
3. Section 26 24 19 "Motor Control Centers."
4. Section 26 28 16 "Circuit and Motor Disconnects."
5. Section 26 29 00 "Motor Controllers."

1.2 DESCRIPTION OF WORK

A. **General.** The Contractor shall provide the labor, tools, equipment, and materials necessary to install fuses in accordance with the plans and as specified herein.

B. **Extent of fuse work required by this section** is indicated by drawings, and by requirements of this section.

C. **Types of fuses specified** in this section include the following:

1. Class L time-delay.
2. Class RK1 and RK5 time-delay.

1.3 QUALITY ASSURANCE

A. **Codes and Standards.** Perform all work associated with fuses in compliance with applicable requirements of governing agencies having jurisdiction and in accordance with these plans and as specified herein.

1. Underwriters' Laboratories, Inc. (UL) Compliance and Labeling. Comply with applicable provisions of UL 198 for the class indicated. Provide overcurrent protective devices which are UL listed and labeled.
2. National Electrical Code (NEC) Compliance. Comply with NEC as applicable to construction and installation of fusible devices.
3. American National Standards Institute (ANSI) Compliance. Comply with applicable requirements of ANSI C97.1 "Low Voltage Cartridge Fuses 600 Volts or Less."

1.4 SUBMITTALS

A. **Transmittals.** Furnish manufacturer's product data, test reports, and materials certifications as required.

B. **Product Data**. Submit manufacturer's technical product data on fuses, including specifications, and electrical characteristics. In addition, include voltages and current ratings, interrupting ratings, current limitation ratings, time current trip and melt characteristic curves, and mounting requirements.

1.5 JOB CONDITIONS

Not used.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **Deliver fuses and components** properly packaged in factory-fabricated-type containers.

B. **Store fuses and components** in original packaging and in a clean dry space; protect from weather and construction traffic.

C. **Handle fuses and components** carefully to avoid breakages, impacts, denting, and scoring finishes. Do not install damaged fuses; replace and return damaged units to equipment manufacturer.

1.7 SPECIAL WARRANTY

Not used.

PART 2 - PRODUCTS

2.1 MATERIALS

A. **General**. Except as otherwise indicated, provide fuses of types, sizes, ratings, and average time current and peak let through current characteristics indicated, which comply with manufacturer's standard design, materials, and constructed in accordance with published product information, and with industry standards and configurations. See plans for specific type selections.

B. **Class RK1 and RK5 Time Delay Fuses**. Provide UL Class RK1 and RK5 time-delay fuses, with 200,000 RMS symmetrical interrupting current rating for protecting motors and circuit breakers.

2.2 EXTRA MATERIALS

A. **Maintenance Stock, Fuses**. For types and ratings required, furnish additional fuses, amounting to one unit for every installed unit.

2.3 MANUFACTURERS

A. **Manufacturers**. Subject to compliance with requirements, provide fuses of one of the following:

1. Bussmann Div.; Cooper Industries.
   Equipment Types: KRP-C, KTN-R, KTS-R, FRN-R, FRS-R, LPN-RK, LPS-RK.
2. Shawmut Div.; Gould Inc.
   Equipment Types: A4BY, A2K, A6K, TR, TRS, A2D, A6D.
3. Little Fuse Tracer.
   Equipment Types: KLPC, KLNR, KLSR, FLNR, FLSR, LLNRK, LLNRK, LLSRK.

2.4 IDENTIFICATION

A. **General.** Provide fuse identification nameplates complying with Division 26 Basic Materials and Methods section "Electrical Identification." Tags shall be engraved plastic laminate and shall clearly identify fuse class, voltage, and current rating. Mount nameplate on switch or protected equipment cover.

PART 3 - EXECUTION

3.1 INSTALLATION OF FUSES

A. **Installation**. Install fuses as indicated, in accordance with manufacturer's written instructions and with recognized industry practices to ensure that protective devices comply with requirements. Comply with NEC and National Electrical Manufacturers Association (NEMA) standards for installation of fuses.

B. **Coordination**. Coordinate with other work, including electrical wiring, as necessary, to interface installation of fuses with other work.

C. **Install fuses** in fusible switches.

3.2 EXAMINATION

A. **General.** Examine areas and conditions under which fuses are to be installed, and notify Engineer/Architect, in writing, of conditions detrimental to proper completion of the work. Do not proceed with the work until satisfactory conditions have been corrected in a manner acceptable to the Engineer/Architect.

3.3 FIELD QUALITY CONTROL

A. **General.** Prior to energization of fusible devices, test devices for continuity of circuitry and for short circuits. Replace malfunctioning units with new units, and then demonstrate compliance with requirements.

END OF SECTION

SECTION 26 28 16

CIRCUIT AND MOTOR DISCONNECTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this section.

B. **Related Sections**. The following sections contain requirements that relate to this section:

1. Section 26 00 01, "Basic Electrical Requirements."
2. Section 26 00 02, "Basic Electrical Materials and Methods."
3. Section 26 05 12, "Wires, Cables, and Connectors."
4. Section 26 05 33, "Raceway."
5. Section 26 05 34, "Cabinets, Boxes, and Fittings."
6. Section 26 28 00, "Overcurrent Protective Devices."

1.2 DESCRIPTION OF WORK

A. **Scope of Work.** The Contractor shall provide the labor, tools, equipment, and material necessary to install circuit and motor disconnects in accordance with the plans and as specified herein.

B. **Extent of circuit and motor disconnect** switch work is indicated by drawings and schedules.

C. **Types of circuit and motor disconnect switches** in this section include the following:

1. Equipment disconnects.
2. Motor circuit disconnects.

1.3 QUALITY ASSURANCE

A. **Codes and Standards**. Perform all work associated with circuit and motor disconnects in compliance with applicable requirements of governing agencies having jurisdiction and in accordance with these plans and as specified herein.

1. National Electrical Code (NEC) Compliance. Comply with NEC requirements pertaining to construction and installation of electrical circuit and motor disconnect devices.
2. Underwriters' Laboratories, Inc. (UL) Compliance. Comply with requirements of UL 98 "Enclosed and Dead Front Switches." Provide circuit and motor disconnect switches which have been UL listed and labeled.

3. National Electrical Manufacturers Association (NEMA) Compliance. Comply with applicable requirements of NEMA Standards Pub. Nos. KS 1, "Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum)," and 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)."

1.4 SUBMITTALS

A. **General.** Submit manufacturer's product data, test reports, and material certifications.

1.5 JOB CONDITIONS

Not used.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **Deliver circuit and motor disconnect** switches properly packaged in factory-fabricated-type containers or wrappings which properly protect devices from damage.

B. **Store circuit and motor disconnect** switches in original packaging and protect from weather and construction traffic. Wherever possible, store indoors; where necessary to store outdoors, store above grade and enclose with watertight wrapping.

C. **Handle circuit and motor disconnect** switches carefully to prevent physical damage. Do not install damaged disconnect switches; remove from site and replace damaged devices with new.

1.7 SPECIAL WARRANTY

Not used.

PART 2 - PRODUCTS

2.1 MATERIALS

A. **Heavy-Duty Safety Switches**. Provide surface-mounted, heavy-duty-type, sheet steel enclosed safety switches, of types, sizes, and electrical characteristics as required for the indicated installation; fused, if noted on plan. Provide switches incorporating quick make, quick break type switches, so that switch blades are visible in OFF position with door open. Equip with operating handle which is integral part of enclosure base and whose operating position is easily recognizable and is padlockable in OFF position. Interlock enclosure door with operating handle such that the door cannot be opened with the switch closed. Provide an inconspicuous defect mechanism for use by maintenance personnel. Construct current carrying parts of high conductivity copper with silver tungsten type switch contacts; and positive pressure type reinforced fuse clips where fusible switches are specified or required by code. Provide NEMA Type 12

enclosures. For switches marked "WP," provide NEMA Type 4X stainless steel enclosures.

B. **Fuses**. Provide fuses for safety switches, as noted on plans and as described in Section 26 28 00, "Overcurrent Protection Devices."

2.2 MANUFACTURERS

A. **Manufacturer**. Subject to compliance with requirements, provide circuit and motor disconnects of one of the following (for each type of switch):

1. Crouse-Hinds Co.
2. Cutler-Hammer, Inc.
3. General Electric Co.
4. Square D Company.

PART 3 - EXECUTION

3.1 INSTALLATION

A. **Install circuit and motor disconnect** switches as indicated, complying with manufacturer's written instructions, applicable requirements of NEC, NEMA, and National Electrical Contractor's Association (NECA) "Standard of Installation," and in accordance with recognized industry practices.

B. **Coordinate circuit and motor disconnect** switch installation work with electrical raceway and cable work, as necessary for proper interface.

C. **Locations of disconnect switches** as shown on the plans are approximate unless dimensioned. Install disconnect switches as close to the equipment served as practical, but at a readily accessible location with adequate working clearances to meet all NEC requirements.

D. **Provide a suitable means** for mounting all disconnect switches.

3.2 GROUNDING

A. **Provide equipment grounding connections**, tightened to ensure a permanent and effective ground, for all electrical disconnect switches.

3.3 FIELD QUALITY CONTROL

A. **Subsequent to completion of installation of electrical disconnect switches**, energize circuitry and demonstrate capability and compliance with requirements. Where possible, correct malfunctioning units at project site, then retest to demonstrate compliance; otherwise remove and replace with new units and retest. Corrective action and repeated tests shall be accomplished at the Contractor's own expense.

END OF SECTION

SECTION 26 29 00

MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General**. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to work of this section.

B. **Related Sections**. The following sections contain requirements that relate to this section.

1. Section 26 00 01, "Basic Electrical Requirements."
2. Section 26 00 02, "Basic Electrical Materials and Methods."
3. Section 26 05 26, "Grounding."
4. Section 26 05 53, "Electrical Identification," for identification labels and warning signs for motor controllers and their components.
5. Section 26 24 19, "Motor Control Centers," for motor controllers used in motor control centers.
6. Section 26 28 00, "Overcurrent Protective Devices," for circuit breakers, fuses, and other similar devices used in motor controllers.
7. Section 26 28 16, "Circuit and Motor Disconnects," for fusible switches used in motor controllers.
8. Section 40 93 13, "Control Devices," for control devices used in motor controllers.

1.2 DESCRIPTION OF WORK

A. **Scope of Work**. The Contractor shall provide the labor, tools, equipment, and materials necessary to furnish and install motor controllers in accordance with the plans and as specified herein.

B. **Extent of motor controller work** is indicated by drawings.

C. **Types of motor controllers** specified in this section include the following:

1. Manual.
2. Full-voltage magnetic.
3. Adjustable frequency.
4. Combination.
5. Solid state reduced voltage.

D. **The harmonic requirements,** simulations, and testing required by this specification associated with adjustable frequency and solid-state motor controllers shall be the responsibility of the equipment supplier. It is not the

intent of this specification to require the equipment supplier to limit harmonics or distortion due to sources other than those specified herein.

1.3 QUALITY ASSURANCE

A. **Codes and Standards.** Perform all work to furnish and install motor controllers in accordance with applicable requirements of governing agencies having jurisdiction and in accordance with these plans and as specified herein.

1. Electrical Code Compliance. Comply with applicable local electrical code requirements of the authority having jurisdiction and National Electrical Code (NEC) Articles 220, 250, and 430, as applicable to installation and construction of motor controllers.
2. National Fire Protection Association (NFPA) Compliance. Comply with applicable requirements of NFPA 70E, "Standard for Electrical Safety Requirements for Employee Workplaces."
3. Underwriters' Laboratories, Inc. (UL) Compliance. Comply with applicable requirements of UL 486A and B, and UL 508, pertaining to installation of motor controllers. Provide controllers and components which are UL listed and labeled.
4. Institute of Electrical and Electronics Engineers (IEEE) Compliance. Comply with recommended practices contained in IEEE Standard 141, "IEEE Recommended Practice for Electric Power Distribution for Industrial Plants," pertaining to motor controllers. Comply with applicable requirements of IEEE Standard 519-1992, "Recommended Practices and Requirements for Harmonic Control in Electric Power Systems."
5. National Electrical Manufacturers Association (NEMA) Compliance. Comply with applicable requirements of NEMA Standard ICS 2, "Industrial Control Devices, Controllers and Assemblies," and Pub No. 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)," pertaining to motor controllers and enclosures.

B. **Qualifications**

1. Manufacturer's Qualifications. Firms regularly engaged in manufacture of motor controllers of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
2. Installer's Qualifications. Firm with at least 3 years of successful installation experience with projects utilizing motor controller work similar to that required for this project.

C. **Factory Test**

1. Adjustable-Frequency Controllers.

   a. All control printed circuit boards shall be dynamically tested for a minimum of 22 hours while heat cycled 1 hour at each temperature setting from 32 degrees Fahrenheit (° F.) to 140° F.

b. All controllers shall be subjected to Run-In Test with a properly sized motor and operated under cycling load conditions on a dynamometer. The controller shall be subjected to a Run-In Test that brings the controller to full rated temperature.

1.4 SUBMITTALS

A. **Submit the following** in accordance with conditions of Contract and Division 1 specification sections:

1. Product Data. Submit manufacturer's data and installation instructions on motor controllers.
2. Wiring Diagrams. Submit power and control wiring diagrams for motor controllers showing connections to electrical power panels, feeders, and equipment. Control wiring diagrams shall be in ladder logic form. Differentiate between portions of wiring which are manufacturer installed and portions which are field installed.
3. Motor Overloads. Submit for approval motor overload sizes for each new motor starter furnished or existing motor starter modified. Overload size shall be based on actual motor nameplate data and power factor correction size where applicable. Submit for approval motor overload sizing criteria, manufacturer, support calculations, motor nameplate data, capacitor nameplate data, and manufacturer tables used. Include thermal overload compensation sizing information where motor(s) are operated at temperatures different than the motor controller(s).
4. Maintenance Data. Submit maintenance data and parts list for each motor controller and component, including "troubleshooting" maintenance guide. Include that data, product data, and shop drawings in a maintenance manual.
5. Test Equipment Data. Submit make, model, and performance specifications of testing equipment to be utilized for measuring harmonic distortion and power factor as required under Part 3 of this specification.
6. Harmonic Analysis. Submit a harmonic analysis of the installation to document compliance with IEEE 519-1992, "General Distribution Systems." The analysis shall include electrical one line drawings defining the resistance and impedance of each wire run and transformer leading to each adjustable frequency controller. Provide a computer generated Fourier analysis of the system and list the current and voltage amplitudes and phase angles of all harmonics up to the 50th harmonic at the point of common coupling (PCC). A summary shall detail the percent voltage and circuit total harmonic distortion, plus distortion, displacement, and total power factors.
7. Field Test Reports. The results of the harmonic distortion and power factor field test shall be submitted for evaluation and compliance with the requirements of IEEE 519-1992 and this specification.

1.5 JOB CONDITIONS

Not used.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **Deliver motor controllers and components** properly packaged in factory fabricated type containers.

B. **Store motor controllers and components** in original packaging and in a clean dry space; protect from weather and construction traffic.

C. **Handle motor controllers and components** carefully to avoid breakages, impacts, and denting and scoring finishes. Do not install damaged equipment; replace and return damaged units to equipment manufacturer.

1.7 SPECIAL WARRANTY

Not used.

1.8 SEQUENCING AND SCHEDULING

A. **Coordination.** Coordinate with other electrical work including wires/cables, electrical boxes and fittings, and raceways, to properly interface installation of motor controllers with other work.

B. **Sequencing.** Sequence motor controller installation work with other work to minimize possibility of damage and soiling during remainder of construction period.

PART 2 - PRODUCTS

2.1 MATERIALS

A. **General.** Except as otherwise indicated, provide motor controllers and ancillary components which comply with manufacturer's standard materials, design, and construction in accordance with published product information, and as required for a complete installation.

B. **Fractional-HP Manual Controllers**. Provide single-phase fractional-HP manual motor controllers, of sizes and ratings indicated. Equip with manually operated quick make, quick break toggle mechanisms; and with one piece melting alloy type thermal units. Controller to become inoperative when thermal unit is removed. Provide controllers with double break silver alloy contacts, visible from both sides of controller; green pilot lights, and switch capable of being padlocked OFF.

C. **Full-Voltage Magnetic Controllers**. Provide full-voltage alternating current magnetic controllers, consisting of magnetic contactor or contactors, and overload relay mounted in a common enclosure. Provide standard NEMA size starters, minimum size 1. Equip reversing and two speed controllers with electrical and mechanical interlocks to prevent both contactors, forward and reverse or fast and slow, closing simultaneously. Equip controllers with solid-state overload relays. Provide a current sensor in each phase monitored by the solid-state overload. The overload relay shall provide running overload

protection that yields a time-current curve closely paralleling that of the motor heating damage boundary, accurate to 2 percent. Running overload protection shall be switch selectable for the specific motor full load amperes within the starter range. Provide selectable class [10] [20] [30] overload trip. Equip two-speed controllers with two overload relays.

D. **Adjustable Frequency Controllers**. Provide adjustable frequency controllers of sizes, ratings, and electrical characteristics specified in Division 23. Construct the controller with three major sections: a full-wave, 3-phase diode rectifier section to convert from alternating current (ac) to direct current (dc), a dc filter section to smooth the dc voltage, and a pulse width modulated 3 phase inverter section to provide a variable voltage, variable frequency output at a constant voltage to frequency ratio. The output frequency range shall be a minimum of 6 to 120 hertz (Hz). The controller shall be capable of operating in ambient temperatures of 0 to 40 degrees Celsius (° C.) without derating. The controller shall be designed to shut down without damage under the following conditions: short circuit, overcurrent, overvoltage, undervoltage, and loss of phase. The controller output shall be adjustable as follows: acceleration and deceleration rate (2 to 20 seconds), minimum frequency (6 to 30 Hz), maximum frequency (60 to 120 Hz), and current limit (100 to 150 percent). Construct the controller with the following accessories: magnetic output contactor, 120 volt control capability, local speed control potentiometer, and 4-20 milliampere (mA) remote speed control input. Start, stop, and speed control are selected by H-O-R selector switch.

E. **Solid-State Reduced Voltage Controller**. Provide solid-state reduced voltage controllers for use with 3 phase squirrel cage induction motors, of types, sizes, ratings, and electrical characteristics indicated; construct with silicon controlled rectifiers (SCRs) for controlling motor voltages during acceleration. Provide on-board diagnostics with light emitting diodes (LEDs) indicating fault conditions. Provide isolated, convertible common fault contact output for remote indication. Equip controllers with an input isolation magnetic contactor, solid-state overload protection, phase loss protection, adjustable current limit, and closed loop feedback system to maintain motor acceleration at a constant rate.

F. **Combination Controllers**. Provide combination controllers consisting of a controller as described above (i.e., full-voltage magnetic, solid-state reduced-voltage, etc.) and a fused switch or thermal magnetic molded-case circuit breaker mounted in a common enclosure. Provide external operator handles for the switches or breakers. Design the handle with an up-down motion and with the down position indicating OFF. Construct the handles to permit locking in the OFF position with up to three padlocks. Standard controls for a combination controller shall include an H-O-A selector switch, fused control power transformer, elapsed time meter, and a (green, red) run light unless indicated otherwise on the plans.

G. **Control Components**. Provide control components as specified in Section 40 93 13, "Control Devices," and as shown on the drawings.

H. **Enclosures**. Controllers shall be mounted in NEMA Type 12 enclosures unless otherwise shown. Controllers shown as weatherproof (WP) shall be mounted in NEMA Type 4 enclosures. Coat the enclosures with the manufacturer's standard color finish.

1. All accessories, including harmonic filters and power factor correction capacitors, shall be provided in the controller enclosure. If an additional enclosure is required, it shall be approved by the Engineer/Architect. Additional enclosures shall be constructed equal to the controller enclosure. All additional interconnections, mounting, and installation hardware and provisions, including wire and conduit between enclosures, shall be included.

I. **Harmonic Distortion Requirements**

1. Harmonic distortion due to the individual adjustable-frequency controllers and the total load of all the adjustable-frequency controllers shall not exceed the requirements of IEEE 519-1992. The PCC shall be the bus of the motor control center or switchboard feeding the controllers.
2. The maximum allowable current distortion limits shall be as recommended in Table 10.3, "Current Distortion Limits for General Distribution Systems," in IEEE 519-1992. The available short circuit current at the PCC shall be defined as the maximum short circuit current available at the motor control center or switchboard feeding the controller.
3. The maximum allowable total harmonic distortion (THD) of the voltage at the PCC shall not exceed 5 percent.
4. The power factor at full load shall be greater than or equal to 92 percent lagging for each unit.

2.2 EXTRA MATERIALS

A. **Maintenance Stock, Fuses.** For types and ratings required, furnish additional fuses, amounting to one unit for every installed unit.

B. **Provide one spare adjustable-frequency controller** operator interface for each type provided.

C. **Provide one spare main control board** for every three adjustable-frequency controllers provided.

2.3 EQUIPMENT/SYSTEM IDENTIFICATION

A. **Provide equipment/system identification** nameplates complying with Section 26 05 53, "Electrical Identification," in accordance with utilization equipment name and its location. Tags shall be engraved plastic laminate.

2.4 MANUFACTURERS

A. **Manufacturers.** Subject to compliance with requirements, provide motor controllers of one of the following (for each type and rating of motor controller):

1. Allen-Bradley Co.
2. Cutler Hammer Products.
3. General Electric Co.
4. Square D Co.

PART 3 - EXECUTION

3.1 INSTALLATION

A. **General.** Examine areas and conditions under which motor controllers are to be installed, and notify the Engineer/Architect in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Engineer/Architect.

B. **Miscellaneous**

1. Install motor controllers where indicated, in accordance with equipment manufacturer's written instructions and with recognized industry practices, complying with applicable requirements of NEC, UL and NEMA standards, to ensure that products fulfill requirements.
2. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A and B, and the NEC.
3. Install fuses of sizes indicated in each fusible disconnect switch.
4. Wall-mount the enclosures using spacers or standoffs (1/4 inch minimum).
5. Provide auxiliary motor starter and overload contacts as required.

3.2 FIELD QUALITY CONTROL

A. **General**

1. Prior to energization of motor controller equipment, check with ground resistance tester, phase-to-phase and phase-to-ground insulation resistance levels to ensure that requirements are fulfilled.
2. Prior to energization, check circuitry for electrical continuity and for short circuits.
3. Ensure that direction of rotation of each motor fulfills requirements.

B. **Testing**. Testing shall be witnessed by the Engineer/Architect. The Engineer/Architect shall be notified at least 48 hours in advance of testing. The current and voltage harmonic distortion and power factor shall be monitored at the motor control center or switchboard feeding the controller being tested with a BMI Model 3030 harmonic analyzer or equal. Data shall be collected for each motor at rated load and speed with all motors running at rated load and speed. Sufficient data shall be collected to prepare a report to compare the harmonic content of the system to the calculated values in the analysis submitted in accordance with subpart 1.4, paragraph A.6 of this specification.

3.3 **GROUNDING**. Provide equipment grounding connections for motor controller equipment and enclosure as indicated. Tighten connections to comply with tightening torques specified in UL Standard 486A to ensure permanent and effective grounding.

3.4 **ADJUSTING AND CLEANING**

A. **Adjust operating mechanisms**, where necessary, for free mechanical movement.

B. **Touch up scratched or marred enclosure surfaces** to match original finishes.

3.5 **DEMONSTRATION**. Upon completion of installation of motor controller equipment and electrical circuitry, energize controller circuitry and demonstrate functioning of equipment in accordance with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and retest to demonstrate compliance.

END OF SECTION

SECTION 31 11 00

CLEARING AND GRUBBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General.** Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this section.

1.2 DESCRIPTION OF WORK

A. **Scope of Work.** This section includes the clearing and grubbing of the work site and the following:

1. Clearing of area.
2. Grubbing of stumps and roots.
3. Removal of all other vegetation.
4. Protection of designated trees.
5. Removing above- and belowgrade structures.
6. Disposal off-site of all material generated by the clearing and grubbing operations.

1.3 QUALITY ASSURANCE

Not used.

1.4 SUBMITTALS

Not used.

1.5 JOB CONDITIONS

A. **Infrastructure Interference.** Conduct site clearing operations to ensure minimum interference with roads, streets, walks, and other adjacent occupied or used facilities. Do not close or obstruct streets, walks, or other occupied or used facilities without permission from authorities having jurisdiction.

B. **Protection.** Provide protection necessary to prevent damage to existing improvements.

C. **Restoration.** Restore damaged improvements to their original condition.

1.6 DELIVERY, STORAGE, AND HANDLING

Not used.

1.7 SPECIAL WARRANTY

Not used.

PART 2 - PRODUCTS

Not applicable.

PART 3 - EXECUTION

3.1 EXAMINATION

A. **Site Verification of Conditions**. The Contractor shall verify in the presence of the Engineer/Architect the specific areas and limits requiring clearing and grubbing. Also review any trees, shrubs, or other items which are not to be disturbed.

B. **Coordination**. The Contractor shall review with Engineer/Architect or other Owner's Representative requirements of surrounding areas such as adjacent property owners, roads, streets, walks, or other occupied or used facilities. Evidence of proper permission for activities from authorities having jurisdiction shall be given the Engineer/Architect.

3.2 PREPARATION

A. **Safety**. Provide protection as required for surrounding area and operation of any adjoining or affected utilities.

B. **Permits**. Obtain all required permits prior to beginning operations.

3.3 **LANDSCAPE REMOVAL.** Remove trees, shrubs, grass and other vegetation, improvements, or obstructions as required to permit installation of new construction. Remove similar items elsewhere on site or premises as specifically indicated. "Removal" includes grubbing and off-site disposing of stumps and roots. Grubbing shall be carried to a depth of 18 inches below existing ground.

3.4 **PROTECTION OF EXISTING TREES AND VEGETATION**. Protect existing trees and other vegetation indicated to remain in place against unnecessary cutting, breaking, or skinning of roots; skinning or bruising of bark; and smothering of trees by stockpiling construction materials or excavated materials. Provide temporary guards to protect trees and vegetation to remain standing.

3.5 **SALVAGEABLE IMPROVEMENTS**. Carefully remove items indicated to be salvaged, and store on Owner's premises where indicated.

3.6 **BURNING.** The Contractor shall obtain prior approval from Owner and appropriate authorities before any burning will be permitted.

3.7 **DISPOSAL.** All trees, shrubs, plants, and other materials removed shall become the property of the Contractor and shall be removed from the site.

END OF SECTION

SECTION 31 23 00

EXCAVATION, BACKFILL, AND EMBANKMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General**. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 1, and all related specification sections, apply to this section.

1.2 DESCRIPTION OF WORK

A. **Scope of Work**. Complete the excavation, backfill, and embankment necessary to construct the work as shown and specified herein. This section includes the following where applicable: structures, underground utilities, and preparing subgrade for pavements, walks, or slabs.

B. **Other Work**. Final grading together with placement and preparation of topsoil for lawns and planting is specified in Section 32 90 02, "Grading and Seeding." Excavation and backfill for buried piping are covered in Division 33.

C. **Definitions**

1. Excavation. The removal of material to required subgrade elevations and disposal of excavated materials.
2. Backfill. Below grade placement and compaction of specified materials to required elevations.
3. Unauthorized Excavation. The removal of materials beyond required subgrade elevations or dimensions without specific direction.
4. Subgrade. The undisturbed earth or the compacted soil layer immediately below foundations, pipe trenches, mud mats, pavement, slabs, walks, base, compacted foundation, embankment, or as shown.
5. Embankment. An engineered fill constructed of compacted, suitable earthen materials used to raise grade to the required elevations.

1.3 QUALITY ASSURANCE

A. **Codes and Regulatory Agencies**. Perform excavation work in compliance with all federal, state, and local codes and regulatory agencies.

1. OSHA - Occupational Safety and Health Administration.

   a. OSHA 29 Code of Federal Regulations (CFR) Part 1926.650 to .652, Subpart P. Construction Standard for Excavations.

B. **Standards**. Conform all work and materials to the following standards.

1. ASTM – American Society for Testing and Materials.
2. ODOT – Ohio Department of Transportation.

1.4 SUBMITTALS

A. General

1. Submit all submittals in accordance with the Division 1 Submittal Requirements and this specification section. Do not deliver or install any materials before Submittal Packages 1 and 2 are approved.

B. Submittal Package No. 1 – Product Data and Test Laboratory Qualifications

1. Submit product data and laboratory qualifications for review and approval. Submittal package shall include:

   a. Product Data. Submit material data, noting each material source, location, sieve analysis, and other information which will show that the source and supplier are capable of furnishing materials meeting the requirements of these specifications. Submit name and location of all borrow pits.

   b. Test Laboratory. Submit name and address of acceptable test laboratory including the name and experience of the Engineer assigned to the field testing.

C. Submittal Package No. 2 – Samples

1. Samples shall include:

   a. Aggregate. Submit samples not less than 1/4 cubic foot each for the following:

      1) Granular backfill.
      2) Porous backfill.
      3) Base.
      4) Drainage Base.

   b. Filter Fabric. One foot square section.

D. Submittal Package No. 3 – Field Test Reports

1. Submit test reports within 48 hours of completion, suspension, or termination of testing the material including the following:

   a. Tests. Submit a copy of each test report called for in this section.

1.5 JOB CONDITIONS

A. Utilities

1. Existing Utilities.

   a. Notify utility companies and locate existing underground utilities in area of work.

b. Where utilities are to remain in place, provide adequate means of support and protection during construction operations.
c. Repair any Contractor-damaged utilities to the owner's satisfaction at the Contractor's expense.

2. Unforeseen Utility Location.

a. Should a utility which is encountered during excavation be unrecorded or recorded incorrectly, consult the utility immediately for directions.
b. Cooperate with the utility or Owner in keeping respective services or facilities in operation.
c. Repair damaged utilities to the satisfaction of the utility owner.

3. Interruption.

a. Do not disrupt existing utilities except when approved.
b. Provide acceptable temporary utility services unless approved otherwise.

4. Notification. Provide a minimum of 48 hours notice to utility companies and Owner or Engineer/Architect before excavating or interrupting utilities.

B. **Blasting**. Do not blast.

D. **Borrow**. Should the excavated material be insufficient to provide all of the fill required, supply satisfactory material from another source at no cost to the Owner.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **Topsoil**

1. Remove, stockpile, and place in the areas to be seeded topsoil that is available as a part of the excavated materials.
2. Shape stockpile and grade to drain.

B. **Excavated Material**

1. Storage Stockpile. Stockpile excavated material when suitable for use as backfill or embankments onsite as directed.

C. **Stockpiles**

1. Shape and grade stockpile. Handle the material so that the gradation remains uniform and foreign material is not incorporated into the mix.

1.7 SPECIAL WARRANTY

Not used.

PART 2 - PRODUCTS

2.1 MATERIALS

A. **General.** All materials shall be free of elastic soil materials, debris, waste, frozen material, vegetation, organics, peats, or other deleterious material.

B. **Backfill and Embankment**

1. Soil.

   a. Earth materials which have resulted from natural processes such as weathering, decay, and chemical action.
   b. More than 35 percent weight of the grains or particles will pass a No. 200 sieve and have a plastic index of 4 or more.
   c. Free of aggregate or rock larger than 2 inches in any dimension.

2. Aggregate Material.

   a. Natural mineral aggregate such as gravel, crushed gravel, crushed rock, or sand.
   b. At least 65 percent by weight of the grains or particles will be retained on a No. 200 sieve.
   c. At least 90 percent by weight of the grains or particles shall pass the 3-inch sieve.
   d. Remove rock pieces larger than 6 inches in any dimension.

3. Shale. Finely stratified, laminated material formed by consolidation in nature, mudstone, claystone, siltstone, and clay bedrock. Break into predominantly fine particles which can be readily tested for compaction requirements as soil.

4. Rock. Sandstone, limestone, dolomite, glacial boulders, and old concrete which are crushed into pieces that can readily be incorporated into a specified lift thickness and compacted according to requirements for granular materials.

C. **Granular Backfill.** Granular backfill shall be crushed or uncrushed granular material meeting the following grading requirements:

Sieve	Total Percent Passing
2-1/2 inch	100
1 inch	70 – 100
No. 4 (3/16 inch)	25 – 100
No. 40	10 – 50
No. 200	5 – 15

The fraction passing a No. 40 sieve shall have a liquid limit not greater than 30 and a plasticity index not greater than 6.

D. **Porous Backfill.** Porous backfill shall be granular material meeting the requirements of ASTM D 448, No. 57, 67, or 78 size.

E. **Mud Mat.** Unless shown or directed otherwise, all mud mats shall be concrete.

1. Concrete. A concrete mud mat shall consist of a 3-inch layer of Class C concrete.
2. Granular Material. A granular mud mat shall consist of a 4-inch layer of crushed aggregate meeting the requirements of porous backfill.

F. **Base.** Base shall be crushed granular material meeting the following grading requirements.

Sieve	Total Percent Passing
2 inch	100
1 inch	70 – 100
3/4 inch	50 – 90
No. 4	30 – 60
No. 30	9 – 33
No. 200	0 – 15

G. **Drainage Base.** Drainage base shall be crushed granular material meeting the requirements of ASTM D 448 No. 57, 67, or 78 size.

H. **Filter Fabric.** Furnish Type D filter fabric unless shown otherwise. The fabric shall be composed of strong, rotproof, polymeric fibers formed into a woven or nonwoven fabric conforming to the following requirements.

Type A: Underdrains and Slope Drains		
Minimum Tensile Strength	ASTM D 4632	80 lb (335 N)
Minimum Puncture Strength	ASTM D 4833	25 lb (110 N)
Minimum Tear Strength	ASTM D 4533	25 lb (110 N)
Apparent Opening Size	ASTM D 4751	
Soil Type 1: Soils with 50% or less passing No. 200 (75μm) sieve		AOS ≤0.6 mm
Soil Type 2: Soils with 50 to 85% passing No. 200 (75 μm) sieve		AOS ≤0.3 mm
Minimum Permeability	ASTM D 4491	$1x10^{-2}$ cm/sec
Type B: Filter Blankets for Rock Channel Protection		
Minimum Tensile Strength	ASTM D 4632	200 lb (890 N)
Minimum Puncture Strength	ASTM D 4833	80 lb (355 N)
Minimum Tear Strength	ASTM D 4533	50 lb (220 N)
Minimum Elongation	ASTM D 4632	15%
Apparent Opening Size	ASTM D 4751	AOS ≤0.6 mm
Minimum Permeability	ASTM D 4491	$1x10^{-3}$ cm/sec

Type C: Sediment Fences		
Minimum Tensile Strength	ASTM D 4632	120 lb (535 N)
Maximum Elongation at 60 lb (265 N)	ASTM D 4632	50%
Minimum Puncture Strength	ASTM D 4833	50 lb (220 N)
Minimum Tear Strength	ASTM D 4533	40 lb (180 N)
Apparent Opening Size	ASTM D 4751	AOS $\leq$0.84 mm
Minimum Permittivity	ASTM D 4491	$1x10^{-2}$ sec^{-1}
Ultraviolet Exposure Strength Retention	ASTM D 4355	70%
Type D: Subgrade-Base Separation or Stabilization		
Minimum Tensile Strength	ASTM D 4632	180 lb (800 N)
Maximum Elongation at 170 lb (755 N)	ASTM D 4632	35%
Minimum Tear Strength	ASTM D 4533	70 lb (310 N)
Minimum Puncture Strength	ASTM D 4833	70 lb (310 N)
Apparent Opening Size	ASTM D 4751	Same as Type A
Permeability	ASTM D 4491	$1x10^{-3}$ cm/sec
Type E: Pavement Reinforcement Fabric		
AASHTO M 288, Section 9, Table 7		

All minimum strengths shown are average roll minimum values in the weakest principal direction.

Ensure that the fabric is free of any treatment that might significantly alter its physical properties. During shipment and storage, wrap the fabric in a heavy-duty protective covering to protect it from direct sunlight, dirt, dust, and other debris.

I. **Filter Fabric Securing Pins**

1. 3/16-inch minimum diameter.
2. Steel.
3. Pointed at one end.
4. Fabricated with a head to retain a steel washer having an outside diameter not less than 1-1/2 inches.
5. At least 18 inches long.

J. **Topsoil**. In accordance with Section 32 90 02, "Grading and Seeding."

PART 3 - EXECUTION

3.1 EXAMINATION

A. **Site Verification**. Verify actual field/site conditions and confirm grades, elevation, and other pertinent information before beginning excavation.

3.2 PREPARATION

A. Notifications

1. Notify all utilities and adjacent owners of structures or pavements of the excavation.
2. Notify owners of adjoining properties or utilities in case of emergencies.

3.3 EXCAVATION

A. **Topsoil.** Remove topsoil and place in separate stockpile.

B. Protection

1. Excavations. Protect all excavations by bracing, sheeting, piling, slope benching, or other acceptable means in accordance with OSHA 29 CFR Part 1926.650 to .652, Subpart P. Be responsible for protection of the excavation at all times.
2. Existing Structures. Protect existing structures, utilities, sidewalks, pavements, and other facilities from damages caused by settlement, lateral movement, undermining, washout, and other hazards created by construction operations including dewatering operations.
3. Barricade open excavations.

C. Drainage

1. Direct surface water away from excavations to prevent erosion and undermining of foundations.
2. Provide and maintain diversion ditches, dikes, and grading as necessary during construction.
3. Protect excavated slopes and backfill surfaces to prevent erosion and sloughing.
4. Perform excavation so that the site and the area immediately surrounding the site and affecting operations at the site shall be continually and effectively drained.

D. Dewatering

1. Control groundwater flowing toward or into excavations to prevent sloughing of excavation slopes and walls, boils, uplift, and heave in the excavation.
2. Do not use French drains, sumps, ditches, or trenches within 3 feet of the foundation of any structure unless authorized.
3. Take control measures by the time the excavation reaches the groundwater level in order to maintain the integrity of the in situ material.
4. While the excavation is open, maintain the water level a sufficient distance below the working level to provide a stable working surface.

E. **Rock Excavation**

1. Definition.

a. Rock excavation is defined as the removal of:

1) Unanticipated solid concrete (excluding pavements), unanticipated solid masonry, or boulders each of which has a volume greater than 1 cubic yard.
2) Bedrock which requires for its removal drilling and blasting, wedging, sledging, barring, or breaking up with a power-operated tool.

b. Rock excavation is not excavating:

1) Existing concrete or masonry structures or pavements shown.
2) Material which can be excavated using an appropriately sized, heavy-duty, power-operated excavator, backhoe, or shovel, all of which are equipped with bucket-mounted ripping teeth.
3) Material that can be excavated with a hand pick and shovel.
4) Soft or disintegrated bedrock such as weathered shale, clay shale, claystone, or mudstone, or overconsolidated soils such as "hardpan."
5) Previously blasted materials or materials that are intermittently drilled and blasted to merely increase production.

2. Blasting. Do not blast unless approved.

3. Limits. Unless otherwise noted, excavate rock to the bottom of structures and to a minimum clear width of 6 inches around the outer limits of the structures.

F. **Disposal**. Dispose of all excavated material unless otherwise shown.

1. Excavated material which is satisfactory may be used for backfill and embankments.
2. Dispose of excavated material which is unsatisfactory or surplus off-site.

G. **Excavation for Structures**

1. Elevations and Dimensions. Conform to required elevations and dimensions within a tolerance of 0.10 foot, and extending a sufficient distance from footings and foundations to permit placing and removal of concrete formwork, installation of services, other construction, and inspection.

a. Excavations for Footings and Foundations.

1) Do not disturb bottom of excavation.
2) Excavate by hand to final grade just before concrete reinforcement is placed.
3) Trim bottoms to required lines and grades to leave solid base to receive other work.

b. Excavations for Pile Foundations.

1) Stop excavations from 6 inches to 12 inches above bottom of pile cap before piles are placed.
2) After piles have been driven, remove loose and displaced material.
3) Excavate to final grade, leaving solid base to receive concrete pile caps.

H. **Excavation for Pavements**. Excavate under pavements to comply with required cross sections, elevations, and grades.

3.4 SUBGRADE

A. **Freeze Protection**. Protect the following from freezing:

1. Excavation bottoms or material on which foundations will be constructed.
2. Constructed foundations.
3. Subgrades.

B. **Disturbed Subgrade**. Using an approved method, remediate disturbed subgrade caused by inundation or inadequate dewatering procedures. Perform these remedial measures at no cost to the Owner.

C. **Mud Mat**. Provide a mud mat as shown or where site conditions require a mud mat to protect subgrade.

D. **Unauthorized Excavation**. Backfill unauthorized excavation below design elevations with Class C concrete or other approved material at no cost to the Owner.

E. **Unsuitable Bearing Materials**. Remove unsuitable bearing materials encountered at design elevations and replace with a suitable bearing material as directed.

F. **Shape the subgrade** at all foundations, slabs, and pavements so that the required thickness of the foundations, slabs, pavements, and granular material can be maintained.

G. **Pavement and Slab Subgrade**

1. Compact all pavement and slab subgrades to a depth of 12 inches.
2. Replace subgrade soils with a maximum dry density of less than 100 pounds per cubic foot under pavement and slabs with suitable soil or granular material.
3. Compact soil subgrades with a maximum dry density of 100 to 105 pounds per cubic foot to at least 102 percent.
4. Compact all other soil subgrades to at least 100 percent.
5. The moisture content shall be between the optimum moisture content and 3 percent above the optimum moisture content.

3.5 PROOFROLLING

A. **General**

1. Unless directed otherwise, proofroll all subgrades for pavements, slabs, and embankments.
2. Remove debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface prior to proofrolling and placement of fill for embankment.
3. The proofrolling equipment shall consist of an acceptable pneumatic-tired vehicle such as a loaded dump truck.
4. The gross load of the vehicle shall be at least 25 tons.
5. Roll the entire plan area of the subgrade with at least two passes of the vehicle or as directed.
6. Adjacent passes shall be offset no more than 6 inches to provide complete coverage of the area.
7. Remove and replace any soft, wet, or weak areas detected by the proofrolling with acceptable material or scarify, moisture-condition, and recompact.

3.6 FILTER FABRIC

A. **General**

1. Surfaces to receive fabric shall be relatively smooth and free of obstructions and debris.
2. Place the fabric loosely without wrinkles and creases.
3. Where joints are necessary, place strips to provide a 12-inch minimum overlap.
4. Place securing pins with washers at 2-foot intervals along joints and at 5-foot intervals elsewhere to prevent slippage of the fabric.

3.7 BACKFILL AND EMBANKMENTS

A. **General**

1. Place and compact backfill material as shown and specified in this section.

2. Adjacent to structures:

   a. Use backfill where it will support landscaping.
   b. Use granular backfill where it will support structures and slabs.

3. Backfill excavations as promptly as work permits, but not until completion of the following:

   a. Acceptance of construction below finish grade including, where applicable, dampproofing, waterproofing, and perimeter insulation.
   b. Inspection, testing, approval, and recording locations of underground utilities have been performed and recorded.
   c. Removal of concrete formwork.
   d. Removal of shoring and bracing, and backfilling of voids with satisfactory materials. Cut off temporary sheet piling driven below bottom of structures and remove in manner to prevent settlement of the structure or utilities, or leave in place if required.
   e. Removal of trash and debris from excavation.
   f. Permanent or temporary horizontal bracing is in place on horizontally supported walls.
   g. After the first floor slab has been poured and set on building walls, unless otherwise approved.
   h. Testing water-bearing walls for watertightness.

B. **Placement**

1. Backfill against other work shall be in a manner and at such time as not to endanger the stability or damage the work.

2. Do not place any lift on surfaces that are muddy or frozen, or contain frost or ice.

3. Place backfill and fill materials evenly around structures, piping, or conduit to required elevations.

4. Place granular materials after the subgrades have been leveled.

5. Unless noted otherwise, all references to degree of compaction are expressed as a percentage of the maximum dry density in accordance with ASTM D 698 (standard Proctor).

6. Before compaction, moisten or aerate each lift as necessary to provide appropriate moisture content.

7. Place and compact materials in lifts as specified in the following paragraph.

a. Backfill.

1) Maximum 6-inch loose layers unless using hand tampers.
2) Maximum 4-inch loose layers when hand-operated tampers are used.
3) Compact each layer to at least 95 percent unless noted otherwise.
4) Compact backfill for voids, depressions, or holes resulting from the demolition of existing structures to 100 percent.
5) Moisture content between 1 percent below optimum and 3 percent above optimum.

b. Granular Backfill.

1) Maximum 6-inch loose layers unless using hand tampers.
2) Maximum 4-inch loose layers when hand operated tampers are used.
3) Compact each layer to at least 100 percent.
4) Moisture content at or near optimum.

c. Base.

1) Maximum 6-inch compacted layers.
2) When shown as more than 6 inches thick, place material in equal layers but no layer more than 6 inches compacted thickness.
3) When supporting a structure or slab, compact each layer to at least 100 percent.
4) In all other situations, compact each layer to at least 98 percent.
5) Moisture content within 1 percent of the optimum.

d. Porous Backfill.

1) Maximum 6-inch compacted layers.
2) Compact each layer to at least 95 percent unless supporting a structure if supporting a structure, compact to 100 percent.

e. Granular Mud Mat.

1) Compact at least 100 percent.

f. Drainage Base.

1) Maximum 6-inch compacted layers.

2) When shown as more than 6 inches thick, place material in equal layers but no layer more than 6-inch compacted thickness.
3) Compact each layer to at least 100 percent.

8. Moisture Conditioning.

1) Where the subgrade or a lift of soil material must be moisture conditioned before compaction, uniformly apply water to surface.
2) Apply water sparingly to prevent free water from appearing on surface during or subsequent to compaction operations.

C. **Grading**

1. Smooth the finished surface within specified tolerances.

2. Grade and compact areas with uniform slopes between required elevations or between such points and existing grades.

3. Grade areas to drain away from structures and to prevent ponding.

4. Finish surfaces free from irregular surface changes and as follows:

a. Lawn or Unpaved Areas. Grade areas to receive topsoil to within not more than 0.10 foot above or below required subgrade elevations.
b. Pavements and Walks. Shape surface of areas under pavement to line, grade, and cross section, with surface not more than 1/2 inch above or below required subgrade elevation.

D. **Embankments**

1. Continuously bench sloped surfaces steeper than 1 vertical to 8 horizontal so that embankment material will bond with existing surface.

2. Maximum 6-inch loose layers.

3. Compact each layer to the minimum percent of maximum dry density specified herein.

Compaction Maximum Dry Density lbs/cf	Minimum Percent Maximum Dry Density
90-104.9	102
105-119.9	100
120 and more	98*

*100 if embankment supports a structure foundation.

4. Moisture Content.

   a. The moisture content shall be between the optimum moisture content and 3 percent above the optimum moisture content.
   b. For material which displays pronounced elasticity or deformation under action of compaction equipment, reduce the moisture content to optimum to secure stability.

3.8 FIELD QUALITY CONTROL

A. Field-Testing

1. Test Laboratory. Employ an acceptable soils testing laboratory to determine the following:

   a. Moisture density relationship of the materials to be compacted.
   b. Field moisture and density to verify the degree of compaction being obtained.
   c. The strength of subgrades supporting structures.

2. The soils testing laboratory personnel shall be on-site **continuously** during all placement and compaction activities including backfills and embankments to determine compliance with this specification section.

3. Tests will be located by the Engineer/Architect.

4. Allow testing services to inspect and approve subgrades, backfill, drainage fill, and embankment layers before further construction work is performed.

5. Perform field density tests as follows, in accordance with ASTM D 1556 or D 2922. Perform footing subgrade strength tests using acceptable calibrated instruments.

   a. Footing Subgrade. Conduct at least one test to verify required design bearing for each footing location. For a strip footing, conduct one test for every 50 linear feet of footing.
   b. Building Slab or Paved Areas. Make at least one field density subgrade test for every 2,000 square feet, but in no case less than three.
   c. Backfill, Base, Drainage Base, and Embankment. Field density tests shall be made at least once for every 50 cubic yards, or fraction thereof, and at least one test per lift (compacted layer).
   d. Wall Backfill. Take at least one field density test, per side, at locations directed for each lift (compacted layer).

6. If the subgrade, backfill, drainage fill, or embankment is below specified density, provide additional compaction and testing at no additional cost to the Owner.

B. **Settling**. Where settling is measurable or observable during the general project warranty period, remove the surface (pavement, lawn, or other finish), add backfill, compact, and replace surface at no cost to the Owner.

3.9 GRADING FOR SEEDING

A. **Rough Grading**

1. Trim and grade all areas to within 4 inches of the finished grades.
2. These areas are to be free from rock or other foreign material 3 inches or greater in any dimension.

B. **Finished Grading**. Spread topsoil to conform to the required finished grades.

END OF SECTION

SECTION 32 90 02

GRADING AND SEEDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General.** Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 1, and all related specification sections, apply to this section.

1.2 DESCRIPTION OF WORK

A. **Scope of Work.** Provide the grading and seeding as shown and specified herein.

1.3 QUALITY ASSURANCE

A. **Certificate of Inspection**

1. Ship all seeds with a certificate of inspection in accordance with the governing authorities.
2. Label all bags of seed and fertilizer with legible waterproof tags or directly on the bag.

1.4 SUBMITTALS

A. **General**

1. Submit all submittals in accordance with the Division 1 Submittal Requirements and this specification section.

B. **Submittal Package No. 1 – Product Data and Certified Statement**

1. Submit seed vendor's certified statement for each grass seed mixture required that includes:

   a. Botanical and common name.
   b. Percentage by weight.
   c. Percentages of purity, germination, and weed seed for each grass seed species.

2. Product Data. Submit information on all materials included in this specification.

1.5 JOB CONDITIONS

A. **General.** Proceed with grading and seeding as soon as portions of the site become available, working within seasonal limitations and the seed manufacturer's recommended limitations regarding weather conditions and temperatures.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Delivery

1. Deliver seed only when site conditions are ready.
2. Deliver materials in unopened containers showing weight, mixture analysis, package date, and manufacturer.

B. Storage and Handling

1. Store and cover material to prevent wetting and deterioration.
2. Remove packages from the site that have become wet, moldy, or damaged, or show water marks.

1.7 SPECIAL WARRANTY

Not used.

PART 2 - PRODUCTS

2.1 MATERIAL

A. **Topsoil**. Topsoil shall contain:

1. A maximum of 40 percent clay in that portion passing a No. 10 sieve.
2. Between 5 and 20 percent organic matter as determined by loss on ignition of samples oven-dried at 212 degrees Fahrenheit (° F.) to a constant weight.

B. **Fertilizer**. Fertilizer shall contain the specified percentages of total nitrogen, available phosphoric acid, and water soluble potash. The weight, name of plant nutrients, and guaranteed percentages shall be marked on the sealed fertilizer containers.

1. 12-12-12. This fertilizer shall be used with Seed Mixes 1, 2, 3, and 5.
2. 5-10-10. This fertilizer shall be used with Seed Mix 4 (Crownvetch).

C. **Inoculant**. Treat Seed Mix 4 (Crownvetch) with inoculant culture of nitrogen fixing bacteria less than 1 year old.

D. **Seed**. Percentages are by weight.

	Minimum Germination	Minimum Purity
1. Seed Mix 1		
40% Kentucky Bluegrass (*Pos pratensis*)	75%	85%
40% Creeping Red Fescue (*Festuca rubra*)	85%	98%
20% Annual Ryegrass (*Lolium multiflorum*)	85%	95%

		Minimum Germination	Minimum Purity
2.	Seed Mix 2 30% Kentucky Bluegrass (*Pos pratensis*) 50% Kentucky 31 Fescue (*Festucaarundinacea* var. Ky. 31) 20% Annual Ryegrass (*Lolium multiflorum*)	75% 85% 85%	85% 95% 95%
3.	Seed Mix 3 90% Perennial Ryegrass (*Lolium perenne*) 10% Alsike Clover (*Trifolium hybridum*)	85% 85%*	95% 98%
4.	Seed Mix 4 (Crownvetch) 30% Crownvetch (*Coronilla varia*) 30% Kentucky 31 Fescue (*Festuca arundinacea var. Ky. 31*) 30% (Pennlawn) Red Fescue (*Festuca rubra*) 10% Annual Ryegrass (*Lolium multiflorum*)	70%* 85% 85% 85%	99% 95% 98% 95%
5.	Seed Mix 5 80% Kentucky Bluegrass (*Poa pratensis*) 20% Annual Ryegrass (*Lolium multiflorum*)	75% 85%	85% 95%

*Germination includes a total of quick germination plus hard seeds.

E. **Mulch**

1. Straw. Straw mulch shall be baled wheat or oat straw free of weed seed, sticks, or other foreign material.
2. Wood Cellulose Fiber. Dye the wood cellulose fiber mulch green.

F. **Asphalt Emulsion**. Do not use asphalt emulsions.

G. **Mow Strip Blocks**

1. Install concrete mow strips as shown and specified herein. Mow strips shall be precast concrete. Provide two anchor pins for each block. Field-cut blocks to achieve necessary radii.

2. Description.

   a. Height. 6 inches.

b. Width. 8 inches.
c. Length. 8 feet.
d. Securing Holes. 7/8-inch diameter.
e. Anchor Pins. No. 6 reinforcement bar, galvanized, 16 inches long.

PART 3 - EXECUTION

3.1 EXAMINATION

A. **Verification**. Verify that final grades and elevations have been achieved in all areas. Remove all exposed debris and stones larger than 3/4 inch in any dimension from seeded areas.

3.2 PREPARATION

A. **Soil Tests**. Test soil as necessary to ensure acceptable seeding conditions.

3.3 SEEDING

A. **Seed Mix**. Seed all privately owned lawns with Seed Mix 5. On all privately owned cultivated fields, place the seedbed but do not seed. Seed all other disturbed areas with Seed Mix 1, unless otherwise noted.

B. **Preparation of Seedbed**

1. Remove, stockpile, and use for seedbed topsoil that is available as part of the excavated material.
2. Remove all grass, weeds, roots, sticks, stones, and other debris and finish the seedbed with careful hand raking.
3. If there is a deficiency of topsoil as part of the excavated materials, provide topsoil from another source at no cost to the Owner.
4. The seedbed shall be a minimum of 4 inches of topsoil.
5. Prepare a smooth seedbed before seeding.

C. **Dry Seeding**. When a seed mix is sown dry, apply the materials as follows:

1. Fertilizing.

   a. Apply fertilizer uniformly to all areas to be seeded at the rate of 10 pounds per 1,000 square feet.
   b. Disk, harrow, or rake the fertilizer into the seedbed to a depth of 2 inches.

2. Seeding. Mix thoroughly and sow uniformly the seed over the prepared areas. After sowing, rake, drag, or otherwise treat the area to cover the seed with soil to a depth of 1/4 inch.

   a. Seed Mixes 1, 2, 3, and 5. Sow these seed mixes at a rate of 3 pounds per 1,000 square feet.
   b. Seed Mix 4 (Crownvetch). Sow this seed mix at a rate of 2 pounds per 1,000 square feet. Before sowing, inoculate it in

accordance with manufacturer's directions. Sow this seed mix only from November through August.

3. Water. Water the seeded areas at the completion of the sowing and weekly thereafter until accepted by the Owner.

4. Mulching.

   a. Place straw mulching material evenly over all seeded areas within 48 hours of seeding at a rate of 2 tons per acre between March 15 and October 15 and at a rate of 3 tons per acre between October 16 and March 14.
   b. Secure straw mulching material by approved methods.
   c. When mulching is displaced, replace it and reseed the area; repair other work damaged as a result of mulch displacement.

D. **Hydraulic Seeding**

1. When seed is applied hydraulically, use a combined slurry of fertilizer, inoculant when required, seed, and wood cellulose fiber mulch in one operation.
2. Increase the inoculant for Seed Mix 4 (Crownvetch) to five times the manufacturer's recommended rate for dry seeding.
3. Mix wood cellulose fiber at a rate of 1,500 pounds per acre.
4. Mix fertilizer and seed at the rate specified for dry seeding.

3.4 MAINTENANCE

A. **General**. Maintain seeded areas. Fill, grade, and reseed settled and eroded areas. Seeding will not be accepted unless it is alive and healthy.

3.5 DEMONSTRATION

A. **Seeded Area**. Before final acceptance the seeded area shall have:

1. A minimum of 100 grass plants per square foot and less than 2 percent bare spots over the entire area.
2. No individual bare spots larger than 6 square inches

END OF SECTION

SECTION 33 05 30

PRESSURE PIPE, FITTINGS, AND VALVES, INSTALLATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General**. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 1, and all related specification sections, apply to this section.

1.2 DESCRIPTION OF WORK

A. **Scope of Work**. Provide the labor, tools, equipment, and materials necessary to install the pipe and fittings in accordance with the drawings and as specified herein. The work includes, but is not limited to, the following:

1. Excavation, preparation of the trench bottom and bedding.
2. Shoring and bracing.
3. Piping beginning at the outside face of structures or building foundations, unless specifically included under other sections.
4. Piping beneath structures.
5. Installation of supports, restraints, and thrust blocks.
6. Work on existing buried pipelines.
7. Installation of all joints, fittings, specials, couplings, adapters, sleeves, tie rods, jointing and gasketing materials, and all other work required to complete the piping installation.
8. Valves, gates, and specials shown or specified for the piping systems.
9. Testing and disinfection.
10. Cleaning.
11. Trench maintenance.

1.3 QUALITY ASSURANCE

A. **Standards**. Conform all materials and workmanship with the following standards.

1. AASHTO – American Association of State Highway and Transportation Officials.
2. Ohio EPA – Environmental Protection Agency.
3. ANSI – American National Standards Institute.
4. ASTM – American Society for Testing and Materials.
5. AWWA – American Water Works Association.
6. PPI – Plastic Pipe Institute.

B. **Trench Maintenance**. Be responsible for the condition of the trenches for a minimum period of year from the date of the final acceptance, which must

include the period of November 1 to the following April 30. Extend the contract bond to cover the entire trench maintenance period.

1.4 SUBMITTALS

A. General

1. Submit all submittals in accordance with the Division 1 Submittal Requirements and this specification section.

B. Submittal Package No. 1 – Backfill Product Data

1. Submit product data for review and approval. Submittal package shall include:

   a. Product Data. Submit material data, noting each material source, location, sieve analysis, and other information which will show that the source and supplier are capable of furnishing materials meeting the requirements of these specifications. Submit name and location of all borrow pits. Product data is required for the following:

      1) Granular pipe bedding.
      2) Granular backfill.

1.5 JOB CONDITIONS

A. **Testing**. Provide all equipment required for testing at no additional cost to the Owner.

B. **Cleaning**. Provide all water required for cleaning and flushing at no additional cost to the Owner.

1.6 DELIVERY, STORAGE, AND HANDLING

A. General

1. Delivery, storage, and handling shall be in accordance with Section 01 60 00, "Materials and Equipment."
2. Pipe, fittings, and accessories that are cracked, damaged, or in poor condition, or have damaged linings will be rejected.
3. Pipe handled on skidways shall not be skidded or rolled against other pipe.
4. Protect PVC or PE pipe from exposure to heat or direct sunlight (ultraviolet rays).

1.7 SPECIAL WARRANTY

Not used.

PART 2 - PRODUCTS

2.1 GENERAL

A. **Pipe and Fittings.** Conform all buried piping, fittings, and joints to the drawings and requirements specified in the corresponding section for each type of pipe installed.

B. **Manufacturer**

1. All new buried piping of one material shall be by a single manufacturer.
2. All buried fittings of one material shall be by a single manufacturer.
3. All pipe and fittings manufactured outside the United States shall be certified to ISO 9001:2000 standards for quality assurance.

C. **Identification**

1. Paint or cast all pipe and fittings 4 inches in diameter and larger with the pipe size, material, and class or schedule on the exterior pipe surface.
2. Factory-mark all piping less than 4 inches in diameter with the pipe size, material, and class or schedule on the exterior pipe surface.

2.2 BACKFILL

A. **Granular Pipe Bedding.** Crushed stone or gravel meeting the following requirements:

Nominal Pipe Size	AASHTO M43 Size
Less than 16 "	67, 7, or 8
16" – 30"	6 or 67
Greater than 30"	57 or 67

B. **Selected Excavated Trench Material**

1. Free from cinders, refuse, organic material, boulders, rocks, frozen material, or other material which in the opinion of the Engineer is unsuitable.

C. **Excavated Trench Material**

1. Free from frozen earth, debris, or earth with an exceptionally high void content.

D. **Granular Backfill.** Granular backfill materials shall be gravel, crushed gravel, crushed stone, or sand meeting the following grading requirements:

Sieve	Total Percent Passing
2-1/2 inch	100
1 inch	70 – 100
No. 4 (3/16 inch)	25 – 100
No. 40	10 – 50
No. 200	5 – 15

The fraction passing a No. 40 sieve shall have a liquid limit not greater than 30 and a plasticity index not greater than 6.

PART 3 - EXECUTION

3.1 EXAMINATION

A. **Verification of Conditions**

1. Verify the location and elevation of required construction.
2. Confirm that conditions are acceptable to begin construction of the work covered in the specification.
3. Coordinate with other construction or activities in the same facility or area.

3.2 PREPARATION

A. **Safety**. For the security and safety of persons in and adjacent to trenches or construction operations, follow the safety regulations of the appropriate federal, state, and local agency.

B. **Dewatering**

1. Should water be encountered, furnish and operate suitable pumping equipment of adequate capacity to dewater the trench.
2. Sufficiently dewater the trench so that the laying and joining of the pipe is in the dry.
3. Convey all trench water in accordance with the requirements contained in the National Pollutant Discharge Elimination System (NPDES) program.
4. Convey all trench water to a natural drainage channel or storm sewer without causing any property damage.

C. **Construction Equipment**. Where mains are located in or adjacent to pavements, all backfilling and materials handling equipment shall have rubber tires. Use crawler equipment only where there is no danger of damaging pavement.

D. **Noise, Dust, and Odor Control**. Conduct construction activities so as to eliminate all unnecessary noise, dust, and odors. Do not use oil or other materials for dust control which may cause tracking.

3.3 INSTALLATION

A. Protection of Trees

1. Take special care to avoid damage to trees and their root systems.
2. Do not use machine excavation when, in the opinion of the Engineer/Architect, it would endanger the tree.
3. Where the line of trench falls within the limits of the limb spread, headers are required across the trench to protect the tree.
4. Conduct the operation of all equipment (particularly when employing booms), the storage of materials, and the deposition of excavation in a manner which will not injure trees, trunks, branches, or their roots unless such trees are designated for removal.

B. Excavation and Construction Materials.

1. Place all excavated material and all construction materials used in the work so as not to endanger the work, annoy the public, or interfere with natural drainage courses.
2. During the process of the work, maintain all material piles in a neat, workmanlike manner.

C. Trench Support

1. Unsupported open cut trenches will not be permitted where they may cause unnecessary damage to pavement, trees, structures, poles, utilities, or other private or public property.
2. During the progress of the work, support the sides of the excavation by adequate and suitable sheeting, shoring, bracing, or other approved means.
3. Remove trench support material and equipment when backfilling operations have progressed to the point where they may be withdrawn without endangering property.
4. In lieu of removing all the sheeting, you may cut off the sheeting 2 feet above the top of the pipe and remove the upper portion.
5. If all the sheeting is to be removed, remove it without causing damage to the pipe.
6. No sheeting, shoring, or bracing will be paid for by the Owner unless remaining in place on written order of the Engineer/Architect. In this case, payment will be made in accordance with the General Conditions.

D. Trench Excavation and Bottom Preparation

1. Trench Width. Hold widths of trenches to a minimum to accommodate the pipe and appurtenances. Measure the trench width at the top of the pipe barrel and shall conform to the following limits:

a. Pipe.

Earth

Minimum	Outside diameter of the pipe barrel plus 8 inches, i.e., 4 inches each side
Maximum	Nominal pipe diameter plus 24 inches

Rock

	Nominal Pipe Diameter 24 inches or less	**Nominal Pipe Diameter Larger than 24 inches**
Minimum	Outside diameter of the pipe barrel plus 12 inches, i.e., 6 inches each side	Outside diameter of the pipe barrel plus 18 inches, i.e., 9 inches each side
Maximum	Nominal pipe diameter plus 24 inches	Nominal pipe diameter plus 24 inches

b. Structures. The minimum excavation limits for structures shall be as excavated. In rock, the excavation limits shall not exceed 12 inches from the outside wall and 6 inches below the footer.

c. Excessive Trench Width. If for any reason the trench width exceeds the maximum trench width defined in this section, provide granular pipe bedding, additional strength pipe, or concrete encasement, at no cost to the Owner and subject to acceptance.

2. Trench Depth.

a. Earth.

1) Excavate the trench to the depth required.
2) Provide a uniform and continuous bearing and support for the pipe barrel on solid and undisturbed ground at every point between joints.
3) It will be permissible to disturb the finished trench bottom over a maximum length of 18 inches near the middle of each length of pipe for the withdrawal of lifting tackle.
4) Provide bell holes.
5) Accurately prepare the finished trench bottom by means of hand tools.

b. Rock.

1) Where excavation is made in rock or boulders, excavate the trench 6 inches below the pipe barrel for pipe 24 inches in diameter or less, and 9 inches for pipe larger than 24 inches in diameter.
2) Remove all loose material from the trench bottom.

3. Rock Excavation.

a. Rock excavation is defined as the removal of:

1) Unanticipated solid concrete (excluding pavements), unanticipated solid masonry, or boulders each of which has a volume greater than 1 cubic yard.
2) Bedrock which requires for its removal drilling and blasting, wedging, sledging, barring, or breaking up with a power-operated tool.

b. Rock excavation is not excavating:

1) Existing concrete or masonry structures or pavements shown on the plans.
2) Material which can be excavated using an appropriately sized, heavy-duty, power-operated excavator, backhoe, or shovel, all of which are equipped with bucket-mounted ripping teeth.
3) Material that can be excavated with a hand pick and shovel.
4) Soft or disintegrated bedrock such as weathered shale, clay shale, claystone, or mudstone, or overconsolidated soils such as "hardpan."
5) Previously blasted materials or materials that are intermittently drilled and blasted to merely increase production.

c. Blasting Rock. Do not blast rock unless approved.

E. **Pipe, Fittings, and Valve Installation**

1. Pipe Laying.

a. Lay pipe with bell ends facing in the direction of laying, unless otherwise directed.
b. After placing a length of pipe in the trench, center the spigot end in the bell and force the pipe home.
c. Lay all pipe with ends abutting and true to line and grade.
d. Deflection of pipe joints in excess of the manufacturer's recommendations will not be permitted.

e. Provide a watertight pipe plug or bulkhead to prevent the entrance of foreign material whenever pipe laying operations are not in progress.
f. Inspect cast metal pipe and fittings for cracks by ringing the pipe with a light hammer while it is suspended.

2. Pipe Cutting.

a. Cut pipe in a neat and workmanlike manner without damage to the pipe or lining.
b. The end shall be smooth and at right angles to the axis of the pipe.
c. Flame cutting of metal pipe by means of an oxyacetylene torch will not be permitted.

3. Push-On Joints.

a. Thoroughly clean the surfaces with which the rubber gasket comes in contact just before assembly.
b. Then insert the gasket into the groove in the bell.
c. Before starting joint assembly, apply a liberal coating of special lubricant to the spigot end.
d. With the spigot end centered in the bell, push the spigot end home.

4. Mechanical Joints.

a. Center the spigot in the bell.
b. Thoroughly clean the surface with which the rubber gasket comes in contact just before assembly.
c. Brush these clean surfaces with a special lubricant just before slipping the gasket over the spigot end and into the bell.
d. Also brush the lubricant over the gasket before installation to remove the loose dirt and lubricate the gasket as it is forced into its retaining space.

5. Restrained Joints.

a. Ball and Socket or Push-On. Assemble and install the ball and socket joint according to the manufacturer's recommendations. Thoroughly clean and lubricate the joint. Check the retainer ring fastener.

6. Joints between Dissimilar Pipe Materials. Make connections to pipe of different materials with adaptors designed to join those materials.

7. Setting Valves.

a. Set valves on a firm foundation so that no load will be transferred to the connecting pipe.

b. Provide a valve box for every buried valve.
c. The valve box shall not transmit shock or stress to the valve and shall be centered and plumb over the operating nut of the valve.
d. Set the box cover flush with the surface of the finished pavement unless otherwise shown.

8. Anchoring. Provide all plugs, caps, tees, and bends with a concrete backing. If shown or specified, prevent movement by attaching suitable metal rods, clamps, or restrained fittings.

a. Concrete Backing.

1) Concrete backing shall be Design Mix A concrete as specified in Section 03 30 00, "Cast-In-Place Concrete."
2) Place backing between undisturbed ground and the fitting to be anchored.
3) The area of bearing on the fitting and on the ground shall be as shown.
4) Place the backing, unless otherwise shown, so that the pipe and fitting joints will be accessible for repair.

b. Tie Rods.

1) Place steel tie rods or clamps, where permitted, of adequate strength to prevent movement.
2) Paint steel tie rods or clamps with three coats of an approved bituminous paint or coal tar enamel.

c. Restrained Fittings. Restrained fittings shall be subject to the acceptance of the Engineer/Architect.

F. **Trench Backfill.** Backfill all trench excavations immediately after pipe is laid as shown and specified.

1. Foundation.

a. Build the mains on a good foundation.
b. If, in the Engineer/Architect's opinion, the material forming the trench bottom is not suitable for a good foundation, replace it with granular pipe bedding as directed.
c. Authorized excavation and restoration of the foundation below the trench bottom will be paid for in accordance with the General Conditions.
d. Fill unauthorized excavation below the trench bottom with pipe bedding at no cost to the Owner.

2. Pipe Bedding.

a. Install all plastic or fiberglass-reinforced plastic (FRP) pipes with a 6-inch-deep granular pipe bed.

b. Install all other pipe materials with no pipe bed unless foundation is rock.
c. For rock foundations, provide a 6-inch granular pipe bed between rock and pipe for pipes 24 inches in diameter or less and a 9-inch granular pipe bed for pipes larger than 24 inches in diameter.
d. Spread granular pipe bedding the full width of trench bottom.

3. Haunching.

a. Use compacted selected excavated trench material unless noted otherwise.
b. Place in uniform 6-inch loose layers and compact each layer to eliminate the possibility of settlement, pipe misalignment, or damage to joints.

4. Initial Backfill.

a. Use selected excavated trench material unless noted otherwise.
b. Take care to avoid injuring or moving the pipe.

5. Final Backfill.

a. Use excavated trench material unless noted otherwise.
b. Use mechanical equipment to place the backfill.
c. Do this in such a manner that the material does not free fall, but so that it will flow onto the previously placed material.
d. Consolidate the backfill to ensure the minimum possible settlement.
e. No compacting of the backfill with mechanical equipment, such as wheeled vehicles, will be permitted unless sufficient cover is provided over the pipe to prevent damage to the pipe.

6. Granular Backfill. When backfilling under pavements, driveways, or as directed, use granular backfill in place of the selected excavated trench material and the excavated trench material.

7. Backfill trenches with Class C concrete where trench excavations pass within 18 inches of column or wall footings and that are carried below bottom of such footings or that pass under wall footings. Place concrete to level of bottom of adjacent footing.

8. Provide 4-inch-thick concrete base slab support for piping or conduit less than 2'-6" below surface of roadways. After installation and testing of piping or conduit, provide minimum 4-inch-thick encasement (sides and top) of concrete prior to backfilling or placement of roadway subbase.

9. Bulkheads.

   a. When granular bedding or backfill is provided, place bulkheads of clay soil across the trench at 100 foot intervals to resist the movement of groundwater through the granular material.
   b. Carefully compact the bulkheads and extend them approximately 3 feet in the direction of the pipe and from the bottom of the trench to a height of 6 inches above the top of the pipe barrel.

10. Surface Conditions. Periodically attend to the trench surface during the course of the Contract. Maintain the trench surface in a safe condition and not interfering with natural drainage.

3.4 CLEANING

A. **Cleanup**. After a section of main is tested and accepted, clean the ground surface of all surplus material including stone, broken pipe, construction material, and all other debris.

3.5 DEMONSTRATION

A. **Leakage Test and Disinfection**. In accordance with Section 01 89 19, "Leakage Test and Disinfection."

B. **Visual**. With Owner and/or Engineer/Architect, visually review the main installation for completion. Demonstrate that all main materials and appurtenances are in conformance with the Contract Documents.

C. **Final Acceptance**. The visual demonstration for completion of the main installation shall not be considered as final acceptance of the work. Correct all discrepancies "punch listed" at final inspection to the satisfaction of the Engineer/Architect and Owner.

3.6 **PROTECTION**. Protect the main appurtenances (valves, hydrants, etc.) from damage during subsequent construction operations. Remove any and all protection at the completion of the project.

END OF SECTION

SECTION 33 05 33

PRESSURE PIPE AND FITTINGS, DUCTILE IRON

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General.** Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 1, Section 33 05 30, and all related specification sections, apply to this section.

1.2 DESCRIPTION OF WORK

A. **Scope of Work.** The Contractor shall provide the labor, tools, equipment, and materials necessary to furnish and install the buried ductile iron pipe and fittings in accordance with the drawings and as specified herein.

1.3 QUALITY ASSURANCE

A. **General.** In accordance with Section 33 05 30, "Pressure Pipe, Fittings, and Valves, Installation."

1.4 SUBMITTALS

A. **General**

1. Submit the following submittal packages in accordance with section 01 33 00, "Submittals." Both packages shall be submitted, reviewed, and approved before installation of the pipe.

B. **Submittal Package No. 1 – Pipe Material and Testing Data**

1. Certification of compliance with the referenced standards.
2. Description of proposed testing methods, procedures, and apparatus.
3. Manufacturer's product data clearly marked for this specific project showing materials, sizes, thicknesses, pressure ratings, coatings, and joint configuration strengths.

C. **Submittal Package No. 2 – Detailed Drawings and Thrust Calculations**

1. Detailed profile drawings for all piping and fittings showing full details of piping, specials, and connections to existing pipes and structures.
2. Submit thrust restraint design calculations.

1.5 JOB CONDITIONS

A. **General.** In accordance with Section 33 05 30, "Pressure Pipe, Fittings, and Valves, Installation."

1.6 DELIVERY, STORAGE, AND HANDLING

A. **General**. In accordance with Section 33 05 30, "Pressure Pipe, Fittings, and Valves, Installation."

1.7 SPECIAL WARRANTY

Not used.

PART 2 - PRODUCTS

2.1 MATERIALS

A. **Ductile Iron Pipe**. Ductile iron pipe shall meet the requirements of ANSI/AWWA C151/A21.51, "Ductile Iron Pipe, Centrifugally Cast, for Water or Other Liquids."

1. Material. The chemical constituents shall meet the physical property recommendations of ASTM A 536, "Ductile Iron Castings," to ensure that the iron is suitable for satisfactory drilling and cutting.

2. Minimum Thickness. Unless otherwise shown, the minimum thickness of the barrel of the pipe shall be:

Size	Thickness Class
3" – 12"	51
14" – 24"	52
30" – 48"	53

a. Unless otherwise shown, the minimum thickness of the barrel of restrained ball and socket joint pipe (river crossing) shall be:

Size	Thickness Class
4" – 6"	54
8" – 12"	55
14" – 24"	56
30" – 36"	57

3. Coating and Lining.

a. The pipe shall be coated outside with a bituminous coating in accordance with ANSI/AWWA C151/A21.51, "Ductile Iron Pipe, Centrifugally Cast, for Water or Other Liquids."

b. Air Mains. All ductile iron air mains shall be unlined in their interior.

B. **Ductile Iron Fittings**. Ductile iron standard and special fittings shall conform to ANSI/AWWA C110/A21.10, "Ductile Iron and Gray Iron Fittings, 3 Inches Through 48 Inches, for Water and Other Liquids," or ANSI/AWWA C153/A21.53, "Ductile Iron Compact Fittings, 3 Inches Through 24 Inches and 54 Inches Through 64 Inches."

1. Working Pressures. Fittings shall be suitable for the following working pressures unless otherwise noted:

Sizes	Pressure (psi) Gray Iron	Pressure (psi) Ductile Iron
2" – 12"	250	
14" – 48"	150	
3" – 24"		350
30" – 48"		250

2. Coating and Lining.

   a. The fittings shall be coated outside with a bituminous coating in accordance with ANSI/AWWA C110/A21.10, "Ductile Iron and Gray Iron Fittings, 3 Inches Through 48 Inches, for Water and Other Liquids," or ANSI/AWWA C153/A21.53, "Ductile Iron Compact Fittings, 3 Inches Through 24 Inches and 54 Inches Through 64 Inches."
   b. Air Mains. All ductile iron fittings on air mains shall be unlined in their interior.

C. **Joints**

1. Push-On and Mechanical (Including Restrained Joints). Push-on and mechanical joints including accessories shall conform to ANSI/AWWA C111/A21.11, "Rubber Gasket Joints for Ductile Iron Pressure Pipe and Fittings." Bolts shall be high strength low-alloy steel tee head with hex nuts.

2. Flanged. Flanged joints shall not be used in underground installations except where specified or shown on the plans. See Section 40 05 13, "Process Piping, General," for more information on flanged joints.

3. Ball and Socket. Ball and socket joints (river crossing) shall be restrained, boltless, and capable of deflecting up to 15 degrees. The bell, ball, and retainer shall be cast of ductile iron. The gasket shall be of high quality rubber.

4. Gaskets.

   a. Air piping shall have high-temperature type gaskets, rated to 300 degrees Fahrenheit (° F.). Material shall be a fluoroelastomer (FKM).
   b. All gasket types shall be suitable for the material being conveyed.

D. **Polyethylene Encasement**. The pipe and fittings shall be encased with polyethylene film conforming to ANSI/AWWA C105/A21.5, "Polyethylene Encasement for Ductile Iron Piping for Water and Other Liquids."

PART 3 - EXECUTION

3.1 INSTALLATION

A. **Pipe and Fittings.** All pipe and fittings shall be installed in conformance with Section 33 05 30, "Pressure Pipe, Fittings, and Valves Installation."

END OF SECTION

SECTION 40 05 13

PROCESS PIPING, GENERAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General.** Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 1, and all related specification sections, apply to this section.

1.2 DESCRIPTION OF WORK

A. **Scope of Work.** Provide the labor, tools, equipment, and materials necessary to furnish and install the process piping in accordance with the drawings and as specified herein. This section, in conjunction with the corresponding process piping material sections, is intended to cover the supply and installation of all exposed (nonburied) process piping. This work shall also include all pipe supports and restraints, fittings, joints, testing, cleaning, and work on existing exposed process piping. See Division 33 for buried piping.

1.3 QUALITY ASSURANCE

A. **Codes and Regulatory Agencies.** Perform all work in compliance with all federal, state, and local codes and regulatory agencies.

B. **Standards.** All materials, testing, and workmanship shall be in conformance with the following standards and as referenced herein.

1. ANSI – American National Standards Institute.
2. ASME – American Society of Mechanical Engineers.
3. ASTM – American Society for Testing and Materials.
4. AWWA – American Water Works Association.
5. NSF – National Sanitary Foundation.

1.4 SUBMITTALS

A. **General.** Submit the specified submittal packages in accordance with Section 01 33 00, "Submittals" and the pipe material's specific specification section included later in this contract document.

1.5 JOB CONDITIONS

A. **General.** Verify job conditions which may impact piping layouts and locations prior to ordering.

B. **Coordination**

1. Coordinate schedule of the work and the location of equipment and conduit to prevent interferences and delays.

2. Coordinate type and materials (gaskets, glands, and bolts) of joints connecting to valves and equipment with the suppliers of each item.

C. **Field Dimensions**. All piping shall be installed to field dimensions unless specifically stated on drawings.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **General**. The delivery, storage, and handling of the process piping and accessories shall be in accordance with Section 01 60 00, "Materials and Equipment," and the manufacturer's instructions.

B. **Handling**. Handle all pipe, fittings, and accessories carefully using proper handling devices. Do not insert lifting devices into barrels of pipe.

C. **Storage**. Store pipe and fittings on wood blocking or platforms to avoid contact with ground. Keep pipe free from dirt and foreign matter. Plastic and fiberglass-reinforced plastic (FRP) piping shall be shaded but not covered directly to allow air circulation and reduce heat build-up due to direct sunlight.

1.7 SPECIAL WARRANTY

Not used.

PART 2 - PRODUCTS

2.1 GENERAL

A. **Pipe and Fittings**. All process piping, fittings, and joints shall conform to the drawings and requirements specified in the corresponding section for each type of pipe installed.

B. **Manufacturer**. All new process piping of one material shall be by a single manufacturer. All process fittings of one material shall be by a single manufacturer. All pipe and fittings manufactured outside the United States shall be certified to ISO 9001:2000 standards for quality assurance.

C. **Identification**

1. All pipe and fittings 4 inches in diameter and larger shall have the pipe size, material, and class or schedule painted or cast on the exterior pipe surface.
2. All piping less than 4 inches in diameter shall have the pipe size, material, and class or schedule factory marked on the exterior pipe surface.

2.2 JOINTS

A. **Flanged**

1. Standard. Conform to ANSI/AWWA C115/A21.15 or ANSI/ASME B16.1, Class 125, unless otherwise noted on the drawings.

2. Gaskets. All joints for 12 inches and smaller shall include 1/8-inch-thick full-face SBR red rubber gaskets unless noted otherwise. All joints for pipe 14 inches and larger shall include 1/8-inch-thick full-face synthetic rubber gaskets with one or more annular rings. Gaskets shall conform to ANSI/AWWA C111/A21.11 and be rated to for a minimum of 170° F unless noted otherwise. All gasket types shall be suitable for the process material being conveyed.

   a. Air and gas piping shall have high temperature type gaskets, rated to 300° F. Material shall be fluoroelastomer (FKM).

3. Bolts.

   a. Nonsubmerged Service. Bolts shall have American Standard heavy unfinished hexagonal head and nut dimensions conforming to ANSI B18.2.1 and ANSI/ASME B18.2.2. For bolts of 1-3/4-inch diameter and larger, bolt studs with a nut on each end are recommended. Material for nuts and bolts shall conform to ASTM A 307, Grade B.
   b. Submerged Service. Bolts shall have American Standard heavy unfinished hexagonal head and nut dimensions, all as specified in ANSI B18.2.2, "Square and Hex Nuts Inch Series." For bolts 1-2/4 inches in diameter and larger, bolt studs with a nut on each end are recommended. Material for bolts and nuts shall be Type 316 stainless steel. Utilize antiseize compound on all nuts.

B. **Threaded**

1. Standard. Pipe threads shall conform to American Standard Taper Pipe thread ANSI B2.1.
2. Preparation. Threaded joints shall include a Teflon tape for sealant purposes.

C. **Grooved and Shouldered**

1. Standard. Conform to AWWA C606 unless otherwise noted on the drawings.
2. Couplings shall be ductile iron.
3. Gaskets. Gaskets shall conform to the same material requirements as the flanged joints.
4. Bolts. Bolts and nuts shall conform to the same material requirements as the flanged joints.

PART 3 - EXECUTION

3.1 EXAMINATION

A. **Inspection**

1. All pipe shall be inspected for damage resulting from shipping and handling. Reject and replace all damaged pipe and fittings with a new piece at the Contractor's expense.
2. If any defective pipe or fitting is discovered after installation, remove and replace defective piece with a sound piece at the Contractor's expense.
3. All pipe and fittings shall be kept clean until they are accepted in the completed work.

3.2 INSTALLATION

A. **General**. Installation of all process piping shall be in accordance with manufacturer's instructions, approved shop drawings, drawings, and as specified herein.

1. Use of flange adapters and flanges, or flexible couplings, shall be acceptable only where shown on the approved dimensional layouts or drawings.
2. Conflicts between the specifications or drawings and the manufacturer's instructions shall be brought to the Engineer/Architect's attention and a solution documented by Field Order.

B. **Cutting**

1. Pipe cutting shall be neat, smooth, at right angles to the axis of the pipe, and without damage to the pipe, coating, or lining.
2. Flame cutting will not be permitted.
3. Ream all pipes and tubing to full inside diameter after cutting. Remove sharp edges on cut ends. Remove all cuttings from inside the pipe before installation.

C. **Alignment**

1. Install straight runs true to line and elevation and vertical pipe plumb in all directions.
2. Install parallel or perpendicular to building walls unless shown otherwise on the drawings.
3. Piping without specific locations or elevations indicated shall be located to avoid obstructions and shall not obstruct corridors, walkways, equipment areas, or work areas. A minimum headroom clearance of 7 feet 6 inches shall be provided under all piping unless otherwise noted.

D. **Temporary Caps**. Provide temporary caps or plugs at all pipe openings at the end of each day's work and where otherwise requested by the Engineer/Architect.

E. **Pipe Supports, Hangers, and Blocking**. Furnish and install, whether shown on the drawings or not, all required supports, hangers, and blocking.

1. Thrust blocking shall be provided at all bends and tees, where changes in pipe diameter occur at reducers or in fittings, at all dead ends, and at pipes which are tapped or plugged.
2. Pipe hangers shall be provided at all bends and tees, and on either side of all valves.
3. Pipe supports, hangers, and thrust blocks shall be of the size, shape, and quantities as shown on the drawings or as required.
4. All proposed hangers, supports, and blocking must be approved before placement.
5. Spacing of supports and hangers shall be as shown on the drawings, and in no instance exceed the manufacturer's recommendations for the type and class of pipe and temperature of liquid being carried.

F. **Pipe Fittings**

1. Unions. Unions shall be provided where shown on the drawings, and at the following locations:

   a. Downstream of each screwed end valve.
   b. Screwed or flanged union at each piece of equipment.
   c. Dielectric unions where dissimilar metals are connected except at bronze or brass valves installed in ferrous piping.
   d. Where necessary to install or dismantle piping.

2. Reducers. Eccentric reducers shall be installed where reducers are shown and where air or water pockets would occur in mains because of reduction in pipe size.

3. Transitions. Provide all necessary adapters, specials, and connector pieces when connecting different type and sizes of pipe, connecting pipe by different manufacturers, or connecting to equipment, valves, or meters.

G. **Joints**

1. Flanged.

   a. Clean. Flange faces shall be clean. Hexagonal bolts and nuts shall be clean and lubricated.
   b. Alignment. Joints shall be fitted so that contact faces bear uniformly on the gasket and are made up with uniform bolt stress.
   c. Assembly. Assemble joints without forcing.

3.3 FIELD QUALITY CONTROL

A. **Testing**. All process piping shall be tested for leaks in accordance with Section 01 89 19, "Leakage Test and Disinfection." Visible leakage will not be accepted in exposed piping. If the test fails, repair or replace the piping and retest.

B. **Cleaning**. All process piping shall be thoroughly cleaned and flushed prior to placing in service in a manner acceptable to the Engineer/Architect. Piping shall be inspected and all debris, dirt, and foreign matter removed. Disinfection shall be done in accordance with Section 01 89 19, "Leakage Test and Disinfection."

END OF SECTION

SECTION 40 05 13.14

PROCESS PIPING, STAINLESS STEEL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General.** Drawings and general provisions of the Contract, including General and Supplementary Conditions; Division 1; Section 40 05 13, "Process Piping, General"; and all related specification sections, apply to this section.

1.2 DESCRIPTION OF WORK

A. **Scope of Work.** Provide all labor, materials, tools, and equipment necessary to furnish and install the stainless steel pipe.

1.3 QUALITY ASSURANCE

A. **General.** In accordance with Section 40 05 13, Process Piping, General."

1.4 SUBMITTALS

A. **General**

1. Submit all submittals in accordance with the Division 1 Submittal Requirements and the requirements within this specification section.

B. **Submittal Package No. 1 – Shop Drawings and Product Data**

1. Submit shop drawings and product data for review and approval. Do not deliver or install piping or fittings before this submittal package has been reviewed and approved. Shop drawings and product data shall include:

   a. Illustrated Product Data. Submit the product data of the pipe, fittings, manufacturer's name, pipe material, size, class, and gaskets specified on the drawings.
   b. The manufacturer's recommended maximum unsupported length of the size piping specified.
   c. Affidavit of compliance and certification of design and performance.
   d. Information on field and installation requirements, including mounting and access requirements and total weight of each component and each complete assembly.
   e. Description of proposed test methods, procedures, and apparatus.
   f. Coatings and linings.

C. **Submittal Package No. 2 -- Layout Drawings**

1. Submit layout drawings according to this specification for review and approval. Do not deliver or install piping or fittings before this submittal package has been reviewed and approved. Layout drawings shall include:

   a. Detailed plan and profile drawings showing details of piping, fittings, end connections, valve locations, and locations of all flanged joints.
   b. Piping supports, hangers, and thrust block type and locations.

1.5 **JOB CONDITIONS**

A. **General**. In accordance with Section 40 05 13, "Process Piping, General."

1.6 **DELIVERY, STORAGE, AND HANDLING**

A. **General**. In accordance with Section 40 05 13, "Process Piping, General."

1.7 **SPECIAL WARRANTY**

Not used.

PART 2 - PRODUCTS

2.1 **FABRICATED STAINLESS STEEL PIPE**

A. **Design Criteria**

1. Standards.

   a. Stainless steel pipe shall conform to American Society for Testing and Materials (ASTM) A 774 and A 778.

2. Wall Design Criteria.

   a. Rated from a 6-pound-per-square-inch (psi) vacuum to an 80 psi pressure.
   b. Supply pipe with wall thickness required for pressure rating above or the following minimum wall thickness, whichever is greater.

Diameter	Wall Thickness
12 Inches and Less	0.109 Inch
14 Inches through 18 Inches	0.125 Inch
20 Inches	0.145 Inch
24 Inches	0.187 Inch

3. Diameter. Outside diameter shall conform to Iron Pipe Size (IPS) standards.

B. **Pipe and Fitting Materials and Construction**

1. Fabrication.

   a. Longitudinal Seams. Maximum of two per section.
   b. Girth Seams. Not less than 6 feet apart except at fittings and special.
   c. Pipe Ends. Perpendicular to longitudinal axis.
   d. Roundness. Plus or minus 1/16 inch.
   e. Straightness. Plus or minus 1/8 inch in 10 feet.
   f. Edges. All joint-edges shall be true so as not to leave a shoulder on the inside of the pipe.
   g. Fittings. Smooth radius.

2. Welding.

   a. All seams shall be shop welded.
   b. Longitudinal Seams. Tungsten inert gas or metallic inert gas method.
   c. Circumferential Seams. Tungsten inert gas method.
   d. Welding Rods or Wire. Same composition or superior to material used to fabricate pipe.
   e. Grinding. All interior welds shall be ground smooth to provide an internal head of 1/16 inch or less.

3. Materials.

   a. ASTM A 240, Type 304L, Schedule 10.
   b. No. 2 finish.

C. **Joints**

1. General. All joints shall be flanged unless noted otherwise on the drawings.

2. Flanged Joints.

   a. In accordance with Section 40 05 13, "Process Piping, General."

   b. Two part flange.

      1) Slip-on rolled angle face rings of 1/8 inch stainless for pipe less than 16 inches in diameter and 3/16 inch thick for pipe 16 inches and larger.

      2) Backing Flange. Hot dipped galvanized ductile iron drilled to American National Standards Institute (ANSI) B16.1, Class 125 standards. Minimum flange thickness shall be:

Diameter	Flange Thickness
6 to 10 Inches	5/8 Inch
12 to 16 Inches	3/4 Inch
18 to 20 Inches	7/8 Inch
24 to 30 Inches	1 Inch

D. **Finishes**

1. After all fabrication operations are complete, pickle and passivate all pipe and fittings.
2. Pipe and Fitting Interior and Exterior. None in the field.

PART 3 - EXECUTION

3.1 **GENERAL.** In accordance with Section 40 05 13, "Process Piping, General."

END OF SECTION

SECTION 40 05 14

PROCESS PIPING, ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General**. Drawings and general provisions of the Contract, including General and Supplementary Conditions; Division 1; Section 40 05 13, "Process Piping, General"; and all related specification sections, apply to this section.

1.2 DESCRIPTION OF WORK

A. **Scope of Work**. Provide the labor, tools, equipment, and materials necessary to furnish and install the process piping accessories.

1.3 QUALITY ASSURANCE

A. **Codes and Regulatory Agencies**. In accordance with Section 40 05 13.

B. **Standards**. All materials, testing, and work performed shall be in conformance with the following standards as referenced herein:

1. ANSI – American National Standards Institute.
2. ASTM – American Society for Testing and Materials.
3. AWWA – American Water Works Association.
4. MSS – Manufacturers Standardization Society of the Valve and Fittings Industry.

1.4 SUBMITTALS

A. **General**

1. Submit all submittals in accordance with the Division 1 Submittal Requirements and the requirements within this specification section.

B. **Submittal Package No. 1 – Shop Drawings and Product Data**

1. Submit shop drawings and product data for review and approval. No piping accessories shall be delivered or installed before this submittal package has been reviewed and approved. Shop drawings and product data shall include:

a. Illustrated product data.
b. Affidavit of compliance and certification of design and performance.
c. Information on field and installation requirements, including mounting and access requirements and total weight of each component and each complete assembly.
d. Description of proposed test methods, procedures, and apparatus.

e. Coatings and linings.

1.5 JOB CONDITIONS

A. **General.** Coordinate work with that of other sections to provide proper combination of pipe size, core or sleeve size, and link size.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **General.** The delivery, storage, and handling of the piping accessories shall be as specified in Section 40 05 13, "Process Piping, General."

1.7 SPECIAL WARRANTY

Not used.

PART 2 - PRODUCTS

2.1 MECHANICAL PIPE SEALS

A. **General.** Mechanical pipe seals shall be expandable link type rubber seals to fill the annular space between pipe or conduit and the cored hole or sleeve through which it passes. The seals shall provide airtightness and watertightness as well as electrical insulation between the pipe or conduit and wall or floor opening.

B. **Application**

1. Pipes or conduits passing through sleeves or cored openings in exterior walls or walls subject to hydrostatic pressure shall be sealed at each face of the wall.
2. All pipes or conduits passing through floor, roof or interior wall sleeves or cored openings shall be sealed at one face only, unless specifically shown otherwise.
3. Included in this section are pipes and conduits including round electrical ducts. These are all referred to as pipes in the balance of this section.

C. **Products**

1. General Use. Seals shall incorporate an ethylene-propylene dienemonomer (EPDM) rubber sealing element with 316 stainless steel bolts and nuts and glass reinforced nylon plastic plates.
2. Seals shall be sized in accordance with manufacturer's recommendations based upon pipe size.
3. Cored opening size shall be as recommended by the mechanical seal manufacturer.
4. Manufacturer. Seals shall be Link-Seal, Service Designation S (corrosive service), by Thunderline Corporation or approved equal.

2.2 WALL AND FLOOR PIPES AND PIPE SLEEVES

A. Wall and Floor Pipes

1. Type. Wall and floor pipes shall be of the same material and wall thickness specified for the connected piping.
2. Collar. An integral collar shall be included at the midpoint of the wall or floor pipe for anchorage and watertightness. Collar shall be integral with the body or continuously welded on both sides to the body.
3. End Connections. End connections shall be as shown on the drawings. Mechanical joint bells and flanged ends shall be drilled and tapped for studs. Studs of the same material as connected piping shall be provided. Submerged or buried studs shall be Type 304 stainless steel.

B. Pipe Sleeves

1. Type. Pipe sleeves shall be ductile iron designed for a minimum working pressure of 350 pounds per square inch (psi).
2. End Connections. Pipe sleeve end connections shall be as shown on the drawings.
3. Size. Pipe sleeve dimensions shall be as required for pipes to pass through the sleeve. Length shall be as required or as shown on the drawings.

2.3 PIPE SUPPORT

A. **General**. Furnish and install all necessary restraints, blocks, bracing, supports, or hangers, including all necessary miscellaneous steel, inserts, anchors, nuts, bolts, and concrete to support and anchor the piping as shown on the drawings and as required to prevent displacement, vibration, sagging, warping, or failure of the piping expansion and contraction. Location of all supports shall be as required by the piping manufacturer.

B. **Standard**. Pipe hangers shall be in accordance with MSS Standard Practice SP-58 unless noted otherwise on the drawings.

C. **Types**. The following types of pipe supports are acceptable.

1. Hanger Type.

   a. Adjustable Clevis. Clevis shall be constructed of carbon steel unless noted otherwise. Clevis shall be in compliance with MSS SP-69, Type 1.

   b. Trapeze. Universal trapeze assembly shall be constructed of carbon steel unless noted otherwise. Trapeze assembly shall be Anvil Figure 46, or equal.

c. Structural Attachments.

1) Welded Steel Bracket. MSS SP-69, Types 31, 32, and 33.
2) Malleable Concrete Insert. MSS SP-69, Type 18.

2. Support Type.

d. Pipe Saddle Support. MSS SP-69, Types 35, 36, and 38.
e. Pipe Stanchion Saddle. MSS SP-69, Type 37.

3. Any additional pipe support required not listed above shall be submitted to the Engineer/Architect for review.

D. **Coatings**. Conform to Section 09 90 00, "Painting."

1. Steel items shall be hot dip galvanized at the factory unless otherwise noted on the drawings.
2. Steel or malleable iron materials used for support of copper piping shall be copper plated.

2.4 CONCRETE PIPE SUPPORT

A. **General**. Install concrete pipe support and thrust blocking as shown on the drawings and at the locations indicated or where directed.

2.5 CORPORATION STOPS

A. **General**. Install corporation stops where shown on the drawings. Corporation stops shall be bronze body and ground key plug with AWWA C800 taper threaded inlet and outlet to match the connecting piping material.

2.6 EXPANSION COUPLINGS

A. **General**. Expansion couplings shall be arch type, constructed of a single piece of synthetic or natural rubber with wire reinforcing and integral full faced flanges. The wall thickness, dimensions, exterior coating, control rod requirements, and number of arches shall be in accordance with manufacturer's recommendations.

B. **Service**

1. Pressure. Pressure rating shall be the same as the connected piping. See appropriate process piping specification sections for pipe pressure ratings.

C. **Joints**. Joints shall be flanged in accordance with ANSI B12.1. Flanges shall be constructed of resilient rubber, full face, with galvanized metal or baked enamel ductile iron retaining rings providing a metal backup ring behind the rubber flange.

D. **Manufacturer**

1. General Rubber Corporation.
2. Mercer Rubber Co.
3. Or equal.

2.7 SLEEVE COUPLINGS

A. **General**. Provide sleeve couplings where shown on the drawings to tightly seal piping without leakage and allow for deflection and vibration within the pipe line and meet the requirements of AWWA C219.

B. **Construction**

1. Followers shall be constructed of cast iron or ductile iron.
2. Sleeves shall be constructed of carbon steel or ductile iron.
3. Bolts. Bolts shall be of a corrosion-resistant material.
4. Gaskets. Provide resilient gaskets to cushion vibration and safely accommodate for pipe deflection or longitudinal pipe movement without leakage. Gaskets shall be suitable for the service of the pipe.
5. Coating. Coatings shall be according to manufacturer's instructions and be suitable for the service of the pipe. The couplings shall be shop primed and field painted in accordance with Section 09 90 00, "Painting."

C. **Service**

1. Pressure. Couplings shall be pressure rated for the same pressure as the connected piping. See appropriate process piping specification sections for pipe pressure ratings.

D. **Manufacturer**

1. Dresser. Style 38/138.
2. Smith Blair. Style 411.
3. Romac. Style 400.
4. JCM. Style 201.
5. Ford Meter Box. Style FC3/FC4.

2.8 FLANGED COUPLING ADAPTERS

A. **General**. Flanged coupling adapters shall be one end flanged and one end sleeve type flexible coupling and meet the requirements of AWWA C219.

B. **Ductile Iron Pipe**

1. Adapters shall be harnessed as required to restrain pressure piping.
2. For adapters 12 inches in diameter or less, harnessing shall be with 1/2-inch stainless steel anchor studs. Number of studs shall be according to manufacturer's recommendations.

3. For adapters larger than 12 inches in diameter, harnessing shall be with a minimum of four corrosion resistant alloy steel bolts tied to adjacent flange or lugs on the pipe. Number of bolts shall be according to manufacturer's recommendation.

C. **Coatings**

1. Coat interior with factory-applied coal tar enamel.
2. Coat exterior as specified in Section 09 90 00, "Painting."

D. **Service**

1. Pressure. Flanged coupling adapters shall be pressure rated for the same pressure as the connected piping. See appropriate process piping specification sections for pipe pressure ratings.

E. **Manufacturer**

1. Smith Blair.
2. Dresser.
3. Or equal.

2.9 DISMANTLING JOINTS

A. **General**. Dismantling joints shall be provided where shown on the drawings to tightly seal piping without leakage and allow for deflection and vibration within the pipe line. This fitting shall also be fully restrained.

B. **Construction**

1. The joints shall be constructed of cast iron or ductile iron.
2. Bolts. Bolts shall be of a corrosion resistant material.
3. Gaskets. Provide resilient gaskets to cushion vibration and safely accommodate for pipe deflection or longitudinal pipe movement without leakage. Gaskets shall be suitable for the service of the pipe.
4. Coating. Coatings shall be according to manufacturer's instructions and be suitable for the service of the pipe. The joints shall be shop primed and field painted in accordance with Section 09 90 00, "Painting."

C. **Service**

1. Pressure. Dismantling joints shall be pressure rated for the same pressure as the connected piping. See appropriate process piping specification sections for pipe pressure ratings.

D. **Manufacturer**

1. Dresser. Style 131.
2. Smith Blair. Model 975.
3. JCM. Restrained Style 309.
4. Romac. Style DJ400.

5. Ford Meter Box. Style FDJ.

PART 3 - EXECUTION

3.1 INSTALLATION

A. **General**. Install all piping accessories according to manufacturer's instructions, and as shown on the drawings.

END OF SECTION

SECTION 40 05 23

PROCESS VALVES AND GATES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General**. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 1, and all related specification sections, apply to this section.

1.2 DESCRIPTION OF WORK

A. **Scope of Work**. Provide the labor, tools, equipment, and materials necessary to furnish and install the valves and accessories. Provide all valves required for complete functional systems.

1.3 QUALITY ASSURANCE

A. **Codes and Regulatory Agencies**. Perform all work in compliance with all federal, state, and local codes and regulatory agencies.

B. **Standards**. Materials and work performed shall be in accordance with the following standards as referenced herein:

1. AGA – American Gas Association.
2. ANSI – American National Standards Institute.
3. ASME – American Society of Mechanical Engineers.
4. ASTM – American Society for Testing and Materials.
5. AWWA – American Water Works Association.
6. IEC – International Electromechanical Commission.
7. NEMA – National Electrical Manufacturers Association.
8. NSF – National Sanitation Foundation.

1.4 SUBMITTALS

A. **Shop Drawings and Product Data**. Shop drawings and product data for each type of valve shall be submitted for review. Shop drawings shall be in accordance with Section 01 33 00 and shall include:

1. Manufacturer's name.
2. Body, seating, and trim materials.
3. Dimensions.
4. Connection details.
5. Required clearances.
6. Parts list with materials and part numbers for the valves and accessories.
7. Maximum operating pressure and temperature ratings.
8. Operator torque calculations.
9. Manufacturer's instructions.
10. Electrical data when applicable.

B. **Test Reports**

1. Submit hydrostatic test reports as specified in this section.

C. **Operation and Maintenance Manuals**. Operation and Maintenance (O&M) manuals shall be submitted in accordance with Section 01 33 00 of these specifications. Submit the initial review copy of the O&M manual and the revised copies prior to delivery of the equipment.

1.5 JOB CONDITIONS

A. **Valve Service**

1. Submerged valves shall be designed for submerged service.
2. Buried valves shall be designed for buried service.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **General**. Deliver, store, and handle the process piping valves and gates in accordance with Section 01 60 00 and the manufacturer's instructions.

B. **Storage**. Store valves under cover and out of direct contact with the ground.

C. **Handling**. Handle valves to avoid damage. Valves which are cracked, dented, dropped, or otherwise damaged will not be accepted.

1.7 SPECIAL WARRANTY

Not used.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. **Manufacturer**

1. Each type of valve shall be by only one manufacturer.

B. **Valve Ends**

1. Coordinate furnishing of joint materials with pipe supplier.

2. Valves on exposed piping shall be as shown on drawings, usually with a symbol. Connections shown include:

a. Flanged. (FF or F) ANSI B16.1, Class 125 unless noted otherwise.
b. Screwed. National (tapered) pipe thread (NPT).
c. Socket. Conform to specifications for adjacent piping.
d. True Union. Conform to specifications for adjacent piping. True union ends shall be used for all polyvinyl chloride (PVC) valves.

3. Buried. Mechanical joint (MJ), unless noted otherwise on the drawings.

   a. MJ. AWWA C111, rubber gasket joints for ductile iron pressure pipe and fittings.
   b. Screwed. NPT.
   c. Socket. Conform to specifications for adjacent piping.

C. **Seals**

1. Buried and submerged valves shall have enclosed, nonlubricated, watertight stem seals.

D. **Operators**

1. Valves shall open counterclockwise unless noted otherwise on the Valve Schedule or on the drawings.
2. All valves shall have permanent open direction indicator.
3. Coordinate valve mounting position with respect to operating convenience, maintenance access, and safety.
4. Valves which are installed with improper orientation shall be removed and reinstalled at no additional cost to the Owner.

E. **Coatings**

1. Valve Operators and Accessories Inside Structures.

   a. Shop priming shall be in conformance with Section 09 90 00, "Painting."
   b. Factory finishing shall be in conformance with Section 09 90 00, "Painting."

2. Buried Valves, Operators, and Accessories.

   a. All buried valve operators and accessories shall be coated with a bituminous material in conformance with ANSI A21.10 (AWWA C110).

3. Painted Surfaces. Unless noted otherwise, all interior and exterior ferrous surfaces of all valves, operators, and accessories shall be primed and finish painted in the factory in accordance with Section 09 90 00, "Painting."

4. All valve operator and accessory coatings in contact with potable water shall meet NSF Standard 61 and will have to be listed by NSF and/or the Ohio Environmental Protection Agency (EPA).

5. Stainless steel surfaces shall not be painted unless otherwise noted.

2.2 VALVE TYPES

A. Butterfly Valves

1. Cast Iron Body, Metal Seat.

   a. Butterfly valves shall conform to AWWA C504, except as modified herein.

   b. Valves shall be designed for tight shutoff against a differential pressure of 150 psi and 300 psi non-shock cold water.

   c. The valve body shall be constructed of ductile iron as per ASTM A-126, Class B with a minimum rated internal working pressure of 250 psi.

   d. Valve body shall include a stainless steel seat ring that is mechanically retained without use of clamping devices, adjusting segments, or other hardware being in the waterway.

   e. Valve disc shall be flow through type, ductile iron. Resilient seat shall be located on edge of the disc, and shall seal against mating stainless steel body seat with 360 degree uninterrupted contact.

   f. The resilient seat shall be locked to the disc by a stainless steel retaining ring and stainless steel cap screws, and shall be field adjustable without any tools other than a standard socket wrench. Replacement of the seat in the field shall be possible without valve disassembly.

   g. The disc shall be connected to the Type 304 stainless steel operating shaft by stainless steel pins and stainless steel cap screws.

   h. Both the operating and thrust shafts shall be Type 304 stainless steel.

   i. Shafts shall have reinforced Teflon stainless steel backed bearings. Bearings shall be self-lubricating.

   j. Manufacturer.

      1) M&H Valve Company, Style 1450, Class 150B.
      2) Pratt.
      3) DeZurik.
      4) Or equal.

2. Cast Iron Body, Resilient Seat, Suitable for Air Service.

   a. Conform to AWWA C504 except as specified herein.

   b. Minimum 150 psi working pressure, unless noted otherwise.

   c. Valves shall be designed for tight shutoff against a differential pressure of 150 psi.

   d. Disc shall be cast iron, ductile iron, Type 304 or 316 stainless steel.

   e. Stainless steel shaft.

   f. Body and stuffing box shall be ASTM A126, Class B cast iron.

   g. Gland assembly shall be cast bronze ASTM B584.

   h. Packing gland shall be housed in a solid-walled cast iron ASTM A48, Class 40 one-piece structure or approved equal.

   i. Two trunnions shall be integral with valve body.

   j. Seats bonded or mechanically fastened on the discs are not acceptable.

   k. Resilient seat material shall be Buna-N suitable for potable water or sewage or oil bearing liquids, and Viton or ethylene propylene terpolmer for air.

   l. Handwheel or chainwheel operators shall be gear operated with position indicator. Lever operators shall include locks.

   m. Buried valves shall have totally enclosed gear box with operator nut, valve box to finished grade, and extension stem. The gear housing shall have raised shoulder to fit valve box and exclude soil from entering valve box.

   n. Manufacturers.

      1) Pratt.
      2) DeZurik.
      3) Or equal.

B. **Check Valves**

1. Weight and Lever, Suitable for Air Service.

   a. Cast iron body, bronze seat.

   b. Seat shall be easily replaced without removing the valve from the line.

   c. Disc shall be cast iron, suspended from a Type 316 stainless steel shaft.

   d. The disc seat ring shall be bronze and easily replaced without removing the valve from the line.

   e. Flanged ends to fit 125 pound ANSI flanges.

   f. Outside lever and weight that can be mounted on either side of valve, nonslamming and externally balanced.

   g. All working parts removable through top of valve.

   h. Valves 4 inches through 12 inches shall be rated for 175 psi working pressure, and valves 14 inches and larger shall be rated for 150 psi working pressure, unless noted otherwise.

   i. Manufacturers.

      1) Clow/M&H.
      2) American Flow Control.
      3) Milliken.
      4) Or equal.

2. Silent Closing.

   a. Description.

      1) The plug shall be guided at both ends with a through integral shaft and shall be opened by the velocity flow and closed by a helical spring.
      2) To permit regrinding of seat in field, the seat, plug, and guide bushing shall all be easily removable and replaceable without the need for any special training and without the need for any special tools unless provided by manufacturer of valve.
      3) Flow area through valve shall exceed cross sectional area of a pipe of the same nominal size. Certified drawings showing the flow area shall be submitted for review.

b. Construction.

1) Valve body shall be ductile iron as per ASTM A 536, Grade 65-45-12.
2) Plug, seat, and guide bushing shall be bronze in accordance with ASTM B 584, C 83600.
3) Helical spring shall be Type 316 stainless steel and constructed in accordance with ASTM A 276.
4) Minimum pressure rating shall be 150 psi.

c. Manufacturers.

1) Apco Valve and Primer Corporation.
2) Or equal.

C. **Plug Valves**

1. Eccentric, nonlubricated, suitable for air service.

a. Body shall be iron or semisteel.

b. Valves rated for 150 psi working pressure unless noted otherwise on the drawings.

c. Port opening shall not be less than 80-percent of full pipe area.

d. EPDM coated, tight sealing plug.

e. Buna-N seats, except Viton or ethylene propylene terpolymer (EPT) for air service.

f. Stem packing material shall be Teflon.

g. Top and bottom bearings of noncorrosive material.

h. Spacer bonnet design shall be provided so that shaft seals are accessible for inspection and replacement. O-ring seals, non-adjustable, or shim-support packing shall not be acceptable.

i. Bonnet gasket designed for gaseous service shall be supplied, Gylon or Engineer-approved material.

j. Provide a dry seat test and provide test documentation per Section 01 33 00 of these specifications for each valve.

k. Manufacturers.

1) Clow.
2) DeZurik.
3) Homestead.
4) Or equal.

D. **Ball Valves**

1. Manufacturer. Subject to compliance with the specifications, provide the stainless steel valves from one of the following approved manufactures.

   a. Red-White (1/4 inch – 2 inches).
   b. NIBCO (1/4 inch – 2 inches).
   c. Stockham (1/4 inch – 2 inches).
   d. Velan (1/4 inch – 2 inches).

2. Performance. Minimum rated cold working pressure shall be 1,000 psi with blowoutproof stem.

3. Materials.

Part	Material
Body and Cap	CF8M stainless steel
Ball and Stem	Type 316 stainless steel
Hardware and Locking Lever Handle	Type 304 stainless steel

4. Fabrication and Assembly. Threaded ends with reduced port design.

E. **Corporation Stops**

1. Type 1.

   a. Standard. AWWA C800.

   b. Material. Bronze.

   c. End Connection.

      1) Inlet. AWWA taper thread.
      2) Outlet. Threaded, inside iron pipe.

d. Manufacturer and Model.

1) Mueller Co., Model H10045.
2) Ford Meter Box Co., Model FB1600.
3) Or equal.

2. Type 2.

a. Standard. AWWA C800.

b. Material. Bronze.

c. End Connection.

1) Inlet. AWWA taper threaded.
2) Outlet. Flared copper.

d. Manufacturer and Model.

1) Mueller Co., Model H15000.
2) Ford Meter Box Co., Model FB600.
3) Or equal.

F. **Curb Stops**

1. Type 1.

a. Standard. AWWA C800.

b. Material. Bronze.

c. End Connection.

1) Inlet. Threaded, inside iron pipe.
2) Outlet. Threaded, inside iron pipe.

d. Manufacturer and Model.

1) Mueller Co., Model Oriseal Mark II H10287.
2) Or equal.

2. Type 2.

a. Standard. AWWA C800.

b. Material. Bronze.

c. End Connection.

1) Inlet. Flared copper.
2) Outlet. Flared copper.

d. Manufacturer and Model.

1) Mueller Co., Model Oriseal Mark II H15154.
2) Ford B22-666M.
3) Or equal.

2.3 OPERATORS

A. Manual

1. Shall be enclosed gear or traveling nut type as noted in the Valve Schedule with no external moving parts.
2. Operating force shall not exceed 40 pounds.
3. Provide chainwheel and chain for valves over 6 feet above floor.

B. Electrical

1. General. The electric operators shall conform to the following specifications.

a. The operator shall be the open or close only type (O/C).

2. Drive Motor.

a. Drive motor shall be of sufficient size to open or close valve against maximum differential pressure when voltage to the motor terminals is 90 percent of nameplate rating.

b. Drive motor shall be specifically designed for operator service and shall be of totally enclosed, nonventilated construction, with permanently lubricated ball bearings.

1) Drive shall have Class F insulation.

c. The drive motor shall be provided with a thermostatically controlled heater.
d. The power source to the motor shall be 240 volt, 3 phase.

1) Provide thermal switches, embedded in motor windings to protect against overheating.
2) Provide NEMA 4 enclosure.

3. Limit Switches.

a. Limit switches and the limit switch drive mechanism shall be an integral part of operator.

b. Limit switches shall be adjustable, allowing for trip points from fully open to fully closed positions of valve travel.

c. Limit switches shall be geared to, and actuated by, the driving mechanism whether in motor drive or manual (handwheel) operation.

1) Operator shall have provisions for mounting at least eight (four N.O., four N.C.) additional limit switches which shall be housed in an integral housing to the operator.

d. Limit switch compartment to have no exposed electrical connections.

1) Provide a space heater in the switch compartment.
2) Provide a NEMA Type 4 enclosure.

4. Torque Switches.

a. Each operator shall have an opening torque switch and a closing torque switch.
b. Torque switches shall have a range of adjustment and be responsive to opening or closing loads such that switches operate to protect valve and operator from damage when there is valve obstruction during opening or closing.

5. Handwheel and Declutching Mechanism.

a. Declutching Mechanism.

1) Declutching mechanism shall operate valve by means of permanently attached auxiliary handwheel.
2) Declutch assembly may be used to operate valve when electrical power is not available.

b. Handwheel.

1) May be used to operate valve when electrical power is not available.
2) Shall require at least 40 pounds of rim pull. Actuation of motor shall automatically return the operator to the electric mode.

3) Not to rotate while operator is in the electric mode.

a) Electric mode can be overridden locally by holding declutch lever down and rotating handwheel manually.

6. Motor Controller.

   a. A NEMA or IEC rated reversing motor controller with either overload relays in each phase or a thermal relay responsive to motor winding temperature, or both, shall be provided.
   b. Each opening and closing contactor shall be equipped with auxiliary contacts and mechanical linkages such that controller shall be electrically and mechanically interlocked.
   c. Controller shall be completely wired to 600 volt terminal blocks or plug assemblies in a minimum NEMA 4 or ingress protection (IP) 65 rated housing which is integral to operator.
   d. Valve travel time shall be 60 seconds from the fully open to fully closed position.
   e. All internal wiring in the housing shall be to terminal strips or plug assembly, and all limit and torque switches shall be wired to these terminals.
   f. Include a control transformer with a minimum volt-ampere rating of 2.5 times the volt-ampere load of the motor contactor coil. The control transformer shall have fuse protection on the primary and secondary side circuits.

7. Open-Close Operators (O/C).

   a. The valve control shall be provided with local switches for local/remote and open/stop/close operation.

      1) The local switches shall be provided on the limit switch compartment.

   b. A mechanical dial for local position indication shall be provided.

8. Local Controls.

   a. The valve control shall be provided with local switches for local/remote and open/stop/close operation.

      1) The local switches shall be provided on the limit switch compartment.

   b. A mechanical dial for local position indication shall be provided.

9. Gear Box Assembly. Gear box is to be completely filled with lubricant, allowing operator to be installed in any position. Operator design shall accommodate removal of motors without loss of lubrication.

10. Manufacturer.

    a. E.I.M.
    b. Auma.

C. **Pneumatic**

1. Size for the size and pressure class of valve.
2. Air pressure for sizing shall be 60 psig unless noted otherwise.
3. Cylinders shall be constructed of hard drawn brass with cadmium plated end caps.
4. Cylinder pistons shall be chrome plated steel and rods shall be 304 or 316 stainless steel.
5. Provisions shall be made to adjust the speed of piston travel and to minimize shock at the end of travel.
6. Provision shall be made for manual operation by handwheel, crank, or lever in case of power or system failure.
7. Provisions for spring return shall be provided for return to the position indicated in the Valve Schedule during loss of air supply.
8. Limit switches shall be housed in NEMA 4 enclosures.
9. Control power shall be 120 volt, 60 Hz, single phase.

D. **Hydraulic**

1. Operator shall be sized for the size and class of valve.
2. Water pressure for sizing shall be 40 psig unless noted otherwise.
3. Cylinders shall be constructed of low zinc bronze.
4. Pistons and end caps shall be corrosion resistant.
5. Pistons shall be equipped with leather seals.
6. Piston rods shall be 304 or 316 stainless steel.
7. Provision shall be made for manual operation by handwheel, crank, or lever in case of power or system failure.
8. Limit switches shall be housed in NEMA 4 enclosures.
9. Control power shall be 120 volt, 60 Hz, single phase.

2.4 ACCESSORIES

A. **Valve Boxes**

1. All buried valves shall be provided with valve boxes.

2. Valve boxes shall be standard, adjustable, heavy pattern, cast iron extension type, three piece, screw type, and with 5 1/4 inch inside diameter.

3. Valve boxes shall be of sufficient length to extend from valve to finished grade.

4. Tops shall be set at established grades and valve box cover shall be marked with pipe function.

Valve Size	Base
4" and smaller	Round, 8" in height, 10-7/8" diameter at bottom
6" and 8"	Round, 11" in height, 14-3/8" diameter at bottom
10" through 16"	Oval, 9-1/2" in height, 21" x 12-1/2" diameter at bottom

18" and 20"	Oval, 10" in height, 25-1/2" x 16" diameter at bottom
24"	Dome, 5" in height, 15" diameter and 17" square flange at bottom

B. **Curb Boxes**

1. Type 1.

   a. Type. Cast iron, extension type, Minneapolis Pattern.

   b. Size. Inside diameter of upper section shall be 2 inches.

   c. Provide stationary rod, lid, and plug.

      1) The stationary rod shall extend to 6 inches below finish grade.

   d. Manufacturer.

      1) Mueller H-10304.
      2) Or equal.

2. Type 2.

   a. Type. Cast iron, Buffalo type.

   b. Size. Inside shaft diameter shall be 2 1/2 inches.

   c. Provide lid.

   d. Manufacturer.

      1) Mueller H-10350, size 93-E.
      2) Star 94E.
      3) Or equal.

C. **Floor Boxes**

1. Floor boxes shall be cast or ductile iron construction with cover.
2. Floor boxes shall be of the bronze bushing type.
3. Boxes shall be designed for installation in floors and slabs as shown.
4. Include with all valves where operating nut is at concrete slab.

D. **Floor Stands**

1. Floor stands shall be Type 304 stainless steel, right angle type, crank operated, straight or offset as required, and rigidly anchored, and shall include position indicator.
2. Floor stands shall be nonrising type unless noted otherwise.

3. Operators shall turn counterclockwise to open.
4. Single or double gear reduction shall be provided as required.
5. Antifriction bearings shall properly support both opening and closing thrust to floor stand.
6. Floor stand shall operate the valve or gate under all operating conditions with 40 pound maximum pull on the crank.
7. All components shall be enclosed in a cast aluminum or stainless steel weatherproof housing with positive mechanical seals to exclude moisture and dirt and prevent lubricant leakage.
8. Lubrication fittings shall be furnished for all gears and bearings.
9. Floor stand pedestal shall position the input shaft approximately 30 inches above the base.
10. A permanently attached or cast arrow with the word "OPEN" on the floor stand shall be furnished indicating the direction of rotation to open the valve or gate.
11. Floor stands shall be suitable for occasional submergence.

E. **Extension Stems**

1. Constructed of extra strength steel rod for buried valves and Type 304 stainless steel rod for the stems inside structures and buildings.
2. Length shall be as required for proper operation of the valve or as specified in the valve schedule.
3. Extension stems shall be securely fastened to the valve stem.
4. Extension stems for buried valves shall extend to within 3 1/2 feet of finished grade unless noted otherwise.

F. **Stem Guides**

1. Constructed of cast iron or stainless steel with bronze bushing.
2. Guide shall be of adjustable design for plumb alignment.
3. Guide shall be complete with stainless steel anchor bolts.
4. Spacing as required to support stem but shall not exceed 10 feet.

G. **Operating Nuts**

1. Operating nuts shall be provided for all valves and as called for in the Valve Schedule.
2. All buried valves shall have operating nuts.
3. All operating nuts shall be 2 inches square.

H. **Hand Operators**

1. Operators shall be sized for 40 pound pull force.

I. **Valve Wrenches**

1. Wrenches shall be of T-bar design with socket.
2. Length shall be sufficient to comfortably operate valves.
3. See Valve Schedule for quantity but provide at least one fixed bar type and one sliding bar type for close quarters.

PART 3 - EXECUTION

3.1 EXAMINATION

A. **Inspection**

1. Verify job conditions and intended valve service before ordering each valve.
2. Inspect for damage to valve resulting from shipping and handling prior to installation.
3. Remove debris from inside piping system before installation.

3.2 PREPARATION

A. **Handling**

1. Handle valves and accessories with care.
2. Comply with the manufacturer's instructions.

3.3 INSTALLATION

A. **Procedures**

1. Install in accordance with manufacturer's instructions.
2. Install operators for most convenient access. All valve operator access shall be located only after coordinated with the Owner's operation personnel and the Engineer/Architect.
3. Install plumb and level.
4. Install free from distortion.
5. Install with proper support and restraint.

3.4 FIELD QUALITY CONTROL

A. **Inspection**

1. Verify conformance with manufacturer's shop drawings and instructions.
2. Report defects in workmanship, materials, and performance.

3.5 ADJUSTING

A. **Procedures**

1. Follow manufacturer's instructions.
2. Adjust stops and friction clamps for proper operation.

3.6 DEMONSTRATION

A. **General**

1. Demonstrate proper operation under actual service conditions.
2. Demonstrate functions of valves that have moving internal mechanisms designed to operate without manual operation for a minimum of three

repeat cycles. This includes air release valves, air and vacuum breaker valves, pressure reducing valves, back pressure valves, check valves, pressure relief valves, surge anticipator, and surge relief valves.

3. Demonstrate that all valves do not leak under maximum design operating pressures when operated for a minimum of three repeat cycles of open and close during the operational demonstration period.

3.7 MAINTENANCE

A. Contractor's Responsibility

1. Conform to manufacturer's recommended procedures.
2. Provide initial lubrication and maintenance.
3. Perform maintenance until the installation is accepted by the Owner.

END OF SECTION

SECTION 40 42 13

PROCESS PIPING AND EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General**. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this section.

B. **Process Piping**. See Section 40 05 13, "Process Piping, General."

C. **Painting**. Painting is specified in Section 09 90 00.

D. **Submittals**. See Section 01 33 00, "Submittals."

1.2 DESCRIPTION OF WORK

A. **General**. Provide the labor, tools, equipment, and materials necessary to furnish and install the process piping insulation.

1.3 QUALITY ASSURANCE

A. **Codes**. Perform all work to furnish and install the process piping insulation in compliance with applicable requirements of governing agencies having jurisdiction and in accordance with these plans and as specified herein.

B. **Standards**

1. ASTM – American Society for Testing and Materials.

1.4 SUBMITTALS

A. **Approval Drawings**. Submit shop drawings and product data for approval. Shop drawings shall be in accordance with Section 01 33 00 and shall include:

1. Manufacturer's name.
2. Product data including insulation and jacketing material, thickness, manufacturer's product number, K-value, and all furnished accessories.
3. Dimensional layouts and locations.
4. Complete description in sufficient detail to permit an item-by-item comparison with the specifications.
5. Manufacturer's instructions.

1.5 JOB CONDITIONS

A. **General**. Verify job conditions which may impact insulation layouts and dimensions prior to ordering materials. Install insulation to field measurements unless specifically noted otherwise.

B. **Coordination**. Coordinate with all other trades to prevent delays, errors, or omissions.

C. **Climatic Conditions**. Do not perform installation when ambient conditions would cause damage to the materials, jacketing, or otherwise violate manufacturer's installation requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **General**. Deliver, store, and handle the process piping insulation in accordance with Section 01 60 00 and the manufacturer's instructions.

B. **Containers**. Insulation, covering, cements, adhesives, and coatings shall be delivered to the site in containers with manufacturer's stamp or label showing fire hazard index of products.

C. **Protection**. Protect insulation against dirt, water, and chemical and mechanical damage. Remove wet or damaged insulation from project site.

1.7 SPECIAL WARRANTY

Not used.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Foam Piping Insulation

1. Foam Insulation. Flexible, unicellular, foamed insulation with sealed end joints. ASTM C 534, Type 1.
2. Insulation shall be coated in accordance with Section 09 90 00, "Painting."
3. Insulation shall be Johns-Manville Aerotube; Rubatex; Armstrong Armaflex; or equal.

B. Fiberglass Piping Insulation

1. Fiberglass insulation shall be in accordance with ASTM C 547, Class 1 for use up to 450 degrees Fahrenheit (° F.).
2. Interior insulation shall be 3/4 inch thick with factory-applied vapor barrier and all joints firmly butted, lapped, and sealed with vapor barrier cement.
3. Exterior insulation shall be 3 inches thick with aluminum jacketing. Jacketing shall meet ASTM C 921, Type I (vapor barrier) including all

the typical requirements in Table 1 in that standard. The aluminum shall meet ASTM B 209.

4. Insulation shall be Johns-Manville Micro-Lok, Owens Corning, or equal.

C. **Equipment Insulation**

1. Flexible Fiberglass Equipment Insulation. ASTM C 553, Type I, Class B-6 (3 pounds per cubic foot density). Insulation shall be Manville Products Corp., Owens-Corning Fiberglas Corp., or equal.

D. **Accessories**

1. Insulation installed outside shall be coated or jacketed as recommended by the manufacturer for a weatherproof installation.
2. Staples, Bands, Wires, and Cement. As recommended by insulation manufacturer for applications indicated.
3. Adhesives, Sealers, and Protective Finishes. As recommended by insulation manufacturer for applications indicated.

PART 3 - EXECUTION

3.1 INSPECTION

A. **Existing Conditions**. Examine areas and conditions under which insulation is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in an acceptable manner.

B. **Insulation**. Inspect insulation for dirt, water, or damage. Do not install wet or damaged insulation.

3.2 INSTALLATION

A. **Insulation Omitted**. Omit insulation on unions, check valves, balance cocks, and flow regulators.

B. **General Piping**. Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to ensure that insulation serves its intended purpose.

1. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.
2. Install insulation on pipe systems subsequent to installation of heat tracing, painting, testing, and acceptance of tests.
3. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full length units of insulation, with a single cut piece to complete run. Do not use cut pieces or scraps abutting each other.
4. Maintain integrity of vapor barrier jackets on pipe insulation, and protect to prevent puncture or other damage.

5. Cover valves, fittings, and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut, or job fabricated units (at installer's option) except where specific form or type is indicated.
6. Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise indicated.
7. Hangers. Butt pipe insulation against pipe hanger insulation inserts. For hot pipes, apply 3 inches wide vapor barrier tape or band over the butt joints. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3 inches wide vapor barrier tape or band.
8. Copper Pipe. Insulation used in below grade and outdoor installations shall be free from nitrites and not contain more than 0.2 percent ammonia.
9. Outdoor Insulation. Protect outdoor insulation from weather by installing outdoor protective finish or jacketing as recommended by the manufacturer.

C. **Insulation Joints**. Install insulation with all end joints with an adhesive as recommended by the manufacturer. Apply insulation without longitudinal joints by slipping the insulation over the lengths of pipe before connections are made. Clean and dry pipe surfaces prior to insulating. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.

D. **Equipment Insulation**

1. General. Install equipment thermal insulation products in accordance with manufacturer's written instructions, and in compliance with recognized industry practices to ensure that insulation serves intended purpose.
2. Surfaces. Install insulation materials with smooth and even surfaces and on clean and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gapping joints and excessive voids resulting from poor workmanship.
3. Vapor Barrier. Maintain integrity of vapor barrier on equipment insulation and protect it to prevent puncture and other damage.
4. Temperature. Do not apply insulation to equipment, breechings, or stacks while hot.
5. Joints. Apply insulation using the staggered joint method for both single and double layer construction, where feasible. Apply each layer of insulation separately.
6. Cement. Coat insulated surfaces with layer of insulating cement, troweled in workmanlike manner, leaving a smooth continuous surface. Fill in scored block, seams, chipped edges and depressions, and cover over wire netting and joints with cement of sufficient thickness to remove surface irregularities.
7. Jacket. Cover insulated surfaces with all service jacketing neatly fitted and firmly secured. Lap seams at least 2 inches. Apply over vapor barrier where applicable.

8. Removable Insulation. Provide removable insulation sections to cover parts of equipment which must be opened periodically for maintenance; include metal vessel covers, fasteners, flanges, frames and accessories.
9. Equipment Exposed to Weather. Protect outdoor insulation from weather by installation of weather barrier mastic protective finish, or jacketing, as recommended by the manufacturer.

3.3 EXISTING INSULATION

A. **Protection**. Insulation installer shall advise Contractor of required protection for insulation work during remainder of construction period to avoid damage and deterioration.

B. **Repair**. Repair damaged sections of existing insulation, both previously damaged or damaged during this construction period. Use insulation of same thickness as existing insulation; install new jacket lapping and seal over existing.

C. **Replacement**. Replace damaged insulation which cannot be repaired satisfactorily, including units with vapor barrier damage and moisture saturated units.

END OF SECTION

SECTION 40 90 00

INSTRUMENTATION SYSTEMS BASIC REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General**. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this section.

B. **Related Sections**. The following sections contain requirements that relate to this section:

1. Section 01 31 19.00, "Project Meetings."
2. Section 01 60 00, "Materials and Equipment."
3. Section 26 00 01, "Basic Electrical Requirements."
4. Section 26 00 02, "Basic Electrical Materials and Methods."
5. Section 26 05 33, "Raceways."
6. Section 26 05 12, "Wires, Cables, and Connectors."
7. Section 26 05 23, "Communication and Signal Cables."
8. Section 26 05 34, "Cabinets, Boxes and Fittings."
9. Section 26 27 26, "Wiring Devices."
10. Section 26 05 29, "Supporting Devices."
11. Section 26 05 53, "Electrical Identification."
12. Section 26 05 26, "Grounding."
13. Section 40 93 13, "Control Devices."

1.2 DESCRIPTION OF WORK

A. **Scope of Work**. Provide the labor, tools, equipment, and materials necessary to implement general administrative and procedural requirements for instrumentation installations. The following administrative and procedural requirements are included in this section to expand the requirements specified in Division 1:

1. Quality assurance.
2. Submittals.
3. Job conditions.
4. Delivery, storage, and handling.
5. Special warranty.
6. Definitions.

B. **Work under this contract** consists of furnishing, installing, testing, and guarantee of the complete instrumentation system as shown on the drawings and as specified herein. Connect and place all equipment in proper working order.

1. Signal wiring between all instrumentation equipment.
2. Interlock wiring between instrumentation equipment and equipment furnished under other divisions of the specifications. Interlocks shall include alarm contacts, control contacts, and 4-20 milliampere (mA) analog signals. Such interlocks are required by diagrams, schematics, notes, or narrative descriptions. Extend these interlocks to and land them on terminal strips provided in equipment, motor starters, motor control centers, etc.

1.3 QUALITY ASSURANCE

A. **Regulatory Requirements**. Comply with requirements of the National Electrical Code (NEC) and all other applicable federal, state, and local codes and regulatory requirements.

B. **Standards**. Materials and workmanship shall conform to the following standards:

1. American National Standards Institute (ANSI).
2. American Society for Testing and Materials (ASTM).
3. Electronic Industries Association (EIA).
4. Factory Mutual (FM).
5. International Electrotechnical Commission (IEC).
6. Institute of Electrical and Electronic Engineers (IEEE).
7. International Society of Measurement and Control (ISA).
8. International Standards Organization (ISO).
9. Joint Industrial Council (JIC).
10. Manufacturer's Standardization Society (MSS).
11. National Electrical Code (NEC).
12. National Electrical Manufacturers Association (NEMA).
13. National Fire Protection Association (NFPA).
14. Scientific Apparatus Manufacturers Association (SAMA).
15. Underwriters' Laboratories (UL).

C. **System Responsibility**. The instrumentation and control system shall be furnished by a single System Integrator who shall be responsible for the entire system. The responsibilities of System Integrator shall include the following:

1. Preparation of all submittals.
2. All factory and field testing.
3. Furnishing and calibration of all instruments.
4. Configuration and programming.
5. Start up and training.
6. Thirty day operational demonstration.
7. Warranty work for the entire system.

D. **Qualifications**

1. Manufacturer's Qualifications.

   a. A financially sound firm with at least 5 years of experience in design, manufacture, supply, service, and support of instrumentation and control equipment specified for this project.
   b. A record of prompt shipments in accordance with contract obligations.
   c. A documented quality assurance program complying with industry and agency standards.
   d. A documented product safety policy relevant to the products being manufactured for this project.

2. Installer's Qualifications. An approved manufacturer's representative factory-educated in maintenance, installation, and start-up of the instrumentation and control equipment to be supplied.

1.4 SUBMITTALS

A. **General**. Follow the procedures specified in section 01 33 00, "Submittals."

B. **Submittal List**. Prepare and submit a complete submittal list. Include all submittal items covered in the Division 40 specification sections. In addition, include dates for all items to be submitted and submit with the first submittal. Update submittal list date changes on a monthly basis. Coordinate the submittal list with the construction schedule and clearly show such coordination. Include expected dates for gaining approval for each Division 40 specification section. Include the expected factory test, equipment shipping, installation, and operational test dates for each Division 40 specification section.

C. **Letter of Responsibility**. Submit a letter from the responsible System Integrator stating acceptance of system responsibility.

D. **Product Data**. Submit manufacturer's technical product data sheets for items listed in the instrument schedule and for any additional components required for a complete functional system. Delete inappropriate or nonapplicable information on each page of product data submittals.

E. **Shop Drawings**. Submit shop drawings to substantiate that the materials and equipment comply with the specification requirements. All drawings shall clearly state the job name, Owner, location, and date.

1. Materials List. Submit a list of materials giving quantities, manufacturer's name, and catalog numbers listed by equipment tag numbers. All equipment shall have a tag number. The list shall identify sheet numbers where each tag numbered item can be found.

2. Dimensional Drawings. Submit dimensional drawings for instrument mounting, process connection details, instrument cabinets, panels, and each piece of equipment.

3. Wiring Diagrams. Submit the following:

   a. Field wiring diagrams for wiring into and out of control panels, identifying terminal numbers of the field equipment or other remote termination points.
   b. Master interconnection wiring and piping drawing showing all field- and panel-mounted equipment and terminal identifications. Each individual manufacturer's system drawings shall be furnished.
   c. Internal wiring drawings for each control panel identifying each and every component, numbered wire, numbered terminal, and terminal block. Loop diagrams shall follow ISA-S5.4 format.

F. **Quality Control Submittals**

1. Test Procedures. Submit a detailed description of both the factory and field test procedures. Test procedure shall include the following:

   a. Description of purpose of each part of test.
   b. List of test equipment required.
   c. Step-by-step description of each part of test.
   d. Sample test data sheets.

2. Test Reports. Submit a written test report for both the factory and field tests. Report shall list results of each step of the test and shall include test data sheets signed and dated by tester.

3. Sample Calibration Sheets. Submit sample of calibration sheets for each type of instrument specified.

4. Detailed operational demonstration plan.

G. **Contract Closeout Submittals**

1. Project Record Documents. Provide two working sets of prints of the Contract Drawings and submittals. Furnish an identical bound set, with index tabs, to the Engineer/Architect when field-wiring is to begin. Make all changes during the course of the work to the field set and transfer to the office set of prints on a weekly basis. Send dated copies clearly showing "As Built" or "As Constructed" information weekly for each affected sheet to the Engineer/Architect. Both sets shall be available for comparison by the Engineer/Architect and Owner during the course of the work. After project completion, deliver both sets of documents to the Owner.

2. Operation and Maintenance (O&M) Manuals. Submit O&M manuals. Each option and accessory shall be clearly and accurately shown. The O&M manuals shall include:

a. Installation instructions and details.
b. Start-up instructions.
c. O&M instructions.
d. Detailed parts list with name, address, and telephone number of supply source.
e. Troubleshooting guide.
f. As-built wiring diagrams and dimensional drawings.
g. Programming procedures.

3. Record Drawings. Furnish detailed wiring drawings for all instruments and controls. Drawings shall show all tag numbers, point-to-point wiring, and terminal numbers used on the external wires. In addition, any changes made by the Contractor to internal wiring of equipment or components inside enclosures furnished by the Contractor shall have "As Constructed" revisions to the original manufacturer's drawings detailing these additions or revisions. The record drawings shall include all wire numbers and terminals used plus a list of all settings for each instrument. Replace all affected drawings supplied in the O&M manuals with record drawings.

4. Maintenance Service. Submit a maintenance agreement to maintain the instrumentation system after the 1 year contract warranty. The agreement shall list the terms and conditions of this maintenance service along with a price for a second year.

5. Spare Parts List. Submit a list of spare parts required. Include part name, equipment name, stored quantity, manufacturer/source address, telephone number, and salespersons name within the secured storage area.

6. Calibration Sheets. Submit signed and dated calibration sheets for each instrument.

1.5 JOB CONDITIONS

Not used.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **Packing and Shipping.** Deliver equipment properly packaged and mounted on pallets or skids to facilitate handling of heavy items. Utilize factory-fabricated type containers or wrappings for components which protect equipment from damage.

B. **Inspection and Handling.** Inspect equipment to ensure that no damage has occurred during shipment. Handle equipment carefully to prevent physical damage to equipment and components. Remove packaging, including the opening of crates and containers, avoiding the use of excessive hammering and jarring which would damage the electrical equipment contained therein. Do not install damaged equipment; remove from site and replace damaged equipment with new. Inspect all equipment at time of delivery as to model, quantity, and

physical condition. All equipment shall be identified by name and tag number. Site conditions must be clean, dry, heated, and dust-free before equipment is removed from packaging or installed.

C. **Storage and Protection**. Store the items furnished under this section until they can be installed. Such storage shall meet the requirements of the system supplier and be approved by the Owner. Use all means necessary to protect the material of this section before, during, and after installation, and to protect the installed work and materials of all other trades. Provide factory-applied end caps to protect all threads on pipes and valves. Obtain a receipt from the Owner for all materials turned over to the Owner. Any materials that the Contractor does not have a receipt for will be considered to have not been turned over to the Owner.

1.7 SPECIAL WARRANTY

Not used.

1.8 DEFINITIONS

A. **Manufacturer**. The designer and fabricator of an instrumentation or control product.

B. **System Integrator**. The designer, assembler, and supplier of the complete instrumentation and control system. The system integrator has responsibility to the Contractor and Owner for a complete functional instrumentation and control system.

C. **Interior**. For the purposes of this specification, interior is any area within the boundaries of the foundation, walls, and roof of any building or other structure.

D. **Wet Locations**. Exterior areas, interior areas below grade, and interior areas above grade in which wet materials are processed, pumped, transported, or stored are designated as wet locations. Equipment installed in these areas must bear a manufacturer's certification of suitability for such environments.

E. **Hazardous (Classified) Areas**. Hazardous (classified) areas, defined in accordance with the NEC, are designated on the drawings. All equipment installed in these areas shall conform to requirements for installation in the designated hazardous area as described in Articles 500, 501, and 502 of the NEC.

PART 2 - PRODUCTS

2.1 GENERAL

A. **Mounting Hardware**. As specified in Section 26 05 29, "Supporting Devices."

B. **Identification**. As specified in Section 26 05 53, "Electrical identification."

C. **Calibrators and Programmers**. Provide calibrators/programmers for all instrumentation equipment furnished under Section 40 90 00 that cannot be

calibrated from the controls built into the unit. Provide a minimum of one calibrator/programmer for each type of equipment supplied.

D. **Adjustable Deadband.** All output contacts from all instrumentation equipment furnished under Section 40 90 00 shall have a minimum of ±5 percent deadband adjustment.

2.2 POWER SUPPLIES

A. **General.** Provide regulated direct current (dc) power supplies suitable for 120 volt input (±10 percent) with fused output regulated to 0.1 percent minimum.

B. **Manufacturers.** Available manufacturers of power supplies include, but are not limited to, the following:

1. Acopian Corporation.
2. Condor DC Power Supplies, Inc.
3. Moore Industries.
4. Square D Company.

PART 3 - EXECUTION

3.1 EXAMINATION

A. **Existing Conditions.** Examine the site and existing facilities. Compare the site and existing facilities with the drawings and specifications. Locate connections of existing facilities and any obstructions which may be encountered and conduct work to minimize disruption to existing conditions.

B. **Field Measurements.** Field-verify all locations and dimensions to ensure that the equipment will be properly located, readily accessible, and installed in accordance with all pertinent codes and regulations, the contract documents, and the referenced standards.

3.2 INSTALLATION - GENERAL

A. **General**

1. Locations of instruments shown on the drawings are approximate unless specifically dimensioned. Install the instruments to perform their intended function in full coordination with existing conditions and the work of other trades.
2. Furnish, fabricate, and mount all instrument stands and brackets. Mounting of stands and instruments shall be per installation detail drawings. All stands must be level, plumb, rigid, and free from vibration. Additional support shall be added where required for vibration-free mounting.

B. **Instrumentation wiring is shown** schematically on the plan or described by narrative in the specifications. Provide type and quantity of wiring necessary to perform the function specified in Division 40 and shown on the plans. See Division 26 wire and cable sections for "uses permitted." Analog signal

conductors and discrete signal conductors shall always be in separate conduits or cable tray compartments. Power wiring shall be in conduits and cable tray compartments separate from all signal wiring. Power wiring wherever required by instruments or equipment provided as part of the instrument system is work of this section.

1. Terminate field wiring for equipment specified under this section. The system integrator shall check instrument installation and field wiring before Contractor powers instrument devices. Terminate wires shall be terminated at terminal blocks with crimp type, preinsulated tongue lugs. Lugs shall be of the appropriate size for the terminal block screws and for the number and size of the wires terminated. All signal shields shall have only one ground point which shall be located at the closest control panel. Seal around all conductors inside conduits as they enter equipment. Use watertight seal (closed cell RTU foam type) entering or leaving every building, box, or instrument. Install conduit water relief or "weep" on the system side of all seals to prevent intrusion of water into the equipment.
2. Spare Wiring. Signal and interlock wiring shall contain spare conductors in every raceway. Provide spare conductors in pairs and shall be clearly and distinctly marked at every access point indicated where the pairs start and stop. Provide a minimum 25 percent of the number of active pairs as spare pairs with a minimum of one spare pair.

3.3 ADJUSTING

A. **Set Points**. Adjust alarm and control set points to their operational values before the start of the field test.

B. **Calibration**. Perform calibration adjustments before the start of the field test. Commence testing after calibration verification for each instrument is provided.

3.4 FIELD QUALITY CONTROL

A. **Piping Tests**. After piping systems have been put into service, inspect for leaks. Adjust pipes, valves, or fittings to stop leaks; replace equipment if leak persists.

B. **Field Test**

1. A technical representative of the system integrator and the Contractor shall perform a field test on the entire instrumentation and control system. All equipment provided by the system integrator and all interrelated equipment provided by other suppliers, such as pumps, blowers, valve operators, chemical feeders, motor controls, etc., shall be installed and operating properly before the test starts.

2. All test equipment and materials shall be provided by the system integrator.

3. As a minimum, the test shall consist of the following:

a. Verify proper calibration of all instruments by independent measurements, such as checking levels with a measuring rod or pole, performing drawdown tests on wells to check flow rates, performing laboratory tests on samples, etc.

b. Create temporary test conditions to simulate variations in process operation by throttling valves, controlling pump speed, shutting down process equipment, operating safety devices, etc. Where safety concerns or process limitations prohibit physical simulation and when agreed to by the Owner, simulated process signals may be used. Test conditions shall be sufficient to test the operation of every function of the instrumentation and control system including:

1) Alarms and safety shutdowns.
2) Equipment start/stop and speed controls.
3) Pacing of chemical feed equipment.
4) Recorders and indicators.
5) Process controller operation and recovery from upsets.
6) Programmable logic controller (PLC) or Supervisory Control and Data Acquisition (SCADA) system inputs and outputs.
7) PLC or SCADA system programming.

c. The test shall be performed according to the test procedures submitted. As each phase of the test is completed, test data sheets shall be signed and dated. The test data sheets shall document any modifications to the control and alarm settings, process engineering unit changes, programming changes, wiring changes, problems encountered, and steps taken to solve the problems.

3.5 CLEANING

A. **Instrumentation System**. Keep the instrumentation system components clean and free of dust during the storage, start-up, demonstration, and warranty period.

B. **Control Panels and Consoles**. Clean dust and dirt accumulation inside and outside control panels and consoles, on a monthly basis, during start-up and demonstration period.

3.6 DEMONSTRATION

A. **General**. Perform a 30-day operational demonstration of the complete instrumentation and control system. The demonstration shall conform to the following requirements and the requirements of Section 01 79 01. The 30 day operational demonstration shall not begin until the field test is completed and all problems and defects encountered during the field test have been corrected.

B. **System Acceptance**. System acceptance shall not occur until the entire instrumentation and control system has performed as a functioning unit

continuously for 30 consecutive days without loss of control and monitoring function, except for periods of scheduled maintenance. Failure of any component, software function, or required function shall require a restart of the 30 day operational demonstration until 30 consecutive days of continuous operation have been completed.

C. **Staffing**. Provide the services of a qualified service technician for the duration of the 30 day demonstration. The service technician shall be on site 8 hours per day Monday through Friday and on call 24 hours per day, 7 days a week.

3.7 PROTECTION

A. **Protect the instrumentation system components** from water, dust, dirt, and corrosion during the start-up, demonstration, and warranty period.

3.8 INSTRUCTION OF OPERATIONS PERSONNEL

A. **Field Training**. Training shall be conducted in accordance with Section 01 79 00 and shall include equipment specified in this section, and related electrical and interfaces to equipment provided by other division sections. Training sessions shall be conducted as follows:

1. One 4-hour session.

2. The training program shall provide the plant operations personnel with the capability of operating the software of the process control system supplied.

3. Training courses shall include hardware components emphasizing operation. Software training shall include the fundamental software organization and operation of the delivered system.

4. Minimum Goals. Training shall incorporate operational requirements described in these specifications. Training shall provide the plant operations personnel with the following:

   a. Control set point and dead band modifications.
   b. Response to alarm displays and error indications.

5. The process control system integrator shall submit a training program which provides the plant operations personnel a theoretical background and a broad range of related skills to achieve the listed goals. The instructor(s) shall be experienced in system applications similar to the equipment specified herein. The resumes of the training staff for instructing the plant operations personnel shall be available for review by the Owner. The plant operations personnel trainees shall be subjected to program testing, evaluation, and counseling. Study assignments shall be made and later reviewed by the instructors to the satisfaction of class attendees. Trainees shall be encouraged to freely ask questions during the instruction periods.

6. Provide all classroom training courses and all hands-on training at the plant site.

7. Provide text material for self-study and to supplement classroom lectures. The personnel attending the training courses shall be permitted to retain text materials for future reference.

8. Develop a training program tailored to the Owner's needs including type and quantity of treatment plant personnel, a curriculum of described courses, duration of courses, and training facilities. Submit for approval a detailed outline of the proposed training schedule, how the training courses are to be conducted, and estimated dates for beginning and end of each training phase. Be responsible for the cost of the training program. The Owner shall be responsible for the trainee salaries and overhead costs.

3.9 INSTRUCTION OF MAINTENANCE PERSONNEL

A. **Field Training**. Training shall be conducted in accordance with Section 01 79 00 and shall include equipment specified in this section, and related electrical and interfaces to equipment provided by other division sections. Training sessions shall be conducted as follows:

1. One 4-hour session.

2. Training courses shall include hardware components emphasizing operation, calibration, maintenance, interface with other systems, and associated theory.

3. Minimum Goals. Training shall incorporate operational requirements described in these specifications. Training shall provide the plant maintenance personnel with the following:

   a. Control system start-up and shutdown.
   b. Routine diagnostic checks and maintenance.
   c. Control set point and dead band modifications.
   d. Field instrument calibration and maintenance.
   e. Response to alarm displays and error indications.
   f. Program software loading.
   g. Equipment diagnostic testing and replacement of failed parts.

4. The process control system integrator shall submit a training program which provides the plant maintenance personnel a theoretical background and a broad range of related skills to achieve the listed goals. The instructor(s) shall be experienced in system applications similar to the equipment specified herein. The resumes of the training staff for instructing the plant maintenance personnel shall be available for review by the Owner. The plant maintenance personnel trainees shall be subjected to program testing, evaluation, and counseling. Study assignments shall be made and later reviewed by the instructors to the

satisfaction of class attendees. Trainees shall be encouraged to freely ask questions during the instruction periods.

5. Provide most classroom training courses at the process treatment plant site. Hands-on training shall be conducted at the Contractor's site which has a facility similar to the system described herein, as well as at the treatment plant. A minimum of three treatment plant trainees shall become qualified to check out, operate, and maintain the control system prior to delivery of the specified equipment to the plant. Training shall continue after delivery and during checkout of the system.

6. Provide text material for self-study and to supplement classroom lectures. The personnel attending the training courses shall be permitted to retain text materials for future reference.

7. Develop a training program tailored to the Owner's needs including type and quantity of plant personnel, a curriculum of described courses, duration of courses, and training facilities. Submit for approval a detailed outline of the proposed training schedule, how the training courses are to be conducted, where various phases of the training will take place, and estimated dates for beginning and end of each training program. The Owner shall be responsible for the trainee salaries and overhead costs. Remote site field training shall be within 30 highway miles from the treatment plant site.

3.10 SCHEDULES

A. **General**. Detailed information to augment specification data may be provided in the form of schedules or in lieu of schedules on ISA S20 specification forms. See each specification section for schedule or ISA specification forms.

B. **Power Supplies Schedule**

1. Application. Power supplies shall be provided to enable all equipment provided with and as a part of the Instrument System. If scheduled, such power supplies are understood to be specifically required, but not necessarily a comprehensive list of all power supplies to be provided.

END OF SECTION

SECTION 40 91 01

PRESSURE MEASUREMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General**. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this section.

B. **Related Sections**. Refer to Section 40 90 00, "Instrumentation Systems Basic Requirements," for additional requirements related to this section.

1.2 DESCRIPTION OF WORK

A. **General**. Provide the labor, tools, equipment, and materials necessary to install pressure measurement equipment.

B. **Types**. The types of equipment specified in this section include the following:

1. Pressure transmitter.
2. Differential pressure transmitter.

1.3 QUALITY ASSURANCE

A. **Codes and Standards**. Perform all work associated with pressure measurement equipment in compliance with applicable requirements of governing agencies having jurisdiction and in accordance with these plans and as specified herein.

1. National Electrical Manufacturers Association (NEMA) Compliance.
2. National Electrical Code (NEC) Compliance.
3. Underwriters' Laboratories, Inc. (UL) Compliance and Labeling. Comply with provisions of UL safety standards pertaining to pressure measurement equipment. Provide products and components which have been UL listed and labeled.
4. See Section 40 90 00, "Instrumentation System Basic Requirements," for additional applicable codes and standards.

B. **Qualifications**

1. Manufacturer's Qualifications. Firms regularly engaged in manufacture of pressure measurement equipment whose products have been in satisfactory use in similar service for not less than 5 years.
2. Installer's Qualifications. Qualified with at least 5 years of successful installation experience on projects with pressure measurement equipment similar to that required for this project. An approved manufacturer's representative factory educated in maintenance, installation, and start-up of the pressure measurement equipment.

1.4 **SUBMITTALS**

A. **General**. Furnish manufacturer's product data, test reports, and material certifications as required. See Section 40 90 00, "Instrumentation Systems Basic Requirements," for additional submittal requirements, all of which apply.

B. **Materials List**. Submit a list of materials giving quantities, manufacturer's name, and catalog numbers.

C. **Wiring Diagrams**. Submit wiring diagrams showing all connections for all equipment furnished under this section.

1.5 **JOB CONDITIONS**. Refer to Section 40 90 00, "Instrumentation Systems Basic Requirements."

1.6 **DELIVERY, STORAGE, AND HANDLING**

A. **Packing and Shipping**. Deliver equipment properly packaged and mounted on pallets or skids to facilitate handling of heavy items. Utilize factory fabricated type containers or wrappings for components which protect equipment from damage.

1.7 **SPECIAL WARRANTY**. Refer to Section 40 90 00, "Instrumentation Systems Basic Requirements."

PART 2 - PRODUCTS

2.1 **MANUFACTURED UNITS**

A. **Pressure Transmitter**

1. Features.

a. Sensing Element. Sealed capacitance sensing with silicone oil fill.
b. Solid state transmitter.
c. Two wire operation.
d. Field serviceable, noninteracting, zero and span controls.
e. Zero elevation and suppression.
f. Adjustable dampening.
g. NEMA 4 housing with 1/4-inch NPT pressure connection.

2. Accessories.

a. Shutoff valve, pulsation dampener, tubing, and fittings.
b. Manual air release with threaded fitting for attachment of portable calibration unit.

c. Local indicated reading in engineering units.
d. Stainless steel tag.

3. Materials.

a. Sensor Body. Type 304 stainless steel.
b. Wetted Parts. Type 304 stainless steel.

4. Sizes and Ratings.

a. Overpressure Protection. 2,000 pounds per square inch gauge (psig) minimum.
b. Accuracy. 0.2 percent of span.
c. Ambient Temperature. -20 to 180 degrees Fahrenheit (° F.).
d. Pressure Input Range. As specified in the schedule at the end of this section.
e. Signal Output. 4-20 milliampere direct current (mAdc).

5. Manufacturer.

a. Available manufacturers of level transmitters include, but are not limited to, the following:

1) Foxboro.
2) ABB.
3) ITT Barton.
4) Rosemount Inc.

B. **Differential Pressure Transmitter**

1. Features.

a. Sensing element protected by a sealing diaphragm with silicone oil fill solution.
b. Microprocessor based transmitter.
c. Integral span and zero adjustments.
d. Electrically erasable programmable read only memory module and programmable transmitter configuration for flow applications.
e. Internal dampening.
f. Two wire operation.
g. Square root or linear output, software selectable.
h. NEMA 9 enclosure.
i. Two 1/2-inch NPT pressure connections.
j. Analog to digital and digital to analog converters.
k. Remote and local testing and configuration via digital signal superimposed on the 4-20 mAdc signal.

2. Accessories.

   a. Three valve manifold, pulsation dampener, tubing, and fittings.
   b. Manual air release with threaded fitting for use with portable calibrator.
   c. Strainer for use in filter, sediment trap with air relief, and drain valve.
   d. Bracket for wall, horizontal pipe, or vertical pipe mounting.
   e. Stainless steel tag.

3. Materials.

   a. Sensor. Type 304 stainless steel with Viton O-rings.
   b. Mounting Hardware. Stainless steel.
   c. Base and Cover. Die cast low copper aluminum with epoxy based finish and Buna O-rings.

4. Sizes and Ratings.

   a. Overpressure Protection. 2,000 pounds per square inch (psi) minimum.
   b. Accuracy. 0.25 percent of span.
   c. Repeatability. 0.05 percent of span.
   d. Temperature Limits. -20 to +80° F.
   e. Signal Output. 4-20 mA.
   f. Ranges as specified in the schedule at the end of this section.

5. Manufacturer.

   a. Available manufacturers of differential pressure transmitters include, but are not limited to:

      1) Rosemount Inc.
      2) ABB.

6. Flow Application Accessories.

   a. Square root extractor integrally mounted in differential pressure transmitter.
   b. Local analog indicator reading in engineering units of flow.
   c. Three valve manifold, tubing, and fittings.

7. Loss of Head Application Accessories.

   a. Filter sediment trap, mudleg, and strainer assembly with air relief and drain valve.
   b. Local analog indicator reading in engineering units.
   c. Tubing and fittings.
   d. Isolation valve(s).

PART 3 - EXECUTION

3.1 EXAMINATION

A. **Verification of Conditions**. Prior to all work of this section, carefully inspect the installed work of all other trades and verify that all such work is complete to the point where this installation may properly commence.

B. **Discrepancies**. In the event any discrepancies are discovered, immediately notify the Owner's Representative in writing. Do not proceed with installation until all such discrepancies have been fully resolved.

3.2 PREPARATION

A. **Protection**

1. All equipment and materials shall be packed at the factory to protect each item from damage during shipment and storage.
2. Provide blocking and cushioning materials to prevent damage during shipment.
3. Provide temporary lifting lugs on shipping package as needed.
4. Include approximately 1 pint of touch-up paint for each finish color in shipment.

B. **Surface Preparation**. The work shall be carefully laid out in advance. Any damage to building, piping, or equipment shall be repaired by skilled mechanics of the trades involved, and at no additional cost to the Owner.

3.3 INSTALLATION

A. **General**. Coordinate the installation of in-line process pressure elements with the process piping elements.

B. **Differential Pressure Transmitter**

1. Install three valve manifold, 1/2-inch copper tubing with fittings and air release for attachment of portable calibration unit.
2. Mount transmitters on 2-inch pipe supports fabricated for floor or bracket mounting.
3. Install transmitter in an orientation where the sensing diaphragms are in a vertical plane and the exposure to shock, heat, and vibration is at a minimum.
4. Flow Applications. Mount differential pressure transmitter below the primary flow element device.
5. Loss of Head Applications. Provide tubing and pressure tap connection to the primary, filter effluent, flow element device.

3.4 FIELD QUALITY CONTROL

A. **Inspection**. Upon completion of this portion of the work, provide for services of a qualified representative of the manufacturer to inspect and approve installation.

B. **Calibration**

1. Verify calibration on field-calibrated devices using calibrated test equipment.

C. **Tests**. Upon completion of all inspections and prior to acceptance by Owner, perform field tests outlined in Section 40 90 00, "Instrumentation Systems Basic Requirements."

3.5 DEMONSTRATION

A. **General**. Before required tests may be performed, the Contractor, along with a qualified representative of the instrument supplier, shall thoroughly demonstrate to the Engineer and to the Owner's personnel the operation and maintenance of all items provided under this section.

B. **Features**. Reliable and accurate operation of each pressure sensor and all specified accessories shall be demonstrated. This shall include accuracy, stability, and repeatability as specified over a range inclusive of the maximum (full scale, overflow, high alarm, etc.) and the minimum (low alarm, low stop) pressures which can occur without operator intervention.

C. **Continuity**. Once a pressure sensor has demonstrated the specified features and accuracy, it shall demonstrate continuity of performance for three continuous successive days. The pressure sensor shall intentionally be exposed to conditions which provide the full range of variations. At a minimum, one daily excursion to high alarm and one daily excursion to low alarm shall be arranged.

END OF SECTION

SECTION 40 91 03.04

FLOW MEASUREMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this section.

B. **Related Sections.** Refer to Section 40 90 00, "Instrumentation Systems Basic Requirements," for additional requirements related to this section.

1.2 DESCRIPTION OF WORK

A. **General.** Provide the labor, tools, equipment, and materials necessary to install flow measurement equipment.

B. **Type.** The type of equipment specified in this section include the following:

1. Insert Venturi flow tube.

1.3 QUALITY ASSURANCE

A. **Codes and Standards.** Perform all work associated with flow measurement equipment in compliance with applicable requirements of governing agencies having jurisdiction and in accordance with these plans and as specified herein.

1. NEMA – National Electrical Manufacturers Association.
2. NEC – National Electrical Code.
3. UL – Underwriters' Laboratories, Inc.

B. **Qualifications**

1. Manufacturer's Qualifications. Firms regularly engaged in manufacture of flow measurement equipment whose products have been in satisfactory use in similar service for at least 5 years.
2. Installer's Qualifications. Qualified with at least 5 years of successful installation experience on projects with flow measurement equipment similar to that required for this project. Also, an approved manufacturer's representative factory educated in maintenance, installation, and start-up of the flow measurement equipment.

1.4 **SUBMITTALS**

A. **General**

1. Submit all submittals in accordance with the Division 1 Submittal Requirements and the requirements within this specification section.

B. **Submittal Package No. 1 – Product Data**

1. General. Furnish manufacturer's product data, test reports, and material certifications as required. See Section 40 90 00, "Instrumentation Systems Basic Requirements," for additional submittal requirements, all of which apply.
2. Materials List. Submit a list of materials giving quantities, manufacturer's name, and catalog numbers.
3. Wiring Diagrams. Submit wiring diagrams showing all connections for all equipment furnished under this section.
4. Conversion Charts. Supply certified head versus rate of flow conversion charts or curve for the Parshall flume and flow tubes, if applicable.
5. Furnish two certified copies of calibrations.

1.5 **JOB CONDITIONS**. Refer to Section 40 90 00, "Instrumentation Systems Basic Requirements."

1.6 **DELIVERY, STORAGE, AND HANDLING**

A. **Packing and Shipping**. Deliver equipment properly packaged and mounted on pallets or skids to facilitate handling of heavy items. Utilize factory fabricated type containers or wrappings for components which protect equipment from damage. Comply with Section 01 60 00, "Materials and Equipment."

1.7 **SPECIAL WARRANTY**. Refer to Section 40 90 00, "Instrumentation Systems Basic Requirements."

PART 2 - PRODUCTS

2.1 **MANUFACTURED UNITS**

A. **Insert Venturi Flow Tube**

1. Features.

a. Short laying length suitable for mounting between ANSI Class 125 flanges.
b. Static inlet throat and pressure taps.
c. 1/4-inch NPT high and low pressure connections located in flange, 180 degrees apart.
d. Diverging downstream cone nozzle for head recovery.
e. Tube shall have no protrusions, sharp edges, slots, or other sediment collecting areas exposed to flow stream.

2. Accessories.

   a. Differential pressure transmitter as specified in Section 40 91 01, "Pressure Measurement."
   b. The manufacturer shall submit certified differential versus rate of flow curve for each meter supplied covering the flow range specified in the schedule at the end of this section.
   c. Stainless steel tag.

3. Materials.

   a. Flange, Throat, and Taps. Type 304 stainless steel.
   b. Entrance and Recovery Former. Fiberglass reinforced plastic.

4. Sizes and Ratings.

   a. Accuracy. 1.0 percent of flow rate without calibration and 0.5 percent of flow rate with calibration.
   b. Head loss less than 4 percent of differential pressure produced at any one point within the specified range.
   c. Differential suitable for measurement over the specified flow range.
   d. Sizes and flow ranges as specified in the schedule at the end of this section.

5. Manufacturer.

   a. Provide insert flow tube manufactured by one of the following:

      1) Primary Flow Signal Inc.
      2) ABB.
      3) Badger Meters, Inc.
      4) Or approved equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. **Verification of Conditions**. Prior to all work of this section, carefully inspect the installed work of all other trades and verify that all such work is complete to the point where this installation may properly commence.

B. **Discrepancies**. In the event any discrepancies are discovered, immediately notify the Engineer/Architect in writing. Do not proceed with installation until all such discrepancies have been fully resolved.

3.2 PREPARATION

A. **Protection**

1. Pack all equipment and materials at the factory to protect each item from damage during shipment and storage.
2. Provide blocking and cushioning materials to prevent damage during shipment.
3. Provide temporary lifting lugs on shipping package as needed.

B. **Surface Preparation**. Carefully lay out the work in advance. Repair any damage to building, piping or equipment at no additional cost to the Owner.

3.3 INSTALLATION

A. **General**

1. Coordinate the installation of in-line process flow elements with the installation of process piping equipment.
2. Install straight lengths of pipe on either side of flowmeter as recommended by the manufacturer unless otherwise noted on the contract drawings. Coordinate actual installation location with Contractor installing piping before piping layouts are submitted.
3. Mount instruments so that they may be readily approached and easily serviced.
4. Install transmitter with local indicators in a position that the operator can observe the indicator from the operating area.

3.4 FIELD QUALITY CONTROL

A. **Calibration**. Furnish labor, materials, tools, and equipment required to calibrate the flowmeters. Perform calibration under conditions of constant flow. Refer to specific product requirements for additional calibration requirements.

B. **Inspection**. Upon completion of this portion of the work, provide the services of a qualified representative of the manufacturer to inspect and approve installation.

C. **Tests**. Upon completion of all inspections, and prior to acceptance by Owner, perform field tests outlined in Section 40 90 00, "Instrumentation Systems Basic Requirements."

3.5 ADJUSTING

A. **Calibration**. Perform calibration adjustments of each flow device as needed for a complete operational system.

3.6 CLEANING

A. **Flow Measurement**. Keep each flow device clean and free of dust during the storage, start-up, demonstration, and warranty period.

3.7 DEMONSTRATION

A. **General**. Before required tests may be performed, thoroughly demonstrate, along with a qualified representative of the instrument supplier, to the Engineer and to the Owner's personnel the operation and maintenance of all items provided under this section.

B. **Features**. Demonstrate reliable and accurate operation of each meter and all specified accessories. This shall include accuracy, stability, and repeatability as specified over a 10 to 1 flow range.

C. **Continuity**. Once a meter has demonstrated the specified features and accuracy, it shall demonstrate continuity of performance for three continuous, successive days. The meter shall intentionally be exposed to conditions which provide the full range of variations of flow supply. At a minimum, one daily excursion to maximum flow and one daily excursion to minimum flow shall be arranged.

END OF SECTION

SECTION 44 42 19

BLOWER, GENERAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General**. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 1, and all related specification sections, apply to this section.

1.2 DESCRIPTION OF WORK

A. **Scope of Work**. The Contractor shall provide all labor, tools, equipment, and materials necessary to furnish and install the blower in accordance with the drawings and as specified herein.

1.3 QUALITY ASSURANCE

A. **Codes and Regulatory Agencies**. Perform all work in compliance with all federal, state, and local codes and regulatory agencies.

B. **Standards**. Materials and workmanship shall be in accordance with the following standards as referenced herein:

1. AFBMA - Antifriction Bearing Manufacturers' Association.
2. ANSI - American National Standards Institute.
3. ASME - American Society of Mechanical Engineers.
4. ASTM - American Society for Testing and Materials.
5. AWS - American Welding Society.
6. IEEE - Institute of Electrical and Electronics Engineers.
7. NEMA - National Electrical Manufacturers Association.

1.4 SUBMITTALS

A. **General**. Submit the specified submittal packages in accordance with Section 01 33 00, "Submittals," and the specific blower specification section included later in the contract documents.

1.5 JOB CONDITIONS

A. **Coordination**. Coordinate all work to prevent delays, errors, and/or omissions.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **Delivery**. All units shall be shipped assembled as much as practical. All units shall be labeled with all labeling intact and legible with item name, model number, size, and manufacturer's name.

B. **Storage**. All units, accessories, and components shall be stored in the manufacturer's original package, under cover and protected from damage. Maintain a grease coating on all bearings and shafts to prevent rusting. All filter material shall be kept dry and dust free. Blower shafts shall be turned at intervals as recommended by the blower manufacturer.

C. **Handling**. Handle all units and components in accordance with the manufacturer's instructions. Use lifting rings and canvas harnesses for lifting to prevent damage, scratching, or abrading finished surfaces.

1.7 **SPECIAL WARRANTY**

Not used.

PART 2 - PRODUCTS

2.1 **MATERIALS**

A. **Blower**

1. General. Blower shall be heavy duty, suitable for intermittant, efficient, and dependable service under operating conditions imposed by the installation and specific blower specification.

2. Castings. All castings shall be free of warp, fins, gas and pit holes, and other defects that might impair strength or appearance. Cast iron castings shall have a minimum tensile strength of 30,000 pounds per square inch (psi) and conform to the applicable ASTM standard.

3. Steel. All steel shall conform to the applicable ASTM standard. All welding shall be in accordance with the standards of the AWS.

4. Shop Test. Unless otherwise noted, certified performance data based on tests of each blower furnished shall be submitted to the Engineer/Architect for acceptance. Tests shall be performed for not less than 1 hour and in accordance with ASME Power Test Code and shall demonstrate compliance with the operating conditions specified. When specified, the Engineer/Architect shall be notified and afforded the opportunity to witness the test.

5. Nameplate. An aluminum or stainless steel nameplate shall be attached to each blower in a clearly visible, easily accessible location. Nameplate shall be stamped with the following for each blower.

   a. Manufacturer's name.
   b. Model number.
   c. Serial number.
   d. Design capacity, standard cubic feet per minute (scfm).
   e. Design pressure, psi.
   f. Design speed, revolutions per minute (rpm).

B. **Motor**

1. Motor shall be rated for continuous duty and normal starting torque unless otherwise specified or shown. Motors shall have NEMA Class F insulation.

2. Motor enclosure shall be as listed in the applicable equipment schedule. Motor enclosure notations are:

   a. E-P (EXP) - Explosionproof.
   b. TENV - Totally enclosed nonventilated.
   c. TEFC - Totally enclosed, fan-cooled.
   d. ODP - Open dripproof.

3. Temperature rise shall be in accordance with NEMA limits for the class of insulation, service factor, and enclosure specified.

4. Motor performance shall conform to the requirements of NEMA MG1 Part 12 and shall be expressed as indicated in NEMA MG1-12.30 and a report of test for routine tests shall be submitted based on IEEE test procedure 112, Method B.

5. Motor terminals shall be provided and marked as required for the application described in NEMA MG1 Section 2 and as required in Division 26, "Electrical."

6. Motor shall have a 1.15 service factor rating. The blower brake horsepower (bhp) requirements shall not exceed the motor nameplate horsepower under the operating conditions as listed in the applicable Equipment Schedule.

7. Motor shall be designed to operate at the highest efficiency and power factor.

8. Motor shall be of standard manufacturer, General Electric, U.S. Motors, Reliance Electric, or equal.

9. Shop Test. Tests shall be performed in accordance with ANSI/IEEE Standard 112 and ANSI C52.1, parts 12 and 20 (NEMA MG1). When specified, the Engineer/Architect shall be notified and afforded the opportunity to witness the test.

   a. Routine Test. A certified report of a routine test of each motor furnished shall be submitted to the Engineer/Architect for acceptance. Tests shall include running light current, power input, and high potential.
   b. Certified Data. Unless otherwise specified, certified data shall be furnished for motor efficiency and power factor at 100 percent, 75 percent, and 50 percent of full load based on test data of a motor of identical design.

c. Full Test. When specified, a certified report of a full motor test of each motor furnished shall be submitted to the Engineer/Architect for acceptance. Tests shall include full load heat run, percent slip, running light current, locked rotor current, starting torque, efficiencies and power factor at 100 percent, 75 percent, 50 percent full load, and winding resistance and high potential tests.

10. Motor Nameplate. An aluminum or stainless steel nameplate shall be attached to each motor clearly visible showing operational data in accordance with NEMA MG-1.

C. **Accessories**. The following accessories shall be supplied for every blower in this project covered by the specifications.

1. Check Valve. Check valve shall be provided for the discharge piping on blower. The valves shall be the size and joint shown. The valve shall have a cast iron body with bronze and stainless steel trim and shall be suitable for 25 pounds per square inch (psi) working pressure and 250 degrees Fahrenheit (° F.) continuous operating temperature.

2. Butterfly Valve. Butterfly valve shall be provided for the inlet and discharge piping on each blower. The valve shall be the size and joint shown. The valve shall have a cast iron body with bronze and stainless steel trim and shall be suitable for 25 psi working pressure and 250° F. continuous operating temperature. The stem shall be bushed and sealed. Valve sizes through 8 inches shall be equipped with a lever operator and locking device.

3. Expansion Joint. Expansion joint shall be provided for the inlet and discharge piping on each blower. The expansion joint shall be reinforced synthetic rubber compatible with the size and type of piping shown. It shall be suitable for 25 psi working pressure and 250° F. operating temperature. The expansion joint shall be tied with resilient mounted steel rods or otherwise restrained from over extension due to internal pressures.

4. Thermometers. The blower package shall include a discharge temperature gauge mounted on the noise enclosure. The discharge temperature gauge shall be as manufactured by Weiss, Model 25UB3-5131, with 2.5-inch dial.

5. Gauges.

a. Pressure. Pressure gauge shall be Bourdon type, aluminum alloy case, bronze Bourdon tube, 4-1/2-inch dial with plastic window. Gauge shall read from 0 to 15 psi with 1/2-pound graduations. Gauge shall come complete with pulsation dampener, brass tee handle stop valve, and mounting stem. Provide 1/4-inch pipe tap

between blower discharge and the check valve for pressure gauge mounting. Gauge shall be Ashcroft 1010 or equal.

b. The blower package shall include a gauge on the discharge of the blower. Gauge shall be mounted on the noise enclosure. Gauges shall be as manufactured by Ashcroft, Model 1009SW, with a 2.5-inch dial.

2.2 FINISHES

A. **Exterior Surfaces**. All surfaces exposed shall be shop primed and field finished in accordance with Section 09 90 00, "Painting," and requirements noted in the specific blower specification section hereinafter.

PART 3 - EXECUTION

3.1 EXAMINATION

A. **Site Verification of Conditions**. Prior to installation of equipment, verify that:

1. All clearances have been met.
2. Bases, anchors, supports, and openings are located correctly and are of the proper size and material.

B. **Variations**. Any variations of the requirements shown on the drawings or required by the manufacturer shall be corrected at no additional cost to the Owner. All methods of correction shall be submitted in writing and acceptable to the Owner and/or Engineer/Architect.

3.2 PREPARATION

A. **Protection**. All surface areas shall be protected from damage. All finished floors shall be protected with a waterproof, oil resistant cover to prevent staining from oil and/or grease.

3.3 INSTALLATION

A. **General**. All blowers and components shall be installed in accordance with the manufacturer's instruction and the conforming shop drawings, including all gasket seals, isolation dampeners, cleanouts, drains, gauges, motors, controls, and power wiring.

B. **Manufacturer's Field Service**. A qualified representative of each equipment manufacturer shall inspect the completed installation, service the equipment, operate the equipment under all design conditions, instruct the Owner's personnel in proper operating and maintenance procedures, and provide the Owner with a written certificate of approval.

C. **Set anchor bolts** in accordance with the approved manufacturer's conforming submittals.

D. **Lubrication.** Contractor shall furnish and apply an initial supply of grease and oil as recommended by the manufacturer and shall grease and oil the equipment throughout all testing until completion.

E. **Interface with Other Products**

1. Contractor shall complete all electrical power and control connections.
2. Contractor shall Install and connect all piping, valves, and gauges.

F. **Inspection**

1. The Contractor shall inspect all parts of the blower for proper installation and conformance to the drawings and manufacturer's recommendations.

3.4 REPAIRS/RESTORATION

A. **Damages**. Any chips, dents, scratches, stains, or other disfiguring of surrounding floors, walls, and/or accessories shall be repaired or replaced to the satisfaction of the Owner and/or Engineer/Architect at no additional cost to the Owner.

3.5 CLEANING

A. **Surface**. The blower, motor, accessories, and surrounding areas shall be cleaned of all foreign material, grease, and oil stains.

B. **Airway**. Remove all rags, sticks, debris, and construction materials. Damage to equipment components shall be replaced in like kind at no additional cost to the Owner.

C. **Protection**. After cleaning, provide protective covering for each piece of equipment from damage.

3.6 FIELD QUALITY CONTROL

A. **Manufacturer's Field Service**

1. Perform field inspection of all components prior to placing in operation and submit manufacturer's installation inspection report addressing the following:
   a. List of deficiencies found.
   b. Recommended corrective action for all deficiencies.
   c. Certification by manufacturer's representative that items are properly installed, aligned, and adjusted.

3.7 DEMONSTRATION

A. **Visual**. The Contractor, Owner, and/or Engineer/Architect shall inspect the equipment for visual deficiencies.

B. **Tests**. Dry and wet tests shall be performed and the equipment adjusted as specified in Section 01 79 00, "Start-up, Demonstration, and Training."

C. **Noise Tests.** The Contractor, in the presence of the manufacturer's representative and the Engineer/Architect, shall measure the sound level. The Contractor shall show that the decibel meter used is calibrated. Sound level shall be measured for one unit operating at a time and measured 3 feet from the unit in all directions. The Contractor shall submit a field test report as specified in Section 01 79 00.

D. **Operational Demonstration**. An operational demonstration shall be performed as specified in Section 01 79 00, "Start-up, Demonstration, and Training." Verify and note in the operational demonstration log that all design conditions for blower capacities and pressures, and motor nameplate data have been equaled or exceeded for the demonstration period.

3.8 **MANUFACTURER'S SERVICES.** The manufacturer shall provide a qualified technical representative for one 8-hour day to instruct the Owner's operating and maintenance personnel on the operation and maintenance of the equipment. After installation and prior to training, the representative shall carefully check and ensure that all equipment components were installed correctly. The representative shall be present during field testing and start-up of the equipment. The representative shall submit the necessary reports as required under Section 1.4 of these specifications.

3.9 **EXTRA MATERIAL**

A. **Spare Parts**. The spare parts called for in the various blower specifications shall be protected and packaged as recommended by the manufacturer. Each package shall be tagged for positive identification noting:

1. Part name.
2. Part number.
3. Associated equipment name and number.
4. Manufacturer's name and address.

END OF SECTION

SECTION 44 42 21

POSITIVE DISPLACEMENT BLOWER

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General.** Drawings and general provisions of the Contract, including General and Supplementary Conditions; Division 1; Section 44 42 19, "Blowers, General"; and all other related specification sections, apply to this section.

1.2 DESCRIPTION OF WORK

A. **Scope of Work.** The Contractor shall provide all labor, tools, equipment, and materials necessary to furnish and install the positive displacement blower in accordance with the drawings and as specified.

B. **Type of Installation**. Blower assembly shall be contained in a sound attenuating enclosure suitable for outdoor installation on a concrete pad, as shown on the drawings.

1.3 QUALITY ASSURANCE

A. **General**. In accordance with Section 44 42 19, "Blowers, General."

B. **Source**. All positive displacement blower components shall be of the same manufacturer. All drives shall be of one manufacturer.

1.4 SUBMITTALS

A. **General**

1. All submittals shall be submitted in accordance with the Division 1 Submittal Requirements and the requirements within this specification section.

B. **Submittal Package No. 1 – Product Data and Shop Drawings**

1. Product Data. Furnish manufacturer's product data including blower curves, accessories, options, dimensions, weights, and list of special tools in accordance with Section 01 33 00.
2. Performance Data. Submit performance data and curves for preliminary review of the blower equipment to be furnished. Such data shall be based on actual tests of similar equipment and include sufficient data to demonstrate suitability of both the blower and driver for the conditions specified.
3. Shop Drawings. Shop drawings shall be submitted showing materials, accessories, coatings, dimensional layouts, anchor bolts, sectional views of blower construction, driver specifications, wiring diagrams, and a bill of materials.

C. **Submittal Package No. 2 – Operation and Maintenance Manuals and Personnel Qualifications**

1. Operation and Maintenance (O&M) Manuals. Submit O&M manuals in accordance with Sections 01 33 00. The initial review copy of the O&M manual and six revised copies shall be submitted to the Engineer/Architect prior to delivery of the equipment.
2. Personnel Qualifications. Submit qualification statements of all manufacturer's representative personnel that will be servicing the equipment shall be submitted with the six revised copies of the O&M manuals.

D. **Submittal Package No. 3 – Shop Tests**

1. Test Report. A test report, in accordance with Section 01 75 16, shall be submitted within 48 hours of completion, suspension, or termination of testing the blowers under all design conditions.
2. Noise Performance and Tests. Each blower with a silencer shall be factory tested and shall produce a sound pressure level as specified in the Equipment Schedule. Exact test procedure proposed shall be submitted to the Engineer/Architect prior to testing. Test results shall be certified and submitted to the Engineer/Architect and the Engineer/Architect shall be given opportunity to witness the tests. Any blower system not passing this test will not be accepted and shall not be shipped. Individual blower system noise production data at maximum pressure and various speeds shall be submitted with the shop drawings. Such data shall be based on actual tests of similar equipment.

E. **Submittal Package No. 4 – Field Tests**

1. Manufacturer's Representative Reports. Manufacturer's representative reports, in accordance with Section 01 75 00, shall be submitted within 48 hours of each site visit. Product and material certifications and inspection data as specified in Section 01 33 00 shall be included with this report(s).

1.5 JOB CONDITIONS

A. **General.** See section 44 42 19, "Blowers, General."

1.6 DELIVERY, STORAGE, AND HANDLING

A. **General.** See section 44 42 19, "Blowers, General."

1.7 SPECIAL WARRANTY

Not used.

PART 2 - PRODUCTS

2.1 BLOWER

A. **Type**. Blower shall be rotary, positive displacement, two or three impeller type, operating without internal sealing fluid or rubbing parts. The blower system shall be a packaged mounted, factory engineered, pre-assembled unit.

B. **General.** Blower shall be in accordance with section 44 42 19, "Blowers, General."

C. **Package System Frame**. The framing system shall be ruggedly built, capable of supporting the operating machine without visually discernible vibration. The base plate shall be a minimum of 3/8-inch-thick steel. Two full-side mounting plates shall be provided. All welds shall be continuous.

D. **Casings**. The blower casings shall be of cast iron, one-piece construction. The case shall be suitably ribbed to prevent distortion under the operating conditions. End or head covers shall be removable for easy access for bearing and gear inspection. The inlet and discharge connections shall be internal national pipe thread (NPT) threads or flanges drilled and tapped to Class 125 American National Standards Institute (ANSI) B16.1 specifications. Oil baths shall be fitted with fill, drain, vent, and level gauge appurtenances. Provide pipe extensions on fill and drain connections for easy access.

E. **Impellers**. The impellers shall be cast or ASTM A 395-100-70-03 ductile iron integral with or permanently fastened to the shaft. Impellers shall be straight, two or three lobe type designed to operate without contact, liquid seals, or lubrication. The assembly shall be machined, ground, and dynamically balanced to prevent excessive vibration. Each impeller shaft shall be fitted with a ASTM A 48, Class 30B cast iron sleeve and ductile iron piston ring.

F. **Timing Gears**. The timing gears shall be manufactured of heat treated alloy steel. The timing gears shall be splash oil lubricated from internal oil reservoirs. The timing shall be field adjustable.

G. **Seals**. Seals shall be located at each bearing. The seals shall be replaceable without disturbing the blower mounting or piping. Seal design shall prevent lubricant from contaminating the air stream. Seal design shall be a double sealing arrangement and include a labyrinth type inner seal.

H. **Bearings**. The bearings shall be antifriction type and designed for a minimum Anti-friction Bearings Manufacturers Association (AFBMA) B-10 bearing life of 52,000 hours. A cylindrical roller bearing shall be provided at the drive shaft designed to handle all radial and thrust loads while single-row ball bearings shall be used at other locations. The drive end bearings shall be grease lubricated, and shall be provided with grease fittings. The gear end bearings shall be lubricated by splash from the gears dipping into the oil. A wavy washer shall be installed on the gear end of both shafts between the bearing and bearing clamps to control rotor axial movement.

I. **Shafts.** Shafts shall be constructed of forged alloy steel.

J. **Base.** The blower and drive shall be mounted on a common fabricated carbon steel base with an adjustable drive base and anchor bolts. The base shall be mounted on a level concrete pad. The base may have combination type discharge silencer and plan pipe stub connection, with connections for a pressure relief valve, pressure gauge, discharge temperature gauge, mechanical unloading valve and drain built into the silencer. Blower equipment shall be properly aligned with respect to the piping, the drive, and the base to minimize transmission of stresses and vibration.

K. **Enclosure.** An 80 dBA or less free field guaranteed noise enclosure shall be provided for the blower system. Blower package components shall be housed in a frame-mounted steel enclosure with zinc-plated or powder coated finish that is designed for sound attenuation with 1-inch minimum of acoustical foam insulation and continuous lip seals. Acoustical foam shall comply with UL 94-HF1 for flammability. The enclosure shall be suitable for outdoor installation, 20 lb per square foot snow load and 70 mph wind speed. The enclosure shall include a vent system and three removable panels for easy access and maintenance. The ventilation fan shall be mounted on blower drive shaft. Separately-wired electric enclosure fans are not acceptable. Hinges, components supports, and Type 304 stainless steel fasteners shall be provided. Enclosure shall be field painted Owner-selected color by the installing Contractor.

L. **Accessories**

1. V-Belts and Guards. Blower and drive shall be connected with multiple V-belts and sheave arrangement, complete with Occupational Safety and Health Administration (OSHA) type guard. Additional sheaves shall be supplied for each blower for a speed of 80 percent of the design capacity speed. The guard shall be of sturdy welded steel construction without sharp edges or projections. Guards for outdoor service shall provide weather protection for the belt drive.
2. Relief Valve. The blower unit shall be supplied with a weighted-type relief valve for installation in the discharge line. The relief valve shall have sufficient capacity to prevent overloading the blower and motor when operating at design capacity with the discharge valve in the blower discharge line closed. The valve shall include sufficient weights for a setting of 0.5 to 1 psi above the design differential pressure.
3. Silencers. The blower shall be equipped with an intake and a discharge silencer. The silencers shall be sized to handle 120 percent of the design capacity specified in the Equipment Schedule. The inlet filter silencer shall be carbon steel with polyester filter elements. Inlet filters shall have front access for element access. The intake silencer shall be Universal Silencer RIS, Burgess Manning, or equal. The discharge silencer shall be Universal Silencer RD, Burgess Manning, or equal. Silencer connections and support legs or hangers shall be sized to match blower and piping arrangement as shown. Provide suitable anchor bolts.
4. Filter. The blower shall be provided with a flanged dry type inlet filter sized for 120 percent of the design capacity. The sizing and design of the filter shall be suitable for fully exposed outdoor service. Filter element

shall be cleanable and replaceable. The filter shall be equipped with a filter restriction indicator suitable for up to 20 inches of water vacuum.

5. Vibration Suppression System. The vibration suppression system shall consist of an inertia base/spring isolation system providing at least 95-percent isolation efficiency. The system shall be both vertically and horizontally stable to insure proper oil level. The mountings and concrete pouring forms shall be of a corrosion resistant coating. Provide complete analysis of loads estimating maximum movement of springs in static and dynamic condition.
6. High-Temperature Shutdown Switch. The blower shall be equipped with a single set point, factory installed high temperature safety switch in a National Electrical Manufacturers Association (NEMA) 7 enclosure with contact closure output to shut the motor off in the event an unsafe blower temperature is reached. The switch shall operate on the vapor pressure principle and shall be Ashcroft P-series, or equal.

2.2 DRIVES

A. **Type.** Motor shall be squirrel cage induction type and of the size and configuration listed in the Equipment Schedule and as specified in Section 44 42 19.

B. **Connections.** Motor shall be belt drive with lead connections necessary to properly function with the type of full voltage or reduced voltage starters indicated on the one line power diagram of the electrical plans.

2.3 MANUFACTURERS

A. **Positive displacement blower** manufacturer shall be:

1. Roots EasyAir X2.
2. Kaeser Omega-Pak.
3. Ingersoll Rand/Hibon Silent Flow.
4. Aerzen Generation 5 Delta.
5. Or equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. **In accordance with Section 44 42 19**, "Blowers, General."

3.2 FIELD QUALITY CONTROL

A. **In accordance with Section 44 42 19**, "Blowers, General."

3.3 DEMONSTRATION

A. **In accordance with Section 44 42 19**, "Blowers, General."

3.4 EXTRA MATERIALS

A. **Spare Parts.** In accordance with Section 44 42 19, "Blowers, General."

1. Seals. Provide one spare set of seals.
2. Bearings. Provide one spare set of bearings.
3. Belts. Provide one spare set of belts.
4. Sheaves. Provide extra sheaves for 80-percent of the design capacity speed.
5. Filters. Provide two spare sets of filters.

PART 4 - SCHEDULE

4.1 GENERAL REQUIREMENTS

A. **Compressed Fluid** Air

B. **Inlet Conditions of Air**

1.	Temperature	100° F.
2.	Atmospheric Pressure	14.3 psi
3.	Relative Humidity	36-percent

C. **Standard Conditions of Air**

1. Summer.

a.	Temperature	68° F.
b.	Atmospheric Pressure	14.7 psi
c.	Relative Humidity	36-percent
d.	Specific Weight	0.075 pcf

2. Winter.

a.	Temperature	0° F.
b.	Atmospheric Pressure	14.7 psi
c.	Relative Humidity	36-percent
d.	Specific Weight	0.075 pcf

4.2 DESIGN REQUIREMENTS

A. **Design Speed and Pressure.** The design speed and pressure shall not exceed 95-percent of the published maximum design speed or pressure of the blower.

4.3 FILTER AIR SCOUR BLOWER

A.	**Number of Blowers**		1 required
B.	**Operating Conditions**		
	1.	Design Capacity	1,800 icfm (1,625 scfm)
	2.	Design Differential Pressure	5.2 psi
	3.	Maximum Gear Speed	4,800 fpm
	4.	Static Back Pressure	3.1 psi
	5.	Intake Losses	
		a. Filter	0.10 psi
		b. Silencer and Piping	0.10 psi
	6.	Discharge Losses	
		a. Silencer	0.10 psi
		b. Piping	0.60 psi
		c. Underdrain	1.2 psi
	7.	Maximum Noise Level at 1 Meter	72 dBA
B.	**Motor Requirements**		
	1.	RPM	1800
	2.	Horsepower	75 hp
	3.	Voltage	208 volts
	4.	Phase	3 phase
	5.	Hertz	60 Hz
	6.	Enclosure	TEFC
	7.	Test.	Routine test

END OF SECTION

SECTION 44 43 50.02

FILTER EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. **General.** Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 specification sections, apply to this section.

1.2 DESCRIPTION OF WORK

A. **Scope of Work**. The Contractor shall provide all labor, material, tools, and equipment required to remove the existing filter underdrains, media and support gravel, and furnish and install new filter equipment and materials, complete and as shown on the drawings and as specified herein.

1. Work specified herein includes renovating 12, dual-bay filters. Each filter bay (total of 24) is 10'-0" by 28'-0".
2. The filter equipment shall consist of underdrains, media, and all fasteners, supports, and appurtenances necessary for a complete filtration system with air scour backwash capability. The filter equipment supplied shall be provided by one manufacturer.
3. The Contractor shall interconnect the new filter equipment (air scour valves and blower) with existing control and filter system equipment where indicated and required to make a fully functional system.

1.3 QUALITY ASSURANCE

A. **Codes and Standards**

1. Codes. Perform all work to furnish and install the filter equipment in compliance with applicable requirements of governing agencies.

2. Standards.

a. NEMA - National Electrical Manufacturers Association.

b. ANSI - American National Standards Institute.

c. NIOSH - National Institute for Occupational Safety and Health.

d. AWWA - American Water Works Association.

1) B100 - "Filtering Material."
2) C653 - "Disinfection of Water Treatment Plants."

B. **Quality**. All equipment and materials shall be installed in accordance with manufacturer's instructions and recommendations. Fabrication and installation shall be in accordance with the approved shop drawings.

C. **Guarantee**

1. Equipment Warranty. The filter equipment manufacturer shall warrant that all equipment furnished by it shall be free of defects in the material and workmanship for a period of 1 year from date of acceptance of equipment by the Owner. In addition to the 1 year equipment warranty, the manufacturer shall warrant the underdrain system to be free from all defects, media leaks, and excessive headloss for a period of 5 years from time of acceptance. Failure has occurred if more than 5-percent of media in any 3 square feet is lost in a 12-month period due to leakage downward through the underdrain system or if more than 5-percent of media in any area is lost in a 12-month period because of defects in materials or workmanship in the underdrain system resulting in excessive or nonuniform backwash rate or if the headloss through the under drain is more than 150-percent of the design headloss. Should any failure occur, the manufacturer shall at no cost to the Owner, repair or replace the defective portion, replace the media, and return the unit to operation.
2. The warranty shall be in writing by an officer of the manufacturing company and guarantee prompt repair or replacement at no cost to the Owner of any components which fail to function properly due to deficiencies in product design, workmanship, materials or installation. If the equipment becomes inoperable because of repairs covered under the warranty, then the warranty shall automatically be extended for the period of time during which it was inoperable. This warranty is in addition to any other warranties required. This warranty shall be submitted prior to shop drawing submittal.
3. Operating Experience. The filter equipment manufacturer shall submit United States references on the proposed equipment including Owner's complete name, address, phone number, key employees, and other necessary information so that the Engineer may contact the Owner of such existing equipment to discuss or to observe operation of said equipment. The reference list shall include at least ten operating locations in the United States that have been in service at least 5 years. This location shall be equipped with similar filtration equipment and underdrain as is proposed.

D. **Media Suppliers Qualifications**

1. Filter media shall be the products of a supplier regularly engaging in supplying this type of material.
2. Supplier shall have a minimum of 10 years experience in producing material specified.

E. **Testing Laboratory**

1. Retain services of an independent testing laboratory, acceptable to the Owner and Engineer, to perform the specified tests and to certify the filter media complies with the requirements set forth herein, and that all testing work has been in accordance with the methods specified.

F. **In-Place Filter Media Sampling and Testing**

1. Prepare composite samples from a minimum of four filters after they have been backwashed and drained, as specified in AWWA B100. Composite samples of each type of filter media (anthracite and silica sand) taken from each sample shall be prepared by combining equal portions of that particular media taken from a minimum of five cores distributed over each filter surface. All costs in connection with sampling and testing of the filter media materials shall be at the Contractor's expense.

G. **Rejection of Filter Media**

1. Failure to meet the specified requirements, as demonstrated by the certified test reports of the testing laboratory, shall constitute cause for rejection.
2. Filter media that has been tested after delivery to the site and installation, and subsequently rejected, shall be removed from the site and replace with acceptable material, at no cost to the Owner. As an alternative, the rejected material may be reprocessed and retested, again at no additional cost to the Owner.
3. All costs related to testing, reprocessing, and replacement of rejected material shall be at the expense of the Contractor.

1.4 **SUBMITTALS**

A. **Approval Drawings**. Shop drawings shall be submitted in accordance with Section 01 33 00 to the Engineer for approval. Shop drawings shall include:

1. Manufacturer's name, model numbers, and product data.
2. Equipment specifications.
3. Materials of construction.
4. Repair parts.
5. Dimensional layouts and required clearances.
6. Weights.
7. Anchor bolts.
8. Bill of material.
9. Complete description in sufficient detail to permit an item-by-item comparison with the specifications.
10. Performance characteristics.
11. Media gradation analysis.
12. Installation instructions.
13. Warranty.

B. **Operation and Maintenance (O&M) Manuals**. O&M manuals shall be submitted to the Engineer in accordance with Section 01 33 00 of these specifications prior to delivery of the equipment. The initial review copy of the O&M manual and six revised copies shall be submitted prior to delivery of the equipment. The O&M Manual shall include:

1. Storage instructions.
2. Installation instructions and details.
3. Start-up instructions.
4. Shut-down instructions.
5. Operation, maintenance, repair and cleaning instructions.
6. Detailed parts list for all equipment items including part numbers.
7. Recommended spare parts and maintenance materials list.

C. **Material Certification of Filter Media**

1. A laboratory sieve analysis of each proposed filter component including the effective size and uniformity coefficient shall be submitted to the Engineer for approval prior to shipment to the site.

2. Submit an Affidavit of Compliance stating that the filter material proposed to be furnished will comply with all applicable provisions of AWWA B100.

D. **Operator Training Information**. Operator training data, in accordance with Section 01 79 00, and operator training lesson plans, in accordance with Section 01 33 00, shall be submitted with the six revised copies of the O&M manuals.

E. **Personnel Qualifications**. Qualifications statements, in accordance with Section 01 33 00, of all manufacturer's representative personnel that will be servicing the equipment or conducting the operator training sessions shall be submitted with the six revised copies of the O&M manuals.

F. **Field Testing Reports**

1. Manufacturer's Representative Reports. Manufacturer's representative reports, in accordance with Section 01 75 00, shall include adjusting, dry testing, and wet testing of the equipment in accordance with Section 01 75 16 and the requirements of this specification section. Product and material certifications and inspection data as specified in Section 01 33 00 shall be included with this report(s).
2. Dry Test Report. Dry test report shall be in accordance with Section 01 75 16 and the requirements of this specification section.
3. Wet Test Report. Wet test report shall be in accordance with Section 01 75 16 and the requirements of this specification section.

G. **Documentation**. Complete system documentation shall be submitted following acceptance of the work.

1.5 JOB CONDITIONS

A. **Coordination with Other Work.** The Contractor shall coordinate the scheduling of the work and the location of equipment, piping, and conduit to prevent interferences and delays. Piping upstream and downstream of the filters shall be disinfected prior to disinfection of the filters.

1.6 DELIVERY, STORAGE, AND HANDLING

A. **General.** The delivery, storage, and handling of the filter equipment shall be in accordance with Section 01 60 00 and the manufacturer's instructions.

B. **Delivery**

1. All equipment shall be delivered in an undamaged condition.

2. Media. Shipment shall be made in bags or semibulk containers.

   a. Bags. Shipment may be made in suitable heavy-duty cloth, paper, or plastic bags containing not more than one cubic foot of material. Each bag shall be marked in an appropriate manner so that its contents are identified. The following information shall be included in the marking: gradation, date of filling, and lot or stockpile identification.

   b. Semibulk Containers. Shipment may be made in suitable heavy-duty, woven semibulk containers, each containing one or more tons of material. Semibulk containers shall have attached straps or sleeves strong enough to support their entire weight when full, to aid in handling. Each semibulk container shall be marked so that its contents are identified, including gradation, date of filling, and lot or stockpile identification.

C. **Storage**

1. Contractor shall make all arrangements and provisions necessary for the storage of the filter equipment in accordance with the manufacturer's instructions.
2. Storage and Handling of Materials. Filter materials shall be kept clean. Materials shipped in bags or semibulk containers shall be covered with a durable opaque material to block sunlight and to provide protection from weather. Bags and semibulk containers shall be stored on pallets or dunnage. Each size and type of filter material shall be stored separately. When materials are shipped in bags or semibulk containers, under no circumstances shall material be removed from the bags or the semibulk containers prior to placement in the filter, except for sampling.

D. **Handling**

1. Provide the equipment and personnel necessary to handle the filter equipment by methods to prevent damage to the delivered equipment and other stored materials or adjacent structures or equipment.

2. The filter equipment shall be at all times handled in a safe manner and as recommended by the manufacturer.

1.7 **SPECIAL WARRANTY**

A. **Provide special warranty** as described in Paragraph 1.3 C

PART 2 - PRODUCTS

2.1 **UNDERDRAINS**

A. **Plastic Block System.**

1. This filter underdrain system shall consist of a series of parallel lateral plastic tile blocks that completely cover the entire floor area. The blocks shall be arranged end-to-end and mechanically joined with an O-ring. All surfaces of each block shall be smooth, and all orifices shall be totally open and free of burrs. Underdrains shall include integral grout strip to prevent grout from dropping into filter effluent trough.
2. The underdrain system for the filters shall be a dual parallel lateral type whereby feeder and compensating chambers are provided within the cross section of a single block. The cross section of the underdrain shall be so arranged that the feeder chamber is adjacent and connected to the compensating chambers through a series of orifices. The orifices shall be located at four different elevations and sized to provide uniform distribution of air and water. All internal orifices shall be integrally molded to provide a smooth bore orifice. The feeder chamber should provide at least 50 square inches of cross sectional area per block to reduce flow velocity during backwash.
3. The compensating chambers shall provide uniform pressure and flow distribution from the top of the blocks. The discharge flow from the top of the blocks into the filter bed shall be provided by approximately twenty-three dispersion orifices per square foot of filter area. The orifices shall be not less than 7/32 inch diameter and shall be recessed from the surface by approximately 1/8 inch. The top of each orifice shall be encircled by a depression approximately 3/8 inch x 3/4 inch, which shall act to prevent the media from resting directly on or blocking the dispersion orifice.
4. The underdrain shall have a horizontal flat top discharge surface, so that the finished filter bottom is nominally flat. A water recovery channel with return holes shall be incorporated into the top of the underdrain block to ensure uniform and continuous air flow from the top deck orifices and greater air stability. The secondary chambers of the underdrain shall have baffles sized and located to provide effective air control and to reduce level sensitivity.
5. Each filter underdrain block shall be provided with an integral media support cap that shall be factory installed prior to shipment. The cap shall be composed of sintered plastic beads that have been molded to match the surface of the plastic block.

B. **Stainless Steel Lateral System**

1. This filter underdrain system shall consist of a series of laterals fabricated from Type 304L stainless steel. Laterals shall be complete with variable-sized water orifices, air scour slots, air release vents, and orifice shields. The flutes shall be designed to prevent two phase wave action generation during air scour, and shall compensate for velocity and momentum changes during backwash. Each lateral shall bolt directly to a Type 304L stainless steel manifold secured to the 28-ft wall of each filter bay.
2. Each filter bay shall be provided with one Type 304L stainless steel air and water manifold. The manifold shall be bolted to the 28-ft wall and floor of the filter bay. Each manifold shall have an independent compartment for air distribution to each lateral. The manifold shall be supplied in a maximum of three sections, and bolted together in the field. Air shall be supplied to each manifold section with a single 4-in air connection for air scour. Internal baffling shall be provided to prevent short circuiting or non-uniform distribution of air and water.
3. Each filter bay shall be provided with one air manifold fabricated from Type 304L stainless steel. The manifold shall have an end flange and be capped at the opposite end. Provide three 4-in drop pipes connections to the air and water manifold, and three corresponding Type 304L stainless steel support brackets.
4. Provide all necessary Type 304 stainless steel hold-down clamps for proper installation of the system. All gaskets, adhesive set bolts, leveling shims, and sealants required for a complete stainless steel underdrain system shall be provided for the 24 filter bays to be renovated.

2.2 FILTER MEDIA

A. **Reference**. Conform to AWWA B100. Acid solubility tests are required. The Contractor shall provide an affidavit with the samples stating that the materials furnished comply with the applicable requirements of AWWA B100.

B. **Description.** The filter media shall be placed over the underdrain system in uniform, level layers of the depth and gradation as stated herein and as shown on the Drawings.

1. Silica Sand. The 12-inch layer of filter sand shall consist of hard, durable silica grains, washed clean and free of clay, loam, silt, dust, or other foreign matter. The sand shall be insoluble in hydrochloric acid. The sand shall have an effective size of 0.45 mm to 0.55 mm, a uniformity coefficient of not more than 1.40, a specific gravity greater than 2.5, and an acid solubility less than or equal to 5-percent.

   After all filter sand is placed, and before any anthracite is placed, the filter bay shall be washed and scraped and placed at the finished elevation for this media layer.

2. Anthracite. Filter anthracite shall be provided to a finished depth of 18 inches, with at least 1 additional inch to be provided and scraped off after washing. Filter anthracite shall consist of hard, durable coal particles of various sizes and shall be visually free of clay, shale, and extraneous dirt.

   a. Acid Solubility. $\leq$ 5 percent.
   b. Hardness. $\geq$ 3.0 on the Moh scale.
   c. Specific Gravity. > 1.60.
   d. Effective Size. $\geq$ 0.95 to < 1.05 mm.
   e. Uniformity Coefficient. < 1.40.

2.3 FASTENERS

A. **All threaded fasteners shall be** corrosion-resistant Type 316 stainless steel of adequate composition and section for the service intended.

2.4 SUPPORTS

A. **All supports shall be** of corrosion-resistant Type 316 stainless steel construction designed by the manufacturer for the service intended.

2.5 FILTER CONTROLS

A. **The Owner will be responsible** for programming the filter PLCs and OITs and coordinating the communication between the existing individual filter control system, the new air scour components (valves and blower), and the existing main OIT.

2.6 AIR HEADER PIPE

A. **The filter manufacturer** shall size, design, and provide the air distribution header for this underdrain. Pipe provided shall be Schedule 5, Type 304 stainless steel.

2.7 MANUFACTURERS

A. **General.** All components of the filter equipment shall be supplied by one manufacturer.

B. **The manufacturer** of the plastic block underdrain system shall be F.B. Leopold, General Filter Company, or Roberts Filter Manufacturing Company.

C. **The manufacturer** of the stainless steel lateral underdrain system shall be AWI Anthratech U.S.

PART 3 - EXECUTION

3.1 EXAMINATION

A. **Site Verification of Conditions.** Verify that surfaces are ready to receive work and the following conditions:

1. Concrete tanks and channels have the correct dimensions.

B. **Responsibility**. Beginning the installation means the installer accepts that the surfaces are acceptable for installation.

3.2 PREPARATION

A. **Protection.** Protect adjacent surfaces against damage during installation. Protect all openings in underdrains during installation. Damaged units shall be removed and fully replaced. Protect filter and associated piping and appurtenances from all debris during all stages of installation.

B. **Manufacturer's Instructions.** Preparatory work in accordance with manufacturer's instructions shall be completed prior to equipment installation.

3.3 INSTALLATION

A. **Method**. Install equipment in accordance with approved shop drawings and manufacturer's installation instructions, and as shown on the drawings and specified herein.

B. **Installation of Parallel Lateral Underdrains**

1. The underdrain system shall be placed, secured, and grouted in accordance with the manufacturer's recommendations. The underdrains must be approved by the Engineer prior to delivery to the project site.
2. In preparation for installing the underdrain blocks in each filter, the floor slab shall be screened or otherwise prepared so that it is level and entirely free of protrusions and depressions. Then ends of each row of blocks shall be closed by means of plates furnished for this purpose by the supplier of the blocks. End plates shall be positioned to allow a minimum of 3/4-inch of Class D concrete grout between end of underdrain and concrete wall. Provide Class D grout per mix design in Section 03 30 00.
3. The filter blocks shall be set level over the entire filter area in a 3/4-inch bed of Class D concrete grout. If grout is non-proprietary, it may be supplied by either the underdrain manufacturer or the Contractor. All blocks shall be set to ensure proper alignment and to provide tight joints. After all blocks have been set and carefully aligned, all space between the rows and ends of blocks and walls up to the top surface of the blocks shall be filled with grout. Grout installation and curing shall be done in accordance with Section 03 30 00.
4. The underdrain manufacturer shall supply sufficient installation supervision to be able to certify and warrant the equipment as being correctly installed. In no case shall such supervision be less than direct supervision of installation in the first filter cell and inspection of all filter cells prior to media placement
5. Refer to paragraph 3.6 B, "Field Tests," for testing required prior to media placement.

C. **Placing Filter Materials**

1. Preparation.

   a. Cleaning. Each filter cell shall be cleaned thoroughly before any filter materials are placed. Each cell shall be kept clean throughout placement operations.
   b. Protection. If media is not installed immediately after testing underdrains, plastic sheeting shall be placed over underdrains to protect orifices and to eliminate need for additional cleaning.
   c. Marking Each Layer. Before any filter media materials are placed, the top elevation of each layer shall be marked by a level line on the inside of the filter.
   d. Verify that all underdrain orifices are free of obstructions, grout, and debris.

2. Placement.

   a. Caution in Installing Material. The sand media shall be placed carefully to avoid damage to the filter underdrain system. Workers shall not stand or walk directly on the underdrain or filter material. They shall walk on boards or plywood that will sustain their weight without displacing the material.
   b. Placement of Layers. Each layer shall be completed before the layer above is started. Each layer of filter material shall be deposited in a uniform thickness, with the top surface screeded and brought to a true level plane. Care shall be exercised in placing each layer to avoid disturbing the surface of the layer beneath.

3. Washing.

   a. Initial Wash. After all filter materials have been placed, wash water shall be admitted slowly upward through the underdrain system until the entire bed is flooded. The bed shall be allowed to stand for as long a period as the Engineer deems necessary to saturate the media before initial wash, provided that this period shall not be less than 12 hours. The wash rate shall be increased gradually during the initial wash to remove air from the bed.
   b. Backwash. The required number of times determined by the Engineer, a minimum of three, to remove all fine particles by scraping. During each backwash, the water shall be applied at an initial rate of not more than 2 gallons per minute per square foot (gpm/ft^2) of filter area. The backwash rate shall then be increased gradually over a period of 3 minutes to 20 gpm/ft^2, and maintained at the maximum rate for not less than 5 minutes.

4. Scraping.

a. After the initial wash, the filter shall be partially drained and a layer of fine material approximately 3/16 inch thick shall be removed from the surface of the filter by scraping.

5. Disinfection.

a. After all work related to placement of media has been completed, and before the filter is placed in service, the entire filter shall be disinfected by chlorination in accordance with AWWA C653, and as specified herein.

D. **Interface with Other Items**

1. Complete all electrical power and control connections under Division 26, "Electrical."
2. Complete all piping connections under Division 13, "Special Construction."

3.4 **CLEANING, DISINFECTION, AND DISPOSAL**

A. **Cleaning**. Cleaning shall be in accordance with Section 01 74 23. Remove any tape from the top of the underdrain that may have been placed to prevent grout from entering the underdrain.

B. **Disinfection**. After all other work is completed, and before the filter is placed into service, the entire filter basin, up to the maximum water level, shall be disinfected by chlorination in conformance with AWWA C653-03.

C. **Water for Testing and Disinfection**. The Contractor shall supply all water for testing and disinfection and may obtain same from the treatment plant water system. The Owner accepts no liability for the rate of availability of water or any interruption in flow. The Contractor shall be responsible for providing hose or piping to convey the water from existing hydrants to the tanks, for pumping equipment and power to transfer water between tanks, and for dewatering tanks.

D. **Disposal.** The Contractor is responsible for the removal from the job site, and if necessary, safe disposal of all excess material and debris as a result of the work completed under this section, including testing procedures. Disposal shall be in accordance with Section 01 74 23. Disposal of heavily chlorinated water shall be in accordance with AWWA C653-03, Appendix A.

3.5 **MANUFACTURER'S SERVICES**. The manufacturer shall provide a qualified representative for one 8-hour day to instruct the Contractor on the installation of the controls and equipment. After construction, the representative shall carefully check and ensure that all equipment components were installed correctly. The representative shall be present during field testing. After start-up, the manufacturer shall provide a minimum of one 8 hour day of training on the operation, maintenance, and control of the Filter System. The representative shall submit the necessary reports as required under Section 1.4 of these specifications.

3.6 FIELD QUALITY CONTROL

A. **Inspection.** It is the Contractor's responsibility to notify and coordinate with the equipment manufacturer in a timely manner in order for them to provide supervision of the underdrain system, instruct Contractor on the installation of the controls and equipment, and conduct their required inspection, testing, and instruction as required by this specification section.

B. **Field Tests**. The testing procedures shall be defined by the Contractor and agreed upon by the Engineer. The Engineer shall be notified and afforded the opportunity to witness the testing procedures. All testing materials and equipment required shall be furnished at no additional cost to the Owner. Tests shall be in accordance with Section 01 75 16 unless specified otherwise.

1. Dry Test. Dry testing shall include:

   a. Underdrains. Underdrains shall be inspected for proper alignment, tight joints, no blockage of orifices, and underdrain blocks that fit tight and secure in finished filter bottom. The finished filter bottoms shall receive a level test to ensure conformance with manufacturer's requirements.
   b. Media. Each filter material layer shall receive a level test before proceeding with placement of the next layer.

2. Wet Testing. Wet testing shall include:

   a. Underdrains. Three days or more after grouting has been completed, and before media has been placed, the underdrains shall be tested with water. Ensure the piping system including washwater line is free of air. Slowly fill the filter from the bottom at approximately 2 gpm/sf. Verify no water jets appear in the grout joints. When water level reaches 6 inches above the underdrain, discontinue backwash and drain until the water falls below the underdrain surface. Start a slow backwash at 5 gpm/sf and verify even distribution of water jets. If distribution pattern is even, slowly raise the backwash rate to 20 gpm/sf in 5 gpm/sf increments. Check for unusual flow disturbances. Measure and record rate or rise for each flow rate. Drain water to below underdrains and visually inspect bottom. Refill filter bays to be tested so that water depth is approximately 3-ft over filter underdrains. Initiate aeration blower to demonstrate that air distribution between the bays and throughout the bay area itself, is uniform. If satisfactory, proceed with media installation.
   b. Flow Testing. Each filter shall be tested over the full operating range for filter rate, wash-water rate, and surface wash rate to demonstrate compliance with the operating conditions specified in the Equipment Schedule.

3.7 ADJUSTING

A. **Test Results**. If the results of the field tests do not show successful operation of the filter equipment, the Contractor shall repair, adjust, modify, or replace the

equipment in accordance with the manufacturer's instructions until the equipment and systems are operating as required and the tests are successfully completed. This shall be done at no additional cost to the Owner.

3.8 PROTECTION

A. **Requirements**. The Contractor shall be responsible for provision to protect the filter equipment and associated equipment after installation but prior to acceptance by Owner. The Contractor shall remove all protective means installed at completion at acceptance of the project.

PART 4 - SCHEDULE

4.1 EQUIPMENT SCHEDULE

Number of filters	12, with two bays each filter
Size, each filter bay	10'-0" x 28'-0"
Type	Gravity
Underdrains	Plastic parallel lateral block or stainless steel lateral
Filter capacity	4.0 mgd/filter at 5.0 gpm/sf
Wash water rate	20 gpm/sf
Backwash air rate	4 cfm/sf

END OF SECTION