

CLAYTON COUNTY WATER AUTHORITY
MORROW, GA



PROJECT MANUAL

FOR

BID NUMBER: 2023-WP-03

**TERRY R. HICKS WATER PRODUCTION PLANT (HICKS WPP)
BLOWER UPGRADE**

DECEMBER 2022

ISSUED FOR BID

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

ESI
ENGINEERING STRATEGIES, INC.



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STRUCTURE DEMOLITION

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	Submittals
3.1	Demolition
3.2	Disposal

B. Scope

1. The work covered by this section includes furnishing all material and equipment and performing all labor necessary for demolishing and disposing of all materials from existing structures, piping and other designated facilities indicated on the drawings. Work includes all excavation and backfilling required for removing existing facilities.

1.2 SUBMITTALS

- A. Submit a written request, to include a detailed demolition procedure, to the Owner for approval at least 10 days before demolition is started. Include the following in the demolition procedures:

1. A detailed description of the methods and equipment to be used for each operation.
2. The sequence of work.
3. A detailed plan for the safe conduct of work, protection of the property and new work, which is to remain undisturbed and coordination with other work or operation which may be in progress.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.1 DEMOLITION

- A. Do not commence demolition of the existing facility until suitable temporary facilities are operational and approval is granted by the Owner and Engineer.
- B. Be responsible for any damage caused to other structures, and for any and all repairs, replacement of parts or renovations required to restore any structure, portion of structure, equipment or items, not intended for demolition. Restore any damaged facilities to their condition prior to demolition provided the damage was a result of the demolition. If the Contractor does not repair any such damage immediately, or if the repairs are not suitable to the Owner, the Owner reserves the right to have such repairs made by another party and deduct the cost of required repairs from money due Contractor.
- C. In addition to these specifications, utilize the demolition details and requirements noted and detailed on the drawings.
- D. Erect dust-tight, weather-tight partitions to protect existing facilities from dust and weather while wrecking is in progress and until such time as closures have been made. Provide partitions constructed of wood with a covering of tarred roofing felt on the weather side.

- E. All items identified to be salvaged shall remain the property of the Owner, unless otherwise noted. Clean and transport such items to the Owner's maintenance facility or other location designated by the Owner.

3.2 DISPOSAL

- A. Take possession/ownership of all materials designated to be demolished and removed, unless noted otherwise.
- B. Remove all demolished structures, piping and materials from the work site and dispose of such in a legal manner.
- C. All demolished structures, equipment and materials, which are either left in place or removed to the disposal site, shall be in a non-hazardous condition.

END OF SECTION

SECTION 02 42 11

REMOVAL OF CONSTRUCTION MATERIAL

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	Submittals
3.2	Workmanship

B. Scope

1. The work covered by this section includes furnishing all labor, materials, and equipment necessary for the removal of all unwanted construction materials and debris from the job site, as directed by the Owner.

1.2 SUBMITTALS

A. Provide submittals in accordance with the requirements of Section 01 33 23.

B. Action Submittals/Informational Submittals

1. Letter from landfill or other property owner where materials will be legally disposed stating acceptance of materials.
2. Identification and license of company hauling/transporting materials from the site.
3. Photographs or videotape, sufficiently detailed, of existing conditions of project site that might be misconstrued as damage, caused by debris, or construction material removal.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.1 WORKMANSHIP

- A. Follow all federal, state, and local regulation related to removal, hauling, and disposal of trash and debris.
- B. Comply with County Ordinance for hauling and disposal of all solid waste removed from the site for the duration of the Work.
- C. Load, haul away, and dispose of debris, trash, structures, automobiles, etc. that may be pre-existing on the worksite.
- D. Remove and dispose of all unused construction materials prior to final acceptance of the Work by the Owner and Engineer.

END OF SECTION

SECTION 03 11 00
CONCRETE FORMING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	References
1.3	System Description
1.4	Submittals
2.1	General
2.2	Form Materials
3.1	General
3.2	Form Tolerances
3.3	Form Preparation
3.4	Form Removal
3.5	Inspection

B. Scope

1. Furnish all labor, materials, equipment and incidentals required and design, install and remove formwork for cast-in-place concrete as shown on the Drawings and as specified herein.
2. Secure to forms as required or set for embedment as required, all miscellaneous metal items, sleeves, reglets, anchor bolts, inserts and other items furnished under other Sections and required to be cast into concrete, or approved in advance by the Engineer.

C. Related Requirements

1. Section 03 15 00 – Concrete Joint and Joint Accessories
2. Section 03 21 00 – Reinforcing Steel
3. Section 03 30 00 – Cast-in-Place Concrete
4. Section 03 60 00 – Grouting

1.2 REFERENCES

A. American Concrete Institute (ACI)

1. ACI 301 - Standard Specification for Structural Concrete
2. ACI 318 - Building Code Requirements for Reinforced Concrete
3. ACI 347 - Formwork for Concrete

B. American Plywood Association (APA)

1. Material grades and designations as specified

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

1.3 SYSTEM DESCRIPTION

- A. General: Architectural Concrete is wall, slab, beam or column concrete which will have surfaces exposed to view in the finished work. It includes similar exposed surfaces in water containment structures from the top of walls to 2-ft below the normal water surface in open tanks and basins.
- B. Design and erect formwork in accordance with the requirements of ACI 301 and ACI 318 and as recommended in ACI 347 and comply with all applicable regulations and codes. The design shall be done by a professional engineer licensed in the State of Georgia. Consider any special requirements due to the use of plasticized and/or retarded set concrete in the design.

1.4 SUBMITTALS

A. Action Submittals/Informational Submittals

- 1. Product Data
 - a. Form release agent
 - b. Form ties
- 2. Shop Drawings
 - a. Layout of panel joints and tie hole pattern.
 - b. Double Wall Construction: Show details of double wall forming and pre-molded joint filler attachment.
 - c. Form Ties-Tapered Through-Bolts: Proposed method of sealing form tie hole.
- 3. Samples
 - a. Form ties
 - b. Demonstrate to the Engineer on a designated area of the concrete substructure exterior surface that the form release agent will not adversely affect concrete surfaces to be painted, coated or otherwise finished and will not affect the forming materials.
- 4. Certificates
 - a. Statement of qualifications for formwork designer, who is a licensed engineer in the State of Georgia.
 - b. Manufacturer's Certificate of Proper Installation in accordance with Division 01.

PART 2 PRODUCTS

2.1 GENERAL

- A. The usage of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configurations desired. Such reference is not intended to indicate a restrictive preference on the part of the Owner for that particular manufacturer or product, or to prohibit the use of equivalent products or equally qualified manufacturers.

2.2 FORM MATERIALS

A. General

- 1. Use forms constructed of wood, metal, or other approved material.
- 2. Construct wood forms of sound lumber or plywood of suitable dimensions and free from knotholes and loose knots.

3. Where used for exposed surfaces, dress and match boards. Sand plywood smooth and fit adjacent panels with tight joints.
4. Metal forms may be used when approved by the Engineer. Use an appropriate type for the class of work involved.
5. Design and construct all forms to provide a flat, uniform concrete surface requiring minimal finishing or repairs.

B. Wall Forms

1. Use "Plyform" exterior grade plywood panels manufactured in compliance with the APA and bearing the trademark of that group, or equal acceptable to the Engineer for all exposed exterior and interior concrete walls.
2. Provide B grade or better veneer on all faces to be placed against concrete during forming. Use a class of material and grades of interior plies of sufficient strength and stiffness to provide a flat, uniform concrete surface requiring minimal finishing and grinding.
3. Tape, gasket, plug, and/or caulk all joints or gaps in forms with an approved material so that the joint will remain watertight and will withstand placing pressures without bulging.
4. Circular Structures
 - a. Use forms conforming to the circular shape of the structure.
 - b. Straight panels may be substituted for circular forms provided panels do not exceed two (2) feet in horizontal width and angular deflection is no greater than 3-1/2 degrees per joint.

C. Column Forms

1. Rectangular Columns: As specified for walls.
2. Circular Columns: Fabricated steel or fiber reinforced plastic with bolted together sections or spirally wound laminated fiber form internally treated with release agent for height of column.

D. Rustication Strips

1. Provide at the locations shown and conforming to the details on the Drawings.
2. Use milled and planed smooth moldings for chamfers and rustications.
3. Provide rustications and corner strips that are of a nonabsorbent material, compatible with the form surface and fully sealed on all sides to prohibit the loss of paste or water between the two surfaces.

E. Form Release Agent

1. Coat all forming surfaces in contact with concrete using an effective, non-staining, non-residual, water based, bond-breaking form coating unless otherwise noted.
2. Use form release agents suitable for use in contact with potable water in potable water containment structures. Use a form release agent that is non-toxic and free of taste or odor.
3. Manufacturers and Products:
 - a. BASF, Shakopee, MN; MBT, Rheofinish 211.
 - b. Cresset Chemical Company; Crete-Lease 20-VOC.
 - c. Unitex Chemicals; Farm Fresh.

- d. Atlas Construction Supply, Inc.; Bio-Guard.
 - e. Engineer approved equal.
- F. Form Ties
- 1. Material: Steel.
 - 2. Spreader Inserts:
 - a. Conical or spherical type with minimum ½-inch diameter.
 - b. Design to maintain positive contact with forming material.
 - c. Furnish units that will leave no metal closer than 1-½ inches to the concrete surface when forms, inserts, and tie ends are removed
 - 3. Wire ties are not permitted.
 - 4. Flat bar ties for panel forms; furnish plastic or rubber inserts having a minimum depth of 1-½ inches and sufficient dimensions to permit proper patching of the tie hole.
 - 5. Water Stop Ties: For liquid containment structures, basements, pipe galleries, and accessible spaces below finish grade, furnish one of the following:
 - a. Integral steel water stop 0.103-inch thick and 0.625-inch in diameter tightly and continuously welded to tie.
 - b. Neoprene water stop 3/16-inch thick and 15/16-inch diameter whose center hole is one half the diameter of tie, or molded plastic water stop of comparable size.
 - c. Orient water stop perpendicular to tie and symmetrical about center of tie.
 - d. Design ties to prevent rotation or disturbance of center portion of tie during removal of ends and to prevent water leaking along tie.
 - 6. Through-Bolts: Tapered minimum 1-inch diameter at smallest end or through-bolts that utilize a removable tapered sleeve of the same minimum size may be used at the Contractor's option. Obtain Engineer's acceptance of system and spacing of ties prior to ordering or purchase of forming.
 - 7. Elastic Vinyl Plug:
 - a. Design and size of plug to allow insertion with tool to enable plug to elongate and return to original length and diameter upon removal forming watertight seal.
 - b. Manufacturer and Product: Dayton/Richmond Co., Miamisburg, OH; A58 Sure Plug, or Engineer approved equal.

PART 3 EXECUTION

3.1 GENERAL

- A. Use forms for all cast-in-place concrete including sides of footings. Construct and place forms so that the resulting concrete will be of the shape, lines, dimensions and appearance indicated on the Drawings.
- B. Provide removable panels at the bottom of wall forms for cleaning, inspection and joint surface preparation. Provide closable intermediate inspection ports on forms for walls of considerable height (15 feet or greater). Use tremies and hoppers for placing concrete to allow concrete inspection, prevent segregation and prevent the accumulation of hardened concrete on the forms above the fresh concrete.
- C. Place molding, bevels, or other types of chamfer strips to produce blockouts, rustications, or chamfers as shown on the Drawings or as specified herein. Provide chamfer at horizontal and vertical projecting corners to produce a ¾-inch chamfer. Place rectangular

or trapezoidal moldings in locations requiring sealants where specified or shown on the Drawings. Conform to the sealants manufacturer's recommendations for the sizes of moldings.

- D. Provide forms sufficiently rigid to withstand construction loads and vibration and to prevent displacement or sagging between supports. Construct forms so that the concrete will not be damaged by their removal. The Contractor shall be entirely responsible for the adequacy of the forming system.
- E. Before form material is re-used, thoroughly clean all surfaces to be in contact with concrete, repair all damaged places, remove all projecting nails and smooth all protrusions. Reuse of wooden forms for other than rough finish will be permitted only if a "like new" condition of the form is maintained. Receive approval of the Engineer prior to reuse of wooden form materials.

3.2 FORM TOLERANCES

- A. Provide forms which are surfaced, designed and constructed in accordance with the recommendations of ACI 347 and meet the following additional requirements for the specified finishes.
 - 1. Formed Surface Exposed to View: Edges of all form panels in contact with concrete shall be flush within 1/16-inch and forms for plane surfaces shall be such that the concrete will be plane within 3/16-inch in 4-ft. Forms shall be tight to prevent the passage of mortar, water and grout. The maximum deviation of the finish wall surface at any point shall not exceed 1/4-in from the intended surface as shown on the Drawings. Form panels shall be arranged symmetrically and in an orderly manner to minimize the number of seams.
 - 2. Formed surfaces not exposed to view or buried shall meet requirements of Class "C" Surface in ACI 347.
 - 3. Formed rough surfaces including mass concrete, pipe encasement, electrical duct encasement and other similar installations shall have no minimum requirements for surface smoothness and surface deflections. The overall dimensions of the concrete shall be plus or minus 1-inch.

3.3 FORM PREPARATION

- A. Coat wood forms in contact with the concrete with an effective release agent prior to form installation.
- B. For steel forms, thoroughly clean and remove mill scale and other ferrous deposits from the contact surface for all forms, except those utilized for surfaces receiving a rough finish. Coat the contact surfaces of all forms with a release agent.

3.4 FORM REMOVAL

- A. Conform to the requirements specified in Section 03 30 00 and apply a curing compound as directed in Section 03 30 00.
- B. Repair all damage resulting from removal of forms.
- C. Forms and shoring for structural slabs or beams shall remain in place in accordance with ACI 301, ACI 318/318R, and ACI 347.
- D. Clean, fill and seal form tie hole with non-shrink cement grout. The Contractor shall be responsible for watertightness of the form ties and any repairs needed.

3.5 INSPECTION

- A. Notify the Inspector or Engineer when the forms are complete and ready for inspection at least 6 hours prior to the proposed concrete placement. Do not place concrete until Engineer's release to proceed with concreting has been obtained.
- B. Failure of the forms to comply with the requirements specified herein, or to produce concrete complying with requirements of this Section, shall be grounds for rejection of that portion of the concrete work. Repair or replace rejected work as directed by the Engineer at no additional cost to the Owner. Such repair or replacement shall be subject to the requirements of this Section and approval of the Engineer.

END OF SECTION

SECTION 03 15 00

CONCRETE JOINT AND JOINT ACCESSORIES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	References
1.3	Submittals
1.4	Delivery, Storage, and Handling
2.1	General
2.2	Materials
3.1	Surface Preparation
3.2	Installation

B. Scope

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

1.2 REFERENCES

A. Reference Standards

1. ASTM International (ASTM):
 - a. A36/A36M – Specification for Carbon Structural Steel.
 - b. A615/A615M – Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
 - c. A653/A653M – Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot Dip Process.
 - d. A675 - Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties.
 - e. A767/A767M – Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement.
 - f. C881 - Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
 - g. C920 – Specification for Elastomeric Joint Sealants.
 - h. C1059 - Standard Specification for Latex Agents for Bonding Fresh to Hardened Concrete.
 - i. D226 – Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing.
 - j. D227 – Specification for Coal-Tar Saturated Organic Felt Used in Roofing and Waterproofing.
 - k. D994 – Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).

- l. D1056 – Specification for Flexible Cellular Materials – Sponge or Expanded Rubber.
 - m. D1171 – Standard Guide for Evaluating Nonwoven Fabrics.
 - n. D1751 – Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
 - o. D1752 – Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
2. Corps of Engineers (COE): CRD-C-572, Corps of Engineers Specification for Polyvinylchloride Waterstop.
 3. Federal Specifications: FS SS-S-210A - Sealing Compound for Expansion Joints.
- B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.3 SUBMITTALS

A. Action Submittals/Informational Submittals

1. Product Data

- a. Standard Waterstops: Catalogue cut, technical data, storage requirements, splicing methods and conformity to ASTM standards.
- b. Special Waterstops: Catalogue cut, technical data, location of use, storage requirements, splicing methods, installation instructions and conformity to ASTM standards.
- c. Premolded Joint Fillers: Catalogue cut, technical data, storage requirements, installation requirements, location of use and conformity to ASTM standards.
- d. Bond Breaker: Catalogue cut, technical data, storage requirements, installation requirements, location of use and conformity to ASTM standards.
- e. Expansion Joint Dowels: The complete assembly including dowels, coatings, lubricants, spacers, sleeves, expansion caps, installation requirements and conformity to ASTM standards.
- f. Compressible Joint Filler: Catalogue cut, technical data, storage requirements, installation requirements, location of use and conformity to ASTM standards.
- g. Bonding Agents: Catalogue cut, technical data, storage requirements, product life, application requirements and conformity to ASTM standards.

2. Shop Drawings

- a. Waterstop: Details of splices, method of securing and supporting waterstop in forms to maintain proper orientation and location during concrete placement.
- b. Construction and Control Joints: Layout and location for each type.

3. Samples

- a. PVC waterstop splice, joint, fabricated cross of each size, shape, and fitting of waterstop.

4. Certificates

- a. Certification that all materials used within the joint system are compatible with each other.

5. Manufacturer's Instructions

- a. Written instructions for product shipment, storage, handling, installation/application, and repair for:
 - 1) Waterstop
 - 2) Joint filler and primer
 - 3) Preformed control joint

1.4 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements

1. Verify delivered materials are in accordance with Specifications and manufacturer's product data sheets prior to unloading and storage onsite.

B. Storage and Handling Requirements

1. Appropriately store materials to protect from damage, loss, oil, dirt, and sunlight.

PART 2 PRODUCTS

2.1 GENERAL

- A. The use of manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired. Such reference is not intended to indicate a restrictive preference on the part of the Owner for that particular manufacturer or product, or to prohibit the use of equivalent products or equally qualified manufacturers.
- B. All materials used together in a given joint (bond breakers, backer rods, joint fillers, sealants, etc.) shall be compatible with one another. Coordinate selection of suppliers and products to ensure compatibility. Under no circumstances shall asphaltic bond breakers or joint fillers be used in joints receiving sealant.
- C. All chemical sealant type waterstops shall be products specifically manufactured for the purpose for which they will be used and the products shall have been successfully used on similar structures for more than five years.

2.2 MATERIALS

A. Standard Waterstops

1. Use 9"x3/8" centerbulb, split flange, PVC waterstop for expansion joints and control joints; Greenstreak No. 727, or equal.
2. Use 6" x3/8" PVC waterstop for construction joints; Greenstreak No. 679, or engineer approved equal.

B. Special Waterstops

1. Preformed Adhesive Waterstops:
 - a. Use rope type preformed plastic waterstop meeting requirements of Federal Specification SS-S-210A.
 - b. Cross sectional area: approximately one (1) square inch
 - c. Use Synko Flex by Synko Flex Products, or engineer approved engineer approved equal.
2. Hydrophilic Waterstops:
 - a. Use at construction joints only, where new concrete is placed against existing concrete.

- b. Use nonbentonite hydrophilic rubber compound.
 - c. Use Greenstreak Hydrotite CJ-1020-2K with Leakmaster LV-1 adhesive sealant, Adeka Ultra Seal, MC-2010M with 3M-2141 adhesive and P-201 sealant, or engineer approved equal.
3. Injection Type Waterstops
- a. Use a reinjectable waterstop hose system when called for on Drawings or directed by Engineer.
 - b. Reinjectable Waterstop Hose:
 - 1) Fabricated of polyvinyl chloride (PVC) compound.
 - 2) Contain discharge openings to allow for disbursement of an injection material into expansion joint.
 - a) Discharge openings designed to be sealed tight during concreting operation to prevent entry of mixing water and cement slurry.
 - 3) Allows free and uniform discharge of injection material over entire length of hose during injection process.
 - 4) Able to be internally cleaned by using water and vacuum pressure.
 - c. Injection Material: Hydrophilic or hydrophobic resin for use in expansion joints as recommended by reinjectable waterstop hose manufacturer.
 - d. Use Greenstreak Fuko Injection Hose System with Multigel 850, Deneef Construction Chemicals, Inc. TRIOject Injection Hose System with Hydro Active Grout, or engineer approved equal.

C. Bond Breaker

- 1. Use an adhesive-backed glazed butyl or polyethylene tape, same width as joint, which will satisfactorily adhere to the premolded joint filler or concrete surface as required.
- 2. Except where tape is specifically called for on the drawings, use either bond breaker tape or a nonstaining type bond prevention coating such as Williams Tilt-up Compound by Williams Distributors Inc.; Silcoseal 77, by SCA Construction Supply Division, Superior Concrete Accessories or equal for bond breaker for concrete.

D. Expansion Joint Dowels

- 1. Use smooth steel dowels conforming to ASTM A675, Grade 70. Dowels must be straight and clean, free of loose flaky rust and loose scale.
- 2. Dowels may be sheared to length provided deformation from true shape caused by shearing does not exceed 0.04-inch on the diameter of the dowel and extends no more than 0.04-inch from the end.
- 3. Coat bars with a bond breaker on the expansion end of the dowel.
- 4. Provide expansion caps which allow for at least 1-1/2-in of expansion on the expansion end.

E. Bonding Agent

- 1. Use a two-component, solvent-free, moisture insensitive, epoxy resin material conforming to ASTM C881, Type II for the bonding agent.
- 2. Acceptable products include Sikadur 32 Hi-Mod by Sika Corporation of Lyndhurst, N.J.; Concessive Liquid (LPL) by Master Builders of Cleveland, OH or engineer approved equal.
- 3. Acrylic may be used if approved by the Engineer.

F. Compressible Joint Filler

1. Provide a non-extruded watertight strip joint filler material to fill expansion joints between structures.
2. Compression Recovery: Recover at least 20 percent of its original thickness in the first 1/2 hour after unloading after being compressed at least 40 percent for 70 hours at 68 degrees F.
3. Acceptable manufacturers include Evasote 380 E.S.P, by E-Poxy Industries, Inc., Ravena, NY , Sikaflex 1a by Sika or engineer approved equal.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

A. Construction Joints: Prior to placement of abutting concrete, clean contact surface.

1. Remove laitance and spillage from reinforcing steel and dowels.
2. Roughen surface to a minimum ¼-inch amplitude:
 - a. Sandblast after concrete has fully cured.
 - b. Water blast after concrete has partially cured.
 - c. Green cut fresh concrete with high pressure water and hand tools.
3. Perform cleaning so as not to damage waterstop, if present.

B. Expansion Joints:

1. Use wire brush or other motorized device to mechanically roughen and thoroughly clean concrete surfaces on each side of joint from plastic waterstop to top of joint.
2. Use dry high pressure air to remove dust and foreign material, and dry joint.
3. Prime surface as required before placing joint filler.
4. Avoid damage to waterstop.

C. Contraction Joint and Control Joint:

1. Coat concrete surfaces above and below plastic waterstop with bond breaker.
2. Do not damage or coat waterstop.

D. Construction Joint with Hydrophilic Waterstop:

1. Follow hydrophilic waterstop manufacturer's written instructions.
2. Clean debris, dirt, dust, and foreign material from concrete surface. Concrete surface must be smooth, clean, and dry. Grind concrete as required.

3.2 INSTALLATION

A. Standard Waterstops

1. Install waterstops for all joints where indicated on the Drawings. Provide continuous waterstops around all corners and intersections so that a continuous seal is provided. Splices shall be made by welding.
2. Clamp horizontal waterstops in slabs in position by the bulkhead (unless previously set in concrete).
3. Install waterstops so that half of the width will be embedded on each side of the joint. Exercise care to ensure the waterstop is completely embedded in void-free concrete.

4. Terminate waterstops 3 inches below the exposed top of walls. Plug expansion joint waterstop center bulbs with foam rubber, 1-inch deep, at point of termination.

B. Special Waterstops

1. Hydrophilic Waterstop:

- a. Provide a minimum of 2-1/2 inches of concrete cover over waterstop. When structure has two layers of reinforcing steel, locate centered between layers of steel, or as shown.
- b. Apply adhesive to concrete surface and allow to dry for specified time before applying waterstop strip.
- c. Butt ends of waterstop strip together at splices and corners and join with sealant.
- d. Verify waterstop is anchored firmly in place before placing concrete. Do not allow vibrator to come in contact with waterstop.

2. Injection Type Waterstop:

- a. Install reinjectable waterstop hose in accordance with manufacturer's instructions.
- b. After concrete has been placed and cured for a minimum of 28 days, inject specified injection material into reinjectable waterstop hose in accordance with manufacturer's instructions.
- c. Upon completion of injection process, clean out remaining injection material in hose in accordance with manufacturer's instructions to allow for future injections.

C. Construction Joints

1. Make construction joints only at locations shown on the Drawings or as approved by the Engineer. Any additional or relocation of construction joints proposed by the Contractor, must be submitted to the Engineer for written approval.
2. Additional or relocated joints should be located where they least impair strength of the member. In general, locate joints within the middle third of spans of slabs, beams and girders. However, if a beam intersects a girder at the joint, offset the joint a distance equal to twice the width of the member being connected. Locate joints in walls and columns at the underside of floors, slabs, beams or girders and at tops of footings or floor slabs. Do not locate joints between beams, girders, column capitals, or drop panels and the slabs above them. Do not locate joints between brackets or haunches and walls or columns supporting them.
3. Make all joints perpendicular to main reinforcement. Continue reinforcing steel through the joint as indicated on the Drawings. When joints in beams are allowed, provide a shear key and inclined dowels as approved by the Engineer.
4. Provide sealant grooves for joint sealant where indicated on the Drawings.
5. At all construction joints and at concrete joints designated on the Drawings to be "roughened", uniformly roughen the surface of the concrete to a full amplitude (distance between high and low points or side to side) of approximately 1/4-inch to expose a fresh face. Thoroughly clean joint surfaces of loose or weakened materials by waterblasting or sandblasting and prepare for bonding.
6. Provide waterstops in all wall and slab construction joints in liquid containment structures and at other locations shown on the Drawings.
7. Keyways shall not be used in construction joints unless specifically shown on the Drawings or approved by the Engineer.

D. Expansion Joints

1. Do not extend through expansion joints, reinforcement or other embedded metal items that are continuously bonded to concrete on each side of joint.
2. Position premolded joint filler material accurately. Secure the joint filler against displacement during concrete placement and compaction. Place joint filler over the face of the joint, allowing for sealant grooves as detailed on the Drawings. Tape all joint filler splices to prevent intrusion of mortar. Seal expansion joints as shown on the Drawings.
3. Expansion joints shall be $\frac{3}{4}$ -inch in width unless otherwise noted on the Drawings.
4. Where indicated on Drawings, install smooth dowels at right angles to expansion joints. Align dowels accurately with finished surface. Rigidly hold in place and support during concrete placement. Unless otherwise shown on the Drawings, apply oil or grease to one end of all dowels through expansion joints. Provide plastic expansion caps on the lubricated ends of expansion dowels.
5. Provide center bulb type waterstops in all wall and slab expansion joints in liquid containment structures and at other locations shown on the Drawings.

E. Control Joints

1. Provide sealant grooves, sealants and waterstops at control joints in slabs on grade or walls as detailed. Provide waterstops at all wall and slab control joints in water containment structures and at other locations shown on the Drawings.
2. Control joints may be sawed if specifically approved by the Engineer. If control joint grooves are sawed, properly time the saw cutting with the time of the concrete set. Start cutting as soon as concrete has hardened sufficiently to prevent aggregates from being dislodged by the saw. Complete cutting before shrinkage stresses have developed sufficiently to induce cracking. No reinforcing shall be cut during sawcutting.
3. Extend every other bar of reinforcing steel through control joints or as indicated on the Drawings. Where specifically noted on the Drawings, coat the concrete surface with a bond breaker prior to placing new concrete against it. Avoid coating reinforcement or waterstops with bond breaker at these locations.

END OF SECTION

SECTION 03 21 00

REINFORCING STEEL

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	References
1.3	Submittals
1.4	Quality Assurance
1.5	Delivery, Storage, and Handling
2.1	Materials
2.2	Fabrication
3.1	Preparation
3.2	Reinforcing Bar Installation
3.3	Reinforcement around Openings
3.4	Splicing of Reinforcement
3.5	Welded Wire Fabric Installation
3.6	Accessories
3.7	Tests and Inspection

B. Scope

1. Furnish all labor, materials, equipment and incidentals required and install all concrete reinforcement complete as shown on the Drawings and as specified herein.
2. Furnish all deformed steel reinforcement required to be entirely built into concrete masonry unit construction.

C. Related Requirements

1. Concrete Forming is included in Section 03 11 00.
2. Concrete Joint and Joint Accessories are included in Section 03 15 00.
3. Cast-in-place Concrete is included in Section 03 30 00.
4. Grout is included in Section 03 60 00.

1.2 REFERENCES

A. Reference Standards

1. American Society for Testing and Materials (ASTM)
 - a. A82 – Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
 - b. A184 - Standard Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
 - c. A185 - Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement

- d. A496 - Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement
 - e. A497 - Standard Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement
 - f. A615 - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
 - g. A616 - Standard Specification for Rail-Steel Deformed and Plain Bars for Concrete Reinforcement
 - h. A996 - Standard Specification for Axle-Steel Deformed and Plain Bars for Concrete Reinforcement
 - i. A706 - Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
 - j. A767 - Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement
 - k. A775 - Standard Specification for Epoxy-Coated Reinforcing Steel Bars
 - l. A884 - Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Fabric for Reinforcement
 - m. A934 – Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars
2. American Concrete Institute (ACI)
 - a. ACI 301 - Standard Specification for Structural Concrete
 - b. ACI 315 – Details and Detailing of Concrete Reinforcement
 - c. ACI 318 - Building Code Requirements for Structural Concrete
 - d. ACI SP-66 – ACI Detailing Manual
 3. Concrete Reinforcing Steel Institute (CRSI)
 - a. Manual of Standard Practice
 4. American Welding Society (AWS)
 - a. AWS D1.4 – Structural Welding Code Reinforcing Steel
 5. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.3 SUBMITTALS

- A. Submit to the Engineer, in accordance with Section 01 33 23 – Shop Drawings, Product Data, and Samples, product information showing materials of construction and details of installation.
- B. Action Submittals/Informational Submittals
 1. Shop Drawings
 - a. Reinforcing Steel.
 - 1) Conform placement drawings to the recommendations of ACI 315.
 - 2) Include all reinforcement in a concrete placement on a single placement drawing or cross referenced to the pertinent main placement drawing. Include the additional reinforcement (around openings, at corners, etc.) shown on the standard detail sheets on the main drawing.

- 3) Clearly identify bars to have special coatings and/or to be of special steel or special yield strength.
 - b. Bar bending details.
 - 1) Reference the bars to the same identification marks shown on the placement drawings.
 - c. Schedule of all placements to contain synthetic reinforcing fibers.
 - 1) Note the amount of fibers per cubic yard to be used for each of the placements on the schedule.
 - 2) Include the name of the manufacturer of the fibers and the product data with the submittal.
2. Certificates
 - a. Welder's certification: The certification shall be in accordance with AWS D1.4 when welding of reinforcement is required.
 3. Test and Evaluation Reports
 - a. Certified copy of mill test on each steel proposed for use showing the physical properties of the steel and the chemical analysis.

1.4 QUALITY ASSURANCE

- A. Provide services of a manufacturer's representative, with at least 2 years' personal experience in the use of the reinforcing fibers for a preconstruction meeting and assistance during the first placement of the material. Experience of the manufacturer shall not be substituted for the personal experience of the representative.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Delivery and Acceptance Requirements
 1. Provide reinforcing steel substantially free from mill scale, rust, dirt, grease, or other foreign matter.
 2. Ship and store reinforcing steel with bars of the same size and shape fastened in bundles with durable tags, marked in a legible manner with waterproof markings showing the same "mark" designations as those shown on the submitted Placing Drawings.
- B. Storage and Handling Requirements
 1. Store reinforcing steel off the ground and keep free from dirt, oil, or other injurious contaminants.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Provide new materials, of domestic manufacture, complying with the following material specifications.
 1. Deformed Concrete Reinforcing Bars: ASTM A615, Grade 60 deformed bars.
 2. Concrete Reinforcing Bars required on the Drawings to be Welded: ASTM A706.
 3. Welded Steel Wire Fabric: ASTM A185. Provide in flat sheets.
 4. Welded Deformed Steel Wire Fabric: ASTM A497.
 5. Welded Plain Bar Mats: ASTM A704 and ASTM A615 Grade 60 plain bars.

6. Fabricated Deformed Steel Bar Mats: ASTM A184 and ASTM A615 Grade 60 deformed bars.
- B. The following alternate materials are allowed:
1. ASTM A615 Grade 60 may be used for ASTM A706 provided the following requirements are satisfied:
 - a. Actual yield strength of the reinforcing steel based on mill tests:
 - 1) No more than 18,000 psi over the specified yield strength.
 - 2) Retests not to exceed this value by more than an additional 3000 psi.
 - b. Ratio of the actual ultimate tensile strength to the actual tensile yield strength: Not less than 1.25.
 - c. The carbon equivalency (CE) of bars: 0.55 or less.
- C. Reinforcing Steel Accessories
1. Plastic Protected Bar Supports: CRSI Bar Support Specifications, Class 1 - Maximum Protection.
 2. Stainless Steel Protected Bar Supports: CRSI Bar Support Specifications, Class 2 - Moderate Protection.
 3. Precast Concrete Block Bar Supports: CRSI Bar Support Specifications, Precast Blocks. Provide blocks with equal or greater strength than the surrounding concrete.
 4. Steel Protected Bar Supports: #4 Steel Chairs with plastic or rubber tips.
- D. Tie Wire
1. 16-gauge or heavier, black annealed wire or stranded wire.
- E. Mechanical reinforcing steel butt splices:
1. Positive connecting taper threaded type employing a hexagonal coupler such as Lenton rebar splices as manufactured by Erico Products Inc., Solon, OH or equal.
 2. Meet all ACI 318 Building Code requirements.
 3. Bar ends must be taper threaded with coupler manufacturer's bar threader to ensure proper taper and thread engagement.
 4. Torque bar couplers to manufacturer's recommended value.
 5. Unless otherwise noted on the Drawings, design mechanical tension splices to produce a splice strength in tension or compression of not less than 125 percent of the ASTM specified minimum yield strength of the rebar.
 6. Compression type mechanical splices:
 - a. Provide concentric bearing from one bar to the other bar.
 - b. Capable of developing the ultimate strength of the rebar in compression.
- F. Welded Wire Fabric
1. ASTM A185 or ASTM A497 and ACI 318/318R, using ASTM A82 wire of 75 ksi minimum tensile strength.
 2. Furnish flat sheets only, rolled sheets not permitted.
- G. Fiber Reinforcement

1. Provide 100 percent polypropylene collated, fibrillated fibers as manufactured by Fibermesh Company of Synthetic Industries Inc., Chattanooga, TN - Fibermesh or equal for synthetic reinforcing fiber for concrete.
2. Fiber length and quantity for the concrete mix shall be in strict compliance with the manufacturer's recommendations as approved by the Engineer.

2.2 FABRICATION

- A. Comply with the CRSI Manual of Standard Practice for the fabrication of reinforcement.
- B. Cold bend bars. Do not straighten or re-bend bars.
- C. Use a revolving collar having a diameter of not less than that recommended by the ACI 318 for bending bars.
- D. Saw cut ends of bars that are to be butt spliced, placed through limited diameter holes in metal, or threaded. Terminate ends in flat surfaces within 1-1/2 degrees of a right angle to the axis of the bar.

PART 3 EXECUTION

3.1 PREPARATION

- A. Notify Engineer when reinforcing is ready for inspection and allow sufficient time for inspection prior to placing concrete.
- B. Clean reinforcing bars of loose mill scale, oil, earth, and other contaminants.
- C. Coat wire projecting from precast concrete bar supports with dielectric material, epoxy, or plastic.

3.2 REINFORCING BAR INSTALLATION

- A. Surface condition, bending, spacing and tolerances of placement of reinforcement shall comply with the CRSI Manual of Standard Practice.
- B. Providing an adequate number of bars and maintaining the spacing and clearances shown on the Drawings is the Contractor's responsibility.
- C. Except as otherwise indicated on the Drawings, minimum concrete cover of reinforcement:
 1. Concrete cast against and permanently exposed to earth: 3 inches
 2. Concrete exposed to soil, water, sewage, sludge and/or weather: 2 inches (including bottom cover of slabs over water or sewage)
 3. Concrete not exposed to soil, water, sewage, sludge and/or weather:
 - a. Slabs (top and bottom cover), walls, joists, shells and folded plate members: 1-inch
 - b. Beams and columns (principal reinforcement, ties, spirals and stirrups): 1-1/2 inches
- D. Coat reinforcement with a heavy coat of neat cement slurry when reinforcement will be exposed for a considerable length of time (over 30 days) after being placed.
- E. Do not weld reinforcing steel bars either during fabrication or erection unless specifically shown on the Drawings or specified herein, or unless prior written approval has been obtained from the Engineer. Remove all bars that have been welded, including tack welds, without such approval from the work. When welding of reinforcement is approved or called for, comply with AWS D1.4. Permission of the Engineer to weld reinforcing steel is specific to location and cannot be extended by the Contractor to other locations regardless of similarity in function, conditions, or materials.

- F. Reinforcing steel interfering with the location of other reinforcing steel, conduits or embedded items, may be moved within the specified tolerances or one bar diameter, whichever is greater. Obtain the approval of the Engineer when greater displacement of bars to avoid interference is necessary. Do not cut reinforcement to install inserts, conduits, mechanical openings or other items without the prior approval of the Engineer.
- G. Securely support and tie reinforcing steel to prevent movement during concrete placement. Secure dowels in place before placing concrete.
- H. Do not field bend reinforcing steel bars except where shown on the Drawings or specifically authorized in writing by the Engineer. If authorized, cold-bend bars around the standard diameter spool specified in the CRSI. Do not heat bars. Closely inspect the reinforcing steel for breaks. If the reinforcing steel is damaged, replace, Cadweld or otherwise repair as directed by the Engineer. Do not bend reinforcement after it is embedded in concrete unless specifically shown otherwise on the Drawings.

3.3 REINFORCEMENT AROUND OPENINGS

- A. Unless specific additional reinforcement around openings is shown on the Drawings, provide additional reinforcing steel on each side of the opening equivalent to one half of the cross-sectional area of the reinforcing steel interrupted by an opening. Provide sufficient length of bar to develop bond at each end beyond the opening or penetration.

3.4 SPLICING OF REINFORCEMENT

- A. Follow ACI 318/318R.
- B. Use lap splices, unless otherwise shown or permitted in writing by Engineer.
- C. Compression Lap Splices:
 - 1. 30 bar diameters, but not less than 12 inches
 - 2. For vertical column bars, base splice length on bar size in column above.
- D. Tension Lap Splices:
 - 1. Stagger splices in adjacent bars.
 - 2. Use Class A splices when 50 percent or less of the bars are spliced within the required lap length.
 - 3. Use Class B splices at all other locations.
- E. Avoid splicing of reinforcing steel in concrete elements noted to be "tension members" on the Drawings. However, if required for constructability, weld splices in the reinforcement subject to direct tension to develop, in tension, at least 125 percent of the specified yield strength of the bar. Offset splices in adjacent bars the distance of a Class B splice.
- F. Use mechanical reinforcing steel splicers only where shown on the Drawings. Offset splices in adjacent bars by at least 30 bar diameters. Mechanical reinforcing splices are only to be used for special splice and dowel conditions approved by the Engineer.

3.5 WELDED WIRE FABRIC INSTALLATION

- A. Use only where specifically shown.
- B. Extend fabric to within 2 inches of edges of slab.
- C. Lap splices in accordance with ACI 318/318R, but not less than 12 inches.
- D. Tie laps and splices securely at ends and at least every 24 inches with tie wire. Lace with wire of the same diameter as the welded wire fabric.

- E. Do not position laps midway between supporting beams, or directly over beams of continuous structures.
- F. Offset splices in adjacent widths to prevent continuous splices.

3.6 ACCESSORIES

- A. Determine, provide and install accessories such as chairs, chair bars and the like in sufficient quantities and strength to adequately support the reinforcement and prevent its displacement during the erection of the reinforcement and the placement of concrete.
- B. Use precast concrete blocks where the reinforcing steel is to be supported over soil.
- C. Stainless steel bar supports or steel chairs with stainless steel tips shall be used where the chairs are set on forms for a concrete surface that will be exposed to weather, high humidity, or liquid (including bottom of slabs over liquid containing areas). Use of galvanized or plastic tipped metal chairs is permissible in all other locations unless otherwise noted on the Drawings or specified herein.
- D. Alternate methods of supporting top steel in slabs, such as steel channels supported on the bottom steel or vertical reinforcing steel fastened to the bottom and top mats, may be used if approved by the Engineer.

3.7 TESTS AND INSPECTION

- A. Do not cover any reinforcing steel with concrete until the installation of the reinforcement, including the size, spacing and position of the reinforcement has been observed by the Engineer or Inspector and the Engineer's release to proceed with the concreting has been obtained. Provide the Engineer or Inspector a minimum of 48 hours' notice of the readiness of placed reinforcement for observation prior to scheduling pouring of concrete. Keep the forms open until the Engineer or Inspector has finished his/her observations of the reinforcing steel.
- B. An independent testing agency will be retained by the Owner to visually inspect and test reinforcing steel welds in accordance with AWS D1.4/D1.4M.
- C. An independent testing agency will be retained by the Owner to inspect each mechanical splice and verify each component is installed in accordance with manufacturer's instructions and ICC Evaluation Services Report or equivalent code agency report.
- D. Special inspections will be provided by the Owner as indicated on the Drawings.

END OF SECTION

SECTION 03 30 00

CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	References
1.3	Submittals
1.4	Quality Assurance
1.5	Delivery, Storage, and Handling
2.1	General
2.2	Materials
2.3	Concrete Mix Design
3.1	Measuring Materials
3.2	Mixing and Transporting
3.3	Concrete Appearance
3.4	Placing and Compacting
3.5	Curing and Protection
3.6	Removal of Forms
3.7	Inspection and Field Testing
3.8	Failure to Meet Requirements
3.9	Patching and Repairs
3.10	Schedule

B. Scope

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

C. Related Requirements

1. Concrete Forming is included in Section 03 11 00.
2. Concrete Joints and Joint Accessories are included in Section 03 15 00.
3. Concrete Reinforcement is included in Section 03 21 00.
4. Grout is included in Section 03 60 00.

1.2 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. C31 - Standard Practice for Making and Curing Concrete Test Specimens in the Field
2. C33 - Standard Specification for Concrete Aggregates

3. C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
 4. C42 - Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
 5. C94 - Standard Specification for Ready-Mixed Concrete
 6. C143 - Standard Test Method for Slump of Hydraulic Cement Concrete
 7. C150 - Standard Specification for Portland Cement
 8. C171 - Standard Specification for Sheet Materials for Curing Concrete
 9. C173 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
 10. C231 - Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
 11. C260 - Standard Specification for Air-Entraining Admixtures for Concrete
 12. C309 - Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
 13. C494 - Standard Specification for Chemical Admixtures for Concrete
 14. C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
 15. C1017 - Standard Specification for Chemical Admixtures for use in Producing Flowing Concrete
- B. American Concrete Institute (ACI).
1. ACI 304R - Guide for Measuring, Mixing, Transporting and Placing Concrete
 2. ACI 305R - Hot Weather Concreting
 3. ACI 306.1 - Standard Specification for Cold Weather Concreting
 4. ACI 318 - Building Code Requirements for Structural Concrete
 5. ACI 350R - Environmental Engineering Concrete Structures
- C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.3 SUBMITTALS

A. Action Submittals/Informational Submittals

1. Mix Design

- a. Concrete mix for each formulation of concrete proposed for use including constituent quantities per cubic yard, water-cementitious materials ratio, concrete slump, type and manufacturer of cement. Provide either 1) or 2) below for each mix proposed.
 - 1) Standard deviation data for each proposed concrete mix based on statistical records.
 - 2) The curve of water-cementitious materials ratio versus concrete cylinder strength for each formulation of concrete proposed based on laboratory tests. Provide the cylinder strength for the average of the 28 day cylinder strength test results for each mix. Provide results of 7 and 14 day tests.

2. Product Data
 - a. Sources of cement, pozzolan and aggregates.
 - b. Material Safety Data Sheets (MSDS) for all concrete components and admixtures.
 - c. Air-entraining admixture. Product data including catalogue cut, technical data, storage requirements, product life, recommended dosage, temperature considerations and conformity to ASTM standards.
 - d. Water-reducing admixture. Product data including catalogue cut, technical data, storage requirements, product life, recommended dosage, temperature considerations and conformity to ASTM standards.
 - e. High-range water-reducing admixture (plasticizer). Product data including catalogue cut, technical data, storage requirements, product life, recommended dosage, temperature considerations, retarding effect, slump range and conformity to ASTM standards. Identify proposed locations of use.
 - f. Sheet curing material. Product data including catalogue cut, technical data and conformity to ASTM standard.
 - g. Liquid curing compound. Product data including catalogue cut, technical data, storage requirements, product life, application rate and conformity to ASTM standards. Identify proposed locations of use.
 3. Samples
 - a. Fine and coarse aggregates if requested by the Engineer.
 4. Certificates
 - a. Certify admixtures used in the same concrete mix are compatible with each other and the aggregates.
 - b. Certify admixtures are suitable for use in contact with potable water after 30 days of concrete curing.
 - c. Certify curing compound is suitable for use in contact with potable water after 30 days (non-toxic and free of taste or odor).
 5. Test and Evaluation Reports
 - a. Fine aggregates – sieve analysis, physical properties, and deleterious substance.
 - b. Coarse aggregates – sieve analysis, physical properties, and deleterious substances.
 - c. Cements – chemical analysis and physical properties for each type.
 - d. Pozzolans – chemical analysis and physical properties.
 - e. Proposed concrete mixes – compressive strength, slump and air content.
 - f. Shrinkage Test Results – In accordance with ASTM C157 as modified hereinafter.
 6. Field Quality Control Submittals
 - a. Field test reports.
 - b. Concrete Delivery/Batch Tickets:
 - 1) For each batch of concrete before unloading at Site.
 - 2) In accordance with ASTM C94/C94M, Section 14 including requirements 14.2.1 through 14.2.10.
 - 3) Indicate the amount of mixing water withheld, and maximum amount that may be permitted to be added at Project Site.
 7. Special Procedure Submittals
-

- a. Detailed plan for cold weather curing and protection of concrete placed and cured in weather below 40 degrees F.
- b. Detailed plan for hot weather placements including curing and protection for concrete placed in ambient temperatures over 80 degrees F.
- c. If Contractor chooses to use self-consolidating concrete: Detailed plan of modified procedures for handling, placing, and finishing.

1.4 QUALITY ASSURANCE

- A. Comply with ACI 318, the recommendations of ACI 350R and other stated requirements, codes and standards. The most stringent requirement of the codes, standards and this Section apply when conflicts exist.
- B. Use only one source of cement and aggregates on any one structure. Provide concrete of uniform color and appearance.
- C. A minimum of 14 days in advance of placing concrete, discuss with the Engineer the sources of individual materials and batched concrete proposed for use. Discuss placement methods, waterstops and curing. Propose methods of hot and cold weather concreting as required. Discuss the properties and techniques of batching and placing plasticized concrete prior to the placement of any concrete containing a high-range water-reducing admixture (plasticizer). Include the plasticizer manufacturer in the discussions.
- D. If, during the progress of the work, it is impossible to secure concrete of the required workability and strength with the materials being furnished, the Engineer may order such changes in proportions or materials, or both, as may be necessary to secure the desired properties. Make all changes ordered at the Contractor's expense.
- E. If, during the progress of the work, the materials from the sources originally accepted change in characteristics, provide all materials, labor, and equipment, at the Contractor's expense, necessary to perform new acceptance tests as were originally required using the new materials prior to their incorporation in the work. If the tests are specified to be conducted by others, the costs of these tests shall be borne solely by the Contractor.
- F. Qualifications
 1. Batch Plant: NRMCA Program for Certification of Ready-Mixed Concrete Production Facilities or an approved equivalent program.
 2. Mix Designer: Person responsible for developing concrete mixture proportions certified as NRMCA Concrete Technologist Level 2 or DOT certified mix designer in the jurisdiction of the Work. Requirements may be waived if the individual is Contractor's Licensed Design Engineer.
 3. Installers: Unless otherwise permitted, at least one person on the finishing crew must be certified as an ACI Flatwork Finisher, or equivalent.
- G. Preconstruction Testing
 1. Have the following materials tested to verify conformity with this Specification Section and the stated ASTM Standards.
 - a. Fine aggregates for conformity with ASTM C33 – sieve analysis, physical properties, and deleterious substances.
 - b. Coarse aggregates for conformity with ASTM C33 – sieve analysis, physical properties, and deleterious substances.
 - c. Cements for conformity with ASTM C150 – chemical analysis and physical properties.

- d. Pozzolans for conformity with ASTM C618 – chemical analysis and physical properties.
- e. Proposed concrete mix designs – compressive strength, slump and air content.

H. Field Samples

- 1. Field testing and inspection services will be provided by the Owner. The Owner will pay the cost of such work, except as specifically stated otherwise. The Owner will test the following items to verify conformity with this Specification Section.
 - a. Concrete placements – compressive strength (cylinders), compressive strength (cores), slump, and air content.
 - b. Other materials or products that may come under question.
- 2. Conform all materials incorporated in the work to accepted samples.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Storage and Handling Requirements

- 1. Cement: Store in weathertight buildings, bins or silos to provide protection from dampness and contamination and to minimize warehouse set.
- 2. Aggregate: Arrange and use stockpiles to avoid excessive segregation or contamination with other materials or with other sizes of like aggregates. Build stockpiles in successive horizontal layers not exceeding 3-ft in thickness. Complete each layer before the next is started. Do not use frozen or partially frozen aggregate.
- 3. Sand: Arrange and use stockpiles to avoid contamination. Allow sand to drain to a uniform moisture content before using. Do not use frozen or partially frozen aggregates.
- 4. Admixtures: Store in closed containers to avoid contamination, evaporation or damage. Provide suitable agitating equipment to assure uniform dispersion of ingredients in admixture solutions which tend to separate. Protect liquid admixtures from freezing and other temperature changes which could adversely affect their characteristics.
- 5. Pozzolan: Store in weathertight buildings, bins or silos to provide protection from dampness and contamination.
- 6. Sheet Curing Materials: Store in weathertight buildings or off the ground and under cover.
- 7. Liquid Curing Compounds: Store in closed containers.

PART 2 PRODUCTS

2.1 GENERAL

- A. The use of manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired. Such reference is not intended to indicate a restrictive preference on the part of the Owner for that particular manufacturer or product, or to prohibit the use of equivalent products or equally qualified manufacturers.
- B. Like items of materials shall be the end products of one manufacturer in order to provide standardization for appearance, maintenance and manufacturer's service.

2.2 MATERIALS

A. Cementitious Materials

1. Portland Cement

- a. In accordance with requirements of ASTM C150.
- b. Brand: Subject to approval of Engineer. Use one brand throughout the Work.
- c. Alkalies: Maximum 0.60 percent.
- d. Nonhydraulic above grade structures: Type I or Type II.
- e. Hydraulic and below grade structures and sewers: Type II

2. Supplementary Cementitious Materials

- a. Fly Ash (Pozzolan): Class F or Class N fly ash in accordance with ASTM C618, except as modified herein:
 - 1) Produced from process that does not use hazardous or potentially hazardous materials.
 - 2) ASTM C618, Table 1, Loss on Ignition: Maximum 3 percent.
 - 3) ASTM C618, Table 2, Water Requirement: Maximum 100 percent of control.
 - 4) ASTM C618, Table 3, Effectiveness in Controlling Alkali-Silica Reaction: Maximum 100 percent expansion of test mixture as a percentage of low-alkali cement control at 14 days.
 - 5) ASTM C618, Table 3, Expansion of Test Mixture: Evaluate results using either Procedure A or Procedure B as follows:
 - a) Procedure A after 6-month sulfate exposure, maximum 0.10 percent.
 - b) Procedure B, expansion of test mixture as a percentage of sulfate resistance cement control, after at least 6-month exposure, maximum 100 percent.
 - 6) Where fly ash is specified to be used with Type I cement, have fly ash meet one of the following requirements:
 - a) CaO: Maximum 15 percent.
 - b) Test cementitious materials as follows:
 - (1) In accordance with ASTM C1012.
 - (2) Furnish test data confirming fly ash in combination with cement used meets strength requirements, is compatible with air-entraining agents and other additives, provides increased sulfate resistance equivalent to or better than Type II cement.
 - (3) Conduct tests using proposed fly ash and cement samples together with control samples using Type II cement without fly ash.
- b. Slag Cement: In accordance with ASTM C989, Grades 100 or 120.

3. Tricalcium Aluminate

- a. Content of Cementitious Materials: Maximum 8 percent.

B. Aggregates: Furnish from one source.

1. Natural Aggregates

- a. Free from deleterious coatings and substances and conforming to requirements of ASTM C33, except as modified herein.
- b. Free from materials and aggregate types causing popouts, discoloration, staining, or other defects on surface of concrete.

2. Nonpotentially Reactive: In accordance with ASTM C33, Appendix XI, Paragraph X1.1.
 3. Aggregate Soundness: Test for fine and coarse aggregates in accordance with ASTM C33 and ASTM C88 using sodium sulfate solution.
 4. Fine Aggregates
 - a. Clean, sharp, and natural sand.
 - b. ASTM C33.
 - c. Material Passing 200 Sieve: 4 percent maximum.
 - d. Limit deleterious substances in accordance with ASTM C33, Table 1 with material finer than 20 sieve limited to 3 percent, coal and lignite limited to 0.5 percent.
 5. Coarse Aggregates
 - a. Natural gravels, combination of gravels and crushed gravels, crushed stone, or combination of these materials containing no more than 15 percent flat or elongated particles (long dimension more than five times the short dimension).
 - b. Materials Passing 200 Sieve: 0.5 percent maximum.
 - c. Limit deleterious substances in accordance with ASTM C33, Table 3 for exposed concrete.
- C. Admixtures: Unless otherwise permitted, furnish from one manufacturer.
1. Characteristics
 - a. Compatible with other constituents in mix.
 - b. Free of chlorides and alkalis (except for those attributable to water).
 - c. Do not use admixtures known to be toxic after concrete has cured for 30 days.
 - d. Furnish type of admixtures as recommended by manufacturer for anticipated temperature ranges.
 - e. Proportion and mix in accordance with manufacturer's recommendations.
 2. Air-Entraining Admixture: ASTM C260
 3. Water-Reducing Admixture: ASTM C494/C494M, Type A or Type D.
 4. Retarding Admixture: ASTM C494/C494M, Type B.
 5. High Range Water Reducing Admixture (Superplasticizer): ASTM C494/C494M, Type F or G. Use only when approved by Engineer.
 6. Plasticizing and Retarding Admixture: ASTM C1017/C1017M, Type II. Use only when approved by Engineer.
 - a. Use of viscosity modifier if intent is to achieve self-consolidating concrete.
 7. Do not use calcium chloride as an admixture.
- D. Water and Ice: Use potable water for mixing water for concrete and water used to make ice, unless alternative sources of water are permitted.
1. Water from alternative sources: Comply with requirements of ASTM C1602/C1602M and contain less than:
 - a. 1,000 ppm of chlorides.
 - b. 3,000 ppm sulfate as SO₄.
 - c. 600 ppm alkalis as (Na₂O + 0.658 K₂O).

- d. 50,000 ppm total solids by mass.

2.3 CONCRETE MIX DESIGN

- A. Use an independent testing laboratory acceptable to the Engineer for development of mix designs and testing.
- B. Select proportions of ingredients to meet the design strength and materials limits specified in Table 1 and to produce concrete having proper workability, durability, strength, appearance and other required properties. Proportion ingredients to produce a homogenous mixture which will readily work into corners and angles of forms and around reinforcement without permitting materials to segregate or allowing excessive free water to collect on the surface.
- C. Base the design mix on standard deviation data of prior mixes with essentially the same proportions of the same constituents or, if such data is not available, be developed by a testing laboratory, acceptable to the Engineer, engaged by and at the expense of the Contractor. Acceptance of mixes based on standard deviation shall be based on the modification factors for standard deviation tests contained in ACI 318.
- D. The water content of the concrete mix, determined by laboratory testing, shall be based on a curve showing the relation between water cementitious ratio and 7 and 28 day compressive strengths of concrete made using the proposed materials. The curves shall be determined by four or more points, each representing an average value of at least three test specimens at each age. The curves shall have a range of values sufficient to yield the desired data, including the specified design strengths as modified below, without extrapolation. The water content of the concrete mixes to be used, as determined from the curve, shall correspond to strengths 16 percent greater than the specified design strengths. The resulting mix shall not conflict with the limiting values for maximum water cementitious ratio and net minimum cementitious content as specified in Table 1.
- E. Compression Tests: Provide testing of the proposed concrete mix or mixes to demonstrate compliance with the specified design strength requirements in conformity with the above paragraphs.
- F. Entrained air, as measured by ASTM C231, as shown in Table 1.
 - 1. If the air-entraining agent proposed for use in the mix requires testing methods other than ASTM C231 to accurately determine air content, make special note of this requirement in the admixture submittal.
- G. Slump of the concrete as measured by ASTM C143, as shown in Table 1. If a high-range water-reducer (plasticizer) is used, measure the slump before plasticizer is added. Plasticized concrete shall have a slump ranging from 7 to 10-in.
- H. Proportion admixtures according to the manufacturer's recommendations. Two or more admixtures specified may be used in the same mix provided that the admixtures in combination retain full efficiency and have no deleterious effect on the concrete or on the properties of each other.

TABLE 1
CONCRETE MIX REQUIREMENTS

Class	Design Strength (1)	Cement (2)	Fine Aggregate (2)	Coarse Aggregate (3)	Cementitious Content (4)
A	2500	C150 Type II	C33	57	440 min.
B	3000	C150 Type II	C33	57	480 min.
C	4000	C150 Type II	C33	57	560 min.
D	5000	C150 Type II	C33	56	600 min.

Class	W/C Ratio (5)	Fly Ash	AE Range (6)	WR (7)	HRWR (8)	Slump Range Inches
A	0.62 max	--	3.5 to 5	Yes	*	1-4
B	0.54 max	--	3.5 to 5	Yes	*	1-3
C	0.44 max	25% max	3.5 to 5	Yes	*	3-5
D	0.40 max	--	3.5 to 5	Yes	*	3-5

NOTES:

1. Minimum compressive strength in psi at 28 days
2. ASTM designation
3. Size Number in ASTM C33
4. Cementitious content in lbs/cu yd
5. W/C is Water-Cementitious ratio by weight
6. AE is percent air-entrainment
7. WR is water-reducer admixture
8. HRWR is high-range water-reducer admixture
9. *HRWR used at contractor's option

PART 3 EXECUTION

3.1 MEASURING MATERIALS

- A. Compose concrete of portland cement, fine aggregate, coarse aggregate, water and admixtures as specified. Use a batch plant acceptable to the Engineer for concrete production. Batch all constituents, including admixtures, at the plant except a high-range water-reducer may also be added in the field.
- B. Measure materials for batching concrete by weighing in conformity with and within the tolerances given in ASTM C94 except as otherwise specified. Have scales certified by the local Sealer of Weights and Measures within 1 year of use.
- C. Measure the amount of free water in fine aggregates within 0.3 percent with a moisture meter. Compensate for varying moisture contents of fine aggregates. Record the number of gallons of water as-batched on printed batching tickets.
- D. Dispense admixtures either manually using calibrated containers or measuring tanks, or by means of an automatic dispenser approved by the manufacturer of the specific admixture.
 1. Charge air-entraining and chemical admixtures into the mixer as a solution using an automatic dispenser or similar metering device.

2. Inject multiple admixtures separately during the batching sequence.

3.2 MIXING AND TRANSPORTING

- A. Provide ready-mixed concrete produced by equipment acceptable to the Engineer. No hand-mixing will be permitted. Clean each transit mix truck drum and reverse drum rotation before the truck proceeds under the batching plant. Equip each transit-mix truck with a continuous, nonreversible, revolution counter showing the number of revolutions at mixing speeds.
- B. Transport ready-mix concrete to the site in watertight agitator or mixer trucks loaded not in excess of their rated capacities as stated on the name plate.
- C. Keep the water tank valve on each transit truck locked at all times. Any addition of water must be directed by the Engineer. Incorporate added water by additional mixing of at least 35 revolutions. Meter all added water with the amount of water added shown on each delivery ticket.
- D. All central plant and rolling stock equipment and methods shall comply with ACI 318 and ASTM C94.
- E. Select equipment of size and design to ensure continuous flow of concrete at the delivery end. Use metal or metal-lined non-aluminum discharge chutes with slopes not exceeding 1 vertical to 2 horizontal and not less than 1 vertical to 3 horizontal. Chutes more than 20-ft long and chutes not meeting slope requirements may be used if concrete is discharged into a hopper before distribution.
- F. Retempering (mixing with or without additional cement, aggregate, or water) of concrete or mortar which has reached initial set will not be permitted.
- G. Handle concrete from mixer to placement as quickly as practicable while providing concrete of required quality in the placement area. Dispatch trucks from the batching plant so they arrive at the work site just before the concrete is required, thus avoiding excessive mixing of concrete while waiting or delays in placing successive layers of concrete in the forms.
- H. Furnish a delivery ticket for ready mixed concrete to the Engineer as each truck arrives. Provide a printed record of the weight of cement and each aggregate as batched individually on each ticket. Use the type of indicator that returns for zero punch or returns to zero after a batch is discharged. Clearly indicate the weight of fine and coarse aggregate, cement and water in each batch, the quantity delivered, the time any water is added, and the numerical sequence of the delivery. Show the time of day batched and time of discharge from the truck. Indicate the number of revolutions of the truck mixer.
- I. Temperature and Mixing Time Control
 1. In cold weather, do not allow the as-mixed temperature of the concrete and concrete temperatures at the time of placement in the forms to drop below 40 degrees F.
 2. If water or aggregate has been heated, combine water with aggregate in the mixer before cement is added. Do not add cement to mixtures of water and aggregate when the temperature of the mixture is greater than 90 degrees F.
 3. In hot weather, cool ingredients before mixing to maintain temperature of the concrete below the maximum placing temperature of 90 degrees F. If necessary, substitute well-crushed ice for all or part of the mixing water.
 4. Do not exceed the values shown in Table 2 for the maximum time interval between the addition of mixing water and/or cement to the batch and the placing of concrete in the forms.

TABLE 2
MAXIMUM TIME TO DISCHARGE OF CONCRETE

<u>Air or Concrete Temperature (whichever is higher)</u>	<u>Maximum Time</u>
80 to 90 Degree F (27 to 32 Degree C)	45 minutes
70 to 79 Degree F (21 to 26 Degree C)	60 minutes
40 to 69 Degree F (5 to 20 Degree C)	90 minutes

- a. If an approved high-range water-reducer (plasticizer) is used to produce plasticized concrete, the maximum time interval shall not exceed 90 minutes.

3.3 CONCRETE APPEARANCE

- A. Remix concrete mix showing either poor cohesion or poor coating of the coarse aggregate with paste. If this does not correct the condition, reject the concrete. If the slump is within the allowable limit, but excessive bleeding, poor workability, or poor finishability are observed, obtain changes in the concrete mix only by adjusting one or more of the following:
 1. The gradation of aggregate.
 2. The proportion of fine and coarse aggregate.
 3. The percentage of entrained air, within the allowable limits.
- B. Provide concrete for the work that results in a homogeneous structure which, when hardened, will have the required strength, durability and appearance. Provide mixtures and workmanship such that concrete surfaces, when exposed, will require no finishing. When concrete surfaces are stripped, the concrete, when viewed in good lighting from 10-ft away, shall be pleasing in appearance, and at 20-ft shall show no visible defects.

3.4 PLACING AND COMPACTING

- A. Placing
 1. Verify that all formwork completely encloses concrete to be placed and is securely braced prior to concrete placement. Remove ice, excess water, dirt and other foreign materials from forms. Confirm that reinforcement and other embedded items are securely in place. Have a competent workman at the location of the placement who can assure that reinforcing steel and embedded items remain in designated locations while concrete is being placed. Sprinkle semi-porous subgrades or forms to eliminate suction of water from the mix. Seal extremely porous subgrades in an approved manner.
 2. Deposit concrete as near its final position as possible to avoid segregation due to rehandling or flowing. Place concrete continuously at a rate which ensures the concrete is being integrated with fresh plastic concrete. Do not deposit concrete which has partially hardened or has been contaminated by foreign materials or on concrete which has hardened sufficiently to cause formation of seams or planes of weakness within the section. If the section cannot be placed continuously, place construction joints as specified or as approved.
 3. Pumping of concrete will be permitted. Use a mix design and aggregate sizes suitable for pumping and submit for approval.
 4. Remove temporary spreaders from forms when the spreader is no longer useful. Temporary spreaders may remain embedded in concrete only when made of galvanized metal or concrete and if prior approval has been obtained.
 5. Do not place concrete for supported elements until concrete previously placed in the supporting element (columns, slabs and/or walls) has reached adequate strength.

6. Where surface mortar is to form the base of a finish, especially surfaces designated to be painted, work coarse aggregate back from forms with a suitable tool to bring the full surface of the mortar against the form. Prevent the formation of excessive surface voids.
7. Slabs
 - a. After suitable bulkheads, screeds and jointing materials have been positioned, place the concrete continuously between construction joints beginning at a bulkhead, edge form, or corner. Place each batch into the edge of the previously placed concrete to avoid stone pockets and segregation.
 - b. Avoid delays in casting. If there is a delay in casting, thoroughly spade and consolidate at the edge of that previously placed and the concrete placed after the delay to avoid cold joints. Then bring concrete to correct level and strike off with a straightedge. Use bullfloats or darbies to smooth the surface, leaving it free of humps or hollows.
 - c. Where slabs are to be placed integrally with the walls below them, place the walls and compact as specified. Allow 1 hour to pass between placement of the wall and the overlying slab to permit consolidation of the wall concrete. Keep the top surface of the wall moist so as to prevent cold joints.
8. Formed Concrete
 - a. Place concrete in forms using tremie tubes and taking care to prevent segregation. Bottom of tremie tubes shall preferably be in contact with the concrete already placed. Do not permit concrete to drop freely more than 4-ft. Place concrete for walls in 12 to 24-inch lifts, keeping the surface horizontal. If plasticized concrete is used, the maximum lift thickness may be increased to 7-ft and the maximum free fall of concrete not exceeding 15-ft.
9. Perform underwater concreting in conformity with the recommendations of ACI 304R. The tremie system shall be used to place underwater concrete. Use tremie pipes in the range of 8 to 12-inch in diameter and space at not more than 16-ft on centers nor more than 8-ft from an end form. Where concrete is being placed around a pipe, provide at least one tremie pipe on each side of each pipe. Where the tremie system is not practical, direct pumped concrete for underwater placement may be used subject to approval of the system including details by the Engineer.

B. Compacting

1. Consolidate concrete by vibration, puddling, spading, rodding or forking so that concrete is thoroughly worked around reinforcement, embedded items and openings and into corners of forms. Continuously perform puddling, spading, etc, along with vibration of the placement to eliminate air or stone pockets which may cause honeycombing, pitting or planes of weakness.
2. Place and compact all concrete with mechanical vibrators. Obtain approval of the number, type and size of the units from the Engineer in advance of placing operations. Do not order concrete until sufficient approved vibrators (including standby units in working order) are on the job.
3. A minimum frequency of 7000 rpm is required for mechanical vibrators. Insert vibrators and withdraw at points from 18 to 30-in apart. At each insertion, vibrate sufficiently to consolidate concrete, generally from 5 to 15 seconds. Do not over vibrate so as to segregate. Keep a spare vibrator on the site during concrete placing operations.
4. Concrete Slabs: Consolidate concrete for slabs less than 8-in thick with vibrating screeds; slabs 8 to 12-in thick with internal vibrators and (optionally) with vibrating

screeds. Always place vibrators into concrete vertically and do not lay horizontally or over.

5. Walls and Columns: Use internal vibrators (rather than form vibrators) unless otherwise approved by the Engineer. In general, for each vibrator needed to melt down the batch at the point of discharge, one or more additional vibrators must be used to densify, homogenize and perfect the surface. Insert the vibrators vertically at regular intervals, through the fresh concrete and slightly into the previous lift, if any.
6. Amount of Vibration: Vibrators are to be used to consolidate properly placed concrete. Do not use vibrators to move or transport concrete in the forms. Continue vibration until:
 - a. Frequency returns to normal.
 - b. Surface appears liquefied, flattened and glistening.
 - c. Trapped air ceases to rise.
 - d. Coarse aggregate has blended into surface, but has not disappeared.

3.5 CURING AND PROTECTION

- A. Protect all concrete work against injury from the elements and defacements of any nature during construction operations.
- B. Curing Methods
 1. Curing Methods for Concrete Surfaces: Cure concrete to retain moisture and maintain specified temperature at the surface for a minimum of 7 days after placement. Use the following curing methods.
 - a. Water Curing: Keep entire concrete surface wet by ponding, continuous sprinkling or covered with saturated burlap. Begin wet cure as soon as concrete attains an initial set and maintain wet cure 24 hours a day.
 - b. Sheet Material Curing: Cover entire surface with sheet material. Securely anchor sheeting to prevent wind and air from lifting the sheeting or entrapping air under the sheet. Place and secure sheet as soon as initial concrete set occurs.
 - c. Liquid Membrane Curing: Apply over the entire concrete surface except for surfaces to receive additional concrete. Curing compound shall NOT be placed on any concrete surface where additional concrete is to be placed, where concrete sealers or surface coatings are to be used, or where the concrete finish requires an integral floor product. Apply curing compound as soon as the free water on the surface has disappeared and no water sheen is visible, but not after the concrete is dry or when the curing compound can be absorbed into the concrete. Comply with the manufacturer's application recommendations.
 2. Specified applications of curing methods.
 - a. Slabs for Water Containment Structures: Water curing only.
 - b. Slabs on Grade and Footings (not used to contain water): Water curing, sheet material curing or liquid membrane curing.
 - c. Structural Slabs (other than water containment): Water curing or liquid membrane curing.
 - d. Horizontal Surfaces which will Receive Additional Concrete, Coatings, Grout or Other Material that Requires Bond to the substrate: Water curing.
 - e. Formed Surfaces: None if nonabsorbent forms are left in place 7 days. Water cure if absorbent forms are used. Sheet cured or liquid membrane cured if forms are

removed prior to 7 days. Water cure exposed horizontal surfaces of formed walls or columns for 7 days or until next placement of concrete is made.

f. Concrete Joints: Water cured or sheet material cured.

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

D. Cold Weather Concreting:

1. "Cold weather" is defined as a period when for more than 3 successive days, the average daily outdoor temperature drops below 40 degrees F. Calculate the average daily temperature as the average of the highest and the lowest temperature during the period from midnight to midnight.
2. Conform cold weather concreting to ACI 306.1 and the additional requirements specified herein. Record temperatures at the concrete placement at 12 hour intervals (minimum).
3. Discuss a cold weather work plan with the Engineer. Discuss the methods and procedures proposed for use during cold weather including the production, transportation, placement, protection, curing and temperature monitoring of the concrete. Also discuss the procedures to be implemented upon abrupt changes in weather conditions or equipment failures. Do not begin cold weather concreting until the work plan is acceptable to the Engineer. Approval of the work Plan by the Engineer shall not relieve the Contractor of their sole responsibility for the quality of the concrete work produced.
4. During periods of cold weather, protect concrete to provide continuous warm, moist curing (with supplementary heat when required) for a total of at least 350 degree-days of curing.
 - a. Degree-days are defined as the total number of 24 hour periods multiplied by the weighted average daily air temperature at the surface of the concrete (eg: 5 days at an average 70 degrees F = 350 degree-days).
 - b. To calculate the weighted average daily air temperature, sum hourly measurements of the air temperature in the shade at the surface of the concrete taking any measurement less than 50 degrees F as 0 degrees F. Divide the sum thus calculated by 24 to obtain the weighted average temperature for that day.
5. Salt, manure or other chemicals shall not be used for protection.
6. Do not terminate the protection period for concrete being water cured during cold weather until at least 24 hours after water curing has been terminated.

E. Hot Weather Concreting

1. "Hot weather" is defined as any combination of high air temperatures, low relative humidity and wind velocity which produces a rate of evaporation estimated in accordance with ACI 305R, approaching or exceeding 0.2 lbs/sqft/hr.
2. Concrete placed during hot weather, shall be batched, delivered, placed, cured and protected in compliance with the recommendations of ACI 305R and the additional requirements specified herein.
 - a. Do not exceed 90 degrees F for the temperature of concrete being placed. The temperature of the concrete shall be such that it will cause no difficulties from loss of slump, flash set or cold joints.
 - b. Take all necessary precautions to promptly deliver, to promptly place the concrete upon its arrival at the job and to provide vibration immediately after placement.

- c. The Engineer may direct the Contractor to immediately cover plastic concrete with sheet material.
- 3. Provide the Engineer with a work plan describing the methods and procedures proposed to use for concrete placement and curing during hot weather periods. Do not begin hot weather concreting until the work plan is acceptable to the Engineer. Approval of the work plan by the Engineer shall not relieve the Contractor of their sole responsibility for the quality of the concrete work produced.

3.6 REMOVAL OF FORMS

- A. Except as otherwise specifically authorized by the Engineer, do not remove forms before the concrete has attained a strength of at least 30 percent of its specified design strength, nor before reaching the following number of day-degrees of curing (whichever is the longer):

TABLE 3
MINIMUM TIME TO FORM REMOVAL

<u>Forms for</u>	<u>Degree Days</u>
Beams and slabs	500
Walls and vertical surfaces	100

(See definition of degree-days in Paragraph 3.5.D above).

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

3.7 INSPECTION AND FIELD TESTING

- A. The batching, mixing, transporting, placing and curing of concrete are subject to the inspection of the Engineer at all times. Advise the Engineer of readiness to proceed at least 24 hours prior to each concrete placement. The Engineer or Inspector will inspect the preparations for concreting including the preparation of previously placed concrete, the reinforcing steel and the alignment, cleanliness and tightness of formwork. Do not place concrete without the inspection and acceptance of the Engineer or Inspector.
- B. Sets of field control cylinder specimens will be taken by the Engineer or Inspector during the progress of the work, in compliance with ASTM C31. Take a minimum of one set of concrete test cylinders per day, one set for each 150 cubic yards of concrete, or one set for each 5,000 sq ft of surface area for slabs or walls of each class of concrete placed each day.
 - 1. A "set" of test cylinders consists of five cylinders: one to be tested at 7 days and two to be tested and their strengths averaged at 28 days. The other two may be used for special tests at 3 days or to verify strength after 28 days if 28-day test results are low.
 - 2. When the average 28-day compressive strength of the cylinders in any set falls below the specified design strength or below proportional minimum 7-day strengths (where proper relation between seven and 28-day strengths have been established by tests), change proportions, water content, or temperature conditions to achieve the required strengths.
- C. Cooperate in the making of tests by allowing free access to the work for the selection of samples, providing an insulated closed curing box for specimens, affording protection to the specimens against injury or loss through the operations, and furnish material and labor required for the purpose of taking concrete cylinder samples. Provide an appropriate number of curing boxes acceptable to the Engineer.
- D. Slump tests will be made in the field immediately prior to placing the concrete. Make such tests in accordance with ASTM C143. Reject concrete if the slump is greater than the specified range.

- E. Air Content: Test for air content shall be made on a fresh concrete samples. Air content for concrete made of ordinary aggregates having low absorption shall be made in compliance with either the pressure method complying with ASTM C231 or by the volumetric method complying with ASTM C173. If lightweight aggregates or aggregates with high absorptions are used, the latter test method shall be used.
- F. The Engineer may have cores taken from any questionable area in the concrete work such as construction joints and other locations as required for determination of concrete quality. The results of tests on such cores shall be the basis for acceptance, rejection or determining the continuation of concrete work.
- G. Cooperate in obtaining cores by allowing free access to the work and permitting the use of ladders, scaffolding and such incidental equipment as may be required. Perform coring and collect core samples at the locations indicated by the Engineer and repair all core holes. The testing of the cores will be at the expense of the Owner. Owner will pay for collection and repair of cores if the test results meet the required specifications.

3.8 CONCRETE FINISHING

A. Walls

- 1. Type W-1 (Ordinary Wall Finish)
 - a. Patch tie holes.
 - b. Surface tolerance Class C as specified in ACI 117.
 - c. Knock off projections larger than ½-inch.
 - d. Patch defective areas.
- 2. Type W-2 (Smooth Wall Finish)
 - a. Patch tie holes.
 - b. Surface tolerance Class B as specified in ACI 117.
 - c. Grind off projections larger than ¼-inch.
 - d. Patch defective areas and repair rough spots resulting from form release agent failure or other reasons to provide smooth uniform appearance.
- 3. Type W-3 (Smooth Rubbed Wall Finish)
 - a. Surface tolerance Class A as specified in ACI 117.
 - b. Remove projections larger than 1/8-inch.
 - c. Only water curing will be permitted on walls being rubbed.
 - d. Perform rubbing while green concrete can be physically worked and smoothed without adding other materials, if structurally possible, the day following placement. Finish no later than 3 days after placement has been completed.
 - e. Remove forms at such a rate that finishing, form tie filling, removal of projections, and patching can be completed on same day forms are removed while curing wall.
 - f. After pointings have set sufficiently to permit working on surface, thoroughly saturate entire surface with water for period of 3 hours and rub until uniform surface is obtained.
 - g. Rub either by hand with carborundum stone of medium-coarse grade or abrasive of equal quality, or mechanically operated carborundum stone.
 - h. Obtain Engineer approval of mechanically operated carborundum stones before concrete finishing.

- i. Do not use cement grout, other than cement paste drawn from the concrete itself by rubbing process.
- j. Finishing past formed by rubbing by either brushing or floating as follows:
 - 1) Brushing:
 - a) Carefully strike with clean brush.
 - b) Brush in long direction of surface being finished.
 - 2) Floating:
 - a) Spread uniformly over surface and allow to reset.
 - b) Finish by floating with canvas, carpet face, or cork float, or rub down with dry burlap.
- k. Continue water curing of wall during finishing operation in areas not being rubbed.
- l. Move water curing onto rubbed areas as soon as water will not erode rubbed surface.

B. Slabs

1. General

- a. Finish slab concrete per the requirements of ACI 302.1R.
- b. Use manual screeds, vibrating screeds, or roller compacting screeds to place concrete level and smooth.
- c. Do not use “jitterbugs” or other special tools designed for purpose of forcing coarse aggregate away from surface and allowing layer or mortar, which will be weak and cause cracks or delamination, to accumulate.
- d. Do not dust surface with dry materials.
- e. Use evaporation retardant.
- f. Round off edges of slabs with steel edging tool, except where cove finish is shown. Use a steel edging tool with a ¼-inch radius for slabs subject to wheeled traffic.

2. Type S-1 (Steel Troweled Finish)

- a. Finish by screeding and floating with straightedges to bring surfaces to required finish elevation. Use evaporation retardant.
- b. While concrete is still green, but sufficiently hardened to bear a person’s weight without deep imprint, wood float to true, even plane with no coarse aggregate visible.
- c. Use sufficient pressure on wood floats to bring moisture to surface.
- d. After surface moisture has disappeared, hand trowel concrete to produce smooth, impervious surface, free from trowel marks.
- e. Burnish surface with an additional troweling. Final troweling shall produce ringing sound from trowel.
- f. Do not use dry cement or additional water during troweling, nor will excessive troweling be permitted.
- g. Power Finishing:
 - 1) Approved power machine may be used in lieu of hand finishing in accordance with directions of machine manufacturer.
 - 2) Do not use power machine when concrete has not attained necessary set to allow finishing without introducing high and low spots in slab.

- 3) Do first steel troweling for slab S-1 finish by hand.
 3. Type S-2 (Wood Float Finish)
 - a. Finish slab to receive fill and mortar setting bed by screeding with straightedges to bring surface to required finish plane.
 - b. Wood float finish to compact and seal surface.
 - c. Remove laitance and leave surface clean.
 - d. Coordinate with other finish procedures.
 4. Type S-3 (Underside Elevated Slab Finish)
 - a. When forming is removed, grind off projections on underside of slab and patch defective areas.
 5. Type S-4 (Broomed Finish)
 - a. Finish as specified for Type S-1 floor finish, except omit final troweling and finish surface by drawing fine-hair broom lightly across surface.
 - b. Broom in same direction and parallel to expansion joints, or, in the case of inclined slabs, perpendicular to slope, except for round roof slab.
 6. Type S-5 (Sidewalk Finish)
 - a. Slope sidewalk down 1/4-inch per foot away from structures, unless otherwise shown.
 - b. Strike off surface by means of strike board and float with wood or cork float to true plane, then flat steel trowel before brooming.
 - c. Broom surface at right angles to direction of traffic or as shown.
 - d. Lay out sidewalk surface in blocks, as shown or as directed by Engineer, with grooving tool.
- C. Beams and Columns
1. General: Inject cracks with crack repair epoxy as specified in Section 03 01 00. Patch and repair defective areas.
 2. Type B-1: Match wall Type W-1.
 3. Type B-2: Match wall Type W-2.
 4. Type B-3:
 - a. Repair rock pockets.
 - b. Fill air voids.
 - c. Match wall Type W-3.
 5. Type C-1: Match wall Type W-1.
 6. Type C-2: match wall Type W-2.
 7. Type C-3:
 - a. Repair rock pockets.
 - b. Fill air voids.
 - c. Match wall Type W-3.

3.9 FAILURE TO MEET REQUIREMENTS

- A. Should the strengths shown by the test specimens made and tested in compliance with the previous provisions fall below the values given in Table 1, the Engineer has the right to require changes in proportions outlined to apply to the remainder of the work. Furthermore, the Engineer has the right to require additional curing on those portions of the structure represented by the test specimens which failed. The cost of such additional curing shall be at the Contractor's expense. In the event that such additional curing does not give the strength required, as evidenced by core and/or load tests, the Engineer has the right to require strengthening or replacement of those portions of the structure which fail to develop the required strength. The cost of all such core borings and/or load tests and any strengthening or concrete replacement required because strengths of test specimens are below that specified, shall be entirely at the expense of the Contractor. In such cases of failure to meet strength requirements confer with the Engineer to determine what adjustment, if any, can be made in compliance with Sections titled "Strength" and "Failure to Meet Strength Requirements" of ASTM C94. The "purchaser" referred to in ASTM C94 is the Contractor in this Section.
- B. When the tests on control specimens of concrete fall below the specified strength, the Engineer will permit check tests for strengths to be made by means of typical cores drilled from the structure in compliance with ASTM C42 and C39. In the case of cores not indicating adequate strength, the Engineer, in addition to other recourses, may require, at the Contractor's expense, load tests on any of the slabs, beams, piles, caps, and columns in which such concrete was used. Tests need not be made until concrete has aged 60 days.
- C. Should the strength of test cylinders fall below 60 percent of the required minimum 28-day strength, the concrete shall be rejected and shall be removed and replaced.

3.10 PATCHING AND REPAIRS

- A. It is the intent of this Section to require quality work including adequate forming, proper mixture and placement of concrete and curing so completed concrete surfaces will require no patching.
- B. Repair defective concrete and honeycombed areas using methods complying with industry standards which meet the approval of the Engineer.
- C. As soon as the forms have been stripped and the concrete surfaces exposed, remove fins and other projections; fill recesses left by the removal of form ties; and repair surface defects which do not impair structural strength. Clean all exposed concrete surfaces and adjoining work stained by leakage of concrete, to approval of the Engineer.
- D. Immediately after removal of forms remove plugs and break off metal ties as required by Section 03 11 00. Promptly fill holes upon stripping as follows: Moisten the hole with water, followed by a 1/16-in brush coat of neat cement slurry mixed to the consistency of a heavy paste. Immediately plug the hole with a 1 to 1.5 mixture of cement and concrete sand mixed slightly damp to the touch (just short of "balling"). Hammer the grout into the hole until dense, and an excess of paste appears on the surface in the form of a spiderweb. Trowel smooth with heavy pressure. Avoid burnishing.
- E. When patching exposed surfaces use the same source of cement and sand as used in the parent concrete. Adjust color if necessary by addition of proper amounts of white cement. Rub lightly with a fine Carborundum stone at an age of 1 to 5 days if necessary to bring the surface down with the parent concrete. Exercise care to avoid damaging or staining the virgin skin of the surrounding parent concrete. Wash thoroughly to remove all rubbed matter.

3.11 SCHEDULE

- A. The following (Table 4) are the general applications for the various concrete classes and design strengths:

TABLE 4
CONCRETE SCHEDULE

Class	Design Strength (psi)	Description
A	2,500	Concrete fill and duct encasement
B	3,000	Concrete overlay slabs and pavements
C	4,000	Walls, slabs on grade, suspended slab and beam systems, columns, grade beams and all other structural concrete
C	5,000	Prestressed concrete

END OF SECTION

SECTION 03 60 00

GROUTING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	References
1.3	Submittals
1.4	Quality Assurance
1.5	Delivery, Storage, and Handling
1.6	Warranty
2.1	General
2.2	Grout Schedule
2.3	Materials
3.1	Preparation
3.2	Installation – General
3.3	Installation – Cement Grouts and Nonshrink Cementitious Grouts
3.4	Installation – Nonshrink Epoxy Grouts
3.5	Installation – Concrete Grout
3.6	Field Quality Control
3.7	Manufacturer’s Services

B. Scope

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

C. Related Requirements

1. Formwork is included in Section 03 11 00.
2. Concrete Joints and Joint Accessories are included in Section 03 15 00.
3. Concrete Reinforcement is included in Section 03 21 00.
4. Cast-in-Place Concrete is included in Section 03 30 00.

1.2 REFERENCES

A. American Society for Testing and Materials (ASTM)

1. C230 – Standard Specifications for Flow Table for Use in Tests of Hydraulic Cement
2. C531 - Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical Resistant Mortars, Grouts and Monolithic Surfacing and Polymer Concretes
3. C579 - Standard Test Method for Compressive Strength of Chemical Resistant Mortars, Grouts and Monolithic Surfacing and Polymer Concretes

4. C621 – Standard Specifications for Packaged Dry, Hydraulic-Cement Grout (Nonshrinkable)
 5. C827 - Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures
 6. C939 – Standard Test Method for Flow of Grout for Preplaced-aggregate Concrete (Flow Cone Method)
 7. C1107 – Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
- B. U.S. Army Corps of Engineers Standard (CRD)
1. CRD C-621 - Corps of Engineers Specification for Nonshrink Grout
- C. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.3 SUBMITTALS

A. Action Submittals/Informational Submittals

1. Product Data

- a. Data sheets for nonshrink cementitious grout and nonshrink epoxy grout to include:
 - 1) Catalog cut sheets.
 - 2) Technical data.
 - 3) Storage requirements.
 - 4) Product life.
 - 5) Working life time after mixing.
 - 6) Temperature considerations.
 - 7) Conformity to required ASTM standards.
 - 8) Material Safety Data Sheet
- b. Cement grout. Include the type and brand of the cement, the gradation of the fine aggregate, data on any proposed admixtures and the proposed mix of the grout.
- c. Concrete grout. Include data as required for concrete as delineated in Section 03 30 00 and for fiber reinforcement as delineated in Section 03 21 00. This includes the mix design, constituent quantities per cubic yard and the water/cement ratio.

2. Certificates

- a. Manufacturer’s Certificate of Compliance
 - 1) Grout free from chlorides and other corrosion-causing chemicals.
 - 2) Nonshrink grout properties of Category II and Category III, verifying expansion at 3 days or 14 days will not exceed the 28-day expansion and nonshrink properties are not based on gas or gypsum expansion.
 - 3) Certificate of Proper Installation.
- b. Certify that commercially manufactured grout products and concrete grout admixtures are suitable for use in contact with potable water after 30 days curing.

3. Test and Evaluation Reports

- a. Test results and service report from demonstration and training session.

- b. Field test reports and laboratory test results for field-drawn samples.
- 4. Manufacturer's Instructions
 - a. Adding fiber reinforcing to batching.
 - b. Cement-water ratio of grout topping.
 - c. Mixing of grout.
- 5. Special Procedure Submittals
 - a. Proposed method for keeping existing concrete surfaces wet prior to placing grout.
 - b. Forming method for fluid grout placement.
 - c. Curing method for grout.
- 6. Qualification Statements
 - a. Documentation that manufacturer has at least 10 years' experience in the production and use of the proposed grouts which they will supply.
 - b. Statement of Qualification: Nonshrink grout manufacturer's representative.

1.4 QUALITY ASSURANCE

A. Qualifications

1. Manufacturers

- a. Have a minimum of 10 years' experience in the production and use of the type of grout proposed for the Work.
- b. Manufacturer's Representative: Authorized and trained representative of grout manufacturer. Minimum 1-year direct personal experience that has resulted in the successful installation of grouts similar to those for this Project. Experience of the Manufacturer shall not be acceptable as a substitution for personal experience of the Representative.

B. Pre-installation Conference

- 1. A minimum of 14 days in advance of grouting, hold a pre-installation meeting to review the requirements for surface preparation, mixing, placing and curing procedures for each product proposed for use. Notify parties concerned with grouting of the meeting at least 10 days prior to its scheduled date.
- 2. Have a qualified field technician of the nonshrink grout manufacturer, specifically trained in the installation of the products, attend the pre-installation conference and be present for the initial installation of each type of nonshrink grout.

C. Field Samples

- 1. Owner will provide all field testing and inspection services required. Contractor shall assist in the sampling of materials and provide any ladders, platforms, etc., for access to the work. The methods of testing to comply in detail with the applicable ASTM Standards.
- 2. Field testing of Concrete Grout shall be as specified for concrete in Section 03 30 00.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements

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

2. Deliver nonshrink cement-based grouts as preblended, prepackaged mixes requiring only the addition of water.
3. Deliver nonshrink epoxy grouts as premeasured, prepackaged, three component systems requiring only blending as directed by the manufacturer.

B. Storage and Handling Requirements

1. Store materials in full compliance with the manufacturer's recommendations. Limit total storage time from date of manufacture to date of installation to 6 months or the manufacturer's recommended storage time, whichever is less.

1.6 WARRANTY

A. Manufacturer Warranty

1. Manufacturer's warranty shall not contain disclaimer on the product data sheet, grout bag, or container limiting responsibility to only the purchase price of products and materials furnished.
2. Manufacturer guarantees participation with Contractor in replacing or repairing grout found defective as a result of faulty materials, as determined by industry standard test methods.

PART 2 PRODUCTS

2.1 GENERAL

- A. The use of a manufacturer's name and product or catalog number is for the purpose of establishing the standard of quality desired. Such reference is not intended to indicate a restrictive preference on the part of the County for that particular manufacturer or product, or to prohibit the use of equivalent products or equally qualified manufacturers.
- B. Provide like materials as the products of one manufacturer or supplier in order to provide standardization of appearance.

2.2 GROUT SCHEDULE

A. General

1. General purpose nonshrink cementitious grout: Use at all locations where non shrink grout is called for on the plans except for base plates greater in area than 3-ft by 3-ft and except for the setting of anchor rods, anchor bolts or reinforcing steel in concrete.
2. Flowable nonshrink cementitious grout: Use under all base plates greater in area than 3-ft by 3-ft. Use at all locations indicated to receive flowable nonshrink grout by the Drawings. The Contractor, at his/her option and convenience, may also substitute flowable nonshrink grout for general purpose nonshrink cementitious grout.
3. Nonshrink epoxy grout: Use for the setting of anchor rods and bolts, reinforcing steel in concrete, and for all locations specifically indicated to receive epoxy grout.
4. Cement grout: Cement grout may be used for grouting of incidental base plates for structural and miscellaneous steel such as post base plates for platforms, base plates for beams, etc. It shall not be used when nonshrink grout is specifically called for on the Drawings or for grouting of primary structural steel members such as columns and girders.
5. Concrete grout: Use for overlaying the base concrete under scraper mechanisms of clarifiers to allow more control in placing the surface grade.

- B. Furnish nonshrink grout for applications in grout category in the following schedule:

Application	Temperature Range	Max. Placing Time	
	40° F to 100° F	20 Min.	> 20 Min.
Filling tie holes	I	I	I
Blockouts for gate guides	I or II		II
Precast joints	I or II		II
Column baseplates single-story	I or II		II
Machine bases 25 HP or less	II	II	II
Precast base joints higher than one story	II	II	II
Through-bolt openings	II	II	II
Machine bases 26 HP and up	III	III	III
Baseplates and/or soleplates w/ vibration, thermal movement, etc.	III	III	III

2.3 MATERIALS

A. Nonshrink Cementitious Grout

1. Category I

- a. Nonmetallic and nongas-liberating.
- b. Prepackaged natural aggregate grout requiring only the addition of water.
- c. Test in accordance with ASTM C1107/C1107M:
 - 1) Grout to have flowable consistency.
 - 2) Flowable for 15 minutes.
- d. Exhibits no shrinkage when tested in accordance with ASTM C827.
- e. Does not bleed at maximum allowable water.
- f. Minimum strength of flowable grout: 3,000 psi at 3 days, 5,000 psi at 7 days, and 7,000 psi at 28 days.
- g. Manufacturers and Products
 - 1) Sika Corp., SikaGrout 212.
 - 2) Euclid Chemical Co., Euco NS.
 - 3) BASF Building Systems, Inc., Construction Grout.
 - 4) Dayton Superior Corp., 1107 Advantage Grout.
 - 5) L&M Construction Chemicals, Inc., Duragrout.
 - 6) Engineer approved equal.

2. Category II

- a. Nonmetallic and nongas-liberating.
- b. Prepackaged natural aggregate grout requiring only the addition of water.
- c. No segregation or settlement of aggregate at fluid consistency at specified times or temperatures.
- d. Test in accordance with ASTM C1107/C1107M:
 - 1) Fluid consistency 20 seconds to 30 seconds in accordance with ASTM C939.
 - 2) Temperatures of 40 degrees F, 80 degrees F, and 100 degrees F.
- e. One hour after mixing, pass fluid grout through flow cone with continuous flow.

- f. Minimum strength of fluid grout: 3,500 psi at 1 day, 4,500 psi at 3 days, and 7,500 psi at 28 days.
- g. Maintain fluid consistency when mixed in 1 to 9 yard loads in ready mix truck.
- h. Manufacturers and Products
 - 1) Sika Corp., SikaGrout 212.
 - 2) Euclid Chemical Co., Hi-Flow Grout.
 - 3) BASF Building Systems, Inc., Master Flow 928.
 - 4) Dayton Superior Corp., Sure Grip High Performance Grout.
 - 5) L&M Construction Chemicals, Inc., Crystex.
 - 6) Engineer approved equal.

3. Category III

- a. Metallic and nongas-liberating.
- b. Prepackaged aggregate grout requiring only the addition of water.
- c. No segregation or settlement of aggregate at fluid consistency at specified times or temperatures.
- d. Test in accordance with ASTM C1107/C1107M:
 - 1) Fluid consistency 20 seconds to 30 seconds in accordance with ASTM C939.
 - 2) Temperatures of 40 degrees F and 100 degrees F.
- e. One hour after mixing, pass fluid grout through flow cone with continuous flow.
- f. Minimum strength of fluid grout: 4,000 psi at 1 day, 5,000 psi at 3 days, and 9,000 psi at 28 days.
- g. Maintain fluid consistency when mixed in 1 to 9 yard loads in ready mix truck.
- h. Manufacturers and Products
 - 1) BASF Building Systems, Inc., EMBECO 885.
 - 2) L&M Construction Chemicals, Inc., Ferrogrout.
 - 3) Engineer approved equal.

B. Nonshrink Epoxy Grout

- 1. Three component, 100 percent solids, epoxy based grout consisting of epoxy resin, hardener, and blended aggregate.
- 2. Minimum Strength: 14,000 psi at 7 days when tested in conformity with ASTM D695.
- 3. Maximum Thermal Expansion: 30×10^{-6} when tested in conformity with ASTM C531.
- 4. Manufacturers and Products
 - a. Sika Corp., Sikadur 42 Grout-Pak.
 - b. Master Builders Inc., Ceilcote 648.
 - c. Euclid Chemical Co., High Strength Epoxy Grout.
 - d. U.S. Grout Corp., Five Star Epoxy Grout.
 - e. Engineer approved equal.

C. Cement Grout

1. Mixture of one part portland cement conforming to ASTM C150, Types I, II, or III and 1 to 2 parts sand conforming to ASTM C33 with sufficient water to place the grout. Sufficient water content to impart workability to the grout but not to the degree that it will allow the grout to flow.

D. Concrete Grout

1. Conform to the requirements of Section 03 30 00 except as specified herein.
2. Proportioned with cement, pozzolan (if approved by Engineer), coarse and fine aggregates, water, water reducer and air entraining agent to produce a mix having an average strength of 2,900 psi at 28 days, or 2,500 psi nominal strength.
3. Maximum 1/2-inch coarse aggregate size.
4. Slump: As low as practical yet still retain sufficient workability. Maximum 5 inches.
5. Add synthetic reinforcing fibers as specified in Section 03 21 00 to the concrete grout mix at the rate of 1.5 lbs of fibers per cubic yard of grout. Add fibers from the manufacturer's premeasured bags and according to the manufacturer's recommendations in a manner which will ensure complete dispersion of the fiber bundles as single monofilaments within the concrete grout.

PART 3 EXECUTION

3.1 PREPARATION

- A. Place grout over cured concrete which has attained its full design strength unless otherwise approved by the Engineer.
- B. Prepare concrete surfaces to receive grout to be clean and sound; free of ice, frost, dirt, grease, oil, curing compounds, laitance and paints and free of all loose material or foreign matter which may affect the bond or performance of the grout.
- C. Roughen concrete surfaces by chipping, sandblasting, or other mechanical means to ensure bond of the grout to the concrete. Remove loose or broken concrete. Irregular voids or projecting coarse aggregate need not be removed if they are sound, free of laitance and firmly embedded into the parent concrete.
 1. Use oilless air compressors to clean surfaces in contact with grout or equip them with an oil trap in the air line to prevent oil from being blown onto the surface.
- D. Remove all loose rust, oil or other deleterious substances from metal embedments or bottom of baseplates prior to the installation of the grout.
- E. Wash concrete surfaces clean and keep moist for at least 24 hours prior to the placement of cementitious or cement grout. Achieve saturation by covering the concrete with saturated burlap bags, use of a soaker hose, flooding the surface, or other method acceptable to the Engineer. Upon completion of the 24-hour period, remove visible water from the surface prior to grouting. When approved by the Engineer for each specific location of grout installation, an adhesive bonding agent may be used in lieu of surface saturation.
- F. Epoxy-based grouts do not require the saturation of the concrete substrate. Completely dry surfaces in contact with epoxy grout prior to placing grout.
- G. Construct grout forms or other leakproof containment as required. Line or coat forms with release agents recommended by the grout manufacturer. Provide forms of adequate strength, securely anchored in place and shored to resist the forces imposed by the grout and its placement.
 1. Design forms for epoxy grout to allow the formation of a hydraulic head and provide chamfer strips built into forms.

- H. Level and align the structural or equipment bearing plates in accordance with the structural requirements and the recommendations of the equipment manufacturer.
- I. Support equipment during alignment and installation of grout by shims, wedges, blocks or other approved means. Prevent the shims, wedges and blocking devices from bonding to the grout by appropriate bond breaking coatings. Remove after grouting unless otherwise approved by the Engineer.

3.2 INSTALLATION – GENERAL

- A. Mix, apply and cure products in strict compliance with the manufacturer's recommendations and this Section.
- B. Have sufficient manpower and equipment available for rapid and continuous mixing and placing. Keep all necessary tools and materials ready and close at hand.
- C. Maintain temperatures of the foundation plate, supporting concrete, and grout between 40 and 90 degrees F during grouting and for at least 24 hours thereafter or as recommended by the grout manufacturer, whichever is longer. Take precautions to minimize differential heating or cooling of baseplates and grout during the curing period.
- D. Take special precautions for hot weather or cold weather grouting as recommended by the manufacturer when ambient temperatures and/or the temperature of the materials in contact with the grout are outside of the 60 and 90 degrees F range.
- E. Install grout in a manner which will preserve the isolation between the elements on either side of the joint where grout is placed in the vicinity of an expansion or control joint.
- F. Reflect all existing underlying expansion, control and construction joints through the grout.

3.3 INSTALLATION – CEMENT GROUTS AND NONSHRINK CEMENTITIOUS GROUTS

- A. Mix in accordance with manufacturer's recommendations. Do not add cement, sand, pea gravel or admixtures without prior approval by the Engineer.
- B. Avoid mixing by hand. Mixing in a mortar mixer (with moving blades) is recommended. Pre-wet the mixer and empty excess water. Add premeasured amount of water for mixing, followed by the grout. Begin with the minimum amount of water recommended by the manufacturer and then add the minimum additional water required to obtain workability. Do not exceed the manufacturer's maximum recommended water content.
- C. When approved by the manufacturer, include the addition of clean, washed pea gravel to the grout mix for placements greater than 3 inches in depth. Comply with the manufacturer's recommendations for the size and amount of aggregate to be added.
- D. Place grout into the designated areas in a manner which will avoid segregation or entrapment of air. Do not vibrate grout to release air or to consolidate the material. Placement should proceed in a manner which will ensure the filling of all spaces and provide full contact between the grout and adjoining surfaces. Provide grout holes as necessary.
- E. Place grout rapidly and continuously to avoid cold joints. Do not place cement grouts in layers. Do not add additional water to the mix (retemper) after initial stiffening.
- F. Just before the grout reaches its final set, cut back the grout to the substrate at a 45 degree angle from the lower edge of bearing plate unless otherwise approved by the Engineer. Finish this surface with a wood float (brush) finish.
- G. Begin curing immediately after form removal, cutback, and finishing. Keep grout moist and within its recommended placement temperature range for at least 24 hours after placement or longer if recommended by the manufacturer. Saturate the grout surface by use of wet burlap, soaker hoses, ponding or other approved means. Provide sunshades as

necessary. If drying winds inhibit the ability of a given curing method to keep grout moist, erect wind breaks until wind is no longer a problem or curing is finished.

3.4 INSTALLATION – NONSHRINK EPOXY GROUTS

- A. Mix in accordance with the procedures recommended by the manufacturer. Do not vary the ratio of components or add solvent to change the consistency of the grout mix. Do not over mix. Mix full batches only to maintain proper proportions of resin, hardener and aggregate.
- B. Monitor ambient weather conditions and contact the grout manufacturer for special placement procedures to be used for temperatures below 60 or above 90 degrees F.
- C. Place grout into the designated areas in a manner which will avoid trapping air. Use placement methods which ensure the filling of all spaces and provide full contact between the grout and adjoining surfaces. Provide grout holes as necessary.
- D. Minimize "shoulder" length (extension of grout horizontally beyond base plate). In no case shall the shoulder length of the grout be greater than the grout thickness.
- E. Finish grout by puddling to cover all aggregate and provide a smooth finish. Break bubbles and smooth the top surface of the grout in conformity with the manufacturer's recommendations.
- F. Epoxy grouts are self-curing and do not require the application of water. Maintain the formed grout within its recommended placement temperature range for at least 24 hours after placing, or longer if recommended by the manufacturer.

3.5 INSTALLATION – CONCRETE GROUT

- A. Screed underlying concrete to the grade shown on the Drawings. Provide the surface with a broomed finish, aligned to drain. Protect and keep the surface clean until placement of concrete grout.
- B. Remove the debris and clean the surface by sweeping and vacuuming of all dirt and other foreign materials. Wash the slab using a strong jet of water. Flushing of debris into drain lines will not be permitted.
- C. Saturate the concrete surface for at least 24 hours prior to placement of the concrete grout. Saturation may be maintained by ponding, by the use of soaker hoses, or by other methods acceptable to the Engineer. Remove excess water just prior to placement of the concrete grout. Place a cement slurry immediately ahead of the concrete grout so the slurry is moist when the grout is placed. Work the slurry over the surface with a broom until it is coated with approximately 1/16 to 1/8-in thick cement paste. A bonding grout composed of 1 part portland cement, 1.5 parts fine sand, an approved bonding admixture and water, mixed to achieve the consistency of thick paint, may be substituted for the cement slurry.
- D. Place concrete grout to final grade using the scraper mechanism as a guide for surface elevation and to ensure high and low spots are eliminated. Unless specifically approved by the equipment manufacturer, do not use mechanical scraper mechanisms as a finishing machine or screed.
- E. Provide grout control joints as indicated on the Drawings.
- F. Finish and cure the concrete grout as specified for cast-in-place concrete.

3.6 FIELD QUALITY CONTROL

- A. Evaluation and Acceptance of Grout
 - 1. Provide a flow cone and cube molds with restraining plates onsite. Continue tests during Project as demonstrated by grout manufacturer's representative.

2. For each 25 cubic feet of each type of grout used perform flow cone and bleed tests, and make three 2-inch by 2-inch cubes. Use restraining caps for cube molds in accordance with ASTM C1107/C1107M.
3. Consistency: As specified in paragraph 2.3, above. Reject grout with consistencies outside range requirements.
4. Segregation: As specified in paragraph 2.3, above. Reject grout if aggregate separates.
5. Grout cubes shall test equal to or greater than minimum strength specified.
6. Strength Test Failures: Remove and replace grout work failing strength tests.
7. Perform bleeding test to demonstrate grout will not bleed.
8. Store cubes at 70 degrees F.
9. Owner's independent testing laboratory shall prepare, store, cure, and test cubes in accordance with ASTM C1107/C1107M.

3.7 MANUFACTURER'S SERVICES

A. General

1. Coordinate demonstrations, training sessions, and applicable Site visits with grout manufacturer's representative.
2. Provide and conduct onsite demonstration and training sessions for bleed tests, mixing, flow cone measurement, cube testing, application, and curing for each category and type of grout.
3. Make the necessary equipment and materials available for demonstrations.

B. Training

1. Training is required for all Type II and Type III nonshrink cementitious and nonshrink epoxy grout installations.
2. Grout manufacturer's representative shall train Contractor to perform grout work.
3. Establish location at Site and schedule time for grout manufacturer's demonstration and training session of proposed nonshrink grouts. Mix nonshrink grouts to required consistency, test, place, and cure on actual Project, such as, baseplates and tie holes to provide actual on-the-job training.
4. Use minimum of five bags for each nonshrink grout type and category. Mix grout to fluid consistency and conduct flow cone and two bleed tests, make minimum of six cubes for testing of two cubes at 1 day, 3 days, and 28 days. Use remaining grout for final Work.
5. Include methods for curing grout in training sessions.
6. Mix and demonstrate patching through-bolt holes and blockouts for gate guides, and similar items.

END OF SECTION

SECTION 05 05 23

METAL FASTENINGS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	References
1.3	Submittals
1.4	Quality Assurance
1.5	Delivery, Storage, and Handling
2.1	General
2.2	Anchor Bolts and Anchor Bolt Sleeves
2.3	Concrete and Masonry Drilled Anchors
2.4	Welded Anchor Studs
2.5	Accessories
3.1	Cast-in-Place Anchor Bolts
3.2	Concrete and Masonry Drilled Anchors
3.3	Field Quality Control
3.4	Fastener Schedule

B. Scope

1. Furnish all labor, equipment, and materials required to install metal fasteners for anchoring and supporting structures and equipment.

1.2 REFERENCES

A. Definitions

1. Corrosive Area: Containment area, area exposed to delivery, storage, transfer, or use of chemicals, or area exposed to wastewater.
2. Exterior Area: Location not protected from weather by a building or other enclosed structure.
3. Interior Dry Area: Location inside building or structure where floor is not subject to liquid spills or washdown, nor where wall or roof slab is common to water-holding or earth-retaining structure.
4. Interior Wet Area: Location inside building or structure where floor is sloped to floor drains or gutters and is subject to liquid spills or washdown, or where wall, floor, or roof slab is common to a water-holding or earth-retaining structure.
5. Submerged: Location at or below top of wall of open water-holding structure, such as a basin or channel, or wall, ceiling, or floor surface inside a covered water-holding structure, or exterior below grade wall or roof surface of water-holding structure, open or covered.

B. Reference Standards

1. American Society for Testing and Materials (ASTM)
 - a. A36 - Standard Specification for Carbon Structural Steel
 - b. A48 - Standard Specification for Gray Iron Castings
 - c. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
 - d. A108 - Standard Specification for Steel Bars, Carbon, Cold Finished, Standard Quality
 - e. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - f. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
 - g. A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip
 - h. A276 - Standard Specification for Stainless Steel Steel Bars and Shapes
 - i. A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 Psi Tensile Strength
 - j. A325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
 - k. F436 – Specification for Hardened Steel Washers
 - l. F468 – Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use
 - m. F593 – Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
 - n. F594 – Specification for Stainless Steel Nuts
 - o. F844 – Specification for Washers, Steel, Plain (Flat), Unhardened for General Use
 - p. F1554 – Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
2. American Iron and Steel Institute (AISI)
 - a. Specification for Structural Steel Buildings
3. American Welding Society (AWS)
 - a. AWS D1.1 - Structural Welding Code Steel
 - b. AWS D1.2 - Structural Welding Code Aluminum
 - c. AWS D1.6 – Structural Welding Code Stainless Steel
4. Federal Specifications
 - a. FS-FF-B-575C – Bolts, Hexagonal and Square
5. American National Standards Institute (ANSI)
6. American Society of Mechanical Engineers (ASME)
 - a. ASME B1.1 – Unified-inch Screw Threads (UN and UNR Thread Form)
7. International Building Code. (IBC)
8. International Code Council (ICC): Evaluation Reports for Concrete and Masonry Anchors
9. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.3 SUBMITTALS

A. Action Submittals/Informational Submittals

1. Product Data
 - a. Concrete and Masonry Drilled Anchors
 - 1) Manufacturer's product description and installation procedures.
 - 2) Current test data or ICC Evaluation Report.
 - 3) Adhesive Anchor Installer Certification.
2. Shop Drawings
 - a. Shop Drawings showing sizes of members, method of assembly, anchorage and connection to other members.
 - b. Specific instructions for concrete anchor installation, including drilled hole size, preparation, placement, procedures, and instructions for safe handling of anchoring system
3. Samples
 - a. Submit samples as requested by the Engineer during the course of construction.
4. Certificates
 - a. Hot-Dip Galvanizing: Certificate of compliance signed by galvanizer with description of material processed and ASTM standard used for coating.
 - b. Certify that welders have been qualified under AWS, within the previous 12 months, to perform the welds required under this Section.

1.4 QUALITY ASSURANCE

- A. Completely coordinate the work of this with the work of other Sections. Verify, at the site, both the dimensions and work of other trades adjoining items of work in this Section before fabrication and installation of items herein specified.
- B. Furnish to the pertinent trades all items included under this Section that are to be built into the work of other Sections.
- C. Qualifications
 1. Adhesive Anchor Installers: Trained and certified by manufacturer.
 2. All welding shall be performed by qualified welders and shall conform to the applicable AWS welding code. Welding of steel shall conform to AWS D1.1, welding of aluminum shall conform to AWS D1.2, and welding of stainless steel shall conform to AWS D1.6.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements

1. Deliver items to be incorporated into the work of other trades in sufficient time to be checked prior to installation.
2. Repair items which have become damaged or corroded to the satisfaction of the Engineer prior to incorporating them into the work.

PART 2 PRODUCTS

2.1 GENERAL

A. Unless otherwise indicated, meet the following requirements:

Item	ASTM Reference
Stainless Steel	
Bolts, Threaded Rods, Anchor Bolts, and Anchor Studs	F593, AISI Type 316, Condition CW
Nuts	F594, AISI Type 316, Condition CW
Steel Bolts and Nuts	
Carbon Steel	A307 bolt, with A563 nuts
High-Strength	A325, Type 1 bolts, with A563 nuts
Anchor Bolts and Rods	F1554, Grade 55, with weld ability supplement S1
Eyebolts	A489
Threaded Rods	A36/A36M
Flat Washers (Unhardened)	F844
Flat and Beveled Washers (Hardened)	F436
Thrust Ties for Steel Pipe	
Threaded Rods	A193/A193M, Grade B7
Nuts	A194/A194M, Grade 2H
Plate	A283/A283M, Grade D
Welded Anchor Studs	A108, Grades C-1010 through C-1020

2.2 ANCHOR BOLTS AND ANCHOR BOLT SLEEVES

A. Cast-in-Place Anchor Bolts

1. Headed type, unless otherwise shown on Drawings.
2. Material type and protective coating as shown in Fastener Schedule at end of this section.

B. Anchor Bolt Sleeves

1. Plastic
 - a. Single unit construction with corrugated sleeve.
 - b. Top of sleeve shall be self-threading to provide adjustment of threaded anchor bolt projection.
 - c. Material: High density polyethylene.
 - d. Manufacturer: Sinco Products, Inc. or Engineer approved equal.
2. Fabricated Steel: ASTM A36/A36M.

2.3 CONCRETE AND MASONRY DRILLED ANCHORS

A. General

1. AISI Type 316 stainless, hot-dip galvanized, or zinc-plated steel as shown in Fastener Schedule at end of this section.
 2. Current evaluation and acceptance report by ICC or other similar code organization.
- B. Wedge Anchors
1. Manufacturers and Products:
 - a. Hilti, Inc. – Kwik-Bolt-3 (KB-3) Anchor.
 - b. ITW Ramset/Red Head – Trubolt Wedge Anchor.
 - c. Power Fasteners – Power-Stud Anchor.
 - d. Simpson Strong-Tie Co., Inc. – Wedge-All Anchor.
 - e. Wej-It Corp. – ANKRtite Wedge Anchor.
 - f. Adhesive Technologies – Kingpin Wedge Anchor.
 - g. Engineer approved equal.
- C. Expansion Anchors
1. Self-drilling anchors, snap-off or flush type, zinc-plated.
 2. Nondrilling Anchors: Flush type for use with zinc-plated or stainless steel bolt, or stud type with projecting thread stud.
 3. Manufacturers and Products:
 - a. Hilti, Inc. – Hilti HDI Drop-In Anchor.
 - b. ITW Ramset/Red Head – Multi-Set II Drop-In and Self Drill Anchor.
 - c. Powers Fasteners – Steel Drop-In Anchor.
 - d. Simpson Strong-Tie Co., Inc. – Drop-In Anchor.
 - e. Engineer approved equal.
- D. Undercut Anchors
1. Manufacturers and Products:
 - a. Hilti, Inc. – HAD Undercut Anchor.
 - b. USP Structural Connectors – DUC Undercut Anchor.
 - c. Engineer approved equal.
- E. Sleeve Anchors
1. Manufacturers and Products:
 - a. Hilti, Inc. – HSL-3 Heavy Duty Sleeve Anchor.
 - b. ITW Ramset/Red Head – Dynabolt Hex Nut Sleeve Anchor.
 - c. Power Fasteners – Hex Head Power-Bolt Anchor.
 - d. Simpson Strong-Tie Co., Inc. – Sleeve-All Hex Head Anchor.
 - e. Wej-It Corp. – Wej-It Sleeve Anchor.
 - f. Engineer approved equal.
- F. Adhesive Anchors
1. Threaded Rod
 - a. ASTM F593 stainless steel threaded rod, diameter as shown on Drawings.
 - b. Length as required to provide minimum depth of embedment.

- c. Clean and free of grease, oil, or other deleterious material.
 - d. For hollow-unit masonry, provide galvanized or stainless steel wire cloth screen tube to fit threaded rod.
2. Adhesive
- a. Two-component, insensitive to moisture, designed to be used in adverse freeze/thaw environments.
 - b. Cure Temperature, Pot Life, Workability: Compatible for intended use and anticipated environmental conditions.
 - c. Mixed Adhesive: Nonsag light paste consistency with ability to remain in a 1-inch diameter overhead drilled hole without runoff.
 - d. Meet requirements of ASTM C881/C881M.
 - e. Adhesive anchor system used in concrete shall be approved by ICC Evaluation Services Report for use in cracked concrete and for short and long term loads including wind and earthquake, and shall be approved for use with IBC 2006.
3. Adhesive Packaging and Storage:
- a. Disposable, self-contained cartridge system capable of dispensing both components in the proper mixing ratio and fitting into a manually or pneumatically operated caulking gun.
 - b. Store adhesive cartridge and adhesive components on pallets or shelving in a covered storage area.
 - c. Container Markings: Include manufacturer's name, product name, batch number, mix ratio by volume, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.
 - d. Dispose of when:
 - 1) Shelf life has expired.
 - 2) Stored other than in accordance with manufacturer's instructions.
4. Manufacturers and Products:
- a. Hilti, Inc. – HIT Doweling Anchor System, HIT RE 500 SD.
 - b. Simpson Strong-Tie Co., Inc. – SET-XP Epoxy Adhesive Anchors.
 - c. Engineer approved equal.
- G. Adhesive Threaded Inserts
- 1. Stainless steel, internally threaded insert.
 - 2. Manufacturer and Product:
 - a. Hilti, Inc. – HIS-R Insert with HIT RE 500 SD adhesive.
 - b. Engineer approved equal.

2.4 WELDED ANCHOR STUDS

- A. Headed anchor studs (HAS) or threaded anchor studs (TAS), as indicated on Drawings.
- 1. Carbon Steel: ASTM A108, Standard Quality Grades 1010 through 1020, inclusive either semikilled or killed aluminum or silicon dioxidation, unless indicated otherwise.
 - 2. Stainless Steel: ASTM F593, AISI Type 316, Condition CW, where indicated.
- B. Manufacturers:

1. Nelson Stud Welding, Fabrasteel Co.
2. Stud Welding Association, Inc.
3. Engineer approved equal.

2.5 ACCESSORIES

- A. Antiseizing Lubricant for Stainless Steel Threaded Connections:
 1. Suitable for potable water supply.
 2. Resists washout.
 3. Manufacturers and Products:
 - a. Bostik – Neverseez.
 - b. Saf-T-Eze Div., STL Corp. – Anti-Seize.
 - c. Engineer approved equal.

PART 3 EXECUTION

3.1 CAST-IN-PLACE ANCHOR BOLTS

- A. Accurately locate and hold anchor bolts in place with templates and the time concrete is placed.
- B. Use anchor bolt sleeves for location adjustment and provide two nuts and one washer per bolt of same material as bolt.
- C. Minimum Bolt Size: ½-inch diameter by 12 inches long, unless otherwise shown.

3.2 CONCRETE AND MASONRY DRILLED ANCHORS

- A. Begin installation only after concrete or masonry to receive anchor has attained design strength.
- B. Install in accordance with manufacturer’s instructions.
- C. Provide minimum embedment, edge distance, and spacing as follows, unless indicated otherwise by anchor manufacturer’s instructions or shown otherwise on Drawings:

Anchor Type	Min. Embedment (bolt diameters)	Min. Edge Distance (bolt diameters)	Min. Spacing (bolt diameters)
Wedge	9	6	12
Expansion and Sleeve	4	6	12
Undercut	9	12	16
Adhesive	9	9	13.5

- D. Use only drill type and bit type and diameter recommended by anchor manufacturer. Clean hole of debris and dust with brush and compressed air.
- E. For undercut anchors, use special undercutting drill bit and rotary hammer drill and apply final torque as recommended by anchor manufacturer.
- F. When embedded steel or rebar is encountered in the drill path, slant drill to clear obstruction. If drill must be slanted more than 10 degrees to clear obstruction, notify Engineer or Inspector for direction on how to proceed.
- G. Adhesive Anchors

1. Do not install adhesive anchors when temperature of concrete is below 40 degrees F or above 100 degrees F.
 2. Remove standing water from hole with oil free compressed air. Provide dry inside surface of hole where required by manufacturer's instructions.
 3. For hollow-unit masonry, install screen tube in accordance with manufacturer's instructions.
 4. Do not disturb anchor during recommended curing time.
 5. Do not exceed maximum torque as specified in manufacturer's instructions.
- H. Prestressed Concrete: Do not use drilled-in anchors in prestressed or post-tensioned concrete members without Engineer's prior approval unless specifically shown on Drawings.

3.3 FIELD QUALITY CONTROL

A. Welded Anchor Studs

1. At start of each production period, perform the following test to determine proper generator, control unit, and stud welding gun settings, in accordance with AWS D1.1, Chapter 7:
 - a. Weld two test studs and visually inspect for full 360-degree flash.
 - b. Bend test studs 30 degrees from vertical for headed anchor studs (HAS). Torque test threaded anchor studs (TAS) per AWS D1.1, Section 7.6.6.2.
 - c. Test studs will be acceptable if there is no failure of welds.
 - d. If weld fails, repeat test until two consecutive test studs test to be satisfactory.
2. During production, if visual inspection reveals that weld does not exhibit full 360-degree flash or that stud has been repaired by welding, perform the following test in accordance with AWS D1.1, Chapter 7:
 - a. HAS studs, bend stud approximately 15 degrees from vertical, away from missing portion of flash. For TAS studs, torque test per AWS D1.1, Section 7.6.6.2.
 - b. Studs meeting this test without exhibiting cracks in weld will be considered acceptable and left in bent position.
 - c. Replace studs failing test.
3. Special inspection will be provided by Owner where indicated on Drawings.

B. Concrete and Masonry Drilled Anchors: Special inspections and testing will be provided by Owner where indicated on Drawings.

C. Manufacturer Services

1. Adhesive Anchors: Conduct site training of installation personnel for proper installation, handling, and storage of adhesive anchor system. Notify Engineer of time and place for session.

3.4 FASTENER SCHEDULE

A. Unless indicated otherwise on the Drawings, provide fasteners and follows:

Service Use Location	Product	Remarks
1. Anchor Bolts Cast Into Concrete for Structural Steel, Metal Fabrications and Castings		
Interior Dry Areas	Stainless steel headed anchor bolts, unless indicated otherwise	
Exterior and Interior Wet Areas	Stainless steel headed anchor bolts	
Submerged and Corrosive Areas	Stainless steel headed anchor bolts with fusion bonded coating	See Section 09 91 00, Painting
2. Anchor Bolts Cast Into Concrete for Equipment Bases		
Interior Dry Areas	Stainless steel headed anchor bolts, unless otherwise specified with equipment	
Submerged, Exterior, Interior Wet, and Corrosive Areas	Stainless steel headed anchor bolts with fusion bonded coating, unless otherwise specified with equipment	See Section 09 91 00, Painting
3. Drilled Anchors for Metal Components to Cast-in-Place Concrete (e.g., Ladders, Handrail posts, Electrical Panels, and Equipment)		
Interior Dry Areas	Stainless steel wedge or expansion anchors	
Submerged, Exterior, Interior Wet, and Corrosive Areas	Adhesive stainless steel anchors	Use stainless steel undercut anchors for overhead and ceiling installations
4. Connections for Aluminum Components		
Submerged, Exterior, Interior Wet, and Corrosive Areas	Stainless steel bolted connections, unless otherwise specified with equipment	
5. All Others		
Exterior and Interior Wet and Dry Areas	Stainless steel fasteners	

- B. Antiseizing Lubricant: Use on all stainless steel threads.
- C. Do not use adhesive anchors to support fire-resistive construction or where ambient temperature will exceed 120 degrees F.

END OF SECTION

SECTION 05 57 00

MISCELLANEOUS METALS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	References
1.3	Submittals
1.4	Quality Assurance
1.5	Delivery, Storage, and Handling
1.6	Field Conditions
2.1	General
2.2	Steel Shelf Angles
2.3	Miscellaneous Aluminum
2.4	Miscellaneous Steel and Stainless Steel
2.5	Accessories
2.6	Fabrication
2.7	Source Quality Control
3.1	Installation of Metal Fabrications
3.2	Electrolytic Protection
3.3	Painting and Repair of Galvanized Steel

B. Scope

1. Furnish all labor, materials, equipment and incidentals required and install all miscellaneous metal complete as shown on the Drawings and as specified herein.

1.2 REFERENCES

A. Reference Standards

1. Aluminum Association (AA)
 - a. AA M31C22A41
 - 1) M31: Mechanical Finish, Fine Satin
 - 2) C22: Finish, Medium Matte
 - 3) A41: Clear Anodic Coating, Class I
2. American Society for Testing and Materials (ASTM)
 - a. A36 - Standard Specification for Carbon Structural Steel
 - b. A48 - Standard Specification for Gray Iron Castings
 - c. A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

- d. A108 - Standard Specification for Steel Bars, Carbon, Cold Finished, Standard Quality
 - e. A123 - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - f. A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
 - g. A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet and Strip
 - h. A276 - Standard Specification for Stainless Steel Steel Bars and Shapes
 - i. A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 Psi Tensile Strength
 - j. A325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
 - k. A366 - Standard Specification for Steel, Sheet, Carbon, Cold-Rolled, Commercial Quality
 - l. A500 - Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
 - m. A501 - Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
 - n. A536 – Standard Specification for Ductile Iron Castings
 - o. A570 - Standard Specification for Steel, Sheet and Strip, Carbon, Hot-Rolled, Structural Quality
 - p. B209 – Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
 - q. B221 – Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles and Tubes
 - r. B429 – Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube
- 3. American Iron and Steel Institute (AISI)
 - a. Specification for Structural Steel Buildings
 - 4. American Welding Society (AWS)
 - a. AWS D1.1 – Structural Welding Code Steel
 - b. AWS D1.2 – Structural Welding Code Aluminum
 - 5. Federal Specifications
 - a. FS-FF-B-575C – Bolts, Hexagonal and Square
 - 6. Occupational Safety and Health Administration (OSHA)
 - 7. International Building Code (IBC)
 - 8. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.3 SUBMITTALS

A. Action Submittals/Informational Submittals

1. Product Data

- a. Provide material data sheets for all metals provided under this section including material properties, production methods, etc.
2. Shop Drawings
 - a. Provide drawings, showing sizes of members, method of assembly, anchorage and connection to other members.
3. Certificates
 - a. Certify that welders have been qualified under AWS, within the previous 12 months, to perform the welds required under this Section.
 - b. Hot-Dip Galvanizing: Certificate of compliance signed by galvanizer with description of material processed and ASTM standard used for coating.
4. Delegated Design Submittals
 - a. Provide design calculations signed and sealed by a professional engineer registered in the State of Georgia for all fabricated structural supports, assemblies, and systems provided under this section.
5. Test and Evaluation Reports
 - a. Certified copy of mill test reports on each aluminum proposed for use showing the physical properties and chemical analysis.

1.4 QUALITY ASSURANCE

- A. The work of this Section shall be completely coordinated with the work of other Sections. Verify, at the site, both the dimensions and work of other trades adjoining items of work in this Section before fabrication and installation of items herein specified.
- B. Furnish to the pertinent trades all items included under this Section that are to be built into the work of other Sections.
- C. Qualifications
 1. Galvanized Coating Applicator: Company specializing in hot-dip galvanizing after fabrication and following procedures of Quality Assurance Manual for the American Galvanizers Association.
 2. All welding shall be performed by qualified welders and shall conform to the applicable AWS welding code. Welding of steel shall conform to AWS D1.1 and welding of aluminum shall conform to AWS D1.2.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Insofar as practical, factory assemble items specified herein. Assemblies that due to necessity have to be shipped unassembled shall be packaged and tagged in a manner that will protect materials from damage and will facilitate identification and field assembly.
- B. Deliver items to be incorporated into the work of other trades in sufficient time to be checked prior to installation.
- C. Package stainless steel items in a manner to provide protection from carbon impregnation.
- D. Protect painted coatings and hot-dip galvanized finishes from damage due to metal banding and rough handling. Use padded slings and straps.
- E. Store fabricated items in dry area, not in direct contact with ground.
- F. Repair items which have become damage or corroded to the satisfaction of the Engineer prior to incorporating them into the work.

1.6 FIELD CONDITIONS

- A. Field measurements shall be taken at the site, prior to fabrication of items, to verify or supplement indicated dimensions and to ensure proper fitting of all items.

PART 2 PRODUCTS

2.1 GENERAL

- A. For hot-dip galvanized steel that is exposed to view and does not receive paint, limit the combined phosphorus and silicon content to 0.04 percent. For steels that require a minimum of 0.15 percent silicon (such as plates over 1.5 inches thick for A36 steel), limit the maximum silicon content to 0.21 percent and the phosphorous content to 0.03 percent.
- B. Form all miscellaneous metal work true to detail, with clean, straight, sharply defined profiles and smooth surfaces of uniform color and texture and free from defects impairing strength or durability. Drill or punch holes. Provide smooth edges without burrs. Fabricate supplementary pieces necessary to complete each item though such pieces are not definitely shown or specified.
- C. Provide connections and accessories of sufficient strength to safely withstand the stresses and strains to which they will be subjected. Exposed joints shall be close fitting and jointed where least conspicuous. Conceal threads where practical for threaded connections. Provide continuous welds or intermittent welds as specified or shown for welded connections. Dress flush and smooth the face of welds. For aluminum items, perform welding on the unexposed side as much as possible in order to prevent pitting or discoloration of the aluminum exposed surface. Grind smooth continuous welds that will be exposed. Provide holes for temporary field connections and for attachment of the work of other trades.
- D. Unless otherwise indicated, meet the following requirements:

<u>Item</u>	<u>ASTM Reference</u>
Steel Shapes and Plates, unless otherwise noted	A36/A36M
Wide Flange Shapes including WT Sections	A992
Steel Pipe	A501 or A53/A53M, Type E or S, Grade B
Structural Steel Tubing	A500, Grade B
Stainless Steel	
Bars, Angles and Shapes	A276, AISI Type 316 (316L for welded connections)
Steel Plate, Sheet, and Strip	A240/A240M, AISI Type 316 (316L for welded connections)
Aluminum Plates and Structural Shapes	B209 and B308/B308M, Alloy 6061-T6
Cast Iron	A48, Class 35

2.2 STEEL SHELF ANGLES

- A. ASTM A36/A36M hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.

2.3 MISCELLANEOUS ALUMINUM

- A. Miscellaneous aluminum items include: beams, angles, closure angles, grates, hatches, floor plates, stop plates, stair nosings, and any other miscellaneous aluminum called for on the Drawings and not otherwise specified.
- B. Provide welded strap anchors on angle frames for hatches, beams, grates, etc.
- C. Provide clean and degreased mill finish for miscellaneous aluminum items.

2.4 MISCELLANEOUS STEEL AND STAINLESS STEEL

- A. Miscellaneous steel items include: beams, angles, lintels, support brackets, base plates for other than structural steel or equipment, closure angles, bridge crane rails, monorail hoist beams, holddown straps and lugs, door frames, splice plates, subframing at roof openings and any other miscellaneous steel called for on the Drawings and not otherwise specified.
- B. Miscellaneous stainless steel items include: beams, angles, bar racks and any other miscellaneous stainless steel called for on the Drawings and not otherwise specified.
- C. Shop coat with primer structural steel angle and channel door frames. Fabricate frames fabricated with not less than three anchors on each jamb.
- D. Provide Schedule 40 pipe for steel pipe pieces for sleeves, lifting attachments and other functions unless otherwise shown on the Drawings. Provide welded circumferential steel waterstops at mid-length on wall and floor sleeves, of steel pipe.
- E. Shop coat with primer lintels, relief angles or other steel supporting masonry or embedded in masonry.
- F. Thoroughly clean all steel finish work of all loose mill scale, rust and foreign matter and give one shop coat of primer compatible with the finish coat after fabrication but before shipment. Omit paint within 3 inches of proposed field welds. Apply paint to dry surfaces. Thoroughly and evenly spread paint and work into joints and other open spaces.
- G. Galvanizing, where required, shall be the hot-dip zinc process after fabrication. Coating shall be not less than 2 oz/sq ft of surface.

2.5 ACCESSORIES

- A. Neoprene Gaskets
 - 1. ASTM D1056, 2Cl, soft, closed-cell neoprene gasket material, suitable for exposure to sewage and sewage gases, unless otherwise shown on Drawings.
 - 2. Thickness: Minimum ¼-inch.
 - 3. Furnish without skin coat.

2.6 FABRICATION

- A. General
 - 1. Finish exposed surfaces smooth, sharp, and to well defined lines.
 - 2. Furnish necessary rabbets, lugs, and brackets so work can be assembled in neat, substantial manner.
 - 3. Conceal fastenings where practical; where exposed, flush countersink.
 - 4. Drill metalwork and countersink holes as required for attaching hardware or other materials.
 - 5. Grind cut edges smooth and straight. Round sharp edges to small uniform radius. Grind burrs, jagged edges, and surface defects smooth.

6. Fit and assemble in largest practical sections for delivery to Site.

B. Materials

1. Use steel shapes, unless otherwise noted.
2. Steel to be hot-dip galvanized: Limit silicon content to less than 0.04 percent or between 0.15 and 0.25 percent.
3. Fabricate aluminum in accordance with AA Specification for Aluminum Structures – Allowable Stress Design.

C. Welding

1. Weld connections and grind exposed welds smooth. When required to be watertight, make welds continuous.
2. Welded fabrications to be free from twisting or distortion caused by improper welding techniques.
3. Steel: Meet fabrication requirements of AWS D1.1, Section 5.
4. Aluminum: Meet requirements of AWS D1.2.
5. Stainless Steel: Meet Requirements of AWS D1.6.
6. Complete welding before applying finish.

D. Painting

1. Shop prime with rust-inhibitive primer as specified in Section 09 91 00 – Painting, unless otherwise indicated.
2. Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09 91 00 – Painting, unless otherwise indicated.
3. Do not apply protective coating to galvanized steel anchor bolts or galvanized steel welded anchor studs, unless otherwise indicated.

E. Galvanizing

1. Fabricate steel to be galvanized in accordance with ASTM A143, ASTM A384, and ASTM A385. Avoid fabrication techniques that could cause distortion or embrittlement of the steel.
2. Provide venting and drain holes for tubular members and fabricated assemblies in accordance with ASTM A385.
3. Remove welding slag, splatter, burrs, grease, oil, paint, lacquer, and other deleterious material prior to delivery for galvanizing.
4. Remove by blast cleaning or other methods surface contaminants and coatings not removable by normal chemical cleaning process in the galvanizing operation.
5. Hot-dip galvanize steel members, fabrications, and assemblies after fabrication in accordance with ASTM 123/A123M.
6. Hot-dip galvanize bolts, nuts, washers, and hardware components in accordance with ASTM A153/A153M. Oversize holes to allow for zinc alloy growth. Shop assemble bolts and nuts.
7. Galvanize steel sheets in accordance with ASTM A653.
8. Galvanize components of bolted assemblies separately before assembly. Galvanizing of tapped holes is not required.

- F. Watertight Seal: Where required or shown, furnish neoprene gaskets. Cover full bearing surfaces.
- G. Fitting: Where movement of fabrications is required or shown, cut, fit, and align items for smooth operation. Make corners square and opposite sides parallel.
- H. Accessories: Furnish as required for a complete installation. Fasten by welding or with stainless steel bolts or screws.

2.7 SOURCE QUALITY CONTROL

- A. Visually inspect all fabrication welds and correct any deficiencies.
 - 1. Steel: AWS D1.1, Section 6 and Table 6.1, Visual Inspection Acceptance Criteria.
 - 2. Aluminum: AWS D1.2.
 - 3. Stainless Steel: AWS D1.6
- B. Hot-Dip Galvanizing
 - 1. An independent testing agency will be retained by Owner to inspect and test hot-dip galvanized fabricated items in accordance with ASTM A123/A123M and ASTM A153/A153M.
 - 2. Visually inspect and test for thickness and adhesion of zinc coating for minimum of three test samples from each lot in accordance with ASTM A123/A123M and ASTM A153/A153M.
 - 3. Reject and retest nonconforming articles in accordance with ASTM A123/A123M and ASTM A153/A153M.

PART 3 EXECUTION

3.1 INSTALLATION OF METAL FABRICATIONS

- A. General
 - 1. Install metal fabrications plumb or level, accurately fitted, free from distortion or defects.
 - 2. Install rigid, substantial, and neat in appearance.
 - 3. Install manufacturer products in accordance with manufacturer's recommendations.
 - 4. Obtain Engineer approval prior to field cutting steel members or making adjustments not scheduled.
- B. Aluminum
 - 1. Do not remove mill markings from concealed surfaces.
 - 2. Remove inked or painted identification marks on exposed surfaces not otherwise coated after installed material has been inspected and approved.
 - 3. Provide fabrication, mechanical connections, and welded construction in accordance with the AA Aluminum Design Manual.
- C. U-Channel Concrete Inserts
 - 1. Provide as indicated for pipe supports and where otherwise shown on Drawings.
 - 2. Except for interior dry areas, use plastic clips or similar dielectric material to isolate channel anchors from concrete reinforcing steel.

3.2 ELECTROLYTIC PROTECTION

A. Aluminum and Galvanized Steel

1. Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09 91 00 – Painting, unless indicated otherwise.
2. Do not apply protective coating to galvanized steel anchor bolts or galvanized steel welded anchor studs, unless otherwise indicated.
3. Allow coating to dry before installation of the material.
4. Protect coated surfaces during installation.
5. Should coating become marred, prepare and touch up in accordance with paint manufacturer's written instructions.

B. Stainless Steel

1. During handling and installation, take necessary precautions to prevent carbon impregnation of stainless steel members.
2. After installation, visually inspect stainless steel surfaces for evidence of iron rust, oil, paint, and other forms of contamination.
3. Remove contamination in accordance with requirements of ASTM A380 and ASTM A967.
4. Brushes used to remove foreign substances shall utilize only stainless steel or nonmetallic bristles.
5. After treatment, visually inspect all surfaces for compliance.

3.3 PAINTING AND REPAIR OF GALVANIZED STEEL

A. Painted Galvanized Surfaces: Prepare as specified in Section 09 91 00 – Painting.

B. Repair of Damaged Hot-Dip Galvanized Coating

1. Conform to ASTM A780.
2. For minor repairs at abraded areas, use sprayed zinc conforming to ASTM A780.
3. For flame cut or welded areas, use zinc-based solder, or zinc sticks, conforming to ASTM A780.
4. Use magnetic gauge to determine thickness is equal to or greater than the base galvanized coating.

END OF SECTION

SECTION 07 92 01

SEALANTS AND CAULKING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	References
1.3	Submittals
1.4	Quality Assurance
1.5	Delivery, Storage, and Handling
1.6	Field Conditions
1.7	Warranty
2.1	Joint Sealers
2.2	Accessories
3.1	Preparation
3.2	Installation
3.3	Cleaning
3.4	Protection

B. Scope

1. Work covered by this Section consists of furnishing all labor, equipment and material required to install all joint sealants, including sealants and joint backing, pre-compressed foam sealers, and related accessories.

1.2 REFERENCES

A. Reference Standards

1. ASTM International
 - a. C834 – Standard Specification for Latex Sealants
 - b. C919 – Standard Practice for Use of Sealants in Acoustical Applications
 - c. C920 – Standard Specification for Elastomeric Joint Sealants
 - d. C1193 – Standard Guide for Use of Joint Sealants
 - e. D1056 – Standard Specification for Flexible Cellular Materials-Sponge or Expanded Rubber
 - f. D1667 – Standard Specification for Flexible Cellular Materials-Vinyl Chloride Polymers and Copolymers (Closed-Cell Foam)
 - g. D2628 – Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements

1.3 SUBMITTALS

A. Action Submittals/Informational Submittals

1. Product Data
 - a. Submit data indicating sealant chemical characteristics, performance criteria, substrate preparation, limitations, and color availability.
2. Samples
 - a. Submit two samples, 2-inch long by width of joint, illustrating sealant materials and colors for each type of sealant and joint filler selected.
3. Manufacturer's Instructions
 - a. Submit special procedures, surface preparation, and perimeter conditions requiring special attention.

1.4 QUALITY ASSURANCE

A. Qualifications

1. Manufacturers
 - a. Company specializing in manufacturing products specified in this section with minimum three years documented experience.
2. Applicators
 - a. Company specializing in performing Work of this section with minimum three years documented experience, and approved by manufacturer.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements

1. Deliver materials to the job site in sealed containers with the manufacturer's original labels attached and accompanied by written certification indicating compliance with requirements of these Specifications.

B. Storage and Handling Requirements

1. Store and use materials in strict conformance with the manufacturer's instructions.

1.6 FIELD CONDITIONS

A. Environmental Requirements

1. Ambient Conditions: Between 40 and 80 degrees F when sealant is applied. Consult manufacturer when sealant cannot be applied within these temperature ranges.

1.7 WARRANTY

A. Manufacturer Warranty

1. Provide a guarantee against defective or deficient materials and workmanship in accordance with requirements of the section titled "Warranties and Bonds" of these Specifications.
2. The following types of failures will be considered defective work and would require replacement: leakage, hardening, cracking, crumbling, melting, shrinking, or running of caulking compound, or staining of adjacent work by caulking compound.

PART 2 PRODUCTS

2.1 JOINT SEALERS

A. Manufacturers

1. Dow Corning Corp.
2. GE Silicones
3. Pecora Corp
4. Sika Corp.
5. Tremco Sealants & Waterproofing
6. Construction Specialties, Inc. (Masonry Expansion Joint Filler)
7. Engineer approved equal

B. Product Description

1. High Performance General Purpose Exterior (Non-traffic) Sealant: Silicone; ASTM C920, Grade NS, Class 50, Uses M, G, and A; single component.
 - a. Color: Colors as selected.
 - b. Warranty: 20 years.
 - c. Applications: Use for:
 - 1) Control, expansion, and soft joints in masonry.
 - 2) Joints between concrete and other materials.
 - 3) Joints between metal frames and other materials.
2. General Purpose Exterior (Non-traffic): Acrylic, solvent release curing; ASTM C920, Grade NS, Class 12-1/2, Uses M, G, and A; single or multi- component.
 - a. Color: Standard colors matching finished surfaces Colors as selected.
 - b. Applications: Use for:
 - 1) Joints between concrete and other materials.
 - 2) Joints between metal frames and other materials.
 - 3) Other exterior non-traffic joints for which no other sealant is indicated.
3. General Purpose Traffic Bearing Sealant: Polyurethane; ASTM C920, Grade P, Class 25, Use T; single or multi- component.
 - a. Color: Standard colors matching finished surfaces.
 - b. Applications: Use for exterior and interior pedestrian and vehicular traffic bearing joints.
4. Exterior Compressible Gasket Expansion Joint Sealer: ASTM D2628, hollow neoprene (polychloroprene) compression gasket.
 - a. Color: Black color.
 - b. Size and Shape: As indicated on Drawings.
 - c. Applications: Use for exterior expansion joints at walls.
5. General Purpose Interior Sealant: Acrylic emulsion latex; ASTM C834, single component, paintable.
 - a. Color: Standard colors matching finished surfaces, as selected.
 - b. Applications: Use for interior wall and ceiling control joints, joints between door and window frames and wall surfaces, and other interior joints for which no other type of sealant is indicated.

- c. Interior Sealants and Sealant Primers: Maximum volatile organic compound content in accordance with SCAQMD Rule 1168.
- 6. Sealant - Acrylic Sealant: ASTM C920, Grade NS, Class 12-1/2, Uses NT, M, A, O; single component, solvent curing, non-staining, non-bleeding, non-sagging.
 - a. Color: Standard colors matching finished surfaces.
 - b. Movement Capability: Plus and minus 12-1/2 percent.
 - c. Service Temperature Range: -13 to 180 degrees F.
 - d. Shore A Hardness Range: 25 to 50.
 - e. Interior Sealants and Sealant Primers: Maximum volatile organic compound content in accordance with SCAQMD Rule 1168.
- 7. Resilient Filler: Polyurethane foam, impregnated with a waterproof polymer sealing compound.
 - a. Type: VF Joint Sealant manufactured by Construction Specialties, Inc.
 - b. Color: Selected to match mortar color.
 - c. Movement capability: plus and minus 50%
 - d. Service temperature range: -40 to 180 degrees F.
 - e. Shore A Hardness of 15 points Durometer
 - f. Applications: Use for Expansion Joint filler at Brick masonry.

2.2 ACCESSORIES

- A. Primer: Non-staining type, recommended by sealant manufacturer to suit application.
 - 1. Interior Sealants and Sealant Primers: Maximum volatile organic compound content in accordance with SCAQMD Rule 1168.
- B. Joint Cleaner: Non-corrosive and non-staining type, recommended by sealant manufacturer; compatible with joint forming materials.
- C. Joint Backing: Round foam rod compatible with sealant; ASTM D1056, sponge or expanded rubber D1667, closed cell PVC; oversized 30 to 50 percent larger than joint width.
- D. Bond Breaker: Pressure sensitive tape recommended by sealant manufacturer to suit application.

PART 3 EXECUTION

3.1 PREPARATION

- A. Verify substrate surfaces and joint openings are ready to receive work.
- B. Verify joint backing and release tapes are compatible with sealant.
- C. Remove loose materials and foreign matter impairing adhesion of sealant.
 - 1. Wipe metal surfaces with Zylol, Mek or equal and allow to dry.
 - 2. Clean masonry surfaces with wire brush and then blow clean. Completely remove any waterproofing treatments contaminating the joint.
- D. Prime joints as recommended by sealant manufacturer.
- E. Perform preparation in accordance with ASTM C1193.
- F. Protect elements surrounding Work of this section from damage or disfiguration.

3.2 INSTALLATION

- A. Perform installation in accordance with ASTM C1193.
- B. Perform acoustical sealant application work in accordance with ASTM C919.
- C. Measure joint dimensions and size joint backers to achieve width-to-depth ratio, neck dimension, and surface bond area as recommended by manufacturer, except where specific dimensions are indicated.
- D. Install bond breaker where joint backing is not used.
- E. Install sealant free of voids, air pockets, foreign embedded matter, ridges, and sags.
- F. Apply sealant within recommended application temperature ranges. Consult manufacturer when sealant cannot be applied within these temperature ranges.
- G. Tool joints concave.
- H. Pre-compressed Foam Sealant: Do not stretch; avoid joints except at corners, ends, and intersections; install with face 1/8 to 1/4 inch below adjoining surface.
- I. Compression Gaskets: Avoid joints except at ends, corners, and intersections; seal joints with adhesive; install with face 1/8 to 1/4 inch below adjoining surface.

3.3 CLEANING

- A. Comply with requirements of Section 01 74 23 – Cleaning and Waste Management
- B. Clean adjacent soiled surfaces.
- C. Replace or repair to Owner's satisfaction damaged surfaces resulting from sealing or cleaning.

3.4 PROTECTION

- A. Protect sealants until cured.

END OF SECTION

SECTION 09 91 00

PAINTING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	References
1.3	Administrative Requirements
1.4	Submittals
1.5	Quality Assurance
1.6	Delivery, Storage, and Handling
1.7	Field Conditions
1.8	Testing Equipment
1.9	Warranty
2.1	Manufacturers
2.2	Paint Materials
2.3	Paint Schedule
2.4	Abrasive Materials
2.5	Accessories
2.6	Mixing
2.7	Shop Finishes
3.1	Examination
3.2	Protection of Surfaces Not Scheduled to be Coated
3.3	Surface Preparation of Steel
3.4	Surface Preparation of Galvanized Steel and Nonferrous Metal
3.5	Surface Preparation of Ductile or Cast Iron
3.6	Surface Preparation of Concrete
3.7	Surface Preparation of Concrete Floors
3.8	Application
3.9	Repair
3.10	Field Quality Control
3.11	Cleaning
3.12	Protection of Coating Systems
3.13	One-Year Inspection
3.14	Pipe Coding
3.15	Color Schedule

B. Scope

1. In general, work included under this section includes the surface preparation, shop priming, field priming, and/or field painting of all exposed items and surfaces throughout the project, unless otherwise indicated.
2. Paint all exposed items and surfaces using the appropriate paint system as specified herein. Coating system schedules and finish schedules may be provided herein and/or on the Drawings, which identify specific paint systems and paint colors to be used on specific items and surfaces. However, these schedules do not necessarily cover all items to be painted. Where the selection of a specific painting system for a particular application is not clear, it is the Contractor's responsibility to request clarification from the Engineer.
3. Surface preparation, priming, and coats of paint specified are in addition to shop priming and surface pretreatment specified in other sections, unless otherwise indicated.
4. Paint all exposed surfaces except where the natural finish of the material is obviously intended to be the finished surface or if the surface is specifically noted not to be painted.
5. In general, items to be painted include:
 - a. All exposed exterior surfaces including:
 - 1) Concrete block.
 - 2) Equipment supports.
 - 3) Pipe, valves, fittings, hydrants, and appurtenances.
 - 4) Ductwork and appurtenances.
 - 5) Non-galvanized conduit and appurtenances.
 - 6) Interior and exterior surfaces of ferrous metal tankage.
 - 7) Ferrous metals.
 - 8) All factory primed steel doors and equipment.
 - 9) Exposed untreated wood.
 - 10) All other surfaces subject to corrosion.
 - b. All exposed interior surfaces including:
 - 1) All wall surfaces in all spaces unless specifically noted not to be painted.
 - 2) All columns, equipment pads, pipe supports, and appurtenances.
 - 3) Pipe, valves, fittings, hydrants, and appurtenances.
 - 4) Ductwork and appurtenances.
 - 5) All electrical conduit unless specifically noted not to be painted.
 - 6) All hangers and supports for overhead items.
 - 7) Ferrous metals.
 - 8) All factory primed steel doors and equipment.
 - 9) Exposed untreated wood.
 - 10) All other surfaces subject to corrosion.

- c. Equipment that does not have an approved final coat or does not have the appropriate finished color as directed by the Engineer.
 - d. All equipment that has been damaged by the existing construction as directed by the Engineer.
 - e. All existing or new items and surfaces damaged by construction as directed by the Engineer.
6. In general, items NOT to be painted include:
- a. Items with Engineer approved factory finish.
 - b. Electrical equipment unless specifically noted.
 - c. Surfaces hidden from view including piping, conduit, ducts, and insulation. Note, the manufacturer's standard coatings, if any, may remain.
 - d. Stainless steel surfaces except piping or tubing.
 - e. Aluminum surfaces except:
 - 1) Where specifically noted to be painted.
 - 2) Where embedded in or in contact with concrete.
 - 3) Where in contact with dissimilar metals.
 - 4) Piping or tubing.
 - f. Fiberglass surfaces except piping and piping appurtenances.
 - g. Interior of pipe, ductwork, and conduits.
 - h. Moving parts of mechanical and electrical units where painting would interfere with the operation of the unit.
 - i. Code labels and equipment identification and rating plates.
 - j. Exterior concrete or pre-cast concrete surfaces.
 - k. Galvanized metal surfaces except interior conduit.
 - l. Face brick, ceramic tile, plastic laminate.
 - m. Concealed deck except where specifically specified to be painted.
 - n. Pre-finished metal.
 - o. Interior and exterior of concrete basins, vaults, and tanks unless noted otherwise.

1.2 REFERENCES

A. Abbreviations and Acronyms

- 1. FRP: Fiberglass Reinforced Plastic.
- 2. HCl: Hydrochloric Acid.
- 3. MDFT: Minimum Dry Film Thickness, mils.
- 4. MDFTPC: Minimum Dry Film Thickness per Coat, mils.
- 5. Mil: Thousandth of an inch.
- 6. PDS: Product Data Sheet.
- 7. PSDS: Paint System Data Sheet.
- 8. SFPG: Square Feet per Gallon.
- 9. SFPGPC: Square Feet per Gallon per Coat.

10. SP: Surface Preparation.

B. Definitions

1. Definitions of Painting Terms: ASTM D16, unless otherwise specified.
2. Coverage: Total minimum dry film thickness in mils or square feet per gallon.
3. Dry Film Thickness (DFT): Thickness of a coat of paint in fully cured state measured in mils (1/1000 inch).

C. Reference Standards

1. American Water Works Association (AWWA):
 - a. C116, Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings.
 - b. C203, Coal-Tar Protective Coatings and Linings for Steel Water Pipelines – Enamel and Tape – Hot Applied.
 - c. C209, Cold-Applied Tape Coatings for Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
 - d. C213, Fusion-Bonded Epoxy Coating for Interior and Exterior of Steel Water Pipelines.
 - e. C214, Tape Coating Systems for the Exterior of Steel Water Pipelines.
2. Environmental Protection Agency (EPA).
3. NACE International (NACE): RP0188, Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
4. Occupational Safety and Health Act (OSHA).
5. The Society for Protective Coatings (SSPC):
 - a. PA 2, Measurement of Dry Coating Thickness with Magnetic Gages.
 - b. PA 3, Guide to Safety in Paint Applications.
 - c. SP 1, Solvent Cleaning.
 - d. SP 2, Hand Tool Cleaning.
 - e. SP 3, Power Tool Cleaning.
 - f. SP 5, White Metal Blast Cleaning.
 - g. SP 6, Commercial Blast Cleaning.
 - h. SP 7, Joint Surface Preparation Standard Brush-off Blast Cleaning.
 - i. SP 10, Near-White Blast Cleaning.
 - j. SP 11, Power Tool Cleaning to Bare Metal.
 - k. SP 12, Surface Preparation and Cleaning of Metals Waterjetting Prior to Recoating.
 - l. SP 13, Surface Preparation of Concrete.
 - m. Guide 15, Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates.

1.3 ADMINISTRATIVE REQUIREMENTS

A. Pre-application Meetings

1. Convene a pre-application meeting two weeks before start of application of coating systems. Attendance of parties directly affecting work of this section, including

Contractor, Engineer, Applicator, Manufacturer's Representative and Independent Testing and Inspection Agencies with NACE III Inspector, is required. The meeting shall cover, but not be limited to, the following:

- a. Environmental requirements.
- b. Protection of surfaces not scheduled to be coated.
- c. Surface preparation.
- d. Application.
- e. Repair.
- f. Field quality control.
- g. Cleaning.
- h. Protection of coating systems.
- i. One-year inspection.
- j. Coordination with other work.

1.4 SUBMITTALS

A. Action Submittals/Informational Submittals

1. Product Data

- a. For each product, furnish a Product Data Sheet (PDS), the manufacturer's technical data sheets, and paint colors available (where applicable). The PDS form is appended to the end of this section.
- b. For each paint system, furnish a Paint System Data Sheet (PSDS). The PSDS form is appended to the end of this section.
- c. Technical and performance information that demonstrates compliance with Specifications.
- d. Furnish copies of paint system submittals to the coating applicator.
- e. Indiscriminate submittal of only manufacturer's literature is not acceptable.
- f. Detailed chemical and gradation analysis for each proposed abrasive material.

2. Samples

- a. Proposed Abrasive Materials: Minimum 5-pound sample for each type.
- b. Reference Panel:
 - 1) Surface Preparation:
 - a) Prior to start of surface preparation, furnish a 4-inch by 4-inch steel panel for each grade of sandblast specified herein, prepared to specified requirements.
 - b) Provide panel representative of the steel used; prevent deterioration of surface quality.
 - c) Panel to be reference source for inspection upon approval of Engineer.
 - 2) Paint:
 - a) Unless otherwise specified, before painting work is started, prepare minimum 8-inch by 10-inch sample with type of paint and application specified on similar substrate to which paint is to be applied.

- b) Furnish additional samples as required until colors, finish, and textures are approved.
 - c) Approved samples to be the quality standard for final finishes.
- 3. Certificates
 - a. Coating Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33 – Manufacturer Services.
 - b. Factory Applied Coatings: Manufacturer's certification stating factory applied coating system meets or exceeds requirements specified.
 - c. Manufacturer's written verification that submitted material is suitable for the intended use.
 - d. If the manufacturer of finish coating differs from that of shop primer, provide finish coating manufacturer's written confirmation that materials are compatible.
- 4. Manufacturer's Instructions
 - a. Manufacturer's written instructions and special details for applying each type of paint.
- 5. Warranty Documentation
 - a. Submit a complete description of the warranty to be provided.
- 6. Special Procedure Submittals
 - a. Paint Schedule:
 - 1) Submit a schedule of all items (structures, equipment, pipe, etc.) to be painted prior to beginning painting operations. Schedule shall include, but not be limited to, items to be painted, surface preparation, paint system, and color. Submit the schedule to the Engineer for approval at which time the Engineer will select the colors to be used that are not specified herein or on the Drawings.
- 7. Qualification Statements
 - a. Manufacturer's Qualifications:
 - 1) List of references demonstrating successful performance on similar projects of the product being provided.
 - b. Applicator's Qualifications:
 - 1) List of references substantiating experience. Include size of project, timeframe when work was completed, and type of product used.
 - 2) Documentation from manufacturer stating applicator is a certified for application of the specific product.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements

- 1. Meet federal, state, and local requirements limiting the emission of volatile organic compounds.
- 2. Perform surface preparation and painting in accordance with recommendations of the following:
 - a. Paint manufacturer's instructions.
 - b. SSPC PA 3, Guide to Safety in Paint Applications.

c. Federal, state, and local agencies having jurisdiction.

B. Qualifications

1. Manufacturers

- a. Specialize in manufacture of coatings with a minimum of 10 years successful experience.
- b. Able to demonstrate successful performance on comparable projects.
- c. Single Source Responsibility
 - 1) Coatings and coating application accessories shall be products of a single manufacturer.

2. Applicators

- a. Experienced in application of specified coatings for a minimum of 5 years on projects of similar size and complexity to this work.
- b. Applicator's Personnel
 - 1) Employ persons trained for surface preparation and application of specified coatings.

C. Manufacturer's Representative During Painting Operations

1. An authorized Manufacturer's representative, with qualifications as stated herein, shall be present at the start-up and weekly during painting operations. Such representative shall inspect, instruct, and observe the Contractor's and Applicator's work and shall, at the completion of work, certify in writing to the Engineer that the Manufacturer's application recommendations have been adhered to. The cost of this work shall be borne by the Contractor.
2. Manufacturer's technical representative or authorized inspector shall be currently certified by NACE (minimum NACE III certification) or SSPC.

D. Testing Agencies

1. The Owner may employ coating inspectors and materials testing agencies to examine and test installation.
2. Repair or replace defective work discovered at no cost to the Owner.

E. Mock-ups

1. Before proceeding with Work under this section, finish one complete space or item of each color scheme required showing selected colors, finish texture, materials, quality of work, and special details.
2. After Engineer approval, sample spaces or items will be the quality standard for similar work throughout the Project.

F. Inspections

1. All coating products to be installed under this Contract may be inspected at the manufacturer's facilities or plant for compliance with these specifications by an independent testing laboratory provided by the Owner. Require the manufacturer's cooperation in these inspections. Cost for facility or plant inspections to be paid for by the Owner.
2. Inspections of the coating products and materials may also be made by representatives of the Owner after delivery.

3. The products and materials shall be subject to rejection at any time on account of failure to meet any of the Specification requirements, even though samples may have been accepted as satisfactory at the place of manufacturing.
4. Materials rejected after delivery shall be marked for identification and removed from the site.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements

1. Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly identifying:
 - a. Coating or material name.
 - b. Manufacturer.
 - c. Color name and number.
 - d. Batch or lot number.
 - e. Date of manufacture.
 - f. Mixing and thinning instructions.

B. Storage and Handling Requirements

1. Store materials in a clean dry area and within temperature range in accordance with Manufacturer's instructions.
2. Keep containers sealed until ready for use.
3. Do not use materials beyond Manufacturer's shelf life limits.
4. Protect materials during handling and application to prevent damage or contamination.

1.7 FIELD CONDITIONS

A. Environmental Requirements

1. Weather
 - a. Air and Surface Temperatures
 - 1) Prepare surfaces and apply and cure coatings within air and surface temperature range in accordance with Manufacturer's instructions.
 - b. Surface Temperature
 - 1) Minimum of 5°F (3°C) above dew point.
 - c. Relative Humidity
 - 1) Prepare surfaces and apply and cure coatings within relative humidity range in accordance with Manufacturer's instructions.
 - d. Precipitation
 - 1) Do not prepare surfaces or apply coatings in rain, snow, fog, or mist.
 - e. Wind
 - 1) Do not spray coatings if wind velocity is above manufacturer's limit. Contractor shall be solely responsible for costs associated with restoration of any areas, equipment, structures, or surfaces impacted by overspray or splatter resulting from the application of coatings during windy conditions.

2. Ventilation

- a. Provide ventilation during coating evaporation stage in confined or enclosed areas in accordance with AWWA D102.
3. Dust and Contaminants
 - a. Schedule coating work to avoid excessive dust and airborne contaminants.
 - b. Protect work areas from excessive dust and airborne contaminants during coating application and curing.

1.8 TESTING EQUIPMENT

- A. Furnish and make available to the Engineer the following items of testing equipment for use in determining if requirements of this section are being satisfied. Make available the specified items of equipment for the Engineer's use at all times when field painting or surface preparation is in progress.
 1. Wet film gauge.
 2. Surface thermometer.
 3. Keane-Tator surface profile comparator.
 4. Set of National Association of Corrosion Engineers (NACE) visual standards.
 5. Holiday (pin hole) detectors (low and high voltage).
 6. Sling-psychrometer.
 7. Magnetic dry film gauge.

1.9 WARRANTY

- A. Manufacturer Warranty
 1. Warrant all paint and coatings installed for a period of two years from the date of final acceptance. During this period, repair or replace all defects discovered in the coating, as determined by the Owner or Owner's representative at no cost to the Owner.
 2. Properly prepare the surface for paint and coating prior to the installation of the systems, including stopping all leaks, patching voids, protecting or removing and handling all mechanical equipment such as valves and valve assemblies and weirs, cleaning surfaces, removing rubble, etc.

PART 2 PRODUCTS

2.1 MANUFACTURERS

- A. Approved manufacturers include:
 1. Tnemec.
 2. Induron.
 3. Carboline.
 4. Engineer approved equal.

2.2 PAINT MATERIALS

- A. General
 1. Manufacturer's highest quality products suitable for intended service.

2. Compatibility: Only compatible materials from a single manufacturer shall be used in the Work. Particular attention shall be directed to compatibility of primers and finish coats.
3. Thinners, Cleaners, Driers, and Other Additives: As recommended by coating manufacturer.

B. Products

1. Acrylic Emulsion
2. Acrylic Epoxy
3. Aliphatic Acrylic Polyurethane
4. Ceramic-Modified Waterborne Aliphatic Polyurethane
5. Cycloaliphatic Amine Epoxy
6. Epoxy Modified Cementitious Mortar
7. Modified Alkyd Primer
8. Modified Novolac Polyamine Epoxy
9. Modified Polyamine Ceramic Epoxy
10. Modified Polyamine Epoxy
11. Modified Silicone Resin
12. Modified Waterborne Acrylate
13. Polyamide Epoxy
14. Polyamide Epoxy-Coal Tar
15. Polyamidoamine Epoxy
16. Polyamine Novolac Epoxy
17. Quartz-Filled Modified Polyamine Epoxy
18. Waterborne Acrylic Epoxy
19. Waterborne Cementitious Acrylic Masonry Filler
20. Waterborne Modified Polyamine Epoxy
21. Zinc Silicone Primer

2.3 PAINTING SCHEDULE

A. General:

1. Manufacturer's highest quality products suitable for intended service.
2. Compatibility: Only compatible materials from a single manufacturer shall be used in the Work. Particular attention shall be directed to compatibility of primers and finish coats.
3. Thinners, Cleaners, Driers, and Other Additives: As recommended by coating manufacturer.

B. The Painting Schedule presented below summarizes the painting systems to be applied to the various surfaces.

C. Exposure terms refer to the environmental conditions to which different surfaces may be exposed. A surface may exist in more than one exposure, e.g. an exterior wall can be

categorized not only as "Exposed", but also as "Buried", where the exposure is below the grade line.

D. In addition to the major items listed in the Painting Schedule, the Contractor shall paint safety warnings and notices as outlined in these specifications.

PAINTING SCHEDULE						
Exposure	System Type	Surface Prep	Prime Coat	Intermediate Coat	Finish Coat	Total DFT
CONCRETE FLOORS – interior concrete floor slabs						
Interior Light Traffic	Epoxy/Urethane	SSPC-SP 13/NACE 6, ICRI-CSP 1-3	Modified Polyamine Epoxy, 4 to 6 mils DFT	Modified Polyamine Epoxy, 4 to 6 mils DFT	Ceramic-Modified Waterborne Aliphatic Polyurethane, 2 to 3 mils DFT	10 to 15 -mils
Severe Chemical/ Functional	Aggregate Filled Epoxy	SSPC-SP 13/NACE 6, ICRI-CSP 3-5	Modified Polyamine Epoxy @ 1/8” double broadcast	Polyamine Novolac Epoxy, 6 to 8 mils DFT	Polyamine Novolac Epoxy, 6 to 8 mils DFT	Greater than 1/8-inch
Severe Chemical/ Decorative	Ceramic Filled Epoxy	SSPC-SP 13/NACE 6, ICRI-CSP 3-5	Quartz-Filled Modified Polyamine Epoxy @ 1/8” double broadcast	Modified Polyamine Epoxy, 8 to 10 mils DFT	Ceramic-Modified Waterborne Aliphatic Polyurethane, 2 to 4 mils DFT	Greater than 1/8-inch
CONCRETE – cast-in-place or precast concrete						
Exterior Exposed	Acrylate	SSPC-SP 13/NACE 6, Clean and Dry	Modified Waterborne Acrylate, 6 to 9 mils DFT		Modified Waterborne Acrylate, 6 to 9 mils DFT	12 to 18 mils
Interior Exposed	Epoxy	SSPC-SP 13/NACE 6, ICRI-CSP 1-3	Polyamidoamine Epoxy, 4 to 6 mils DFT		Polyamidoamine Epoxy, 4 to 6 mils DFT	8 to 12 mils
Exterior below grade walls	ASTM E1745 Class A Vapor Barrier	Per Mfgr. Specs.			Polyethylene	15 mils
STEEL - STRUCTURAL, TANKS, PIPE, AND EQUIP – pump supports, anchorage, misc. steel.						
Exterior Exposed (outside structure)	Epoxy/ Polyurethane	SSPC-SP 6	Polyamidoamine Epoxy, 3 to 5 mils DFT		Aliphatic Acrylic Polyurethane, 3 to 5 mils DFT	6 to 10 mils
Interior Exposed (inside structure)	Epoxy	SSPC-SP 6	Polyamidoamine Epoxy, 3 to 5 mils DFT		Polyamidoamine Epoxy, 4 to 6 mils DFT	7 to 11 mils
Below Grade	Coal Tar Epoxy	SSPC-SP 10	Polyamide Epoxy, 3 to 5 mils DFT		Polyamide Epoxy-Coal Tar, 14 to 20 mils DFT	17 to 25 mils
High Temperature	High Heat Silicone	SSPC-SP 10	Zinc Silicone Primer, 2 to 3 mils DFT		Modified Silicone Resin, 2 to 3 mils DFT	4 to 6 mils
FACTORY PRIMED OR GALVANIZED STEEL – doors, frames, exposed metal deck on ceilings, miscellaneous equipment						
Exterior Exposed	Epoxy/ Polyurethane	Clean and Dry	Factory Primed	Polyamide Epoxy, 3 to 5 mils DFT	Aliphatic Acrylic Polyurethane, 2 to 3 mils DFT	4 to 6 mils
Interior Exposed	Epoxy	Clean and Dry	Factory Primed	Polyamide Epoxy, 2 to 3 mils DFT	Polyamidoamine Epoxy, 2 to 3 mils DFT	4 to 6 mils
DUCTILE OR CAST IRON - PIPE, PUMPS, AND VALVES						
Exterior Buried (below ground)	Pipe Mfgr Asph Coating	Per Mfgr. specs				N/A

PAINTING SCHEDULE						
Exposure	System Type	Surface Prep	Prime Coat	Intermediate Coat	Finish Coat	Total DFT
Interior Exposed (Inside building.)	Epoxy	Per Mfgr. specs	Polyamide Epoxy, 3 to 5 mils DFT		Polyamide Epoxy, 4 to 6 mils DFT	7 to 11 mils
Exterior Exposed	Epoxy/ Polyurethane	Per Mfgr. specs	Polyamide Epoxy, 3 to 5 mils DFT	Polyamide Epoxy, 4 to 6 mils DFT	Aliphatic Acrylic Polyurethane, 2 to 3 mils DFT	9 to 14 mils
High Temperature	High Heat Silicone	SSPC-SP 10	Zinc Silicone Primer, 2 to 3 mils DFT		Modified Silicone Resin, 2 to 3 mils DFT	4 to 6 mils
GALVANIZED STEEL AND NONFERROUS METAL – Pipe and miscellaneous fabrications						
Exterior Exposed	Epoxy/ Polyurethane	Per Mfgr. specs	Polyamide Epoxy, 2 to 3 mils DFT		Aliphatic Acrylic Polyurethane, 2 to 3 mils DFT	4 to 6 mils
Interior Exposed	Epoxy	Per Mfgr. specs	Polyamide Epoxy, 2 to 3 mils DFT		Polyamide Epoxy, 2 to 3 mils DFT	4 to 6 mils
Immersion	Epoxy	SSPC-SP 1, followed by abrasive blast	Polyamide Epoxy, 3 to 5 mils DFT		Polyamide Epoxy, 4 to 6 mils DFT	7 to 11 mils

2.4 ABRASIVE MATERIALS

- A. Select abrasive type and size to produce surface profile that meets coating manufacturer's recommendations for specific primer and coating system to be applied.

2.5 ACCESSORIES

A. Coating Application Accessories

1. Accessories required for application of specified coatings are to be used in accordance with manufacturer's instructions, including thinners.
2. Products and accessories used in the preparation and application of the coating systems shall be manufactured by, or approved for use by, the coating manufacturer.

2.6 MIXING

A. Multiple-Component Coatings:

1. Prepare using each component as packaged by paint manufacturer.
2. No partial batches will be permitted.
3. Do not use multiple-component coatings that have been mixed beyond their pot life.
4. Furnish small quantity kits for touchup painting, for painting other small areas, and for preparation of mockups.
5. Mix only components specified and furnished by paint manufacturer.
6. Do not intermix additional components for reasons of color or otherwise, even within the same generic type of coating.

- B. Colors: Formulate paints with colorants free of lead, lead compounds, or other materials that may be affected by presence of hydrogen sulfide or other gas likely to be present at the Site.

2.7 SHOP FINISHES

- A. Surface Preparation: Provide Engineer minimum 7 days' advanced notice to start of shop surface preparation work and coating application work.
- B. Shop Coating Requirements:
 - 1. When required by equipment specifications, equipment shall be primed and finish coated in shop by manufacturer and touched up in field with identical material after installation to the satisfaction of the Engineer.
 - 2. Where manufacturer's standard coating is not suitable for intended service condition, Engineer may approve use of a tie-coat to be used between manufacturer's standard coating and specified field finish. In such cases, provide a surface tolerant epoxy tie-coat as recommended by manufacturer of specified field finish coat. Coordinate details of equipment manufacturer's standard coating with field coating manufacturer.
- C. Pipe:
 - 1. Ductile Iron Pipe:
 - a. Use SSPC standards as a guide for desired prepared surface.
 - b. Follow recommendations of pipe and coating manufacturers for means and methods to achieve SSPC-equivalent surface.
 - c. The surface preparation and application of the primer shall be performed by pipe manufacturer.
 - d. For high performance (epoxy) coatings, follow additional recommendations of pipe and coating manufacturers.
 - e. Prior to blast cleaning, grind smooth surface imperfection, including, but not limited to delaminating metal or oxide layers.
 - f. For conventional (alkyd) coatings, clean asphalt varnish supplied on pipe and apply one full coat of a tar stop before two full coats of the color coats specified.

PART 3 EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions under which coating systems are to be applied. Notify Engineer of areas or conditions not acceptable. Do not begin surface preparation or application until unacceptable areas or conditions have been corrected.
- B. Surface Preparation Verification: Inspect and provide substrate surfaces prepared in accordance with these Specifications and printed directions and recommendations of paint manufacturer whose product is to be applied. Follow the more stringent requirements.
- C. Factory Finished Items: Schedule inspection with Engineer before repairing damaged factory-finished items delivered to the Site.

3.2 PROTECTION OF SURFACES NOT SCHEDULED TO BE COATED

- A. Protect surrounding areas and surfaces not scheduled to be coated from damage during surface preparation and application of coatings.
- B. Remove, mask, or otherwise protect hardware, lighting fixtures, switchplates, aluminum surfaces, machined surfaces, couplings, shafts, bearings, nameplates on machinery, and other surfaces not specified elsewhere to be painted.
- C. Provide drop cloths to prevent paint materials from falling on or marring adjacent surfaces.
- D. Protect working parts of mechanical and electrical equipment from damage during surface preparation and painting process.

- E. Mask openings in motors to prevent paint and other materials from entering.
- F. Protect surfaces adjacent to or downwind of Work area from overspray.
- G. Immediately remove coatings that fall on surrounding areas and surfaces not scheduled to be coated.

3.3 SURFACE PREPARATION OF STEEL

- A. Prepare steel surfaces in accordance with Manufacturer's instructions.
- B. Fabrication Defects
 - 1. Correct steel and fabrication defects revealed by surface preparation.
 - 2. Remove weld spatter and slag.
 - 3. Round sharp edges and corners of welds to a smooth contour.
 - 4. Smooth weld undercuts and recesses.
 - 5. Grind down porous welds to pinhole-free metal.
 - 6. Remove weld flux from surface.
- C. Ensure surfaces are dry.
- D. Immersed or Below Grade Surfaces
 - 1. Remove visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter in accordance with SSPC-SP 10/NACE 2.
- E. Exterior Exposed or Interior Exposed Surfaces
 - 1. Remove visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter in accordance with SSPC-SP 6/NACE 3.
- F. Interior or Immersed Surfaces, Severe Atmospheres
 - 1. Remove visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter in accordance with SSPC-SP 5/NACE 1.
- G. Abrasive Blast-Cleaned Surfaces
 - 1. Coat abrasive blast-cleaned surfaces with primer before visible rust forms on surface. Do not leave blast-cleaned surfaces uncoated for more than 8 hours.
- H. Shop Primer
 - 1. Prepare shop primer to receive field coat in accordance with manufacturer's instructions.

3.4 SURFACE PREPARATION OF GALVANIZED STEEL AND NONFERROUS METAL

- A. Prepare galvanized steel and nonferrous metal surfaces in accordance with Manufacturer's instructions.
- B. Ensure surfaces are dry.
- C. Remove visible oil, grease, dirt, dust, protective mill coatings, and other soluble contaminants in accordance with SSPC-SP 1 or Manufacturer's instructions as specified for coating system.
- D. Immersed Service
 - 1. Clean surfaces by abrasive blasting.
- E. Remove Rust From Galvanized Steel

1. Remove white rust from galvanized steel by hand or power brushing.
 2. Remove rust from old galvanized steel in accordance with SSPC-SP 2 or SP 3.
 3. Do not damage or remove galvanizing.
- F. Increase mechanical adhesion under moderate to severe conditions, such as exterior exposure or chemical environments, by abrasive blast and/or chemical cleaning.

3.5 SURFACE PREPARATION OF DUCTILE OR CAST IRON

- A. Prepare ductile or cast iron surfaces in accordance with Manufacturer's instructions.
- B. Ensure surfaces are clean, dry, and free of oil, grease, dirt, dust, and other contaminants.

3.6 SURFACE PREPARATION OF CONCRETE

A. Interior, Exposed

1. Prepare concrete surfaces in accordance with Manufacturer's instructions, SSPC-SP 13/NACE 6, and International Concrete Repair Institute (ICRI) 03732.
2. Allow concrete to cure for a minimum of 28 days.
3. Test concrete for moisture in accordance with ASTM D4263 and F1869.
4. Abrasive blast surface to remove laitance and solid contaminants and to provide clean, sound substrate with uniform anchor profile.
5. Fill holes, pits, voids, and cracks with Modified Polyamine Epoxy.
6. Ensure surfaces are clean, dry, and free of oil, grease, chalk, form release agents, and other contaminants.

B. Exterior

1. Prepare concrete surfaces in accordance with Manufacturer's instructions, SSPC-SP 13/NACE 6, and ICRI 03732.
2. Allow concrete to cure for a minimum of 14 days.
3. Test concrete for moisture in accordance with ASTM D4263 and F1869.
4. Level concrete protrusions and mortar spatter.
5. Fill hairline cracks less than 1/64 inch (0.4 mm) in accordance with Manufacturer's instructions.
6. Prepare cracks wider than 1/64 inch (0.4 mm), moving cracks, gaps, and expansion joints in accordance with Manufacturer's instructions.
7. Ensure surfaces are clean, dry, and free of oil, grease, chalk, form release agents, and other contaminants.

3.7 SURFACE PREPARATION OF CONCRETE FLOORS

- A. Prepare concrete surfaces in accordance with Manufacturer's instructions, SSPC-SP 13/NACE 6, and ICRI 03732.
- B. Ensure surfaces are clean, dry, and free of oil, grease, dirt, dust, and other contaminants.
- C. Allow concrete to cure for a minimum of 28 days before coating.
- D. Test concrete for moisture in accordance with ASTM D4263 and F1869.

3.8 APPLICATION

- A. Apply coatings in accordance with Manufacturer's instructions.
- B. Mix and thin coatings, including multi-component materials, in accordance with manufacturer's instructions.
- C. Keep containers closed when not in use to avoid contamination.
- D. Do not use mixed coatings beyond pot life limits.
- E. Use application equipment, tools, pressure settings, and techniques in accordance with Manufacturer's instructions.
- F. Uniformly apply coatings at spreading rate required to achieve specified DFT.
- G. Apply coatings to be free of film characteristics or defects that would adversely affect performance or appearance of coating systems.
- H. Stripe paint with brush at critical locations on steel such as welds, corners, and edges using specified primer.

3.9 REPAIR

- A. Materials and Surfaces Not Scheduled To Be Coated
 - 1. Repair or replace damaged materials and surfaces not scheduled to be coated.
- B. Damaged Coatings
 - 1. Touch-up or repair damaged coatings. Touch-up of minor damage shall be acceptable where result is not visibly different from adjacent surfaces. Recoat entire surface where touch-up result is visibly different, either in sheen, texture, or color.
- C. Coating Defects
 - 1. Repair in accordance with manufacturer's instructions coatings that exhibit film characteristics or defects that would adversely affect performance or appearance of coating systems.

3.10 FIELD QUALITY CONTROL

- A. Applicator's Services
 - 1. Verify coatings and other materials are as specified.
 - 2. Verify surface preparation and application are as specified.
 - 3. Verify DFT of each coat and total DFT of each coating system are as specified using wet film and dry film gauges.
 - 4. Coating Defects
 - a. Check coatings for film characteristics or defects that would adversely affect performance or appearance of coating systems.
 - b. Check for holidays on interior steel immersion surfaces using holiday detector.
 - 5. Report
 - a. Submit daily written reports describing work performed, inspections made, and actions taken to correct nonconforming work. Daily reports shall contain, but not be limited to, the following information:
 - 1) Start date and time of work in each area.
 - 2) Weather conditions.
 - 3) Date and time of application for each following coat.

- 4) Moisture content of substrate prior to each coat.
 - 5) Provisions utilized to maintain temperature and humidity of work area within Manufacturer's recommended ranges.
- b. Report nonconforming work addressed and any areas not corrected.
 - c. Submit copies of report to Engineer and Contractor.
- B. Manufacturer's Field Services
1. Manufacturer's representative shall provide technical assistance and guidance for surface preparation and application of coating systems and shall be available per paragraph 1.5.C.
- C. Testing:
1. Thickness and Continuity Testing:
 - a. Measure coating thickness specified in mils with magnetic type, dry film thickness gauge, in accordance with SSPC PA 2. Check each coat for correct millage. Do not make measurement before a minimum of 8 hours after application of coating.
 - b. Holiday detect coatings 20 mils thick or less, except zinc primer and galvanizing, with low voltage wet sponge electrical holiday detector in accordance with NACE RP0188.
 - c. Holiday detect coatings in excess of 20 mils dry with high voltage spark tester as recommended by coating manufacturer and in accordance with NACE RP0188.
 - d. After repair and recoated areas have dried sufficiently, retest each repaired area. Final tests may also be conducted by Engineer.
- D. Inspection: Leave staging and lighting in place until Engineer has inspected surface or coating. Replace staging removed prior to approval by Engineer. Provide additional staging and lighting as requested by Engineer.
- E. Unsatisfactory Application:
1. If item has an improper finish color or insufficient film thickness, clean surface and topcoat with specified paint material to obtain specified color and coverage. Obtain specific surface preparation information from coating manufacturer.
 2. Evidence of runs, bridges, shiners, laps, or other imperfections is cause for rejection.
 3. Repair defects in accordance with written recommendations of coating manufacturer.
- F. Damaged Coatings, Pinholes, and Holidays:
1. Feather edges and repair in accordance with recommendations of paint manufacturer.
 2. Hand or power sand visible areas of chipped, peeled, or abraded paint, and feather the edges. Follow with primer and finish coat. Depending on extent of repair and appearance, a finish sanding and topcoat may be required.
 3. Apply finish coats, including touchup and damage-repair coats in a manner that will present a uniform texture and color-matched appearance.

3.11 CLEANING

- A. Remove temporary coverings and protection of surrounding areas and surfaces.
- B. Place cloths and waste that might constitute a fire hazard in closed metal containers or destroy at end of each day.
- C. Upon completion of the Work, remove staging, scaffolding, and containers from Site or destroy in a legal manner.

- D. Remove paint spots, oils, or stains upon adjacent surfaces and floors and leave entire job clean.

3.12 PROTECTION OF COATING SYSTEMS

- A. Protect surfaces of coating systems from damage during construction.

3.13 ONE-YEAR INSPECTION

- A. Owner will set date for one-year inspection of coating systems.
- B. Inspection shall be attended by Owner, Contractor, Engineer, and Manufacturer's representative.
- C. Repair deficiencies in coating systems as determined by Engineer in accordance with Manufacturer's instructions.

3.14 PIPE CODING

- A. All process piping shall be color-coded. Pipe color and band color, when required, shall be in accordance with the Color Schedule of this section.
- B. Bands shall be spaced at maximum 6 feet on center. On pipe runs less than 6 feet in length, one band shall be located at the center of the run.

- 1. Place bands:

- a. Along continuous lines.
- b. At changes in direction.
- c. At changes in elevation.
- d. On both sides of an obstruction.

- 2. Band width shall be as follows:

- a. For pipes up to 8" in diameter: 2" minimum.
- b. For pipes 10" to 24" in diameter: 4" minimum.
- c. For pipes 30" to 48" in diameter: 6" minimum.
- d. For pipes greater than 48" in diameter: 8" minimum.

- C. Pipe Labels

- 1. After painting of pipe work is completed, stencil labels indicating the contents of the pipe (i.e. "RAW WASTEWATER") on all pipes.
- 2. Place labels on each side of the pipe (180 degrees from each other) and spaced at maximum 20 feet on center. Place labels such that they are in direct line of site. For pipe runs less than 20 feet, place label at the center of the run or the most visible location. Label may be omitted from one side of pipe if view is obstructed from that side.
- 3. When the flow in a pipe is in one direction at all times, place flow direction arrows in front of each label on the pipe.
- 4. Provide lettering with a width of each letter equal to 80% of the height of each letter. Lettering height to be as follows:
 - a. For pipes ¾" to 1½" in diameter: ½" in height.
 - b. For pipes 2" in diameter: ¾" in height.
 - c. For pipes 2½" to 6" in diameter: 1¼" in height.

- d. For pipes 6” to 10” in diameter: 2½” in height.
 - e. For pipes greater than 10” in diameter: 3½” in height.
5. For pipes smaller than ¾” in outside diameter, use a laminated plastic or aluminum tag with the lettering etched or stamped and filled in with black or contrasting enamel.
 6. Provide labels that are black or white in color such that it is contrasting with the primary pipe color.

D. Equipment Labels

1. Where specified or directed by the Engineer, label, in the same manner as the pipe, the individual units of equipment such as blowers, pumps, collector drives, compressors, silencers, etc. Provide labels of the engraved plastic type affixed to or adjacent to the remote switch, push button, starter, etc. for all push buttons, starters, switches, etc., when remote from the equipment.

3.15 COLOR SCHEDULE

A. Piping

Service	Pipe Color	Band Color
Raw Wastewater	Gray	None
Sludge	Brown	None
Reuse Water	Purple	None
Potable Water	Blue	None
Compressed Air	Green	None

B. OSHA Safety Colors

Service	Color
Fire Protection Equipment, Fire Boxes, Fire Extinguishers, Exit Signs, Fire Sprinkler Piping, Portable Containers of Flammable Liquid, Emergency Stop Bars.	Safety Red
Exposed Box Housings, Exposed Edges of Pulleys, Gears, Etc., Safety Starting Buttons.	Safety Orange
Unguarded Edges of Platforms, Elevated Door Edges, Bollards, Pulley Blocks, Material Handling Equipment.	Safety Yellow
First Aid Kits, First Aid Signs, First Aid Dispensaries, Drinking Water Stations	Safety Green

3.16 ATTACHMENTS

- A. The attachments listed below, following “End of Section” are a part of this Specification.
 1. Paint System Data Sheet (PSDS)
 2. Product Data Sheet (PDS)

END OF SECTION

PAINT SYSTEM DATA SHEET

Complete this PSDS for each coating system, include all components of the system (surface preparation, primer, intermediate coats, and finish coats). Include all components of a given coating system on a single PSDS.

Paint System Title (from Spec):		
Coating Supplier:		
Representative:		
Surface Preparation:		
Paint Material (Generic)	Product Name/Number (Proprietary)	Min. Coats, Coverage

PAINT PRODUCT DATA SHEET

Complete and attach manufacturer's Technical Data Sheet to this PDS for each product submitted. Provide Manufacturer's recommendations for the following parameters at temperature (F)/relative humidity:

Temperature/RH	50/50	70/30	90/25
Induction Time			
Pot Life			
Shelf Life			
Drying Time			
Curing Time			
Min. Recoat Time			
Max Recoat Time			

Provide Manufacturer's Recommendation for the following:

Mixing Ratio: _____

Maximum Permissible Thinning: _____

Ambient Temperature Limitations: Min.: _____ Max.: _____

Surface Temperature Limitations: Min.: _____ Max.: _____

Surface Profile Requirements: Min.: _____ Max.: _____

Attach additional sheets detailing manufacturer's recommended storage requirements and holiday testing procedures.

SECTION 22 04 00

BASIC MATERIALS AND METHODS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	References
1.3	Quality Assurance
1.4	Delivery, Storage, and Handling
2.1	Piping
2.2	Valves
2.3	Unions
2.4	Mechanical Expansion Joints
2.5	Motors
2.6	Substitution of Materials
3.1	General
3.2	Valve Installation
3.3	Piping Installation
3.4	Welding
3.5	Drain Piping
3.6	Equipment Connections
3.7	Cutting and Patching
3.8	Large Apparatus and Equipment
3.9	Electrical Items
3.10	Motor Installation
3.11	Foundations and Bases
3.12	Thermal Expansion of Piping
3.13	Testing and Adjusting

B. Scope

1. Provide all labor, materials, necessary equipment and services to complete sleeves, escutcheons, access panels, motors, power controllers, excavation, flashing, and welding work as indicated on drawings, as specified herein or both, except as for items specifically indicated as "NIC ITEMS". Provide for connection of "NIC ITEMS" where applicable.
2. Work items included in this section are common to more than one section of Division 22, 41, 43, and 46.
3. Including but not necessarily limited to the following:
 - a. Sleeves.

- b. Escutcheons.
 - c. Access Panels.
- C. Related Requirements
- 1. Division 22
 - 2. Division 41
 - 3. Division 43
 - 4. Division 46

1.2 REFERENCES

A. Reference Standards

- 1. National Certified Pipe Welding Bureau (NCPWB).
- 2. ASME Boiler Pressure Code.
- 3. American Water Works Association (AWWA).
- 4. ANSI B31 Code for Pressure Piping.
- 5. Underwriters Laboratories (UL).
- 6. National Fire Protection Association (NFPA).
- 7. National Electrical Manufacturers' Association (NEMA).
- 8. National Electrical Code (NEC).

1.3 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with applicable Standards, Codes, Regulations and Requirements.

B. Qualifications

- 1. Fabricators
 - a. Welder Qualifications: Certified welders under National Certified Pipe Welding Bureau (NCPWB) standards for type of work performed. File operators' certificates at site and make available to Engineer for examination.

1.4 DELIVERY, STORAGE, AND HANDLING

- A. Box, crate, or otherwise completely enclose and protect all equipment during shipment, handling, and storage. Protect all equipment from exposure to the elements and keep thoroughly dry at all times. Store pumps, motors, electrical equipment, and other equipment having antifriction or sleeve bearings in weathertight buildings which are maintained at a temperature of at least 60 degrees F.
- B. Protect painted surfaces against impact, abrasion, discoloration, and other damage. Repaint all painted surfaces which are damaged prior to acceptance of equipment to match the original paint.
- C. Protect electrical equipment, controls, and insulation against moisture or water damage. Connect and operate all space heaters provided in the equipment storage areas at all times until equipment is placed in service.
- D. If items are stored inside an existing building, give consideration to weight of the items and the effect of concentrated loads on the building slabs, foundation, and other structural members. Contact Engineer or Owner for permission to store materials with a load exceeding 200 pounds per square foot.

PART 2 PRODUCTS

2.1 PIPING

- A. See appropriate sections of Divisions 22, 33, and 40 for specifications on various piping systems. See Part 3 of this specification for general stipulations on installation of piping systems.

2.2 VALVES

- A. See appropriate sections of Division 33 for specifications and Part 3 of this specification for general stipulations on valve installation.

2.3 UNIONS

- A. Provide and install unions between each item of equipment and the valve controlling and/or the various piping connections to it.
 - 1. Steel Pipe
 - a. Unions 2½ inches and smaller: ground joints.
 - b. Unions 3 inches and larger: flanged unions.
 - 2. Copper Pipe
 - a. Unions 2½ inches and smaller: brass ground joints, copper to copper.
 - b. Unions 3 inches and larger: brass flanged unions, with brass bolts.
 - 3. PVC Pipe
 - a. Unions 2 inches and smaller: threaded having Buna O-rings.
 - b. Unions 2½ inches and larger: flanged.

2.4 SLEEVES:

- A. Fabricated from sections of Schedule 40 black steel pipe for passage of pipe or insulated pipe.

2.5 MECHANICAL EXPANSION JOINTS

- A. Should the installation of mechanical expansion joints become necessary in the opinion of the Engineer, provide as follows:
 - 1. Joints ½-inch and smaller: Fulton Sylphon No. 111 packless expansion joints.
 - 2. Joints on 2-inch and larger lines: Adscos, Flexones, or Tube Turn, bellows type expansion joints with the proper number of bellows sections of stainless steel.

2.6 MOTORS:

- A. General: Motors provided with equipment furnished under these specifications shall conform to this article. Provide high efficiency type for motors size 1 horsepower and larger.
- B. Minimum Requirements:
 - 1. Constructed for operation at project altitude.
 - 2. Dustproof/leakproof bearing rings.
 - 3. Built to NEMA standards.
 - 4. Factory balanced.

5. Open drip-proof.
6. Thermal overload protection for 1/2 horsepower and smaller motors.
7. For voltage indicated under Division 26 work.

C. Equipment Standards:

1. ANSI/NEMA Standards
2. Provide satisfactory operation within plus or minus 10% of nameplate voltage without adversely affecting performance or life.
3. Continuous duty classification based on 40 degrees C ambient temperature.
4. Service factor not less than 15%.
5. Sized for duty performed and not exceed service factor when driven equipment is operating at specified capacity under most severe conditions encountered.
6. Nameplates indicate rated efficiency and power factor in addition to standard data.
7. Submittal to include certification with respect to high efficiency classification, motor power factor and efficiency at full load, three quarter load, and half load.

D. Specific Requirements:

1. Polyphase, squirrel-cage induction motors, NEMA design B, 1.15 service factor normal starting torque and low starting current unless other operational characteristics are required for duty performed. Continuous duty classification based on 40 degrees C ambient temperature. Two speed motors single winding type. Motors operating on 240 or 480 volt systems use dual voltage motors, 230/460 volts. Motors operating on 208 volt systems rated at 200 volts.
2. Nominal full load power factor and efficiency ratings not less than those listed below. Data listed is for 1,800 RPM, 3 phase, 230/460 volts NEMA design B, Class B insulation, 40 degrees C ambient, continuous duty motor with drip proof housing. Motors of other ratings and characteristics shall conform to high efficiency standards for efficiency and power factor.

HP	EFF	P.F.	HP	EFF	P.F.
1	82%	84%	15	89%	87%
1.5	83%	86%	20	91%	88%
2	84%	87%	25	91%	89%
3	85%	86%	30	92%	87%
5	87%	87%	40	92%	88%
7.5	88%	87%	50	92%	89%
10	89%	87%			

3. Integral horsepower motors installed indoors provided with drip proof housing and Class B insulation. Motors installed out of doors or where subject to excessive moisture or high humidity and where specified or indicated on drawings provided with drip proof housing, Class B insulation, and moisture proof encapsulated windings. Motors in hazardous locations as defined by National Electrical Code provided with explosion proof housing.
4. Integral horsepower motors 25 HP and larger provided with thermal devices imbedded in motor windings which, in conjunction with motor controller, provide motor overload protection. Protection shall be static type, sensitive to both over temperature and rate of temperature rise, and provide motor protection from overheating due to frequent starting, overload, high ambient temperature, abnormal voltage, ventilation failure, phase failure and locked rotor.

- E. Manufacturers:
 - 1. Westinghouse
 - 2. G.E.
 - 3. Louis Allis
 - 4. Gould
 - 5. Emerson
 - 6. Engineer approved equal

2.7 SUBSTITUTION OF MATERIALS

- A. Manufacturers' names are listed herein to establish a standard. The products of other manufacturers will be acceptable, if in the opinion of the Engineer, the substitute material is of a quality as good or better than the material specified, and will serve with equal efficiency and dependability the purpose for which the items specified were intended.
- B. Provide all material and equipment as specified or equal. Should a substitution be accepted by the Engineer and proved to be defective or unsatisfactory in the opinion of the Engineer for the service for which it was intended, replace this material or equipment with the material or equipment specified at no additional cost to the Owner.

PART 3 EXECUTION

3.1 GENERAL

- A. The Contractor is responsible for coordination of the entire project, including verification that all structures, piping, and equipment components are compatible. Start each equipment system and make all necessary adjustments so that each system is in proper operating condition.
- B. Install materials and equipment at proper time to keep pace with general construction and the work of other trades involved.
- C. Lay out work maintaining all lines, grades, and dimensions according to the drawings with due consideration for other trades and verify all dimensions at the site prior to any fabrication or installation. Should any conflict develop or installation be impractical, notify the Engineer before any installation or fabrication and investigate the existing conditions to allow for proper changes without any additional cost.
- D. Comply with requirements of these Specifications and manufacturer recommendations.

3.2 VALVE INSTALLATION

- A. Provide and install all valves that are shown on the drawings, specified, or that may be necessary to install complete, controlled and properly operating systems as required by code.
- B. Locate valves in accessible positions or make accessible through removable panels, etc., and where several valves are related as to function, group them in a battery. Arrange for proper location of all access panels required. Exercise particular care to avoid leaving tool marks and scratches where connections are exposed in toilet rooms, machine rooms, and other conspicuous places.
- C. Provide and install stop valves of the indicated or required type in all piping systems where shown or required; at mains, at outlets, and items of equipment, at the inlet and outlet of each pump, and other appurtenances; in by-passes; in special service lines such as drain lines, make-up water lines and fill lines; and at all other places designated on the plans and/or required to control flow of water, or to various sections of the buildings and to

various groups of fixtures; items of equipment, etc. Provide a positive shut-off and stop valve on the supply of water to every plumbing fixture specified to be installed under this Contract.

3.3 PIPING INSTALLATION

- A. Furnish and install piping for every purpose, pump base and air unit drains, and all other piping illustrated on the plans and not covered under other headings of these Specifications.
- B. In general, use the materials described under Piping Specifications and the following methods of assembly in fabricating the various listed systems. The method of assembly may be varied only to meet special conditions. Where special classes of piping are involved and are not listed, request exact instructions from the Engineer as to the class of material involved and the method of fabricating it before ordering any material.
- C. Install piping following as closely as possible the routes shown on plans, taking into consideration conditions to be met at the site. Should any unforeseen conditions arise, change lines or reroute as required after proper approval has been obtained.
- D. Install all piping with due regard to expansion and contraction and so as to prevent excessive strain and stress in the piping, in connections, and in equipment to which the lines are connected.
- E. Unions
 - 1. Provide and install unions at proper points to permit removal of pipe and various equipment and machinery items without injury to other parts of systems. No unions will be required in welded lines or lines assembled with soldered joint fittings except at equipment items, machinery items, and other special pieces of apparatus. Provide unions of the same material and strength as other fittings in the lines. Companion flanges on lines at various items of equipment, machines, and pieces of apparatus shall serve as unions to permit removal of the particular items. Install unions in all piping connections to all items of equipment and fixtures. Use only approved type unions.
- F. Provide nipples of the same size and material as the piping in the system in which they are being installed.
- G. Keep all open ends of piping, including those extending through the roof, plugged or capped to prevent dirt or other debris from entering the pipe during construction. Thoroughly ream the ends of all piping installed to the full inside diameter of the pipe. Use a thread lubricant or pipe dope made up of powdered graphite and pure boiled linseed oil, and apply to the male threads only of all screwed pipes prior to installation.
- H. Run lines parallel with, or perpendicular to building lines and wherever possible group for easier service and identification. Wherever possible, hold horizontal and vertical runs as close as possible to the walls, ceilings, struts, members, etc., so as to occupy the minimum space consistent with the proper requirements for insulation, expansion, removal of pipe and access to valves, fittings, unions, etc. Finish off all concealed work within the limits permitted by the vertical or horizontal chases. Grade all lines to permit complete drainage by gravity of all piping systems of any and all pieces of equipment or fixtures.

3.4 WELDING

- A. Make all welded pipe joints by the fusion welding process, employing a metallic arc or gas welding process.
- B. Conform all welding operations to the latest recommendations of the American Welding Society or to applicable provisions of the Code for Pressure Piping. Pay for all electrical energy and/or gas used in welding.

3.5 DRAIN PIPING

- A. Provide drain piping systems consisting of all piping from the source to a floor drain or other point of disposal in the building plumbing system. Make final connections to the plumbing system through open sight, or indirect trapped connection. Use Type "L" copper water tube for all drain lines unless otherwise specified. Pitch all horizontal drains at 1/8-inch per foot and provide with plugged tee cleanouts, unless otherwise accessible for cleaning. Use drainage pattern fittings.
- B. Provide all pump bases, air conditioning unit drip pans, and all other equipment and apparatus which are provided with drain tappings and which are required to be drained continuously or intermittently as a function of normal operation with drain lines whether or not specifically shown on the drawings. Provide blow off valves, drain valves and drain valves at strainers with 3/4-inch male hose threads and cap with chain.

3.6 EQUIPMENT CONNECTIONS

- A. Extend wastewater, water, gas, vacuum, and compressed air lines to the various items of equipment as indicated or required, terminating the lines where and as directed. Make all final plumbing connections. Provide shut-off valves and unions at each connection to each item of equipment requiring same. Furnish all P-traps for waste connections to this equipment.
- B. During the roughing-in phase of the work, extend service lines to the various items of equipment, terminating them at the proper points for connection to those items of equipment as indicated on detailed drawings of the equipment and/or as directed. During the time the equipment is being installed or after it is in place, make all final connections thereto.
- C. Equipment manufacturer will provide all holes in the tops, racks, splash backs or aprons required and will furnish all sinks, waste tailpieces, supply fittings, cocks, pedestals, etc., required for all water and gas to be mounted on the equipment.

3.7 CUTTING AND PATCHING

- A. Where cutting or patching becomes necessary to permit the installation of any work or should it become necessary to repair any defects that may appear in patching, make the necessary repair at no cost to the Owner.

3.8 LARGE APPARATUS AND EQUIPMENT

- A. All large apparatus and equipment which is specified or shown to be furnished or installed under this contract, and which may be too large to be moved into its final position through the normal building openings planned, shall be placed by the Contractor in its approximate final position before any obstructing structure is installed. Crib all apparatus up from the floor and cared for as specified under "Storage and Protection" or as directed by the Engineer.

3.9 ELECTRICAL ITEMS

- A. On all equipment requiring electrical connections, furnish all required and necessary starters, switches, relays, controls, devices and other appurtenances required. Also furnish complete and approved interlocking and wiring diagrams. Set (unless furnished as an integral part of the equipment by the manufacturers) all controls and devices and completely wire same in accordance with the approved wiring diagrams, as specified in Electrical Drawings and Specifications.
- B. Provide the sizes and types of service to be installed for each and every motor or device furnished under these Specifications and ascertain that each motor and device is compatible with the service to be installed.

- C. Except for such items as are normally wired up at their point of manufacture and so delivered and unless specifically noted to contrary therein, the Contractor will do all electrical wiring of every nature for both power and controls in accordance with Electrical Drawings and Specifications.

3.10 MOTOR INSTALLATION:

- A. Do not exceed motor nameplate ampere rating under normal operating conditions. Replace motor with larger horsepower rating when necessary to meet this requirement; replace motor controller as necessary and coordinate with power wiring provided under Division 26 work.
- B. Align motor with driven equipment. Adjust motor base to maintain belt tension where belt drive is used.
- C. Connect with flexible conduit not exceeding 18" in length. Do not stretch conduit tight but allow some slack.
- D. Ground motor within junction box with bolt used for no other purpose.

3.11 FOUNDATIONS AND BASES

- A. Provide foundations and supports (as shown on the Drawings) for each piece of equipment furnished. Coordinate the details shown on the Drawings with the specific piece and/or pieces of equipment to be furnished and notify the Engineer of any discrepancies prior to fabrication or installation of said equipment and/or supports.
- B. In general, fans and other belt-connected equipment shall incorporate adjustable slide rails for the motors.

3.12 THERMAL EXPANSION OF PIPING

- A. Furnish and install all devices required to permit the expansion and contraction of all work installed, particularly in water supply and circulating systems. In the main water and circulating lines, employ expansion joints as required or directed. Provide swing joints, turns, expansion loops, or long offsets wherever shown on the drawings or wherever necessary to allow for the expansion of piping within the building. Pipes or fittings broken due to rigid connections must be removed and replaced at the Contractor's expense.
- B. Anchor all lines having expansion joints so that expansion and contraction effect is equally distributed. Verify exact locations of anchors with the Engineer prior to making installation. Accurately guide the lines having expansion joints on both sides of each joint. These guides shall consist of saddles and "U" clamps properly arranged and supported. Submit complete details for approval.
- C. In installing expansion members, exercise care to preserve proper pitch on lines. Furnish and install all special fittings, connectors, etc., as required.

3.13 TESTING AND ADJUSTING

- A. Testing of Equipment
 - 1. Make all necessary changes in fan drives and pumps and other equipment furnished to assure proper operation.

END OF SECTION

HANGERS AND SUPPORTS FOR PLUMBING AND EQUIPMENT

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	References
1.3	Submittals
1.4	Quality Assurance
2.1	Design Requirements
2.2	General
2.3	Saddle Supports
2.4	Pipe Clamps
2.5	Steel Pipe Saddles
2.6	Seismic Restraints
2.7	Accessories
2.8	Pipe Anchors
2.9	Anchoring Systems
3.1	Installation
3.2	Field Finishing

B. Scope

1. The work covered by this section includes providing all pipe supports, hangers, and brackets necessary to install piping furnished under these Contract Documents. Furnish and install all foundations, anchor bolts, pipe supports, shims, hangers, clamps, and hardware required for a complete installation as shown on the Drawings and/or specified herein.
2. For clarity, not all pipe supports are shown on the drawings. Support all pipes in accordance with these specifications. Support all valves and changes in pipe direction by concrete pier or mechanical type pipe support.

1.2 REFERENCES

A. Definitions

1. Wetted or Submerged: Submerged, less than 1 foot above liquid surface, below top of channel wall, under cover or slab of channel or tank, or in other damp location.

B. Reference Standards

1. American Society of Civil Engineers (ASCE): 7, Minimum Design Loads for Buildings and Other Structures.
2. American Society of Mechanical Engineers (ASME): B31.1, Power Piping
3. ASTM International (ASTM):

- a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
 - b. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanealed) by the Hot-Dip Process.
 - c. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
4. International Code Council (ICC):
 - a. International Building Code (IBC).
 - b. International Mechanical Code (IMC).
 5. Manufacturers' Standardization Society (MSS):
 - a. SP-58, Pipe Hangers and Supports – Materials, Design and Manufacture.
 - b. SP-69, Pipe Hangers and Supports – Selection and Application.
 - c. SP-89, Pipe Hangers and Supports – Fabrication and Installation Practices.
 - d. SP-127, Bracing for Piping Systems, Seismic-Wind-Dynamic Design, Selection and Application.

1.3 SUBMITTALS

A. Action Submittals/Informational Submittals

1. Product Data
 - a. Catalog information for each type of hanger or support proposed on the Work for any size pipe.
 - b. Maintenance information on piping support system.
2. Shop Drawings
 - a. Drawings of piping support system, locating each support, sway brace, seismic brace, hanger, guide, component, and anchor for piping 6 inches and larger. Identify support, hanger, guide and anchor type by catalog number and shop drawing detail number.
 - b. Revisions to support system resulting from changes in related piping system layout or addition of flexible joints.
3. Delegated Design Submittals
 - a. Seismic anchorage and bracing calculations, as required.

1.4 QUALITY ASSURANCE

A. Qualifications

1. Piping support systems shall be designed and shop drawings prepared and sealed by a registered professional engineer in the state of Georgia.

PART 2 PRODUCTS

2.1 DESIGN REQUIREMENTS

A. General

1. Design, size, and locate piping support systems throughout facility, whether shown or not.

2. Piping Smaller than 30 Inches: Supports are shown only where specific types and locations are required; additional pipe support may be required.
 3. Piping 30 Inches and Larger: Support systems have been designed for piping shown.
 4. Meet requirements of MSS SP-58, MSS SP-69, MSS SP-89, and ASME B31.1 or as modified by this section.
- B. Pipe Support Systems
1. Design pipe support systems for gravity and thrust loads imposed by weight of pipes or internal pressures, including weight of fluid in pipes and insulation.
 2. Seismic loads in accordance with governing codes and as shown on Structural General Drawings.
 3. Wind loads in accordance with governing codes and as shown on Structural General Drawings.
 4. Maximum support spacing and minimum rod sizes in accordance with MSS SP-58.
 5. Electrical Conduit Support: Include in design of framing support system.
- C. Anchoring Devices: Design, size, and space support anchoring devices, including anchor bolts, inserts, and other devices used to anchor support, to withstand shear and pullout loads imposed by loading and spacing on each particular support.
- D. Vertical Sway Bracing: 10-foot maximum centers or as shown.
- E. Existing Support Systems: Use existing support systems to support new piping only if Contractor can show they are adequate for additional load, or if they are strengthened to support additional load.

2.2 GENERAL

- A. When specified items are not available, fabricate pipe supports of correct material and to general configuration indicated.
- B. Special support and hanger details may be required for cases where standard catalog supports are inapplicable.
- C. Materials: Provide supports fabricated of Type 316 stainless steel for all applications, unless noted otherwise.
- D. Provide type 316 stainless steel threaded rods, U-bolts, and hardware, where required.
- E. Specific manufacturer and model numbers are identified in this specification for various types of pipe supports and hangers to establish a minimum acceptable standard. Alternative manufacturers may be submitted for approval by the Engineer.

2.3 SADDLE SUPPORTS

- A. Pedestal Type: Schedule 40 pipe stanchion, saddle, and anchoring flange.
 1. Nonadjustable Saddle: MSS SP-58 and MSS SP-69, Type 37 with U-bolt.
 - a. Anvil; Figure 259, sizes 4 inches through 36 inches with Figure 62C base.
 - b. B-Line; Figure B3090, sizes ¾ inches through 36 inches with B3088 base.
 2. Adjustable Saddle: MSS SP-58 and MSS SP-69, Type 38 without clamp.
 - a. Anvil; Figure 264, sizes 2-1/2 inches through 36 inches with Figure 62C base.
 - b. B-Line; Figure B3093, sizes 1-inch through 36 inches with B3088T base.
- B. Elbow and Flange Supports:

1. Elbow with Adjustable Stanchion
 - a. Sizes 2-1/2 inches through 42 inches.
 - 1) Anvil; Figure 62C base
2. Elbow with Nonadjustable Stanchion
 - a. Sizes 2-1/2 inches through 42 inches.
 - 1) Anvil; Figure 63C base
3. Flange Support with Adjustable Base
 - a. Sizes 2 inches through 24 inches.
 - 1) B-Line; Figure B3094, with Figure B3088T base.
 - 2) Standon: Model S89.

2.4 PIPE CLAMPS

- A. Riser Clamp: MSS SP-58 and MSS SP-69, Type 8.
 1. Anvil; Figure 261, sizes 3/4-inch through 24 inches.
 2. B-Line; Figure B3373, sizes 1/2-inch through 30 inches

2.5 STEEL PIPE SADDLES

- A. Provide 120-degree pipe saddle with base plates drilled for anchor bolts; minimum four 7/8-inch holes for 3/4-inch anchor bolts.
 1. Sizes 20 inches through 60 inches.
 2. Manufacturer: Piping Technology & Products, Inc.; Figure 2000 modified per above.

2.6 SEISMIC RESTRAINTS

- A. Solid pipe bracing attachment to pipe clevis with clevis cross brace and angle rod reinforcement.
- B. Manufacturer: Mason Industries.

2.7 ACCESSORIES

- A. Insulation Shields
 1. Type: Stainless Steel, MSS SP-58 and MSS SP-69, Type 40.
 2. Manufacturers and Products
 - a. Anvil; Figure 176, sizes 1/2-inch through 24 inches.
 - b. B-Line; Figure B3151, sizes 1/2-inch through 24 inches.
- B. Welding Insulation Saddles
 1. Type: MSS SP-58 and MSS SP-69, Type 39.
 2. Manufacturers and Products
 - a. Anvil; Figure 160, sizes 1-inch through 36 inches.
 - b. B-Line; Figure B3160, sizes 1/2-inch through 24 inches.
- C. Plastic Pipe Support Channel
 1. Type: Continuous support for plastic pipe and to increase support spacing.
 2. Manufacturer and Product

- a. B-Line; Figure B3106V, sizes ½-inch through 6 inches with Figure B3106 Vee bottom hangers.
- D. Hanger Rods, Clevises, Nuts, Sockets, and Turnbuckles: In accordance with MSS SP-58.
- E. Attachments
 - 1. I-Beam Clamp: Concentric loading type MSS SP-58 and MSS SP-69, Type 21, Type 28, Type 29, or Type 30 which engage both sides of flange.
 - 2. Concrete Insert: MSS SP-58 and MSS SP-69, Type 18, continuous channel insert with load rating not less than that of hanger rod it supports.
 - 3. Welded Beam Attachment: MSS SP-58 and MSS SP-69, Type 22.
 - a. Anvil; Figure 66
 - b. B-Line; Figure B3083
 - 4. U-Channel Concrete Inserts: As specified in Section 05 57 00 – Miscellaneous Metals.
 - 5. Concrete Attachment Plates
 - a. Anvil; Figure 47, Figure 49, or Figure 52.
 - b. B-Line; Figure B3084, Figure B3085, or Figure B3086.

2.8 PIPE ANCHORS

- A. Type: Anchor chair with U-bolt strap.
- B. B-Line; Figure B3147A or Figure B3147B.

2.9 ANCHORING SYSTEMS

- A. Size and Materials: Sized by equipment manufacturer, ½-inch minimum diameter, and as specified in Section 05 05 23 – Metal Fastenings.

PART 3 EXECUTION

3.1 INSTALLATION

A. General

- 1. Install support systems in accordance with MSS SP-69 and MSS SP-89, unless shown otherwise.
- 2. Install pipe hanger rods plumb, within 4 degrees of vertical during shut down, start up or operations.
- 3. Support piping connections to equipment by pipe support and not by equipment.
- 4. Support large or heavy valves, fittings, and appurtenances independently of connected piping.
- 5. Support no pipe from pipe above it.
- 6. Support pipe at changes in direction or in elevation, adjacent to flexible joints and couplings, and where shown.
- 7. Do not install pipe supports and hangers in equipment access areas or bridge crane runs.
- 8. Brace hanging pipes against horizontal movement by both longitudinal and lateral sway bracing and to reduce movement after startup.
- 9. Install lateral supports for seismic loads at changes in direction.

10. Install pipe anchors where required to withstand expansion thrust loads and to direct and control thermal expansion.
 11. Repair mounting surfaces to original condition after attachments are made.
- B. Standard Pipe Supports:
1. Horizontal Piping Supported from Floors:
 - a. Stanchion Type:
 - 1) Pedestal type; adjustable with stanchion, saddle, and anchoring flange.
 - 2) Use yoked saddles for piping whose centerline elevation is 18 inches or greater above floor and for exterior installations.
 - 3) Provide minimum 1-1/2-inch grout beneath base plate.
 - b. Floor Mounted Channel Supports:
 - 1) Use for piping smaller than 3-inch nominal diameter running along floors and in trenches at piping elevations lower than can be accommodated using pedestal pipe supports.
 - 2) Attach channel framing to floors with base plate on minimum 1-1/2 inch grout and with anchor bolts.
 - 3) Attach pipe to channel with clips or pipe clamps.
 - c. Concrete Cradles: Use for piping larger than 3 inches along floor and in trenches at piping elevations lower than can be accommodated using stanchion type.
 2. Vertical Pipe: Support with wall brackets and base elbow or riser clamps on floor penetrations.
 3. Standard Attachments:
 - a. To Concrete Ceilings: U-Channel Concrete Inserts, U-Channel, or Concrete Attachment Plates.
 - b. To Steel Beams: I-beam clamp or welded attachments.
 - c. To Wooden Beams: Lag screws and angle clips to members not less than 2-1/2 inches thick.
 - d. To Concrete Walls: Concrete inserts or brackets or clip angles with anchor bolts.
 - e. To Concrete Beams: U-Channel Concrete Inserts, or if inserts are not used attach to vertical surface similar to Concrete Wall. Do not drill into beam bottom.
 - f. Existing Walls and Ceilings: Install as specified for new construction, unless shown otherwise.
- C. Accessories:
1. Insulation Shield: Install on insulated piping. Oversize rollers and supports.
 2. Welding Insulation Saddle: Install on insulated steel pipe. Oversize rollers and supports.
 3. Dielectric Barrier:
 - a. Provide plastic coated hangers, or isolation tape such as B-Line Iso Pipe, B-Line B1999 Vibra Cushion, or B-Line B3195 Felt Isolators between painted or galvanized carbon steel members and copper or stainless steel pipe or between stainless steel supports and nonstainless steel ferrous metal piping.
 - b. Install 1/4-inch by 3-inch neoprene rubber wrap between submerged metal pipe and oversized clamps.

3.2 FIELD FINISHING

- A. Paint atmospheric exposed surfaces hot-dip galvanized steel components as specified in Section 09 91 00 – Painting.

END OF SECTION

SECTION 26 00 01

GENERAL ELECTRICAL PROVISIONS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	References
1.3	Submittals
1.4	Quality Assurance
2.1	Reference to Drawings
2.2	Choice of Materials and Equipment
2.3	Equipment and Materials
2.4	Wire Markers
2.5	Raceway Markers
2.6	Nameplates
2.7	Terminal Blocks
2.8	Electrical Numbering System
2.9	Arc Flash Mitigation Methods
3.1	General
3.2	Wiring Electrically Operated Equipment
3.3	Equipment Operation
3.4	Circuit Continuity
3.5	Cleaning and Painting
3.6	Identification
3.7	Testing and Start-up
3.8	Test Period
3.9	Grounding
3.10	Installation of Equipment
3.11	Temporary Electric Power
3.12	Attachments

B. Scope

1. This section specifies general requirements for electrical work. Detailed requirements for specific electrical items are specified in other sections but are subject to the general requirements of this section. The electrical drawings and schedules included in this project manual are functional in nature and do not specify exact locations of equipment or equipment terminations.

2. Furnish and install all materials, equipment, labor, supervision and services necessary to complete all electrical work specified herein, and shown on the Drawings.
3. Principal Features
 - a. Complete system of conduits, cables and conductors to supply electrical energy to the new control panel and blowers.
 - b. Blower control panel.
 - c. MCC modifications.
- C. Coordination with Other Trades
 1. Furnish and locate all anchor bolts, inserts and supports for installation by the other trades as required. Coordinate the location of all fixtures, outlets, equipment, and devices with other trades to avoid conflicts.
- D. Fees and Tests
 1. Contractor shall be responsible for all fees for permits, inspections, and tests necessary to complete this work. Demonstrate to the Owner and the Engineer that all items of equipment installed are completely operational and free of defects in all modes.

1.2 REFERENCES

A. Definitions

1. Elementary or Schematic Diagram: A schematic (elementary) diagram shows, by means of graphic symbols, the electrical connections and functions of a specific circuit arrangement. The schematic diagram facilitates tracing the circuit and its functions without regard to the actual physical size, shape, or location of the component devices or parts.
2. One-Line Diagram: A one-line diagram shows by means of single lines and graphical symbols the course of an electrical circuit or system of circuits and the components, devices or parts used therein. Physical relationships are usually disregarded.
3. Block Diagram: A block diagram is a diagram of a system, instrument, computer, or program in which selected portions are represented by annotated boxes and interconnecting lines.
4. Wiring Diagram or Connection System: A wiring or connection diagram includes all of the devices in a system and shows their physical relationship to each other including terminals and interconnecting wiring in an assembly. This diagram shall be (a) in a form showing interconnecting wiring only by terminal designation (wireless diagram), or (b) a panel layout diagram showing the physical location of devices plus the elementary diagram.
5. Interconnection Diagram:
 - a. Show all external connections between terminals of equipment and outside points, such as motors and auxiliary devices on interconnection diagrams. Show references to all connection diagrams which interface to the interconnection diagrams. Interconnection diagrams shall be of the continuous line type. Show bundled wires as a single line with the direction of entry/exit of the individual wires clearly shown. Wireless diagrams and wire lists are not acceptable.
 - b. Show each wire identification as actually installed. Use identical wire identification for each end of the same wire. Identify all devices and equipment shall be identified. Show terminal blocks as actually installed and identified in the equipment complete with individual terminal identification.

- c. Show all jumpers, shielding and grounding termination details not shown on the equipment connection diagrams on the interconnection diagrams. Do not show wires or jumpers shown on the equipment connection diagrams on the interconnection diagram. Show signal and DC circuit polarities and wire pairs. Show spare wires and cables.
6. Arrangement, Layout, or Outline Drawings: An arrangement, layout, or outline drawing is one which shows the physical space and mounting requirements of a piece of equipment. It may also indicate ventilation requirements and space provided for connections or the location to which connections are to be made.
 7. Hazardous Area: Any area that is classified based on the properties of the flammable vapors, liquids, or gases, or combustible dusts or fibers that might be present and the likelihood that a flammable or combustible concentration or quantity is present. See NFPA 70 and NFPA 820.
 8. Corrosive Area: Any area where gases or chemicals may be present which are corrosive to standard metal or iron products such as carbon steel or ductile iron.

B. Reference Standards

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids).
3. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.
4. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
NECA-1	National Electrical Contractors Association – Standard Practices for Good Workmanship in Electrical Contracting
NFPA	National Fire Protection Association
NFPA-70	National Electrical Code (NEC)
NFPA-70E	Standard For Electrical Safety in the Workplace
NFPA 820	Standard for Fire Protection in Wastewater Treatment and Collection Facilities
ACI 318	Building Code Requirements for Structural Concrete

5. Other Reference Documents
 - a. Local, State, and National Electrical Codes.
 - b. National Electrical Code, latest edition.
 - c. Rules of the Electrical Utility and the National Electrical Safety Code.

d. Life Safety Code 101.

1.3 SUBMITTALS

A. Action Submittals/Informational Submittals

1. Provide complete manufacturers' descriptive information and shop drawings for all equipment, material and devices furnished under Division 26, Electrical, including certified outline drawings, arrangement drawings, elementary (schematic) diagrams, interconnection and connection diagrams, in accordance with provisions elsewhere in these Contract Documents. Provide the number of copies specified herein for the Engineer, Contractor and Operation and Maintenance Manuals.
2. Provide certified shop drawings, literature and requested samples showing items proposed for use, size, dimensions, capacity, special features required, schematic (elementary) control diagrams, equipment schedules, rough-in, etc., as required by the Engineer for complete review and for use during installation. Use NEMA device designations and symbols for all electric circuit diagrams submitted.
3. Product Data
 - a. Catalog cuts of equipment, devices, and materials requested by the individual specification sections. Include technical specifications and application information, including ratings, range, weight, accuracy, etc. Edit to show only the items, model numbers, and information which apply. Assemble in a folder containing a cover sheet, indexed by item, and cross-referenced to the appropriate specification paragraph.
 - b. In addition to submittals for specific items mentioned above, furnish shop drawing information on the following items:
 - 1) Conduit and fittings.
 - 2) Conductors.
 - 3) Control cable.
 - c. Safety disconnect switch list including legend with equipment tag, equipment description, and power feeder circuit source and location information.
4. Shop Drawings
 - a. Interconnection diagram: Prepare interconnection diagrams depicting all cable requirements together with their actual terminations as specified in paragraph 1.2.A above.
 - b. Conduit layout drawings indicating size, location, and support, for all conduits other than single runs of 1-inch diameter or less cast in concrete construction.
 - 1) Conduit layout drawings shall illustrate a system which conforms to the requirements of paragraph 3.1.B.
 - 2) For layouts that do not conform to 3.1.B, provide engineering design and calculations signed and sealed by a Professional Engineer registered in the state of the project. Engineering design and calculations shall demonstrate that the proposed layout does not impair or significantly reduce the design structural strength.
 - c. Certified arrangement drawings, outline dimensions, and weights for all major (engineered) equipment including, but not limited to:
 - 1) MCC Breaker
 - 2) Blower Control Panel

d. Drawings

- 1) Where the Contractor is required to provide information on drawings as part of the specified work, prepare such drawings on 11-inch by 17-inch drafting media complete with borders and title blocks clearly identifying project name, equipment and the scope of the drawing.
- 2) Drawing quality and size of presentation shall be such as to permit.

5. Special Procedure Submittals

- a. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each requested deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.
- b. Failure to include a copy of the marked-up specification sections, along with justification for requested deviations from the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

B. Closeout Submittals

1. Record Documentation

- a. Maintain at the job site a set of Contract Documents kept current by indicating thereon all changes, revisions and substitutions, between work as specified and as installed.
- b. Furnish Owner with 1 complete set of reproducible drawings and 2 complete, clean sets of Specifications showing installed locations, size, catalog numbers, etc., of all work and material as taken from record documents.
- c. For each piece of equipment, provide 4 sets of manufacturer's printed catalog pages, operating and maintenance instructions, and wiring and connections diagrams. Bind this information into 8½-inch by 11-inch booklets.

1.4 QUALITY ASSURANCE

A. Qualifications

1. Manufacturers

- a. List of Proposed Materials: Submit a complete list of the proposed manufacturers for each of the items listed in the following electrical specifications. Additional submittal data, sufficient to determine equality, shall be required if the Contractor proposes to substitute another manufacturer's equipment.

B. Intent of Drawings

1. Electrical plan drawings show only general locations of equipment, devices and raceways, unless specifically dimensioned. The Contractor shall be responsible for the proper routing of raceway, subject to the review of the Engineer.

C. Departure from Contract Documents

1. Submit to the Engineer, in writing, details of any necessary, proposed departures from these Contract Documents, and the reasons therefor. Submit such requests as soon as practicable and within 30 days after award of the Contract. Make no such departures without written approval of the Engineer.

D. Identification of Listed Products:

1. Electrical equipment and materials shall be listed for the purpose for which they are to be used, by an independent testing laboratory. Three such organizations are Underwriters Laboratories (UL), Canadian Standards Association (CSA), and Electrical Testing Laboratories (ETL). Independent testing laboratory shall be acceptable to the inspection authority having jurisdiction.
2. When a product is not available with a testing laboratory listing for the purpose for which it is to serve, the product may be required by the inspection authority, to undergo inspection at the manufacturer's place of assembly. All costs and expenses incurred for such inspections shall be included in the original contract price.

E. Factory Tests:

1. Where specified in the individual product specification section, factory tests shall be performed at the place of fabrication and performed on completion of manufacture or assembly. The costs of factory tests shall be included in the contract price.

PART 2 PRODUCTS

2.1 REFERNECE TO DRAWINGS

- A. Make reference to Drawing Schedules, Details, Notes, and Specifications for: Manufacturer, model, catalog number, size, capacity, performance, ratings and installation of equipment and material.

2.2 CHOICE OF MATERIALS AND EQUIPMENT

- A. In submitting substitutions, bidders should note the following minimum considerations:

1. Capacities shown are absolute minimum and must be equaled
2. Physical size limitations for space allotted
3. Structural properties
4. Noise level
5. Interchangeability
6. Compatibility with other materials and assemblies
7. Similar items shall be same manufacture and style wherever possible

- B. All material and equipment, for which a UL, ANSI, or a NEMA Standard is established, shall be so approved and labeled or stamped.

- C. Adhesives are not acceptable as a mounting, supporting, or assembling technique, unless noted otherwise.

2.3 EQUIPMENT AND MATERIALS

A. General

1. Provide equipment and materials that are new and free from defects.
2. Provide all material and equipment of the same or a similar type from the same manufacturer throughout the work.

3. Use standard production materials wherever possible.
4. NEMA Standards shall be taken as minimum requirements for electrical equipment.
5. Equipment shall operate properly under a plus or minus 10 percent voltage variation.
6. 3 Phase power, if necessary, must be obtained from the power company and may not be created using a phase inverter or similar device.

B. Equipment Finish

1. Unless otherwise specified, electrical equipment shall be painted by the manufacturer as specified in Section 09 91 00 - Painting.

2.4 WIRE MARKERS

- A. Identify each power and control conductor at each terminal to which it is connected. Use identification sleeves on conductors size No. 10 AWG or smaller. Use cable markers of the locking tab type on conductors No. 8 AWG and larger. Use white plastic tabs with conductor identification number permanently embossed.
- B. Identify conductors in accordance with paragraph 2.8.B. Adhesive strips are not acceptable.
- C. Machine print the letters and numbers that identify each wire on sleeves with permanent black ink with figures 1/8-inch high. Use yellow or white tubing for sleeves and size to fit the conductor insulation. Shrink the sleeves with hot air after installation to fit the conductor.
- D. Conductor and Wire Marker Manufacture:
 1. TMS Thermofit Marker System by Raychem Co
 2. Sleeve style wire marking system by W. H. Brady Co.
 3. or engineer approved equal.

2.5 RACEWAY MARKERS

- A. Raceway markers tags:
 1. Solid brass with 0.036-inch minimum thickness.
 2. Raceway number stamped in 3/16-inch minimum height characters
 3. Attached to the raceway with 316 stainless steel wire.

2.6 NAMEPLATES

- A. Provide nameplates made from laminated phenolic plastic.
 1. Nominal size: 3/4-inch high by 2 inches long.
 2. Black backgrounds with 3/16-inch white letters.
 3. Fastened using self-tapping stainless steel screws.
- B. Submit abbreviations to the Engineer prior to manufacture because of space limitations. Nameplate adhesives will not be permitted on the outside of enclosures.

2.7 TERMINAL BLOCKS

- A. Unless otherwise specified, provide panhead strap screw type terminal blocks. Provide terminals with integral marking strips that permanently identify with the connecting wire numbers as shown on the drawings:

1. Terminal blocks for P-circuits (power 208-600 volts)
 - a. Rated not less than the conductor current rating
 - b. Rated not less than 600 volts AC.
2. Terminal blocks for C-circuits and S-circuits:
 - a. Rated not less than 20 amperes
 - b. Rated not less than 600 volts AC.
3. Terminals shall be tin-plated.
4. Insulating material shall be nylon.

2.8 ELECTRICAL NUMBERING SYSTEM

A. Raceway Numbering System

1. Tag raceways at all terminations. Assign raceway numbers in accordance with the following system where raceway numbers have not been assigned:

Raceway Prefix	Type of Function
C	Control or power - 120V or less
H	Power above 600V
N	Pneumatic tubing
P	Power 208V to 600V
S	Signal - data communication or instrumentation
X	Spare

2. Prefixes shall be followed by a 4-digit number. Add a letter suffix to distinguish the raceways where more than one raceway is routed to a particular piece of equipment.
 - a. Example: Raceway number = P3109A where:
 - 1) P = conduit contains power
 - 2) 3109 = unique 4-digit number
 - 3) A = letter to distinguish raceways to same equipment

B. Conductor Numbers

1. Identify conductors with numbers at both ends. Conductor tag numbers shall consist of the equipment number followed by a dash followed by the conductor number specified on the control diagram.
2. Example: Equipment Tag number = 1900 - L1 where:
 - a. 1900 = cable number
 - b. L1 = conductor number
3. Provide the same conductor number for conductors in parallel or in series between equipment. Provide the same conductor number for neutral conductors. Wherever possible, use the same conductor number as the equipment terminal to which it connects.
4. Where factory-wired equipment has terminal numbers different than the conductor numbers shown on the control diagrams:
 - a. Both shall be shown on the interconnection diagram

- b. Include a copy of the interconnection diagram inside of the equipment cabinet.

2.9 ARC FLASH MITIGATION METHODS

- A. The following mitigation method requirements apply to all power distribution and utilization equipment supplied, for any products supplied on the project and applies to all equipment divisions in the Contract Documents. Refer to the NFPA-70 (NEC), and NFPA-70E (Standard for Electrical Safety in the Workplace) for equipment labeling requirements.
- B. Equipment Labels:
 - 1. Install County standard equipment labels on the outside of the electrical equipment enclosure, cabinet, or panels to avoid opening the equipment to access the arc flash data or the PPE requirements.
- C. Hinged Doors:
 - 1. Provide hinged rear doors on power distribution equipment where back access is shown.
- D. Remote Racking Devices:
 - 1. Provide remote racking devices on power distribution equipment for Operators to insert or remove rack-mounted breakers, rack-mounted devices, or auxiliary equipment drawers into the associated equipment location.
- E. Insulated Power Bus and Insulated Cable Boots:
 - 1. Provide insulated power bus in power distribution equipment where accessible to installers or maintenance workers.
 - 2. Provide cable boots for power conductor connections to insulate the exposed power conductor connections.
- F. View Windows for Monitoring:
 - 1. Provide protected view windows into cabinets that allow infra-red analyzers, monitors, or cameras to monitor hot temperature for unusual heat generated by deteriorating connections. The view windows shall have a method to move the window protector and hold-in-place during the monitoring operation.
- G. Power and Control Equipment Separation:
 - 1. Provide separation between power equipment within an enclosure, cabinet, or panel by the uses of barriers, separate access doors, or by other means.
 - 2. Provide separation barriers between main breaker feeders coming into equipment and other termination points or bussing on the load side of the main breaker.
- H. Automatic Shutters:
 - 1. Provide automatic shutters, where possible, to close the access to the power bus when a power device is not engaged.
- I. Maintenance Switches
 - 1. Install circuit breaker maintenance switches as specified and where shown to make circuit breakers operate in the instantaneous region of the trip curve in all modes (LSIG).

PART 3 EXECUTION

3.1 GENERAL

- A. Construction:

1. Perform the work under Division 26 in accordance with these specifications.
2. Refer to the National Electrical Contractors Association's (NECA) National Electrical Installation Standards (NEIS) for Standard Practices for Good Workmanship in Electrical Contracting (NECA-1) as a minimum baseline of quality and workmanship for installing electrical products and systems that defines what is meant by "neat and workmanlike" as required by the National Electrical Code Section 110-12. Specified requirements supersede NECA practices.
3. Electrical layout drawings are diagrammatic, unless otherwise detailed or dimensioned. Coordinate the location of electrical material or equipment with the work.
4. Major electrical openings may compromise the structural integrity of the slab and wall elements. Major electrical openings are defined as openings or penetrations greater than two times the wall thickness in any dimension, and include duct bank transitions into a building through structural elements. Construct major electrical openings according to standard details on the drawings, up to an opening dimension of three feet. For opening dimensions greater than three feet, construct walls and slabs as specifically detailed on the drawings for that case. Submit major electrical openings proposed by the Contractor to the Structural Engineer of Record for the project for review.
5. Minor changes in location of electrical material or equipment made prior to installation shall be made at no cost to the Owner.

B. Conduits in Concrete Construction:

1. Conduits for power, control and instrumentation may be embedded in and pass through concrete construction subject to the limitations in this paragraph. Where concrete strength or serviceability requirements prevent the direct embedment of conduit, provide adequate support, bracing, and serviceability details:
 - a. Do not significantly impair concrete strength by the embedment of conduits in or through structural sections.
 - b. Conform conduit layout shall to the requirements of ACI 318, Sections 3.3 – Aggregates and 6.3 – Conduits and Pipes Embedded in Concrete.
 - c. Treat conduits similarly to reinforcing steel for purposes of clearance. In general, code sections require conduit spacing the greater of:
 - 1) 1.33 times the maximum concrete aggregate size, clear
 - 2) Three diameters center to center
 - d. Alternate spacing and layout shall be as reviewed and accepted by the Engineer.
 - e. Detail and construct to prevent liquid and moisture penetration through the wall or slab section for conduit and raceway penetrations through walls and slabs where:
 - 1) one side is a conditioned or an occupied space and the other side not, or
 - 2) one side has liquid or groundwater contact and the other not.

C. Housekeeping:

1. Protect electrical equipment from dust, water and damage. Wipe motor control centers, switchgear, and buses free of dust and dirt, keep dry, and vacuum on the inside within 30 days of acceptance of the work.
2. Before final acceptance, touch up any scratches on equipment as specified in Section 09 91 00.
3. Protect electrical equipment temporarily exposed to weather, debris, liquids, or damage during construction as specified in Section 01 66 00.

D. Electrical Equipment Labeling

1. Provide electrical equipment with field marked signs and labeling to warn qualified persons of the potential electric arc flash hazards per NEC Article 110.16 Flash Protection.
2. Install NFPA 70E labels on electrical equipment stating the results of the Arc Flash analysis.
3. Field label electrical distribution equipment and utilization equipment to identify the power source and the load as specified. Refer to NEC Article 110.22 for Identification of Disconnecting Means installation criteria. Specific information is required such as the equipment tag number and equipment description of both the power source and the load equipment.

E. Safety Disconnect Switches:

1. Provide heavy duty fused and non-fused disconnect switches with current range of 30 to 600 amperes as shown on the drawings with the enclosure type matching the area rating. Provide lock-off provision for a hasp padlock. Provide visible knife blades through a cover viewing window. Provide shielded or insulated line terminals with quick-make / quick-break switch operator. Provide internal barrier kit for additional personnel barrier from accidental contacts with live parts. Provide a legend plate with equipment tag, equipment description, and power feeder circuit source and location identification.
2. Disconnects shall include one auxiliary contact that operates with the power switch blades. Wire the auxiliary contact as shown on the drawings for remote status monitoring of the disconnect position where shown or for disconnecting motor space heater where shown.
3. Provide Class R rejection type fuse clips sized for UL Class R, one-time, time-delay fuses. Fuse assembly shall have a minimum short circuit capacity of 100,000 amps symmetrical. Provide fuses as shown and one set of spare fuses with each switch.

F. Motor Connections

1. Verify that the motors are purchased with the correct size motor termination boxes for the circuit content specified as shown on the power single line diagrams or submit custom fabrication drawing indicating proposed motor termination box material, size, gasket, termination kit, grounding terminal, motor lead connection method, and motor terminal box connection/support system. Verify the motor termination box location prior to raceway rough-in.

G. Conductor Installation

1. Do not use an enclosure containing disconnecting means, overcurrent devices, or electrical equipment as a wireway or raceway for conductors not terminating within the enclosure. Provide wireways, raceways, termination boxes, or junction boxes external to the enclosure for the other conductors.

3.2 WIRING ELECTRICALLY OPERATED EQUIPMENT

- A. Make all electrical connections to all equipment requiring electrical power. This responsibility applies to equipment furnished under this and other Divisions and by the Owner.

3.3 EQUIPMENT OPERATION

- A. This Division is responsible for:
 1. Proper phase rotation

2. Observing that lubrication has been properly performed
3. That motors operate within nameplate limits
4. Adjustment of circuit breaker and MCP trip settings.
5. Adjustment of VFD or soft starter operational parameters and protection settings.

3.4 CIRCUIT CONTINUITY

- A. Provide a complete installation free of short circuits, grounds, open circuits, and other defects. Make tests as required to prove that all parts of installation meet specified performances.

3.5 CLEANING AND PAINTING

- A. Thoroughly clean fixtures, panels and equipment. Touch-up or repaint all equipment as required to present a clean professional appearance. Prime and paint all ferrous metal which is not otherwise protected against corrosion. Paint exposed pipe threads with Bitumastic No. 50.

3.6 IDENTIFICATION

- A. Identify all major items of equipment including controls, panels, switches, contactors, motor starters, junction boxes and metering by permanent nameplates, with wording approved by Engineer. Secure metal nameplate frame with screws or brads. Adhesives are acceptable on components within NEMA 1 enclosures.
- B. Install nameplates to be easily visible. Coordinate notations on nameplates to correspond to those shown on record drawings.
- C. Identify all conduits with a stamped stainless steel tag system (Brady or approved equal). Permanently attach conduit tags to each exposed end of conduit runs such as in manholes, pull boxes, panels, junction boxes, etc. and at each point of entry into a structure or building. Stamp each tag with the appropriate conduit number per the conduit and cable schedules.
- D. Identify each instrument with a stamped stainless steel tag system (Brady or approved equal). Permanently attach instrument tags to each individual instrument and stamp with the appropriate number per instrument specification section.
- E. Identify each cable with a permanent labeling system (Brady Catalog Number B-292 with printed legends or approved equal). Label instrumentation cables with the appropriate instrument number of the originating signal (Ex. FT-2020-1). Label multiplex cables, power and control cables with the appropriate cable number per the conduit and cable schedules.
- F. Identify all circuit breakers, control panels, control cabinets, etc. with permanently mounted phenolic labels.

3.7 TESTING AND START-UP

- A. General:
 1. Prior to energizing the electrical circuits, perform insulation resistance measurements tests using a 1000-volt megohmmeter to verify the conductor is acceptable for use on the project. Record the test measurements on the specified forms and provided in accordance with paragraph 1.3 above.
 2. Prior to energizing any equipment, thoroughly vacuum clean the equipment with an industrial type vacuum cleaner. Clean the outside of all electrical equipment and touch-up paint as required to leave equipment in an "as purchased" condition.

3. During start-up of new equipment, provide sufficient personnel to aid with start-up of the electrical equipment to remove any faults, and to make the necessary adjustment for proper operation of electrical equipment and installation. This includes sufficient personnel to aid equipment service personnel in their check-out of the electrical equipment and service.
 4. Furnish all testing equipment.
 5. Correct all failures under tests due to defective material or poor workmanship at no expense to the Owner.
 6. Do not, under any circumstances, energize any electrical equipment covered by these Specifications without first obtaining permission from the Engineer.
- B. Grounding
1. After all connections have been made to the ground, make ground tests to verify its adequacy.
- C. Insulation Resistance Measurements:
1. General:
 - a. Make insulation resistance measurements on conductors and energized parts of electrical equipment. Minimum acceptable values of insulation resistance shall be in accordance with the applicable ICEA, NEMA or ANSI standards for the equipment or material being tested, unless otherwise specified. Record the ambient temperature at which insulation resistance is measured on the test form.
 - b. Record insulation resistance measurements in a format similar to Form 26 00 01-A, provided at the end of this Section. Insulation with resistance of less than 10 megohms is not acceptable.
 2. Conductor and Cable Tests: Measure the phase-to-ground insulation resistance for all circuits rated 120 volts and above except lighting circuits. Measurements may be made with motors and other equipment connected. Disconnect solid state equipment unless the equipment is normally tested by the manufacturer at voltages in excess of 1000 volts DC.
 3. Motor Tests:
 - a. Complete the Installed Motor Test Form, 26 00 01-B, provided at the end of this Section, for each motor after installation.
 - b. Measure the insulation resistance of motors before they are connected. For motors 50 HP and larger measure the insulation resistance at the time of delivery, as well as, when they are connected. Insulation resistance values less than 10 megohms are not acceptable.
- D. Pre-Functional Test Checkout:
1. Perform functional testing in accordance with the requirements of Section 01 91 13. Prior to functional testing, adjust and make operative all protective devices.
 - a. Submit a description of the proposed functional test procedures prior to the performance of functional checkout.
 - b. Prior to energization of equipment, perform a functional checkout of the control circuit. Checkout:
 - 1) Energizing each control circuit.
 - 2) Operating each control device, alarm device, or monitoring device.
 - 3) Operate each interlock to verify that the specified action occurs.

- 2. Verify motors are connected to rotate in the correct direction. Verification may be accomplished by momentarily energizing the motor, provided the Contractor confirms that neither the motor nor the driven equipment will be damaged by reverse operation or momentary energization.
- E. Insert typewritten directories in all panels showing the designation of each circuit. Furnish all power and replacement fuses necessary for testing.

3.8 TEST PERIOD

- A. Each piece of equipment shall continue to meet performance specifications throughout the first year of actual operation. Replace or repair any defect due to faulty workmanship or material which develops within 1 year from date of acceptance. This guaranty shall cover both material and labor.
- B. For first year after final acceptance, provide, at no cost to Owner, any required maintenance and service necessary to assure the proper operation of the system. Date of acceptance shall be certified by Engineer as that date on which the contract has been satisfactorily completed in accordance with the Contract Documents.

3.9 GROUNDING

- A. See section 26 05 26 – Grounding of these specifications.

3.10 INSTALLATION OF EQUIPMENT

- A. The electrical contractor shall coordinate with the Contractor and Owner in order to have electric power available when required.

3.11 TEMPORARY ELECTRIC POWER

- A. Refer to General Conditions and/or other drawings in these Contract Documents for necessary provisions for electric power used during construction.

3.12 ATTACHMENTS

- A. Attachments listed below, following “END OF SECTION,” are a part of this Specification:

Form No.	Title
26 00 01-A	Wire and Cable Resistance Test Data Form
26 00 01-B	Installed Motor Test Data Form
26 00 01-G	Protective Relay Test Form
26 00 01-L	Neutral Ground Resistor Test

END OF SECTION

26 00 01-A. WIRE AND CABLE RESISTANCE TEST DATA FORM

Wire or Cable No.: _____ Temperature, °F: _____

Location of Test	Insulation resistance, megohms
1.	
2.	
3.	
4.	
5.	
6.	
7.	

CERTIFIED _____ Date _____
 Contractor's Representative

WITNESSED _____ Date _____
 Owner's Representative

26 00 01-B. INSTALLED MOTOR TEST FORM

Motor Equipment Number: _____ Date of test: _____

Equipment Driven: _____

MCC Location: _____

				Ambient temp	°F
Resistance:					
Insulation resistance phase-to-ground megohms:					
Phase A		Phase B		Phase C	
Current at Full Load:					
Phase		Current, amps			
Phase		Current, amps			
Phase		Current, amps			
Thermal Overload Device:	Manufacturer/catalog #			Amperes	
Circuit breaker (MCP) setting:					

Motor Nameplate Markings:

Mfr		Mfr Model		Frame		HP	
Volts		Phase		RPM		Service factor**	
Amps		Freq		Ambient temp rating			°C
Time rating				Design letter**			
	(NEMA 1-10.35)				(NEMA MG-1.16)		
Code letter				Insulation class			

**Required for 3-phase squirrel cage induction motors only.

CERTIFIED _____ Date _____
Contractor's Representative

WITNESSED _____ Date _____
Owner's Representative

26 00 01-G. PROTECTIVE RELAY TEST FORM

Location: _____

Switchgear Breaker No.: _____

Protective Relay Description: _____

The protective relays shall be tested in the following manner:

1. Each protective relay circuit shall have its insulation resistance tested to ground.
2. Perform the following tests on the specified relay setting:
 - a. Pickup parameters on each operating element.
 - b. Timing test shall be performed at three points on the time dial curve.
 - c. Pickup target and seal-in units.

The results shall be recorded and signed. A copy shall be given to the Engineer.

26 00 01-L. NEUTRAL GROUNDING RESISTOR TEST

Equipment No.: _____

Location: _____

The pickup and time delay setting on the ground fault relay shall be set in accordance with Division 26.

1. The transformer neutral insulation resistance shall be measured with and without the grounding resistor connected to insure no parallel ground paths exist.
2. The protective relay pickup current shall be determined by injecting test current into the current sensor. The pickup current should be within 10 percent of the dial setting. Record the dial setting and actual pickup tie.
3. The relay timing shall be tested by injecting 150 and 300 percent of pickup current into the current sensor. The relay timing shall be in accordance with the manufacturer's published time-current characteristic curves. Record the relay timing at 150 and 300 percent of pickup current.
4. The circuit interrupting device shall be operated by operating the relay.

The results shall be recorded and signed by the Contractor and Engineer. A copy shall be given to the Engineer.

SECTION 26 00 02

BASIC MATERIALS AND METHODS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	References
1.3	Submittals
1.4	Quality Assurance
1.5	Delivery, Storage, and Handling
2.1	Hazardous Areas
2.2	Materials
2.3	Control Devices
2.4	Control Relays
2.5	Magnetic Contactors
2.6	Safety Disconnect Switches
2.7	Overcurrent Protection
2.8	Elapsed Time Indicators
2.9	Current Transformers and Transducers
2.10	Terminal Strips, Blocks, and Devices
2.11	Thermostats
2.12	Static Ground Indicator
2.13	Nameplates
3.1	General
3.2	Conduit Installation
3.3	Cutting and Patching
3.4	Equipment Mounting

B. Scope

1. Provide all labor, equipment and materials required to complete the installation specified herein, and shown or scheduled on the Drawings. Since the drawings are schematic, all fittings, connectors, etc. are not shown, but shall be furnished as required for a complete and functional installation.

C. Description

1. The vendor, manufacturer, and custom control panels shall provide enclosures, selector switches, pushbuttons, indicators, terminal strips, surge devices, nameplates, testing procedures, wiring method, wiring color coding, wire labeling, separation between power, controls, and instruments, hardwired logic relays or PLC logic products as specified herein and in Section 40 90 01.

2. This section specifies electrical control and monitoring devices:
 - a. Control Devices:
 - 1) Pushbuttons
 - 2) Selector Switches
 - 3) Indicating Lights
 - 4) Control Station Enclosures
 - b. Control Relays:
 - 1) Load-Switching
 - 2) Logic Level Switching
 - 3) Timers and Time Switch
 - 4) Alternators
3. This section specifies power devices:
 - a. Magnetic Contactors:
 - 1) Lighting Contactors
 - 2) Motor Contactors
 - b. Safety Disconnect Switches
 - c. Manual starters – Individual Motor Starters
 - d. Field Instrument and Field Analyzer: Key-Switch in control station with surge devices
 - e. Overcurrent Protection: Circuit breakers
 - f. Elapsed Time Indicators
 - g. Current transformers and transducers
 - h. Time Switch
 - i. Motor Driven Timers – On Delay and Off Delay
 - j. Intrusion Switches and Override Key Switches
 - k. Thermostats
 - l. Static Ground Indicator and Interlock System
4. Request clarification where conflicts occur with this section and other sections in these Specifications.

1.2 REFERENCES

A. Reference Standards

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid or on the effective date of the Agreement if there were no Bids.

3. If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued.
4. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
NEMA 250	Enclosures for Electrical Equipment (1000 volts maximum)
NEMA ICS 1	General Standards For Industrial Controls and Systems
NEMA ICS 2	Industrial Control Devices, Controllers, and Assemblies
NEMA KS 1	Enclosed Switches

5. Other Reference Documents
 - a. Local, State, and National Electrical Codes.
 - b. National Electrical Code, latest edition.
 - c. Rules of the Electrical Utility and the National Electrical Safety Code.
 - d. Life Safety Code 101.
 - e. NECA Standard of Installation.
 - f. NFPA (National Fire Protection Association).

1.3 SUBMITTALS

A. Action Submittals/Informational Submittals

1. Provide shop drawings and product data for the following items:
 - a. Circuit breakers
 - b. Surge suppressor
2. A list of product manufacturers is required for all other items covered by these Specifications.
3. Shop Drawings
 - a. Arrangement drawings of the panel enclosure indicating the front door and panel equipment arrangement and dimensions, and enclosure type.
 - b. Nameplate legend with engraving and sizes.
 - c. Internal layout drawings showing all components.
 - d. List of materials and components with the layout drawings.
 - e. Elementary / schematic diagrams
 - f. Internal wiring connection diagrams.
 - g. External wiring interconnection diagrams including interlocks.
 - h. Power and control single line diagrams, where motor controllers are included.
4. Manufacturer's catalog data for all material provided under this section shall be assembled in a folder with each page clearly marked with the item model number and reference number to the specification.

5. Special Procedure Submittals

- a. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each requested deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications.
- b. Failure to include a copy of the marked-up specification sections, along with justification for requested deviations from the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

1.4 QUALITY ASSURANCE

- A. Where not otherwise specified, provide all material and methods of the highest industrial quality suitable for the application.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Storage and Handling Requirements

1. Protect all panelboards, motor starters, transformers, and other electrical equipment that is stored prior to installation, or that is installed outdoors, from corrosion and rust with a product equal to Zerust Vapor Capsules or Cutler-Hammer Oxidation Inhibitor Capsules.

PART 2 PRODUCTS

2.1 HAZARDOUS AREAS

- A. Provide devices, materials, and equipment for installation in hazardous areas that are specifically approved for installation in hazardous areas of the Class, Division and Group indicated, and are of construction that will ensure safe performance under conditions of proper use and maintenance. Provide devices, materials, and equipment meeting the requirements of the NEC [NFPA 70 (latest edition)], applicable state and local codes, and the authority enforcing these codes. Acceptable manufacturers: Crouse Hinds, Appleton, or engineer approved equal.

2.2 MATERIALS

A. Conduits

1. See Section 26 05 33.13 – Conduit

B. Wire and Cable

1. See Section 26 05 19 – Wire and Cable

C. Supporting Devices

1. Expansion and/or Deflection Fittings
 - a. O.Z. Gedney, Appleton, Spring City or engineer approved equal.

2. Channel Support
 - a. Unistrut, Kindorf, Super Strut, or equal. Provide supports that are PVC coated galvanized steel or PVC coated aluminum. Do not use uncoated galvanized steel. Recoat cut ends of supports with a PVC like coating.
 - b. Stainless steel, type 316 may be used in lieu of PVC coated supports.
 3. Fastening Devices
 - a. Caddy, Appleton, or engineer approved equal.
 4. Cable Ties
 - a. Panduit, Thomas & Betts, or engineer approved equal.
- D. Electrical Transient Protection
1. General
 - a. Protect all elements of the Blower Control Panel against damage due to electrical transients induced in interconnecting lines by lightning and nearby electrical systems. As a minimum, provide surge suppressors at the following:
 - 1) At any connection at AC power to control panel.
 - 2) At analog or digital monitoring or controls (DI, DO and AI).
 - 3) Output of DC power supply.
 - 4) Ethernet cables.
 - b. Suppressors on 120 V AC Power Supply Connections
 - 1) Construction: First stage high energy metal oxide varistor and second stage bipolar silicon avalanche device separated by series impedance. Grounding wire, stud or terminal provided.
 - 2) Occurrences: Suppressor tested and rated for a minimum of 50 occurrences of IEEE 587 Category B test waveform.
 - 3) Clamping voltages: 350 volts or less for first stage, 210 volts or less for second stage.
 - 4) Response: 5 nanoseconds maximum.
 - 5) Recovery: Automatic
 - 6) Continuous operation: 5 amps minimum at 130 volts AC for suppressor on power supply for one (1) 4-wire transmitter or receiver, 20 amps minimum otherwise.
 - 7) Temperature range: -20 degrees C to + 85 degrees C.
 - 8) Manufacturers: EDCO HSP-121, Phoenix Contact FSP-1, Schneider Electric TVS120LC, or engineer approved equal.
 - c. Suppressor on Analog Signal Lines
 - 1) Construction: First stage high energy metal oxide varistor and second stage bipolar silicon avalanche device separated by series impedance. Grounding wire, stud or terminal provided.
 - 2) Test waveform: Linear 8 microsecond rise in current from zero amps to a peak current value followed by an exponential decay of current reaching for half the peak value in 20 microseconds.

- 3) Surge rating: Suppressor tested and rated for a minimum of 50 occurrences of 2000 amp peak test waveform.
- 4) DC clamping voltage: Twenty to forty percent above operating voltage for circuit. Clamping voltage tolerance less than plus or minus 10 percent.
- 5) Response: 5 nanoseconds.
- 6) Recovery: Automatic.
- 7) Maximum loop resistance: 18 ohms per conductor.
- 8) Temperature range: -20 degrees C to + 85 degrees C.
- 9) Approved vendor EDCO PC-642 or SRA-64 Series or engineer approved equal.

2.3 CONTROL DEVICES

A. Pushbuttons

1. Provide flush head, heavy-duty pushbuttons, with NEMA rating to match enclosure type. Operator colors as follows:
 - a. Green – start function
 - b. Red – stop functions
 - c. Black – all other functions.
2. The escutcheon legend shall be as specified on the drawings.
3. Other Features
 - a. UL Listed.
 - b. Dielectric Strength: 1300 Volts for one minute for Logic Reed contacts, 2200 Volts for one minute for other contacts.
 - c. 30.5mm mounting hole.
 - d. Temperature operating range –10 degree C. to +55 degree C.
 - e. Momentary contact type
 - f. When switching circuits are monitored by programmable controllers or other solid state circuits, furnish hermetically-sealed, logic-reed type contacts rated not less than 0.15 amperes at 150 Vac and 0.06 amperes at 30 Vdc.
 - g. When switching circuits are not monitored by programmable controllers or other solid state circuits, furnish contacts with NEMA Utilization Category rating A600 rated not less than 10 amperes continuous and 6 amperes break at 120 Vac.
4. Manufacturer: Allen-Bradley 800T/800H series or engineer approved equal.

B. Selector Switches

1. Provide heavy-duty selector switches with NEMA rating to match enclosure type. Selector switches shall have maintained position contacts. Provide switches with contact blocks and number of positions as required for performing the specified or indicated operations.
2. The escutcheon legend shall be as specified on the drawings.
3. Other Features
 - a. UL Listed.

- b. Dielectric Strength: 1300 Volts for one minute for Logic Reed contacts, 2200 Volts for one minute for other contacts.
 - c. 30.5mm mounting hole.
 - d. Temperature operating range –10 degree C. to +55 degree C.
 - e. Standard knob operator (not lever type nor wing lever type)
 - f. Number of positions and contact configuration as shown on Drawings.
 - g. When switching circuits are monitored by programmable controllers or other solid state circuits, furnish hermetically-sealed, logic-reed type contacts rated not less than 0.15 amperes at 150 Vac and 0.06 amperes at 30 Vdc.
 - h. When switching circuits are not monitored by programmable controllers or other solid state circuits, furnish contacts with NEMA Utilization Category rating A600 rated not less than 10 amperes continuous and 6 amperes break at 120 Vac.
4. Manufacturer: Allen-Bradley 800T/800H series or equal.
 5. Provide a lock-out style selector switch for locking on or locking off the 120Vac power source for field instruments and field analyzers specified in Section 40 96 20 – Instrument Index. The selector switch shall use a control station in NEMA-12, 4, 4X, or 7 as required by the area classification. Provide O-Z/Gedney Class 441 with two position key-operated maintained contact switch. Provide surge protection device that matches the enclosure type of the power disconnect type control station, field instrument, or field analyzer: Telematic TP48 transmitter surge protection device or engineer approved equal.

C. Indicating Lights

1. Red, amber, green, and blue indicating lights shall be heavy-duty full voltage 120Vac or 24Vdc push-to-test LED type with NEMA rating to match enclosure type for installation in a 30.5mm hole. Furnish with 28 chip high visibility LED. The escutcheon and lens color shall be as shown on Drawings or scheduled.
2. White indicating lights shall be as above.
3. Manufacturer:
 - a. Allen-Bradley 800H-QRTH10 series or equal for 120Vac applications with colors other than white.
 - b. Allen-Bradley 800HQRTH24 series or equal for 24Vdc applications with colors other than white.
 - c. Allen-Bradley 800H-QRT10 series or equal for 120Vac applications with white.
 - d. Allen-Bradley 800H-QRT24 series or equal for 24Vdc applications with white.
4. Indicating Light Lens Color:

Lens Color	Typical Function	Example
Red	Danger, running	Equipment operating, motor running, valve open, power voltage applied, cycle in automatic
Amber	Fault condition, attention	Equipment failure, status abnormal
Green	Ready condition	End of cycle; unit or head returned; motors stopped; motion stopped; contactors open, valve closed

White or Clear	Normal Condition	Normal pressure of air, water, lubrication, control power on, status okay
Blue	Advisory+	Control mode not in automatic

D. Control Station Enclosures

1. Enclosures locations and ratings:
 - a. Indoors: NEMA 12
 - b. Outdoors and Corrosive areas: NEMA 4X stainless steel
 - c. NEC 500 Hazardous Areas: NEMA 7.

E. Control Power Transformers

1. Sized for the panel devices and products.
2. Dual primary and single secondary fusing.

2.4 CONTROL RELAYS

A. Load-Switching Control Relays

1. Provide heavy-duty machine tool type control relays used for switching loads such as solenoids, actuators, contactors, motor starter coils, remote interlocking, etc.
2. Provide 4-pole contacts that are field interchangeable to either normally-open or normally-closed. Relay shall be capable of accepting a 4-pole adder.
3. AC relays shall have NEMA A600 contact ratings and electrical clearances for 600 volts. DC relays shall have NEMA P300 contact ratings and electrical clearances for 250 volts.
4. Manufacturer: Allen Bradley Bulletin-700, Square D Class 8501, or engineer approved equal.

B. Logic Level Switching Control Relays

1. Control relays for signal circuits shall have a minimum of three SPDT, gold-flashed, fine silver contacts rated 3-ampere resistive at 120Vac or 28Vdc.
2. Provide plug-in type control relays with heavy-duty, barrier-protected screw terminal sockets and clear polycarbonate dust cover with clip fastener.
3. AC models shall have neon lamp indicator wired in parallel with coil. DC models shall have LED lamp indicator wired in parallel with coil.
4. Manufacturer: Potter Blumfield series KUP; Schrack Series RA; or engineer approved equal

C. Timers

1. Multi-function, micro-controller based, socket mounted timing relay.
2. Single functions:
 - a. Delay on Make
 - b. Delay on Break
 - c. Recycle (on time first, equal recycle delays)
 - d. Single shot
 - e. Interval
 - f. Trailing edge single shot

- g. Inverted single shot
 - h. Inverted delay on break
 - i. Accumulative delay on make
 - j. Re-triggerable single shot
3. Dual functions:
- a. Delay on make/delay on break
 - b. Delay on make/recycle (on time first, equal recycle delays.)
 - c. Delay on make/interval
 - d. Delay on make/single shot
 - e. Interval/recycle (on time first, equal recycle delays)
 - f. Delay on break/recycle (on time first, equal recycle delays)
 - g. Single shot/recycle (on time first, equal recycle delays)
 - h. Recycle – both times adjustable (on time first)
 - i. Recycle – both times adjustable (off time first)
 - j. Interval/delay on make
 - k. Accumulative delay on make/interval
4. Time delay range, switch selectable:
- a. Single function 0.1 second to 1,705 hours in 8 ranges.
 - b. Dual function 0.1 second to 3,100 minutes in 8 ranges.
 - c. Setting accuracy +/- 1 percent or 50 milliseconds, whichever is greater.
 - d. Repeat accuracy +/- 0.1 percent or 16 milliseconds, whichever is greater.
5. Output:
- a. Two Form-C electromechanical isolated contacts rated 10-amperes resistive at 240Vac
 - b. Rated 1/3-horsepower at 120 or 240Vac
 - c. Double-pole double-throw: DPDT.
 - d. Mechanical life: 10,000,000 operations
6. Electrical life: 1,000,000 operations at full load.
7. Mounting: Magnal Plug 11-pin socket
8. Environment: -20 to +65 degree C.
9. Manufacture:
- a. ABB / SSAC's multifunction type TRDU time delay relay with dip-switch function setting with 12Vdc, 24Vac, 120Vac, 240Vac inputs as required or indicated or engineer approved equal.

D. Alternating Relay

- 1. Alternate assignment between "Duty" and "Stand-by" at the end of each run cycle.
- 2. Double-pole, double-throw output relay rated for 7-amps inductive at 120-volts AC. Isolation not less than 1,500-volt RMS input to output. Life of 1,000,000 operations at full electrical load.
- 3. Switch to select alteration or continuous operation of either load.

4. Mount in Magnal 11-pin socket.
5. Operating temperature range of -20 to +60-degree C.
6. Manufacturer: ABB-SSAC type ARP series or Engineer accepted substitute.

2.5 MAGNETIC CONTACTORS

A. Motor Contactors

1. Provide motor contactors designed for continuous operation of induction motors at 600Vac or less at 60-Hertz and in compliance with NEMA ICS 2-210. Unless otherwise specified or indicated, minimum contactor size shall be NEMA Size-1.
2. Supply motor contactors with a normally open auxiliary contact for use as a hold-in-contact and status contacts with a minimum of two additional Form-C contacts. Provide 120Vac coil voltage and 60-Hertz frequency with the number of poles and auxiliary contacts as indicated.
3. Manufacturer: GE, ABB, Allen Bradley, Square D, Eaton-Cutler Hammer or equal.
4. Provide solid-state overloads relays with one alarm contact. Where specified and shown as E-SSOL, provide the electronic SSOL relay: Automatic Timing and Controls (ATC) Motor Guardian for alarming and tripping on under-current, over-current, single-phase, ground-fault, motor-jam conditions. Provide ATC current transformers and voltage connections.
5. Manufacturer: ATC Lancaster, PA. Model: Motor Performance Analyzer; or engineer approved equal.

2.6 SAFETY DISCONNECT SWITCHES

1. Provide heavy-duty safety disconnect switches with 30-400-ampere ratings as indicated, circuit breaker operating or non-fused as indicated, stainless steel operator, safety type rated 600 volts AC.
2. Enclosure locations and ratings:
 - a. Indoor enclosures: NEMA 12
 - b. Outdoor or corrosive areas: NEMA 4X stainless steel
 - c. Hazardous areas: NEMA 7
 - d. Classified areas: Suitable for the specified classification.
3. Provide operating handle capable of being padlocked in the "off" position. The operator shall be a positive, quick-make, quick-break mechanism. Provide bolt-on hubs. Provide door lock. Provide nameplates with the equipment tag number, equipment description, and power source as indicated on the drawings. Submit nameplate list.
4. Provide horsepower rated switches for motors which comply with NEMA KS-1. Provide switches with defeatable door interlocks that prevent the door from opening when the operating handle is in the "on" position. Switches shall have line terminal shields.
5. Manufacturer: ABB, Cutler-Hammer, General Electric, Square-D, or engineer approved equal.

2.7 OVERCURRENT PROTECTION

A. Circuit Breakers

1. Provide thermal magnetic, molded case type circuit breakers with the ampere rating as specified. Unless otherwise specified or indicated, circuit breaker interrupting rating shall be 22,000 amperes symmetrical.

2.8 ELAPSED TIME INDICATORS

- A. Provide elapsed time indicators that are panel mounted, non-resettable, 5.5-digit, hour indicator, rated 120Vac, 60-Hertz.

2.9 CURRENT TRANSFORMERS AND TRANSDUCERS

- A. Provide monitoring current transformers with 600Vac insulation and primary ampere rating as indicated with 5-ampere output.
- B. Provide AC current transducer for any one of the phase conductors of the power circuit to be installed through onboard toroid. Provide a loop-powered transducer with input rated from 0 to 50-ampere with 4-20mADC analog output scaled for the primary current of the current transformer. Provide zero and span adjustments.
- C. Manufacturer: ABB AC current transducer TCSA Series Loop Powered and mounting accessories, or engineer approved equal.
- D. Provide a DIN rail or back plate mounted AC current transducer that is a loop-powered transducer with input rated from 0 to 5-ampere and with 4-20mADC analog output scaled for the primary current of the current transformer.
- E. Manufacturer: ABB AC current transducer DCSA Series Loop Powered and mounting accessories, or engineer approved equal.

2.10 TERMINAL STRIPS, BLOCKS, AND DEVICES

- A. Power Wiring: Provide back plate mounted terminal strips rated at 600Vac.
- B. Control Wiring: Provide a DIN rail with spring powered contact rated at 300Vac 24 ampere with pluggable terminals.
- C. Terminal identification standard to the product provided.
- D. Manufacturer:
 1. Standard: Allen Bradley or engineer approved equal.
 2. Standard: DIN rail: Phoenix Contact, Weidmuller Z-Series, or engineer approved equal.

2.11 THERMOSTATS

- A. Provide line voltage type thermostats with motor current rated contact and 70-degree to 140-degree Fahrenheit set point range.
- B. Manufacturer: Honeywell T631A-1022 or engineer approved equal.

2.12 STATIC GROUND INDICATOR

- A. Provide a static ground indicator and interlock system for verification of static ground connection to plant equipment, tanker trucks, drums, containers with flammable liquids or powders that are transferred and requiring effective grounding and bonding.
- B. Provide an explosion proof controller that meets NFPA 77 requirements with an intrinsically safe monitoring circuit that verifies a low resistant ground connection and dissipation path to ground. Product shall include an indicator light and interlock enabling product transfer and shall be rated for 120Vac power circuit.

- C. Manufacturer: Earth-Rite Plus with Hytrel Cable and Ground Clamp or engineer approved equal.

2.13 NAMEPLATES

- A. Nameplates for all control stations, relays, timers, motor contactors and disconnect switches shall be provided in accordance with the requirements of Section 26 00 01.

PART 3 EXECUTION

3.1 GENERAL

- A. Mount control stations, contactors and safety disconnect switches 48 inches above the floor, ground, or slab to center of device.
- B. Test miscellaneous electrical devices shall be tested in accordance with Section 26 00 01.

3.2 CONDUIT INSTALLATION

- A. See Section 26 05 33.13 – Conduit

3.3 CUTTING AND PATCHING

- A. Provide all cutting and patching required to perform this work.
- B. Do not cut into any major structural element without approval of Engineer.
- C. Provide patching of quality equal to, and of appearance matching, existing construction.

3.4 EQUIPMENT MOUNTING

- A. Wherever any electrical component, such as panels, raceways, pipes and conduits, will be in contact with surfaces which may become damp or wet, mount using spacers to hold electrical work ¼ inch away from damp surfaces.

END OF SECTION

SECTION 26 05 19

WIRE AND CABLE

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	References
1.3	Submittals
1.4	Quality Assurance
1.5	Delivery, Storage, and Handling
1.6	Sizing of Conductors
1.7	Warranty
2.1	Conductors – General
2.2	Conductors 600 Volts and Below
2.4	600-Volt Rated Cable
2.5	Grounding Conductors
2.6	Accessories for Conductors 600 Volts and Below
2.8	Pulling Compound
2.9	Source Quality Control
3.1	General
3.2	Power Conductor Color Coding
3.3	Circuit Identification
3.4	Conductors 600 Volts and Below
3.6	Conductor Arc and Fireproofing
3.8	Testing

B. Scope

1. Work covered by this section includes furnishing all labor, equipment, and materials required to install, connect, and test all wire and cable, including splices, terminations, connectors, and accessories for a complete installation as shown on the Drawings and/or specified herein.
2. The Contractor's attention is directed to the fact that all wires and cables are not necessarily shown on the Drawings, which are more or less schematic. However, the Contractor shall be responsible for furnishing and installing all wire and cable indicated or required to properly connect and place into operation all equipment and services requiring such wiring and/or cable.

1.2 REFERENCES

A. Reference Standards

1. The Association of Edison Illuminating Companies (AEIC): CS 8, Specification for Extruded Dielectric Shielded Power Cables Rated 5kV through 46 kV.
2. ASTM International (ASTM)
 - a. A167 – Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
 - b. B33 – Standard Specification for Soft or Annealed Copper Wire
 - c. B8 – Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
 - d. B496 – Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors
3. Insulated Cable Engineer’s Association (ICEA)
 - a. S-58-679 – Standard for Control Cable Conductor Identification
 - b. S-73-532 – Standard for Control Cables
 - c. T-29-520 – Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input of 210,000 Btu/hour
4. Institute of Electrical and Electronics Engineers, Inc. (IEEE)
 - a. 48 – Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminations 2.5 kV through 765 kV
 - b. 386 – Separable Insulated Connector Systems for Power Distribution Systems above 600V
 - c. 404 – Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500000 V
5. National Electrical Manufacturer’s Association (NEMA)
 - a. CC 1 – Electric Power Connectors for Substations
 - b. WC 57 – Standard for Control, Thermocouple Extension, and Instrumentation Cables – ICEA S-73-532
 - c. WC 70 – Standard for Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
 - d. WC 71 – Standard for Nonshielded Power Cables Rated 2001 – 5000 Volts for Use in the Distribution of Electrical Energy
 - e. WC 74 – 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electrical Energy
6. National Fire Protection Association (NFPA)
 - a. 70 – National Electric Code (NEC)
 - b. 262 – Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces
7. Underwriters Laboratories Inc. (UL)
 - a. 13 – Standard for Safety Power-Limited Circuit Cables
 - b. 44 – Standard for Safety Thermoset-Insulated Wires and Cables
 - c. 62 – Standard for Safety Flexible Cord and Cables
 - d. 486A-486B – Wire Connectors
 - e. 486C – Standard for Splicing Wire Connections

- f. 510 – Standard for Safety Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape
- g. 854 – Standard for Safety Service-Entrance Cables
- h. 1072 – Standard for Safety Medium-Voltage Power Cables
- i. 1277 – Standard for Safety Electrical Power and Control Tray Cables with Optional Optical-Fiber Members
- j. 1569 – Metal Clad Cables
- k. 1581 – Standard for Safety Reference Standard for Electrical Wires, Cables, and Flexible Cords

1.3 SUBMITTALS

A. Action Submittals/Informational Submittals

1. Product Data

- a. Wire and cable descriptive product information.
- b. Wire and cable accessories descriptive product information.
- c. Cable Pulling Calculations:
 - 1) Submit calculations for review before cable installation.
 - 2) Provide cable pulling calculations for the following cable installations:
 - a) Medium voltage cable runs that cannot be hand pulled.
 - b) Multi-conductor 600-volt cable sizes larger than #2 AWG that cannot be hand pulled.

2. Test and Evaluation Reports

- a. Factory test report per AEIC CS 6, including AEIC qualification report for conductors above 600 volts.

1.4 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ)

- 1. Provide the work in accordance with NFPA 70. Where required by the AHJ, use material and equipment labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
- 2. Provide materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc., which conforms to those standards and has an applied UL listing mark.

B. Qualifications

- 1. Installers/Applicators/Erectors
 - a. Have Journeyman Lineman with splicing credentials perform terminations and splices for conductors above 600 Volts.

C. Field Samples

- 1. Submit samples of all wire and cable, clearly marked and long enough to show complete identification, to the office of the Engineer for approval prior to wiring installation.
- 2. Do not use defective or damaged wire and cable in the work.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Storage and Handling Requirements

1. Store and protect all wire and cable in accordance with the manufacturer's recommendations and requirements of Section 01 66 00 – Storage and Protection.
2. Store wire and cable indoors in a dry and warm location and in its original packaging.

1.6 SIZING OF CONDUCTORS

- ### A. Unless otherwise required or directed by the Engineer, furnish conductors in the sizes shown on the Drawings. Minimum wire sizing is as follows:
1. Lighting and Power: No. 12 AWG.
 2. Motor Control Circuits Carrying Less Than 8 Amps: No. 14 AWG.
 3. Instrumentation and Low-Level Signal Transmission Pairs: No. 16 AWG for single pairs or No. 20 AWG for bundled cable.
- ### B. Size all wires and cables to conform to the regulations of the current edition of the National Electrical Code for current carrying capacity.
- ### C. Where the size of lighting wiring is not given on the Drawings, provide wire of such size that the voltage drop from the main panel to the lighting panel is not more than 1 percent, and the drop in the branch circuit is not more than 2 percent. The voltage drop in motor feeder, when the wire size is not specified, shall not be more than 3 percent at full load from the Motor Control Center to the motor terminal.

1.7 WARRANTY

- ### A. Provide a guarantee against defective materials and workmanship in accordance with requirements of Section 01 78 33 – Warranties and Bonds.

PART 2 PRODUCTS

2.1 CONDUCTORS – GENERAL

- ### A. Conductors: Solid or Class B concentric stranded, soft or annealed, uncoated copper, free from kinks and defects in accordance with ASTM B3 or B8.
- ### B. Conductivity: Not less than 97 percent.
- ### C. Insulation Thickness: Not less than that specified by the National Electrical Code.
- ### D. Provide wire and cable with the size, grade of insulation, voltage, and manufacturer's "E-Number" permanently marked on the outer covering at not more than 2-foot intervals.
- ### E. Provide all wires conforming to the latest Standards of the ASTM and ICEA, which are tested for their full length by these Standards.
- ### F. Provide stranded wiring for all control circuit wiring and all wiring No. 8 AWG and larger. Lighting branch circuits No. 12 and No. 10 AWG may be solid. Wiring shall be stranded as follows:
1. No. 14 thru No. 2 AWG: Minimum of 7 strands.
 2. No. 1 thru No. 4/0 AWG: Minimum of 19 strands.
 3. No. 250 MCM thru No. 500 MCM: Minimum of 37 strands.
 4. Provide all circuits, except control and instrumentation circuits, with a separate grounding conductor carried in the conduit.

2.2 CONDUCTORS 600 VOLTS AND BELOW

- A. Conform to applicable requirements of NEMA WC 70.
- B. Conductor Type
 - 1. 120-Volt and 277-Volt Lighting, 10 AWG and Smaller: Solid Copper.
 - 2. 120-Volt Receptacle Circuits, 10 AWG and Smaller: Solid Copper.
 - 3. All other Circuits: Stranded.
- C. Insulation: Type THHN/THWN-2, except for sizes No. 6 and larger, with XHHW-2 insulation.
- D. Direct Burial and Aerial Conductors and Cables
 - 1. Type USE/RHH/RHW insulation, UL 854 listed, or Type RHW-2/USE-2.
 - 2. Conform to physical and minimum thickness requirements of NEMA WC 70.
- E. Flexible Cords and Cables
 - 1. Type SOW-A/50 with ethylene-propylene rubber insulation in accordance with UL 62.
 - 2. Conform to physical and minimum thickness requirements of NEMA WC 70.

2.3 600-VOLT RATED CABLE

- A. General
 - 1. Type TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 70,000 Btu per hour, and NFPA 70, Article 340, or UL 13 meeting requirements of NFPA 70, Article 725.
 - 2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
 - 3. Suitable for installation in open air, in cable trays, or conduit.
 - 4. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
 - 5. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil- resistant.
- B. Multi-Conductor Power Cable
 - 1. General
 - a. Meet or exceed UL 1581 for cable tray use.
 - b. Meet or exceed UL 1277 for direct burial and sunlight-resistance.
 - c. Overall Jacket: PVC.
 - 2. Conductors
 - a. Class B stranded, coated copper.
 - b. Insulation: Chemically cross-linked ethylene-propylene or cross-linked polyethylene.
 - c. UL Rated VW-1 or listed Type XHHW-2.
 - d. Color Code:
 - 1) Conductors, size 8 AWG and smaller, colored conductors, ICEA S-58-679, Method 1, Table 1.
 - 2) Conductors size 6 AEG and larger, ICEA S-73-532, Method 4.

3. Passes ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
 4. Manufacturers
 - a. Okonite Co.
 - b. Southwire Co.
 - c. Engineer approved equal.
- C. Multi-Conductor Control Cable
1. Conductors
 - a. 14 AWG, seven-strand copper.
 - b. Insulation: 15-mil PVC with 4-mil nylon.
 - c. UL 1581 listed as Type THHN/THWN rated VW-1.
 - d. Conductor group bound with spiral wrap of barrier tape.
 - e. Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.
 2. Passes ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
 3. Manufacturers
 - a. Okonite Co.
 - b. Southwire Co.
 - c. Engineer approved equal.
- D. Multi-Conductor Adjustable Frequency Drive Power Cable
1. Conductors
 - a. Class B stranded, coated copper.
 - b. Insulation: 600-Volt cross-linked polyethylene, UL Type XHHW-2.
 - c. Grounding Conductors: Insulated stranded copper.
 2. Sheath
 - a. UL 1277 Type TC, 90 degree C.
 - b. Continuous shield, A1/polyester foil, drain wires, overall copper braid.
 3. Outer Jacket: Polyvinyl chloride (PVC) per UL 1569.
 4. Manufacturers
 - a. Alpha Wire, Series V.
 - b. Belden, Series 29500.
 - c. LAPP USA, OLFLEX VFD Slim.
 - d. Engineer approved equal.
- E. Multi-Conductor Metal-Clad (UL Type MC) Power Cable for Adjustable Frequency Drive Applications
1. Meeting requirements of UL 44 and UL 1569.
 2. Conductors
 - a. Class B stranded, coated copper.
 - b. Insulation: 600-Volt cross-linked polyethylene, UL Type XHHW or EPR.
 - c. Grounding Conductors: Bare stranded copper. Provide three symmetrical grounding conductors.

3. Sheath
 - a. UL listed Type MC.
 - b. Continuous welded, corrugated aluminum sheath.
 - c. Suitable for use as grounding conductor.
 4. Outer Jacket: Polyvinyl chloride (PVC) per UL 1569.
 5. Passes ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
 6. Manufacturers
 - a. Okonite Co., Type CLX MC-HL.
 - b. Engineer approved equal.
- F. 16 AWG Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.
1. Outer Jacket: 45-mil nominal thickness.
 2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
 3. Dimension: 0.31-inch nominal OD.
 4. Conductors
 - a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
 - b. 20 AWG, seven-strand tinned copper drain wire.
 - c. Insulation: 15-mil nominal PVC.
 - d. Jacket: 4-mil nominal nylon.
 - e. Color Code: Pair conductors, black and red.
 5. Manufacturers
 - a. Okonite Co.
 - b. Alpha Wire Corp.
 - c. Belden.
 - d. Engineer Approved equal.
- G. 16 AWG Twisted, Shielded Pair, Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.
1. Outer Jacket: 45-mil nominal thickness.
 2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
 3. Dimension: 0.32-inch nominal OD.
 4. Conductors
 - a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
 - b. 20 AWG, seven-strand tinned copper drain wire.
 - c. Insulation: 15-mil nominal PVC.

- d. Jacket: 4-mil nominal nylon.
 - e. Color Code: Triad conductors, black, red, and blue.
5. Manufacturers
- a. Okonite Co.
 - b. Alpha Wire Corp.
 - c. Belden.
 - d. Engineer approved equal.
- H. 18 AWG Multi-Twisted, Shielded Pairs with a Common Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable meeting NEMA WC 57 requirements.
1. Conductors
- a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
 - b. Tinned copper drain wires.
 - c. Pair drain wire size AWG 20, group drain wire size AWG 18.
 - d. Insulation: 15-mil nominal PVC.
 - e. Jacket: 4-mil nominal nylon.
 - f. Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.
 - g. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer.
2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer overlapped for 100 percent coverage.
3. Manufacturers
- a. Okonite Co.
 - b. Alpha Wire Corp.
 - c. Belden.
 - d. Engineer approved equal.

2.4 GROUNDING CONDUCTORS

- A. Equipment: Stranded copper with green, Type USE/RHH/RHW-XLPE or THHN/THWN insulation.
- B. Direct Buried: Bare stranded copper.

2.5 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

- A. Tape
 - 1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33+, rated for 90 degrees C minimum, meeting requirements of UL 510.
 - 2. Flame Retardant, Cold and Weather Resistant: 8.5-mil vinyl plastic, Scotch Brand 88.
 - 3. Arc and Fire Proofing
 - a. 30-mil, elastomer.
 - b. Manufacturers

- 1) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tape binder.
- 2) Plymouth; 53 Plyarc, with 77 Plyglas glass cloth tape binder.
- 3) Engineer approved equal.

B. Identification Devices

1. Sleeve
 - a. Permanent, PVC, yellow or white, with legible machine-printed black markings.
 - b. Manufacturers
 - 1) Raychem; Type D-SCE or ZH-SCE.
 - 2) Brady, Type 3PS.
 - 3) Engineer approved equal.
2. Heat Bond Marker
 - a. Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive.
 - b. Self-laminating protective shield over text.
 - c. Machine-printed black text.
 - d. Manufacturer: 3m Co.; Type SCS-HB, or Engineer approved equal.
3. Marker Plate: Nylon, with legible designation permanently hot stamped on plate.
4. Tie-On Cable Marker Tags
 - a. Chemical-resistant white tag.
 - b. Size: ½-inch by 2 inches.
 - c. Manufacturer: Raychem; Type CM-SCE, or Engineer approved equal.
5. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum.

C. Connectors and Terminations

1. Nylon, Self-Insulated Crimp Connectors
 - a. Manufacturers
 - 1) Thomas & Betts; Sta-Kon
 - 2) Burndy; Insulug.
 - 3) ILSCO.
 - 4) Engineer approved equal.
2. Nylon, Self-Insulated Crimp Locking-Fork, Torque-Type Terminator
 - a. Suitable for use with 75 degree C wire at full NFPA 70, 75 degree C ampacity.
 - b. Seamless.
 - c. Manufacturers
 - 1) Thomas & Betts; Sta-Kon
 - 2) Burndy; Insulink.
 - 3) ILSCO; ILSCONS.
 - 4) Engineer approved equal.
3. Self-Insulated, Freespring Wire Connector (Wire Nuts)

- a. UL 486C.
- b. Plated steel, square wire springs.
- c. Manufacturers
 - 1) Thomas & Betts.
 - 2) Ideal; Twister.
 - 3) Engineer approved equal.
- 4. Self-Insulated, Set Screw Wire Connector
 - a. Two piece compression type set screw in brass barrel.
 - b. Insulated by insulator cap screw over brass barrel.
 - c. Manufacturers
 - 1) 3M Co.
 - 2) Thomas & Betts.
 - 3) Marrette.
 - 4) Engineer approved equal.
- D. Cable Lugs
 - 1. In accordance with NEMA CC 1.
 - 2. Rated 600 volts of same material as conductor metal.
 - 3. Uninsulated Crimp Connectors and Terminators
 - a. Suitable for use with 75 degree C wire at full NFPA 70, 75 degree C ampacity.
 - b. Manufacturers
 - 1) Thomas & Betts; Color-Keyed
 - 2) Burndy; Hydent.
 - 3) ILSCO.
 - 4) Engineer approved equal.
 - 4. Uninsulated, Bolted, Two-way Connectors and Terminators
 - a. Manufacturers
 - 1) Thomas & Betts; Loctite
 - 2) Burndy; Quiklug.
 - 3) ILSCO.
 - 4) Engineer approved equal.
- E. Cable Ties
 - 1. Nylon, adjustable, self-locking, and reusable.
 - 2. Manufacturers: Thomas & Betts; TY-RAP, or Engineer approved equal.
- F. Heat Shrinkable Insulation
 - 1. Thermally stabilized cross-linked polyolefin.
 - 2. Single wall for insulation and strain relief.
 - 3. Dual Wall, adhesive sealant lined, for sealing and corrosion resistance.

4. Manufacturers
 - a. Thomas & Betts; SHRINK-KON.
 - b. Raychem; RNF-100 and ES-2000.
 - c. Engineer approved equal.
- G. Data Cable Accessories: Terminators, connectors, and junctions necessary for a complete DeviceNet system.

2.6 PULLING COMPOUND

- A. Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant; UL listed.
- B. Suitable for rubber, neoprene, PVC, Polyethylene, hypalon, CPE, and lead-covered wire and cable.
- C. Approved for intended use by cable manufacturer.
- D. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.
- E. Manufacturers
 1. Ideal Co.
 2. Polywater Inc.
 3. Cable Grip Co.
 4. Engineer approved equal.

2.7 SOURCE QUALITY CONTROL

- A. Tests and Inspections
 1. Conductors 600 Volts and Below: Test in accordance with UL 44 and UL 854.
 2. Conductors Above 600 Volts: Test in accordance with NEMA WC 71 and AEIC CS 6 partial discharge level test for EPR insulated cable.

PART 3 EXECUTION

3.1 GENERAL

- A. Install conductors in accordance with manufacturer's recommendations.
- B. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.
- C. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii.
- D. Terminate all conductors and cables, unless noted otherwise.
- E. Tighten screws and terminal bolts in accordance with UL 486A – 486B for copper conductors.
- F. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.
- G. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 18 inches on center.
- H. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.

- I. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrel approximately 1/4-inch smaller than raceway inside diameter.
- J. Cable Tray Installation
 - 1. Install wire and cable parallel and straight in tray.
 - 2. Bundle, in groups, wire and cable of same voltage having common routing and destination; use cable ties, at maximum intervals of 8 feet.
 - 3. Clamp cable bundles prior to making end termination connections.
 - 4. Separate cables of different voltage rating in same cable tray with barriers.
 - 5. Fasten wires, cables, and bundles to tray with nylon cable straps at the following maximum intervals.
 - a. Horizontal Runs: 20 feet.
 - b. Vertical Runs: 5 feet.

3.2 POWER CONDUCTOR COLOR CODING

A. Conductors 600 Volts and Below

- 1. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering an area 1-1/2 inches to 2 inches wide.
- 2. 8 AWG and Smaller: Provide colored conductors.
- 3. Colors

System	Conductor	Color
All Systems	Equipment Grounding	Green
240/120 Volts Single-Phase, Three-Wire	Grounded Neutral	White
	One Hot Leg	Black
	Other Hot Leg	Red
208/120 Volts Three-Phase, Four Wire	Grounded Neutral	White
	Phase A	Black
	Phase B	Red
	Phase C	Blue
240/120 Volts Three-Phase, Four-Wire Delta, Center Tap Ground on Single-Phase	Grounded Neutral	White
	Phase A	Black
	High (wild) Leg	Orange
	Phase C	Blue
480Y/277 Volts Three-Phase, Four-Wire	Grounded Neutral	White
	Phase A	Brown
	Phase B	Orange
	Phase C	Yellow

- 4. Tracer: Outer covering of white with an identifiable colored strip, other than green, in accordance with NFPA 70.

3.3 CIRCUIT IDENTIFICATION

- A. Identify power, instrumentation, and control conductor circuits at each termination, and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.
- B. Circuits Appearing in Circuit Schedules: Identify using circuit schedule designations.
- C. Circuits Not Appearing in Circuit Schedules

1. Assign circuit name based on device or equipment at load end of circuit.
2. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.

D. Method

1. Conductors 3 AWG and Smaller: Identify with sleeves or heat bond markers.
2. Cables and Conductors 2 AWG and Larger
 - a. Identify with marker plates or tie-on cable marker tags.
 - b. Attach with nylon tie cord.
3. Do not use taped-on markers or tags relying on adhesives.

3.4 CONDUCTORS 600 VOLTS AND BELOW

A. Install 10 AWG or 12 AWG conductors for branch circuit power wiring in lighting and receptacle circuits.

B. Do not splice incoming service conductors and branch power distribution conductors 6 AWG and larger, unless specifically indicated or approved by Engineer.

C. Connections and Terminations

1. Install wire nuts only on solid conductors. Wire nuts are not allowed on stranded conductors.
2. Install nylon self-insulated crimp connectors and terminators for instrumentation and control circuit conductors.
3. Install self-insulated, set screw wire connectors for two-way connection of power circuit conductors 12 AWG and smaller.
4. Install uninsulated crimp connectors and terminators for instrumentation, control, and power circuit conductors 4 AWG through 2/0 AWG.
5. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors 3/0 AWG and larger.
6. Install uninsulated terminators bolted together on motor circuit conductors 10 AWG and larger.
7. Place no more than one conductor in any single-barrel pressure connection.
8. Install crimp connectors with tools approved by connector manufacturer.
9. Install terminals and connectors acceptable for type of material used.
10. Compression Lugs:
 - a. Attach with a tool specifically designed for purpose. Tool shall provide complete, controlled crimp and shall not release until crimp is complete
 - b. Do not use plier type crimpers.

D. Do not use soldered mechanical joints.

E. Splices and Terminations

1. Insulate all uninsulated connections.
2. Indoors: Use general purpose, flame retardant tape or single wall heat shrink.
3. Outdoors, Dry Locations: Use flame retardant, cold- and weather-resistant tape or single wall heat shrink.

4. Below Grade and Wet or Damp Locations: Use dual wall heat shrink.
- F. Cap spare conductors with UL listed end caps.
- G. Cabinets, Panels, and Motor Control Centers
 1. Remove surplus wire, bridle and secure.
 2. Where conductors pass through openings or over edges in sheet metal, remove burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.
- H. Control and Instrumentation Wiring
 1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
 2. Terminate with methods consistent with terminals provided and in accordance with terminal manufacturer's instructions.
 3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.
 4. Where connections of cables installed under this section are to be made under Section 40 90 01 – General Requirements for Instrumentation and Control.
 5. Cable Protection:
 - a. Under Infinite Access Floors: May install without bundling.
 - b. All Other Areas: Install individual wires, pairs, or triads in flex conduit under floor or grouped into bundles at least ½-inch in diameter.
 - c. Maintain integrity of shielding of instrumentation cables.
 - d. Ensure grounds do not occur because of damage to jacket over the shield.
- I. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in free standing panels and minimum 2 feet in other assemblies.

3.5 CONDUCTOR ARC AND FIREPROOFING

- A. Install arc and fire proofing tape on 5 kV cables throughout their entire exposed length in manholes, handholes, vaults, cable trays, and other indicated locations.
- B. Wrap conductors of same circuit entering from separate conduit together as a single cable.
- C. Follow tape manufacturer's installation instructions.
- D. Secure tape at intervals of 5 feet with bands of tape binder. Each band to consist of a minimum of two wraps directly over each other.

3.6 UNDERGROUND DIRECT BURIAL CABLE

- A. Install in trench as specified in Section 31 23 00 – Excavation and Fill.
- B. Warning Tape: Install approximately 6 inches above cable, aligned parallel to, and within 12 inches of centerline of the run.

3.7 TESTING

- A. Perform visual and mechanical inspection of each individual exposed power cable 6 AWG and larger for physical damage, correct terminations in accordance with the Drawings, cable bends in accordance with bending radius requirements, proper circuit identification, proper lug type, tightness of bolted connections with proper torque level per NETA ATS, Table 10.12 or manufacturer's specifications, and proper grounding.

- B. Perform Insulation Resistance Testing of all conductors 6 AWG and larger with respect to ground and each adjacent conductor. Apply 1,000 volts DC for one minute on 600 volts insulated conductors in accordance with NETA. Minimum insulation resistance values shall not be less than 50 meg-ohms. Investigate all deviations between adjacent phases.
- C. Perform Continuity Test by ohmmeter method to ensure proper cable connection of all conductors 6 AWG and larger.
- D. Keep a written record of all insulation tests on forms approved for the purpose. These forms shall show the number or other suitable identification of each circuit or piece of apparatus tested, the date of the test, the temperature at the time the test was made, the instrument used, the test voltage applied, the resistance values found, and the name of the person in charge of and witnessing the test.

END OF SECTION

SECTION 26 05 26

GROUNDING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Article</u>	<u>Title</u>
1.2	References
1.3	Submittals
2.1	Ground Conductors
2.2	Ground Rods
2.3	Compression Connectors
2.4	Bolted Connectors
2.5	Welded Connectors
2.6	Test Wells
2.7	Equipment Ground Bars
2.8	Equipment Ground Plate
2.9	Product Data
3.1	General
3.2	Raceway Ground
3.3	Equipment and Enclosure Bonding
3.4	Isolated Grounding
3.5	Service and Separately Derived System Bonding
3.6	Grounding System Tests

B. Scope

1. This section specifies the system for grounding electrical distribution and utilization equipment, including but not limited to cabinets, motor frames, manholes, instrumentation, metal surfaces of process/mechanical equipment that contain energized electrical components, metal structures and buildings, outdoor metal enclosures, fences and gates.
2. Provide Equipment Grounding Conductors to ground or bond equipment, structures, or equipment frames to the Grounding Electrode System as defined in the National Electrical Code Article 250 and addressed herein.
3. The minimum size of the Equipment Grounding Conductors installed with the circuit conductors shall be per the National Electrical Code Table 250.122. The circuit grounding conductor size routed with a feeder or branch circuit conductors is as shown on the drawings.

1.2 REFERENCES

A. Reference Standards

1. This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.
2. Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

Reference	Title
IEEE 81	Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
IEE Std 81.2-1991	Guide to Measurement of Impedance and Safety Characteristics of Large, Extended or Interconnected Grounding Systems
NETA - ATS	International Electrical Testing Association Inc. - Acceptance Testing Specifications
NFPA 70	National Electric Code (NEC) Article 250

1.3 SUBMITTALS

A. Action Submittals/Informational Submittals

1. Product Data

- a. Marked product literature for ground rods, test wells, and equipment ground plate.

2. Special Procedure Submittals

- a. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. A check mark shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. *Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.*

PART 2 PRODUCTS

2.1 GROUND CONDUCTORS

- A. Soft-drawn, bare annealed copper, concentric stranded, as specified.

B. Minimum sizes as follows, where American Wire Gage (AWG) conductor sizes are not shown or specified:

- | | |
|-----------------------------|----------------|
| 1. 5 and 15 kV switchgear | 2/0 or 4/0 AWG |
| 2. 5 kV motor starters | 2/0 or 4/0 AWG |
| 3. 15 kV-5 kV transformers | 2/0 or 4/0 AWG |
| 4. 5 kV-480V transformers | 2/0 or 4/0 AWG |
| 5. 480V switchgear | 2/0 or 4/0 AWG |
| 6. 480V switchboards | 2/0 or 4/0 AWG |
| 7. 480V MCC and | 2/0 or 4/0 AWG |
| 8. Cable tray | 2/0 or 4/0 AWG |
| 9. Large motors 250 hp & > | 2/0 or 4/0 AWG |
| 10. Lighting & Power panels | 2 AWG |
| 11. Exposed metal cabinets | 2 AWG |
| 12. Electrical equipment | 2 AWG |
| 13. Buildings and enclosure | 2 AWG |
| 14. Fences and gates | 2 AWG |
| 15. Motors 25 hp to 250 hp | 2 AWG |
| 16. Motors 1 hp to 25 hp | 6 AWG |

2.2 GROUND RODS

- A. Copper covered steel, 3/4-inch diameter and 10-feet long.
- B. Threaded type removable caps so that extension rods of same diameter and length may be added where necessary.

2.3 COMPRESSION CONNECTORS

- A. Irreversible, cast copper as manufactured by Thomas and Betts, or Engineer approved equal.

2.4 BOLTED CONNECTORS

- A. Burndy, O. Z. Gedney, or Engineer approved equal.

2.5 WELDED CONNECTORS

- A. Exothermic welding products shall be Erico's Cadweld Plus system with a remotely operated battery powered electronic ignition device and moisture resistant weld metal cup for the required mold, or Engineer approved equal.

2.6 TEST WELLS

- A. Provide concrete test well with cover and connect the ground grid extension using a removable connector.

2.7 EQUIPMENT GROUND BARS

- A. Copper bars, Erico Eritech EGB Series or Engineer approved equal.
- B. Sized as required for the installation.

2.8 EQUIPMENT GROUND PLATE

- A. Two-hole copper flush mounted grounding plate, Erico Cadweld, Burndy YGF Series, or Engineer approved equal.

2.9 PRODUCT DATA

- A. Ground resistance readings specified in paragraph 26 05 26-3.6 shall be provided in accordance with Section 01 33 23.

PART 3 EXECUTION

3.1 GENERAL

- A. Provide grounding system in compliance with the NFPA 70 National Electrical Code (NEC). Do not use grounding conductor as a system neutral.
- B. Make embedded and buried ground connections by compression connectors utilizing diamond or hexagon dies and a hand compression tool for wire sizes 2 AWG and smaller and a hydraulic pump and compression head for wire sizes 2/0 AWG and larger. Alternate method allowed: exothermic welding using a remote igniter device.
- C. Use tools and dies approved for this purpose; dimple compressions are not acceptable. Prepare compression connections in accordance with the manufacturer's instructions. Use compression-type lugs in accordance with manufacturer's recommendations. Make exposed ground connections to equipment by bolted clamps unless otherwise specified. Do not use solder material in any part of the ground circuits.
- D. Securely attach embedded ground conductors and fittings to concrete reinforcing steel with tie wires and prevented from displacement during concrete placement.
- E. Notify the Engineer two hours prior to backfilling, as each part of the grounding system installed below finished grade is complete and ready for inspection. Non-compliance shall affect the payment schedule for this work.
- F. Extend grounding conductors beyond concrete surfaces for equipment connection a sufficient length to reach the final connection point without splicing. Provide grounding fittings, pads, or plates as shown in the electrical details. Minimum grounding conductor extension shall be 3-feet.
- G. Locate grounding conductors which project from a concrete surface as close as possible to a corner of the equipment pad, protected by rigid conduit bonded to the grounding conductors, or terminated in a flush grounding plate.
- H. Support exposed grounding conductors by noncorrosive metallic hardware at 4-foot intervals or less. Terminate grounding conductors for shown and future equipment using an equipment grounding plate.
- I. Bond ground conductors entering electrical enclosures to a single ground bus or terminal strip in the enclosure and to metallic raceways within or terminating at the enclosure. Direct ground connections to enclosure chassis or back plate are not acceptable. Prior to making ground connections or bonds, clean the metal surface at the point of connection.
- J. Directly connect lightning arresters to the ground grid system using lightning industry braided copper conductors, sized as specified.
- K. Terminate metallic sheaths or shields of shielded power cable by a copper ground bus provided with cable connection for connection to the grounding system.

3.2 RACEWAY GROUND

- A. All service, feeder and branch circuit raceways shall contain a green insulated ground conductor sized per applicable NFPA 70 National Electrical Code (NEC) tables:
 - 1. T250.66 - Grounding Electrode Conductor for Alternating-Current Systems or
 - 2. T250.122 - Minimum Size Equipment Grounding Conductors for Grounding Raceways and Equipment.
- B. Bond metallic conduits terminating at concentric knock-outs or reducing washers using insulated grounding bushings. Connect grounding bushings to the grounding system using conductors sized in compliance with NEC.
- C. Cable trays shall have 2/0 or 4/0 bare copper ground conductor run on the outside of each tray or tray group of tiered cable tray. Connect conductor to each section or fitting using an approved ground-clamp and supported at 5 foot intervals.

3.3 EQUIPMENT AND ENCLOSURE BONDING

- A. Bond electrical distribution and utilization equipment enclosure ground bus, motor frames, manholes, metal structures and buildings, outdoor metal enclosures, fences and gates to the grounding system with conductor sizes as specified.
- B. Connect the conductor to the metal enclosure using a UL listed connector, where the enclosure does not contain an internal ground bus
- C. Connect non-electrical equipment with metallic enclosures, that are located outdoor and without a cover or a shade to the grounding system.

3.4 ISOLATED GROUNDING

- A. Install an isolated ground system where required by an equipment manufacturer. The isolated ground conductor shall have green insulation with a yellow stripe and shall be run in the same raceway as the power and neutral conductors. Keep the isolated ground bus isolated from neutral and grounding buses.
- B. Where specifically directed by the Engineer and required by an equipment manufacturer, provide an additional isolated ground conductor from the service or separately derived system to an isolated ground bus bar at each associated distribution point.

3.5 SERVICE AND SEPARATELY DERIVED SYSTEM BONDING

- A. Install a neutral bonding jumper in only one location for each service or separately derived system. Locate the bonding jumper at the service source or the first immediate distribution point downstream from the source. Keep the neutral and ground buses isolated from each other except where the bonding jumper is installed.

3.6 GROUNDING SYSTEM TESTS

- A. Test the facility grounding system and the building grounding system to determine the ground resistance. Follow IEEE Standard 81 using the NETA Fall-of-Potential procedure for the grounding test. Submit a plot of ground resistance readings for each isolated ground rod, ground mat, or ground bus on 8-1/2 x 11 inch size graph paper. Point-to-point resistance measurements are not acceptable.
- B. Drive the current reference rod at least 100 feet from the ground rod or grid under test or as recommended by IEEE Standard 81. Make the measurements at 10-foot intervals beginning 25 feet from the test electrode and ending 75 feet from it, in direct line between the ground rod or center of grid and the current reference electrode.
- C. A grounding system that shows greater than 2 ohm resistance for the flat portion of the plotted data shall be considered inadequately grounded.

- D. Add additional parallel connected ground rods and/or deeper driven rods until the ground resistance measurements meet the 2 ohm requirement.
- E. Use of salts, water, or compounds to attain the specified ground resistance is not acceptable.

END OF SECTION

SECTION 26 05 33.13

CONDUIT

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	References
1.3	Administrative Requirements
1.4	Submittals
1.5	Quality Assurance
1.6	Delivery, Storage, and Handling
1.7	Field Conditions
1.8	Warranty
2.1	General
2.2	Rigid Metal Conduit
2.3	PVC-Coated Rigid Galvanized Steel Conduit
2.4	Liquid-Tight Flexible Metal Conduit
2.5	Conduit Bushings and Fittings
2.6	Conduit Boxes
3.1	General
3.2	Installation of Rigid Metal Conduit
3.3	Installation of Liquid-Tight Flexible Metal Conduit
3.4	Installation of Underground Conduit
3.5	Conduit Applications

B. Scope

1. Work covered by this section includes furnishing all labor, equipment, and materials required to install electrical conduit and fittings as specified herein and/or shown on the Drawings.
2. The Contractor's attention is called to the fact that all conduits and conduit fittings are not necessarily shown completely on the Drawings, which are more or less schematic. However, the Contractor shall furnish and install all conduit and conduit fittings indicated or required for the proper connection and operation of all equipment and services requiring such conduit.

1.2 REFERENCES

A. Reference Standards

1. ASTM International (ASTM)
 - a. A123/A123M – Standard Specification for Zinc (Hot-Dipped Galvanized) Coating on Iron and Steel Products

- b. C857 – Standard Practice for Minimum Structural Design loading for Underground Precast Concrete Utility Structures
 - c. D149 – Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
2. National Electrical Contractors Association (NECA)
 - a. 101 – Standard for Installing Steel Conduit (Rigid, IMC, EMT)
 - b. 105 – Recommended Practice for Installing Metal Cable Trays
 3. National Electrical Manufacturers Association (NEMA)
 - a. 250 – Enclosures for Electrical Equipment (1,000 Volts Maximum)
 - b. C80.1 – Specification for Rigid Steel Conduit, Zinc Coated
 - c. C80.3 – Specification for Electrical Metallic Tubing, Zinc Coated
 - d. RN 1 – Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit
 - e. VE 1 – Metallic Cable Tray Systems
 4. National Fire Protection Association (NFPA)
 - a. 1 – Standard for Flexible Metal Conduit
 - b. 5 – Standard for Surface Metal Raceways and Fittings
 - c. 6 – Standard for Electrical Rigid Metal Conduit – Steel
 - d. 50 – Standard for Enclosures for Electrical Equipment
 - e. 360 – Standard for Liquid-Tight Flexible Steel Conduit
 - f. 514B – Standard for Conduit, Tubing, and Cable Fittings
 - g. 797 – Standard for Electrical Metallic Tubing
 - h. 870 – Standard for Wireways, Auxiliary Gutters, and Associated Fittings

1.3 ADMINISTRATIVE REQUIREMENTS

A. Coordination

1. Coordinate with other trades when installation of conduit will impact the location of other work or be enclosed by other work.

1.4 SUBMITTALS

A. Action Submittals/Informational Submittals

1. Product Data

- a. Manufacturer’s Literature
 - 1) Rigid galvanized steel conduit.
 - 2) PVC-coated rigid galvanized steel conduit, submittal to include copy of manufacturer’s warranty.
 - 3) Flexible metal, liquid-tight conduit.
 - 4) Conduit fittings.
 - 5) Wireways.
 - 6) Junction and pull boxes used at or below grade.
 - 7) Large junction and pull boxes.

- 8) Terminal junction boxes.
- b. Precast Manholes and Handholes:
 - 1) Dimensional drawings and descriptive literature.
 - 2) Traffic loading calculations.
 - 3) Accessory information.
- c. Cable Tray Systems:
 - 1) Dimensional drawings, calculations, and descriptive information.
 - 2) NEMA load/span designation and how it was selected.
 - 3) Support span length and pounds-per-foot actual and future cable loading at locations, with safety factor used.
 - 4) Location and magnitude of maximum simple beam deflection of tray for loading specified.
 - 5) Layout drawings and list of accessories being provided.
- d. Equipment and machinery proposed for bending metal conduit.
- e. Seismic anchorage and bracing drawings, calculations, and cut sheets.
- 2. Certificates
 - a. Manufacturer's certification of training for PVC-coated rigid steel conduit installer.

1.5 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ)

- 1. Provide the work in accordance with NFPA 70. Where required by the AHJ, use material and equipment labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
- 2. Provide materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc., which conforms to those standards and has an applied UL listing mark.

B. Qualifications

- 1. Installers/Applicators/Erectors
 - a. PVC-Coated, Rigid Steel Conduit Installer: Certified by conduit manufacturer as having received minimum 2 hours of training on installation procedures.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Storage and Handling Requirements

- 1. Store conduit on suitable spaced supports above ground and protected from weather.
- 2. Do not allow water or debris into conduits during storage and handling.

1.7 WARRANTY

- A. Provide a guarantee against defective equipment and workmanship in accordance with requirements of Section 01 78 33 - Warranties and Bonds

PART 2 PRODUCTS

2.1 GENERAL

- A. Unless otherwise shown or specified, provide all conduits as rigid galvanized steel.
- B. Make conduit terminations at electrical equipment subject to vibration using liquid-tight, flexible metal conduit.
- C. Do not use damaged, dented, flattened, or kinked conduit.

2.2 RIGID METAL CONDUIT

- A. Heavy wall, mild steel, rigid metal conduit conforming to ANSI C80.1 and Federal Specification WW-C-581.
- B. Hot dip galvanized both inside and out.
- C. UL listed and stamped.
- D. Provide two coats of bitumastic compound protective coating for rigid galvanized steel conduit used for underground installation.

2.3 PVC-COATED RIGID GALVANIZED STEEL CONDUIT

- A. Meet requirements of NEMA RN 1.
- B. Material
 - 1. Meet requirements of NEMA C80.1 and UL 6.
 - 2. Exterior Finish: PVC coating, 40 mils nominal thickness, bond to metal shall have tensile strength greater than PVC.
 - 3. Interior Finish: Urethane coating, 2 mils nominal thickness.
- C. Threads: Hot-dipped galvanized and factory coated with urethane.
- D. Bendable without damage to either interior or exterior coating.

2.4 LIQUID-TIGHT FLEXIBLE METAL CONDUIT

- A. Provide an oil-resistant, liquid-tight jacket in combination with flexible metal reinforcing tubing designed for use with waterproof fittings.
- B. Include an integral ground wire.
- C. Only use Underwriter's Laboratories approved fittings.
- D. Manufacturers
 - 1. Electric-Flex Company; American Brass Sealtite Type UA.
 - 2. Ideal Industries, Inc.; Flexible Metallic Conduit.
 - 3. Engineer approved equal.

2.5 CONDUIT FITTINGS AND BUSHINGS

- A. Wherever conduits terminate in sheet steel boxes, use double bonding type locknuts and bushings except when terminating in cast hubs. Only use insulated metallic type bushings, equal to O. Z. Electrical Manufacturing Company, Type B; T & B Company, 1200 Series; Appleton Electric Company, Type BU-I; or engineer approved equal.
- B. Where conduits terminate in steel or cast NEMA 4 enclosures with no factory-installed threaded hubs, install a threaded hub equal to Myers Electric Products, Inc., Type ST or

STG; Appleton Electric Company, Type HUB; Crouse-Hinds, Type HUB; or engineer approved equal.

- C. Suitably ground all conduits terminating at motor control centers to the motor control center ground bus using grounded type insulated bushings equal to O. Z. Electrical Manufacturing Company, BLB or IGB; Appleton, Type BIB; Thomas and Betts, 3800 Series; or engineer approved equal.
- D. Conduit expansion fittings shall be O. Z. Electrical Manufacturing Company, Type EX with Bonding Jumper, Type XJ; Appleton, Type SJ with Type XJB4 Bonding Jumpers; Crouse-Hinds, Type XJ with GC100 Bonding Jumper; or engineer approved equal.

2.6 CONDUIT BOXES

- A. Exposed conduit boxes and pulling elbows shall be of die-cast, copper-free aluminum with threaded body and removable neoprene-gasketed cover. Use conduit boxes conforming to Federal Specification W-C-586a. Acceptable manufacturers include Crouse-Hinds "Condulet", Appleton "Unilet Form 85", or engineer approved equal.

PART 3 EXECUTION

3.1 GENERAL

- A. Use a minimum size conduit of 3/4-inch for above ground installation and 1-inch for below ground installation unless noted otherwise. Do not allow more than 40 percent of a conduit's internal area to be occupied by conductors.
- B. During construction temporarily plug, cap, or otherwise protect all installed conduits from the entrance of dust, trash, moisture, etc. Replace any conduits which may become clogged. Do not pull in any conductor until all work that might cause damage to the conduit or conductors has been completed.
- C. Securely fasten conduit connections to sheet metal enclosures with double lock nuts inside and outside and provide grounding bushings.
- D. Secure conduit straps or brackets to concrete, brick, or masonry by means of expansion bolts, toggle bolts, or approved drill anchors. No wood plugs will be permitted.
- E. Install conduits supported from building walls with at least 1/4-inch clearance from the wall using pipe spacers equal to Appleton Electric Company, T & B Company, Steel City, or equal. Clamp back to prevent the accumulation of dirt and moisture behind the conduit.
- F. Unless otherwise shown or specified, install exposed rigid conduit parallel or at right angles to structural members, surfaces, and building walls.
- G. Install two or more conduits in the same general routing parallel with symmetrical bends.
- H. Install conduits at least 12 inches from high temperature piping, ducts, and flues.
- I. Allow headroom of at least 7 feet for conduit installed horizontally, except where it may be installed along structures, piping, equipment, or in other areas where headroom cannot be maintained because of other considerations.
- J. Wherever necessary and where shown on the Drawings, insert conduit boxes and pulling elbows in the lines. Use gaskets to ensure a dust and watertight installation on all conduit boxes and fittings.
- K. Provide a bend radius of not less than 6 times the internal diameter of the conduit for all bends and turns in conduits. Make bends using an approved bender to provide smooth bends with no kinks, dents, or flattening.
- L. Run all conduit exposed wherever practical.

- M. Place all concealed conduit in walls, floors, ceilings, or slabs at the proper time in accordance with the progress of the work. Cooperate in every respect in meeting schedules and do not delay the structural work unnecessarily. Block and brace conduits embedded in concrete in place by use of adequate conduit separators to prevent displacement during pouring of the concrete. Where conduit interferes with structural steel, steel reinforcement, or in the opinion of the Engineer occupies too much space in the slab, rearrange the conduits or install it exposed as directed by the Engineer. No additional payment will be made for such rearrangement of conduit whether or not additional conduit or fittings might be required.
- N. Install conduit wall seals with water stops in outside walls below grade for all incoming or outgoing underground conduit emerging directly into the building area. Provide a pressure ring and sealing grommet on the conduit wall seals to ensure a watertight installation.
- O. Install conduit expansion fittings and ground bonding jumpers on all conduits passing through building expansion joints to provide movement in the conduit system.
- P. Where groups of conduits terminate together or pass through floors, provide template to hold conduits in proper relation to each other and to building.
- Q. Plug or cap conduits with plastic caps during construction to protect threads and prevent entrance of dirt and water.
- R. Adequately support conduits at intervals as required by the National Electrical Code. One to two exposed conduits running parallel to each other may be supported by strap anchors, or 1-hole clamps (walls only). Support exposed conduits larger than 2 inches or groups of more than 2 conduits run parallel by means of minimum 12 gauge, slotted steel channels fitted with 2-piece, bolted pipe clamps. All conduit supports, clamps, straps and brackets shall be heavily hot dip galvanized for corrosion resistance.
- S. Do not allow more than four 90-degree bends (360-degrees total) in runs of conduit between conduit boxes, panel boards, or terminations. In general and to the extent practical do not exceed a conduit length of 100 feet between conduit boxes or similar means of access.
- T. Identify exposed service entrance conduits and main feeder conduits using stenciled letters at intervals not to exceed 20 feet. Use a lettering size equal to one-half the diameter of the conduit or 2 inches, whichever is less.

3.2 INSTALLATION OF RIGID METAL CONDUIT

- A. Use threaded terminations and connections for rigid metal conduit. Ream conduits free of burrs and terminate with insulated metallic conduit bushings.
- B. Coat conduit threads with a petroleum base corrosion-inhibitor with low electrical contact resistance before assembly equal to Burndy Engineering Company, Inc., Penetrax "A" or equal screw thread lubricant (zinc-petroleum or zinc-chromate compounds are permissible).
- C. Suitably ground all conduits to the plant ground grid using grounded type insulated bushings, O. Z. Electrical Manufacturing Company, Type BLG or IGB, T & B Company, Appleton Electric Company, or equal.
- D. Provide bonded, weathertight expansion and deflection fitting the same size as the conduit where conduit is installed across structural joints where structural movement is allowed.
- E. Do not exceed a support spacing of 6 feet for conduits 1 inch and smaller or 10 feet for conduits 1¼ inches and larger. Provide supports as specified under basic electrical materials and methods. Conduits 1½-inch and smaller may be supported by 1-hole conduit straps. Support conduits 2 inches and larger by 2-hole conduit straps. Use conduit racks as

manufactured by Unistrut, Kindorf, or equal. Use PVC coated or type 316 stainless steel conduit racks.

- F. Make conduit joints up tight using a pipe wrench. Do not use channel lock pliers. Provide unions as necessary to aid in the installation. Cut conduits square and ream the ends smooth after threading to prevent injury to conductors. Conduit joints in concrete or exposed to weather or damp locations shall be drawn up tight and coated with insulating paint before casting in concrete or painting exposed conduit system.
- G. Install plastic-coated rigid metal conduit and fittings in accordance with the manufacturer's specifications and recommendations. Repair any damage to the plastic coating in accordance with the manufacturer's requirements.

3.3 INSTALLATION OF LIQUID-TIGHT FLEXIBLE METAL CONDUIT

- A. Make terminations at motors with flexible liquid-tight metal conduit from conduit stub to terminal box; make flexible connection as short as possible. Use Type UA, black flexible conduit. Underwriter's Laboratories approved flexible liquid-tight conduit connectors shall be as manufactured by Thomas and Betts Company, Appleton Electric Company, or equal.
- B. Uncoated flexible metal conduit may be used for short connections between junction boxes and lighting fixtures installed in suspending ceiling systems. Connect flexible metal conduit using Underwriters Laboratories approved grounding connectors.

3.4 INSTALLATION OF UNDERGROUND CONDUIT

- A. Do not conceal or encase conduit until the Engineer has inspected the conduit for proper installation and accurate placement.
- B. The Contractor shall be responsible for all excavating, draining trenches, forming of duct assembly and protective concrete envelope, backfilling, and removal of excess earth.
- C. Install underground conduit with a minimum 3-inch per 100-foot downward slope for drainage. Provide drains at all low points.
- D. Make bends and turns using long sweeps. Only use ninety-degree bends where required and keep usage at a minimum.
- E. Install all underground conduit runs for voltages less than 600 volts at least 24 inches below grade with a minimum conduit separation of 4 inches.
- F. Rod and pull a mandrel through all underground conduit runs followed by a swab to clean out any obstructions which may cause cable abrasions. Use a mandrel 12 inches in length with a diameter ½ inch less than the inside diameter of the conduit.
- G. Mark all underground conduit runs with a strip of permanently-colored red polyethylene tape, 0.004 inch thick and 6 inches wide, buried above the conduit and 6 inches below finished grade.
- H. Where concrete encased duct banks are installed, mix the concrete with a red dye or paint the top of the concrete red after it has cured and prior to backfilling.
- I. Unless otherwise shown, provide spare conduits, with water-proof plugs at stub-ups and furnish with a No. 8 aluminum pulling wire.

3.5 CONDUIT APPLICATION

- A. Install the following conduit types, unless otherwise shown on the drawings.
 - 1. Outdoors, Exposed (Not Buried): PVC-coated rigid galvanized steel
 - 2. Indoor, Exposed: PVC-coated rigid galvanized steel.

3. Underground: Schedule 40 PVC encased in concrete ductbank.
4. Transition Areas and Final Connections to Equipment: Flexible metal, liquid-tight conduit.

END OF SECTION

SECTION 40 12 13.21

STAINLESS STEEL AIR PIPING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	Submittals
1.3	Quality Assurance
1.4	Delivery, Storage, and Handling
1.5	Warranty
2.1	Manufacturers
2.2	Pipe and Fittings
2.3	Flanges
2.4	Couplings
2.5	Joints
3.1	Examination
3.2	Fabrication
3.3	Installation and Testing

B. Scope

1. The work covered by this section includes furnishing all materials, tools, equipment, transportation, labor, supervision and incidentals required to supply, store, install, clean, and test the shop fabricated stainless steel pipe & fittings as shown on the drawings and as specified herein.

1.2 SUBMITTALS

A. Action Submittals/Informational Submittals

1. Product Data
 - a. Catalog cuts and other data necessary to show conformance to these specifications.
2. Shop Drawings
 - a. Piping layouts, schedules, shop fabrication drawings and assembly schedules to show conformance of the complete piping system to these specifications.
 - b. Provide dimensions, fittings, locations of equipment, valves/dampers, appurtenances, joint locations and details, types of supports, and coordination with all other work.
 - c. Show alloys, diameters, wall thicknesses, flanges and other joint preparation details, dimensions, fittings and other appurtenances to be supplied.
3. Test and Evaluation Reports

- a. Provide test reports bearing witness certification to ASME Section IX by an independent testing laboratory for each welder, welding operator, and tacker, within the last six months, to be employed in the work.

1.3 QUALITY ASSURANCE

A. Qualifications

1. Manufacturers

- a. Furnish all shop fabricated stainless steel pipe and fittings from a single manufacturer who is experienced, reputable and qualified in the manufacture and fabrication of the items to be furnished.

2. Fabricators/Installers

- a. Shop fabricate and field install the pipe and fittings in accordance with common industry wide practices and methods and comply with these specifications.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements

1. Inspect all ducts and accessories for damage prior to unloading. Do not accept any damaged materials and have removed from the site.

B. Storage and Handling Requirements

1. Store ducts and accessories off the ground on adequate supports to prevent bending or deflection.
2. Lift and handle ducts and accessories with non-metallic straps.

1.5 WARRANTY

A. Manufacturer Warranty

1. Provide a guarantee against defective equipment and workmanship in accordance with requirements of the section titled "Warranties and Bonds" of these Specifications.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Pipe and fittings described in this section shall be supplied by:

1. Douglas Brothers
2. Felker Brothers Corporation
3. Bristol Metals
4. Engineer approved equal

2.2 PIPE AND FITTINGS

- A. Manufacture pipe from ASTM A240 annealed and pickled sheets and plates in accordance with ASTM A778 in type 316L stainless steel. Manufacture pipe to nominal pipe sizes as listed in ANSI B36.19, Table 2, with Schedule 40s wall thickness.
- B. Provide butt weld type fittings manufactured in accordance with ASTM A774 of the same raw material and in the same thicknesses as the pipe. Provide smooth flow long radius elbows up to 24" diameter; i.e. centerline to end of elbow equals 1.5 times the nominal pipe size. Provide straight tapered, cone type reducers. Shop fabricate tees, crosses, laterals and wyes from pipe.

- C. The finish on the raw material, manufactured to ASTM A240 will be No. 1, HRAP (hot rolled annealed and pickled) or better. The finish on the completed pipe and fittings shall be as specified in ASTM A778 and A774, respectively.

2.3 FLANGES

- A. Make flanged pipe ends of type 316L stainless steel slip-on type rolled angle face rings and type 316L stainless steel back-up flanges drilled to ANSI 16.1 class 125 standard. Make the thickness of the angle face ring equal to or greater than the wall of the pipe or fitting to which it is welded. Continuously weld the face ring on both sides to the pipe or fitting. Do not allow the angle leg to interfere with the flange bolt holes. Supply the back-up flanges with the following nominal thicknesses:

Nominal Pipe Size (in.)	Flange Thickness (in.)
4	1/2
6	1/2
8	1/2
10	5/8
12	5/8
14	5/8
16	5/8
18	3/4
20	3/4
24	1
30	1
36	1-1/4

2.4 COUPLINGS

- A. Shop prepare the piping for pipe couplings at pipe-to-pipe connections, where shown on the drawings or specified herein.
- B. Provide stainless steel couplings of equal or superior alloy and wall thickness as the pipe. Use Depend-O-Lok type as manufactured by Victaulic Depend-O-Lok, or equal. Provide couplings with restrained style ends – DOL FxF, or equal. Use plain end pipe with external weld beads ground smooth and with stainless steel restraining rings shop welded to the piping for fixed type couplings.
- C. Provide stainless steel expansion couplings of equal or superior alloy and wall thickness as the pipe. Use the flanged rubber arch type design for air piping up to 200-psi internal pressure. Provide pipe flanges for these couplings where shown on the drawings.
- D. Provide Ethylene Propylene Diene Monomer, EPDM gasket material for all.

2.5 JOINTS

- A. Use flanged joints at all flanged valves, meters, couplings, and connection to other equipment. Bolt all flange connections with through stud or tap bolts of required size as directed. Use grade 316L stainless steel alloy machine bolts conforming to ASTM A593 for buried or submerged flanges. Use grade 316 stainless steel, heavy hex nuts conforming to ASTM A594.
- B. Shop fabricate pipe and fitting spools to the fullest extent possible in 40'0" maximum lengths with 7'6" maximum widths for efficient commercial transport to the project site. Spools with fittings may exceed 40'0" so long as length allows commercial transport. Provide smaller pipe spools with joints as shown on the drawings for special handling, installation, and/or disassembly requirements.

- C. Use couplings for all other joints required for shipping, handling and installation of the piping spools.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verification of Conditions

- 1. Verify all existing conditions and require dimensions for proposed piping and duct work prior to ordering materials.

3.2 FABRICATION

- A. After the manufacture of individual stainless steel fittings and pipe lengths, pickle by immersion in a tank containing an ambient nitric hydrofluoric acid solution made up from Oakite Deoxidizer SS, or equal, and monitored to generally maintain a 25% or higher solution by volume of water. Immerse for 15 to 20 minutes. Immersion may be supplemented by manually scrubbing or brushing with non-metallic pads or stainless steel wire brushes. Follow the acid treatment by immersion in a rinse water tank, followed if necessary by a spray rinse. Air dry the stainless steel products to achieve passivation.
- B. Perform welding of pipe spools using welders and procedures qualified in accordance with ASME Section IX. Weld piping with wall thicknesses up to and including 11-gauge (0.125") with the TIG (GTAW) process. Bevel heavier walls according to procedure, root pass weld with the TIG (GTAW), and have subsequent weld passes performed using the TIG (GTAW), MIG (GMAW), or Metallic Arc (SMAW) process. Only add filler metal of equal or superior ELC grades to all welds to provide a cross section at the weld equal to or greater than the parent metal. Weld deposit shall be smooth and evenly distributed.
- C. Do not allow concavity, undercut, cracks or crevices in welding. Provide full penetration butt welds to the interior surface. Provide inert argon gas shielding to the interior and exterior of the joint. Continuously weld angle face rings on both sides to pipe or fitting. Make exterior welds, such as the back side of face rings or flanges and structural attachments by the MIG (GMAW) or Metallic Arc (SMAW) process, however take care to avoid melting through to the interior surface on very light walls. Remove excessive weld deposits, slag, spatter and projections by grinding. Grind smooth welds on gasket surfaces.
- D. Fabricate spools to the "Pipe Fabrication Institute" fabricating tolerances ES-3.
- E. Plug openings in all fabricated piping and secure flanges for storage and/or transport after fabrication. Piece mark all fabricated piping with identifying numbers or codes which correspond to the contractor's layout and installation drawings. Locate the marks on the spools at opposite ends and 180 degrees apart.
- F. Use extreme care to avoid the contact of any ferrous materials with the stainless steel piping during manufacturing, fabrication, handling, and installation stages. All saws, drills, files, wire brushes, etc. shall be used for stainless steel piping only. Use non-ferrous, stainless steel, or rubber lined racks for pipe storage and fabrication. Use nylon slings or straps or alloy chains or cable for handling stainless steel piping. After installation, wash and rinse all foreign matter from the piping surface. If rusting of embedded iron occurs, pickle the affected surface with Oakite Deoxidizer SS or equal, scrub with stainless steel brushes and rinse clean.

3.3 INSTALLATION AND TESTING

- A. Support piping in a manner which will prevent undue strain on valve, fitting, or equipment. Provide pipe supports on interior pipe at changes in direction or elevation, adjacent to flexible couplings, adjacent to non-rigid joints, and where otherwise shown.

- B. Clean off dirt, dust, oil, grease and other foreign material, before pressure and leakage tests.
- C. Furnish and install temporary testing plugs or caps; pressure pumps, pipe connections, meters, gauges, equipment, and labor.
- D. Testing
 - 1. Low Pressure Air Piping
 - a. Subject low pressure air piping (working pressures 15 PSI and less) to a pneumatic gauge pressure test. Use a test pressure of 150 percent of the maximum expected operating pressure or 20 PSI, whichever is greater. Maintain the pressure for a minimum of 2 consecutive hours. No leakage will be allowed.
 - 2. High Pressure Air Piping and Vacuum Piping
 - a. Subject high pressure air piping (working pressures greater than 15 PSI) and vacuum piping to a pneumatic gauge pressure test. Use a test pressure of 225 PSI. Maintain the pressure for a minimum of 2 consecutive hours. No leakage will be allowed.

END OF SECTION

SECTION 40 27 01

PROCESS PIPING SPECIALTIES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	References
1.3	Submittals
2.1	General
2.2	Connectors
2.3	Couplings
2.4	Expansion Joints
2.5	Flexible Expansion Joints
2.6	Butterfly Valves
3.1	General
3.2	Piping Flexibility Provisions
3.3	Piping Transitions
3.4	Pipe Expansion
3.5	Couplings
3.6	Flexible Pipe Connections to Equipment

B. Scope

1. The work covered by this section includes providing all materials, labor, and equipment required to install piping specialties within piping systems to make complete and functioning systems. All required fittings and specials may not be shown on the Drawings, but the Contractor is responsible for providing and installing fittings and specials as required for pipeline installation.

1.2 REFERENCES

A. Reference Standards

1. American Society of Mechanical Engineers (ASME):
 - a. B16.1 – Gray Iron Pipe Flanges and Flanged Fittings
 - b. B16.5 – Pipe Flanges and Flanged Fittings: NPS ½ through NPS 24
2. American Water Works Association (AWWA):
 - a. C153/A21.53 – Ductile-Iron Compact Fittings for Water Service
 - b. C210 – Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines
 - c. C213 – Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines
 - d. C219 – Bolted, Sleeve-Type Couplings for Plain-End Pipe

- e. Manual M11 – Steel Pipe-A Guide for Design and Installation
- 3. ASTM International (ASTM):
 - a. A153/A153M – Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
 - b. A276 – Standard Specification for Stainless Steel Bars and Shapes
 - c. A536 – Standard Specification for Ductile Iron Castings
- 4. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

1.3 SUBMITTALS

A. Action Submittals/Informational Submittals

- 1. Product Data
 - a. Manufacturer’s data on materials, construction, end connections, ratings, overall lengths, and live lengths (as applicable).
 - b. Details, ratings, calculations and test reports for thrust restraints relying on welded bars or rings.
- 2. Test and Evaluation Reports
 - a. Load proof-testing report of prototype restraint for any size coupling.
- 3. Manufacturer’s Instructions
 - a. Manufacturer’s specifications, installation instructions, and general recommendations.

PART 2 PRODUCTS

2.1 GENERAL

- A. Provide required piping specialty items, whether shown or not shown on Drawings, as required by applicable codes and standard industry practice.
- B. Rubber ring joints, mechanical joints, flexible couplings, and proprietary restrained ductile iron pipe joints are considered flexible joints; welded, screwed, and flanged pipe joints are not considered flexible.

2.2 CONNECTORS

A. Metal Bellows Connector:

- 1. Type: Single-ply, annular corrugated metal bellows with limit rods. Circumferential convolution welds not permitted.
- 2. Material: Type 316 stainless steel.
- 3. End Connections: ANSI 150-pound carbon steel flanges.
- 4. Minimum Design Working Pressure: 150 psig at 750 degrees F.
- 5. Length: Minimum of four convolutions and minimum manufacturer recommendation for vibration isolation.
- 6. Manufacturers and Products:
 - a. Victaulic Depend-O-Lok, Omniflex with short metal bellows
 - b. Metraflex, Model MN

- c. Engineer approved equal.
- B. Flexible Metal Hose Connector:
 - 1. Type: Close pitch, annular corrugated with single braided jacket.
 - 2. Material: Bronze.
 - 3. End Connections: Female copper solder joint.
 - 4. Minimum Burst Pressure: 500 psig at 70 degrees F.
 - 5. Length: Minimum manufacturer recommendation for vibration isolation.
 - 6. Manufacturers:
 - a. Senior Flexonics
 - b. Anamet Industrial, Inc.
 - c. Unisource Manufacturing, Inc.
 - d. Proco Products, Inc.
 - e. Engineer approved equal.

2.3 COUPLINGS

- A. General
 - 1. Provide couplings rated for working pressure not less than 150 psi or the rated pressure of the pipeline, whichever is greater.
 - 2. Line and coat couplings with fusion-bonded epoxy in accordance with AWWA C213.
 - 3. Unless thrust restraint is provided by other means, harness couplings in accordance with requirements of AWWA Manual M11, and restrain with retainer bar or ring welded to pipe end, or as shown on Drawings.
 - 4. Sleeve type couplings shall conform to AWWA C219 and shall be hydraulically expanded beyond minimum yield for accurate sizing and proofing of tensile strength.
- B. Flexible Sleeve Type Coupling
 - 1. Manufacturers and Products:
 - a. Steel Pipe:
 - 1) Dresser Piping Specialties; Style 38
 - 2) Smith-Blair, Inc.; Style 411
 - 3) Engineer approved equal.
 - b. Ductile Iron Pipe:
 - 1) Dresser Piping Specialties; Style 253
 - 2) Smith-Blair, Inc.; Style 411
 - 3) Engineer approved equal.
- C. Bolted Split Sleeve Type Expansion Coupling
 - 1. Seal and provide for axial movement (expansion and contraction) at pipe joint.
 - 2. Furnish with restraint rings that ensure expansion coupling is in the proper position over pipe ends when affixed to one of the pipe ends.
 - 3. Manufacturers and Products:
 - a. Victaulic Co., Depend-O-Lok FxE Expansion Couplings

- b. Engineer approved equal.
- D. Transition Coupling for Steel Pipe
 - 1. Manufacturers and Products:
 - a. Dresser Piping Specialties; Style 162
 - b. Smith-Blair, Inc.; Style 413
 - c. Engineer approved equal.
- E. Flanged Coupling Adapter
 - 1. Manufacturers and Products:
 - a. Steel Pipe:
 - 1) Dresser Piping Specialties; Style 128
 - 2) Smith-Blair, Inc.; Style 913
 - 3) Engineer approved equal.
 - b. Ductile Iron Pipe:
 - 1) Dresser Piping Specialties; Style 128
 - 2) Smith-Blair, Inc.; Style 912
 - 3) Engineer approved equal.
- F. Restrained Flange Adapter
 - 1. Pressure Rating:
 - a. Minimum Working Pressure Rating: Not less than 150 psi.
 - b. Safety Factor: Not less than two times working pressure and shall be supported by manufacturer's proof testing.
 - 2. Thrust Restraint:
 - a. Provide hardened steel wedges that bear against and engage outer pipe surface, and allow articulation of pipe joint after assembly while wedges remain in their original setting position on pipe surface.
 - b. Products employing set screws that bear directly on pipe will not be acceptable.
 - 3. Manufacturer and Product: EBAA Iron Sales Co.; Mega-Flange or Engineer approved equal.

2.4 EXPANSION JOINTS

- A. Metal Bellows
 - 1. Type: Single-ply, annular corrugated metal bellows with limit rods. Circumferential convolution welds not permitted.
 - 2. Material: Type 316 stainless steel.
 - 3. End Connections: ASME 150-pound carbon steel flanges.
 - 4. Minimum Design Working Pressure: 150 psig at 750 degrees F.
 - 5. Length: Minimum of four convolutions and minimum axial compression of 3 inches.
 - 6. Manufacturers and Products:
 - a. Victaulic Depend-O-Lok, Omniflex with long metal bellows
 - b. Metraflex, Model MN

- c. Senior Flexonics, Free Flexing Expansion Joints
 - d. Engineer approved equal.
- B. Flexible Metal Hose
1. Type: Close pitch, annular corrugated with single braided jacket.
 2. Material: Stainless steel, ASTM A276, Type 321.
 3. End Connections:
 - a. 3 Inches and Larger: Shop fabricated flanged ends to match mating flanges.
 - b. 2-1/2 Inches and Smaller: Screwed ends with one union end.
 4. Minimum Burst Pressure: 600 psig at 70 degrees F for 12 inches and smaller.
 5. Length: Provide hose live-length equal to lengths shown on Drawings.
 6. Manufacturer:
 - a. Senior Flexonics; Series 401M
 - b. Anamet Industrial, Inc.; BWC21-1
 - c. Engineer approved equal.

2.5 FLEXIBLE EXPANSION JOINTS

A. Design

1. Ball and socket type for earth settlement compensation.
2. Use double ball joint assemblies rated for 15-degree minimum deflection and not less than 4 inches offset from centerline of connecting piping.
3. Accommodate up to 4 inches of expansion in length.
4. Ductile iron conforming to AWWA C153/A21.53.
5. Rated for 350 psi.
6. Manufacturer lined and coated with fusion-bonded epoxy on all surfaces not bearing gaskets.
7. End Connections: Flanged or mechanical joint as shown and as required by connecting pipe and fittings.
8. Provide thrust restraint for joints connecting to mechanical joint.
9. Bonding:
 - a. Factory install thermite welded joint bonds for assembled expansion joint.
 - b. Provide 24-inch bond wires for field bonds to adjacent metallic piping.
 - c. Use No. 2 AWG bond wires with two 12-inch-long THHN insulated No. 2 as AWG wire pigtails.

B. Manufacturer and Product

1. EBAA Iron Sales Co.; Flex-Tend
2. Engineer approved equal.

2.6 BUTTERFLY VALVES

- A. Provide resilient seated butterfly valve in accordance with AWWA C504.
- B. Materials
 - 1. Valve Body: ASTM A536, Grade 65-45-12 ductile iron.
 - 2. Valve Disc: ASTM A536, ductile iron with Type 316 stainless steel edge.
 - 3. Valve Stem: Type 316 stainless steel (ASTM A276)
 - 4. Seats
 - a. Water Service: EPDM
 - b. Air Service: Viton
- C. Working Pressure: Minimum 150 psi
- D. Valves shall open counter-clockwise (left).
- E. End Connections: Flange by Flange
- F. Interior and exterior surfaces shall be coated with fusion-bonded epoxy coating in accordance with ANSI/AWWA C550.
- G. Valve shall be NSF/ANSI Standard 61 compliant.
- H. Acceptable Manufacturers:
 - 1. Henry Pratt Company
 - 2. Mueller Company
 - 3. Val-Matic Valve and Manufacturing Corporation
 - 4. Engineer approved equal.

PART 3 EXECUTION

3.1 GENERAL

- A. Provide accessibility to piping specialties for control and maintenance.

3.2 PIPING FLEXIBILITY PROVISIONS

- A. General
 - 1. Install flexible couplings to facilitate piping installation, in accordance with approved shop drawings.
- B. Flexible Joints at Concrete Backfill or Encasement: Install within 18 inches or one-half pipe diameter, whichever is less, from the termination of any concrete backfill or concrete encasement.
- C. Flexible Joints at Concrete Structures:
 - 1. Install 18 inches or less from face of structures; joint may be flush with face.
 - 2. Install a second flexible joint, whether or not shown.
 - a. Pipe Diameter 18 Inches and Smaller: Within 18 inches of first joint.
 - b. Pipe Diameter Larger than 18 Inches: Within one pipe diameter of first joint.

3.3 PIPING TRANSITION

- A. Applications:

1. Provide complete closure assembly where pipes meet other pipes or structures.
2. Pressure Pipeline Closures: Plain end pieces with double flexible couplings, unless otherwise shown.
3. Restrained Joint Pipe Closures: Install with thrust tie-rod assemblies as shown or in accordance with NFPA 24.
4. Gravity Pipe Closures: As specified for pressure pipelines, or concrete closures.
5. Concrete Closures: Use to make connections between dissimilar pipe where standard rubber gasketed joints or flexible couplings are impractical, as approved.
6. Elastomer sleeves bonded to pipe ends are not acceptable.

B. Installation:

1. Flexible Transition Couplings: Install in accordance with coupling manufacturer's instructions to connect dissimilar pipe and pipes with a small difference in outside diameter.
2. Concrete Closures:
 - a. Locate away from structures so there are at least two flexible joints between closure and pipe entering structure.
 - b. Clean pipe surface before placing closure collars.
 - c. Wet nonmetallic pipe thoroughly prior to pouring collars.
 - d. Prevent concrete from entering pipe.
 - e. Extend collar a minimum of 12 inches on each side of joint with minimum thickness of 6 inches around outside diameter of pipe.
 - f. Make entire collar in one placement.
 - g. After concrete has reached initial set, cure by covering with well-moistened earth.

3.4 PIPE EXPANSION

- A. Piping Installation: Allow for thermal expansion due to differences between installation and operating temperatures.
- B. Expansion Joints:
 1. Grooved Joint and Flanged Piping Systems: Elastomer bellows expansion joint.
 2. Nonmetallic Pipe: Teflon bellows expansion joint.
 3. Screwed and Soldered Piping Systems: Copper or galvanized and black steel pipe expansion compensator, as applicable.
 4. Air and Water Service above 120 Degrees F: Metal bellows expansion joint.
 5. Pipe Run Offset: Flexible metal hose.
- C. Anchors and Anchor Walls: Install as specified in Section 22 05 29 – Hangers and Supports for Plumbing and Equipment, to withstand expansion joint thrust loads and to direct and control thermal expansion.

3.5 COUPLINGS

- A. General:
 1. Install in accordance with manufacturer's written instructions.
 2. Before coupling, clean pipe holdback area of oil, scale, rust, and dirt.

3. Do not remove pipe coating. If damaged, repair before joint is made.
4. Application:
 - a. Metallic Piping Systems: Flexible couplings, transition couplings, and flanged coupling adapters.
 - b. Concrete Encased Couplings: Flexible coupling.

3.6 FLEXIBLE PIPE CONNECTIONS TO EQUIPMENT

- A. Install to prevent piping from being supported by equipment, for vibration isolation, and where shown.
- B. Product Applications Unless Shown Otherwise:
 1. Nonmetallic Piping: Teflon bellows connector.
 2. Copper Piping: Flexible metal hose connector.
 3. Compressor and Blower Discharge: Metal bellows connector.
 4. All Other Piping: Elastomer bellows connector.
- C. Limit Bolts and Control Rods: Tighten snug prior to applying pressure to system.

END OF SECTION

POSITIVE DISPLACEMENT BLOWER PACKAGES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes

<u>Paragraph</u>	<u>Title</u>
1.2	Administrative Requirements
1.3	Submittals
1.4	Quality Assurance
1.5	Delivery, Storage, and Handling
1.6	Warranty
2.1	Equipment
2.2	Electrical and Control Requirements
2.3	Accessories
2.4	Source Quality Control
3.1	Installation
3.2	Field Quality Control
3.3	Adjusting

B. Scope

1. Furnish, install, test, and place in satisfactory operation two tri-lobe positive displacement blowers to replace the single blower currently at the project site. Blowers shall be installed at locations shown on Drawings in compliance with the Specifications.
2. Provide blowers with all accessories, couplings, valves, and other appurtenances as specified, and as may be required for a complete and operating installation.

1.2 ADMINISTRATIVE REQUIREMENTS

A. Coordination

1. The Contract Documents are intended to describe a blower installation for the specified purpose, complete and ready to be placed into service at the levels of performance indicated in the Drawings and outlined herein. By offering this service to the Owner, Contractor affirms that they are fully knowledgeable regarding the required methods and materials, and are capable of performing such installation. The omission of specific details and / or steps from the Drawings or Specifications, required to perform this installation shall not relieve the Contractor of their sole responsibility for this end result, nor shall such omissions be grounds for requests for additional compensation. Coordinate with other manufacturers and suppliers to provide all details and appurtenances necessary to properly install, adjust, and place in satisfactory operation a complete working unit.

1.3 SUBMITTALS

A. Action Submittals/Informational Submittals

1. Shop Drawings
 - a. Submit the following items with the Shop Drawings in accordance with, or in addition to, the requirements specified in Section 01 33 23 – Shop Drawings, Product Data, and Samples and Section 01 60 00 – General Equipment Stipulations.
 - 1) Certified blower performance curves at rated speed and reduced speed (if reduced speeds are specified)
 - a) Indicate discharge pressure, airflow (scfm and icfm), efficiency, brake horsepower, blower inlet/outlet air temperatures, and speed (rpm).
 - b) Include limits (minimum and maximum speeds) for stable operation without overheating, excessive noise, or excessive vibration.
 - 2) General cutaway sections, materials, dimension of shaft projections, shaft and keyway dimensions, shaft diameter, dimension between bearings, general dimensions of blower, primary and alternate drive belt routes, and anchor bolt locations and forces.
 - 3) Dimensioned installation drawings, including drawings indicating the size and location(s) of the air inlets/outlets(s), sound attenuating enclosure, anchor locations, inlet air filter, and access panels.
 - 4) Detailed description of construction, including a parts list with materials of construction and metallurgy with ASTM designations
 - 5) Details of sound attenuating enclosure and inlet/outlet silencers.
 - 6) Functional description of internal and external instrumentation and controls, including a list of parameters monitored, controlled, or alarmed
 - 7) Control panel elevation drawings showing fabrication and placement of operator interface devices and associated elements
 - 8) A motor performance chart showing curves for torque, current, power factor, input/output power, and efficiency and data on starting and no-load characteristics

2. Manufacturer Reports

- a. Submit a certified report prepared by the manufacturer's technical representative certifying satisfactory installation, operation, and in-service placement of blowers.
- b. Provide Certificate of Proper Installation in accordance with Section 01 91 13, signed by manufacturer's authorized personnel prior to start-up of system.

- B. Closeout Submittals

1. Operation and Maintenance Data

- a. Submit Operating and Maintenance Manuals in accordance with Section 01 78 23 – Operating and Maintenance Data.

2. Warranty Documentation

- a. Include the manufacturer's warranty in the compiled warranty submittal of all manufacturers' warranties in accordance with Section 01 78 33 – Warranties and Bonds with the exception of the warranty period being specified to be for a minimum period of 24 months after date of acceptance by Owner.

- C. Maintenance Material Submittals

1. Spare Parts

- a. Include manufacturer's information for the spare parts specified herein with the Shop Drawing submittal.
- 2. Tools
 - a. Include manufacturer's information for the special tools and supplies specified herein with the Shop Drawing submittal.

1.4 QUALITY ASSURANCE

A. Qualifications

- 1. Manufacturers
 - a. Furnish all blowers from a single manufacturer.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Acceptance Requirements

- 1. Ship components containing bearings with lubricant on all bearings.
- 2. Deliver all components to site in manufacturer's shipping crates or boxes.
- 3. Deliver to site undamaged.

B. Storage and Handling Requirements

- 1. Store above ground, covered, and on platforms, skids, or other supports.
- 2. Protect from corrosion and mechanical damage.
- 3. Protect electrical components from condensation.
- 4. Ship any power and control cables with securely-attached caps on cable ends to prevent moisture wicking into cable during storage.
- 5. Store with lubricant on all bearings.
- 6. Handle all components in such a manner to prevent damage during unloading and installation.
- 7. Follow manufacturer's instructions regarding lifting and setting.

1.6 WARRANTY

A. Manufacturer Warranty

- 1. Provide manufacturer two (2) year warranty meeting the requirements of Section 01 78 33 – Warranties and Bonds.

PART 2 PRODUCTS

2.1 EQUIPMENT

A. Manufacturers

- 1. Manufacturer List
 - a. Aerzen USA
 - b. Gardner Denver USA
 - c. Engineer approved equal
- 2. Substitution Limitations
 - a. The naming of a manufacturer in this Section is not an indication that the manufacturer's standard equipment is acceptable in lieu of the specified component

features. Naming is only an indication that the manufacturer may have the capability of engineering and supplying a system as specified.

B. Performance/Design Criteria

1. Blower Schedule:

Number of Units	2 (1 Duty, 1 Standby)
Designation/Tag Numbers	RAB-1, RAB-2
Outlet Diameter (inches)	8
Medium Blown	Air
Inlet Air Temperature (degrees F)	100
Rotor Type	Tri-lobe
Drive Type	Belt Driven
Blower Rotor Maximum Speed (rpm)	3000
Maximum Motor Speed (rpm)	2000
Maximum Motor Horsepower (hp)	125
Minimum Motor Horsepower (hp)	100
Minimum Efficiency (%)	60
Sound Enclosure Type	Close Fitting
Sound Level 3' from Enclosure (dBA)	80
Design Condition	
Site Elevation (Feet above MSL)	909
Air Flow (icfm)	1580
Discharge Static Pressure (psig)	10.5
Intake Static pressure (psia)	14.5

C. Operation

1. Operators

- a. Operate each blower using the blower HAND-OFF-AUTO (H-O-A) selector switch at the local control panel.
- b. Operate each blower using start/ stop inputs from the plant PLC.

2. Controls

- a. Blower H-O-A Selector Switch in HAND Position: Blower continuously operates unless automatically stopped by a motor failure.
- b. Blower H-O-A Selector Switch in OFF Position: Blower does not operate.
- c. Blower H-O-A Selector Switch in AUTO Position: Blower starts when a filter backwash cycle is initiated. In general, the plant PLC system sequences blower(s) ON as the backwash cycle is initiated and the actuated valves on the backwash air manifold open. OFF as the backwash cycle is completed and backwash air valves are closed.

3. Operation Sequences

- a. Motor Failure
 - 1) Disables the blower to prevent damage
 - 2) Activates the Motor FAIL light and alarm
 - 3) After motor fail condition is reset, blower automatically resumes operation in the current mode (HAND or AUTO).
- b. Power Failure
 - 1) When blower is Running: Operation resumes when power is restored.
 - 2) When blower is in a Fail Condition: Fail indicator reactivates when power is restored.
- c. Provide logic to maintain all alarm and fail condition indication and contact outputs until the Owner manually presses the RESET pushbutton at the local control panel to reset the alarm and fail conditions.

D. Materials

1. Positive Displacement Blower

a. General

- 1) Factory build and test positive displacement blowers for mounting on concrete pad and for connection to the existing backwash air manifold. Manufacture the assembly to meet the requirements of the latest specifications for a positive displacement blower and all related specifications, with the minimum requirements identified as follows. Construct the blower and enclosure in one complete, factory-built assembly. Size the assembly to rest on the top of proposed equipment pad.
- 2) Principal Items of Equipment
 - a) Two tri-lobe positive displacement belt driven blowers
 - b) Central control panel with circuit breakers, motor starters, and automatic controls. A single control panel shall operate the two proposed blowers.
 - c) Sound attenuating enclosure with vibration dampening anchor points
 - d) Vibration dampening flex couplers for connection to process air piping.
 - e) Internal wiring
 - f) All required appurtenances for a complete and functioning system

b. Minimum Requirements

- 1) Provide the most efficient blower available at the desired design point as recommended by the manufacturer.
- 2) Capable of handling hot, unconditioned, humid air within the Process Building.
- 3) Filters and Maintenance: Equipment must be serviceable in the installed location and shall not have to be removed or rotated to service the necessary parts at their recommended intervals.
- 4) Blower Lobes
 - a) Tri-lobe rotors.
- 5) Accessories
 - a) Blower Running Lights
 - b) Remote Alarm Contacts

- c) Two PRV's
 - (1) Factory set to 15.2 psig
 - d) Instrumentation panel
 - (1) 4" gauges for P1, P2, T2 with high temp switch for each blower
 - e) Sequential Alternation
- c. Blower Nameplate
- 1) In addition to the requirements of Section 01 60 00 – General Equipment Stipulations, include capacity (scfm), discharge static pressure (psig), speed, and efficiency at the rated design point.

E. Finishes

- a. Primer Materials
 - 1) Clean and apply primer material to steel and cast iron surfaces of blower and enclosure in factory in accordance with Section 09 91 00 – Painting.
- b. Shop Finishing Methods
 - 1) Perform shop finishing methods on steel and cast iron surfaces of blower and enclosure in accordance with Section 09 91 00 – Painting.
- c. Finish Materials
 - 1) Prepare and apply finish materials to steel and cast iron surfaces of blowers and enclosure in field in accordance with Section 09 91 00 – Painting.
 - 2) Field touch-up any damaged paint or coatings with compatible paint/coating system in accordance with Section 09 91 00 – Painting.

2.2 ELECTRICAL AND CONTROL REQUIREMENTS

- A. Provide all electrical components, wiring, and control devices necessary for a complete, functional system.
- B. Electrical Requirements

Motors	
Rating	460V, 3 phase, 60 Hz
Maximum Horsepower (hp)	125
Maximum Speed (revolutions/minute)	2000
Enclosure	TEFC (Totally enclosed, fan cooled)
Insulation	Class F
Inverter Duty	No
Service Factor	1.15
Space Heater	No
Separate Cooling Fan	Yes
Motor Winding Temperature Switches	Yes
Control Panel	
NEMA Rating	4X
Materials of Construction	Type 316 Stainless Steel powder coated white on interior and exterior

C. Motor

1. Positive Displacement Blower

a. General

- 1) Motors will be horizontal TEFC with cast iron frame. The motors not to overload at the design condition or at any pressure in the operating range as specified
- 2) Motors shall be tested in accordance with provisions.

b. Inverter Ready per NEMA MG-1, Part 31.4.4.2

c. UL-recognized and CSA-approved

d. Motor Windings: 200 degree Celsius ISR (Inverter Spike Resistant) magnet wire.

e. Epoxy-coated rotors for corrosion protection.

f. Limit Class F insulation temperature to Class B.

g. 1.15 Service Factor for normal starting torque and low-starting current as specified by NEMA Design B characteristics.

h. Totally Enclosed and Fan Cooled design with forced air circulation by integral fan. Uniformly space openings for ventilation around the motor frame.

i. Provide clearly-identified cast connection box for termination of leads.

j. Drive transmission

- 1) Power to blowers transmitted by v-belt assemblies. The sheave/belt combination will provide speed ratio needed to achieve the specified operating conditions.
- 2) Each drive assembly will utilize at least two v-belts providing minimum a combined safety factor of 1.5. Single belt drives or systems with a safety factor of less than 1.5 are not acceptable. Computation of safety factors will be based on performance data published by the drive manufacturer.
- 3) Blower manufacturer will submit power transmission calculations which document the following:
 - a) Ratio of blower/motor speed
 - b) Pitch diameter of driver and driven sheaves
 - c) Number of belts required per drive
 - d) Theoretical horsepower transmitted per belt, based on blower manufacture's data
 - e) Center distance between blower and motor shafts
 - f) Arc-length correction factor applied to theoretical horsepower transmitted
 - g) Service factor applied to established horsepower
 - h) Safety factor ratio of power transmitted/brake horsepower required

D. Control Panel

1. Furnish a UL Listed (UL508A serialized label) blower control panel capable of controlling both blowers with the following features:
 - a. Main breaker with minimum 65,000A RMS symmetrical short circuit rating. Provide through door rotary disconnect.
 - b. Provide combination circuit breaker soft start starters for each blower. Each starter shall have a "Hand-Off-Auto" selector switch and an elapsed time meter.

- c. Provide a two position selector switch to select the blower to run. An interlock shall be provided to lock out the other blower.
- d. Provide CompactLogix L30 ER PLC with required I/O modules plus 20% spare.
- e. Provide PanelView Plus 7, 12-inch touch screen HMI.
- f. Provide an unmanaged Ethernet switch for input control and status and alarm communication to/from the Plant PLC via Ethernet cable.
- g. Provide a 460/120V control power transformer and a 120VAC UPS.

2.3 ACCESSORIES

A. Spare Parts

- 1. Furnish the following spare parts for each blower in accordance with Section 01 60 00 – General Equipment Stipulations:
 - a. One (1) gallons of lubricant
 - b. Two (2) complete belt sets
 - c. Two (2) replacement air filters
- 2. Properly pack in containers suitable for long-term storage.
- 3. Attach labels that clearly designate the contents and the piece(s) of equipment for which they are intended.
- 4. Store all materials in a location as directed by the Owner.
- 5. Provide spare parts of the same type and quality as the original components in the furnished blower package(s).

B. Special Tools and Supplies

- 1. Furnish all special tools necessary to disassemble, service, repair, and adjust the blower.
- 2. Furnish a one-year supply of all lubricating oils and greases as recommended by the manufacturer.

2.4 SOURCE QUALITY CONTROL

A. Tests and Inspections

- 1. Perform shop testing in accordance with Section 01 60 00 – General Equipment Stipulations, all applicable methods and standards of the Wire-to-Air Performance Test Code for Blower Systems (PTC 13) by the American Society of Mechanical Engineers (ASME), and the following additional requirements:
 - a. Perform shop testing and inspection and provide signed and sealed report of testing results to Owner and Engineer
 - 1) Submit testing procedure to Owner for review and approval before scheduling shop test.
 - 2) Provide Owner with a minimum of two weeks advance notice of the scheduled test date.
 - b. Certification Test
 - 1) Perform on each of the actual assembled blowers to be furnished.
 - 2) Test blowers in the manufacturer's facility in accordance with the Wire-to-Air Performance Test Code for Blower Systems by the American Society of

Mechanical Engineers (ASME) to determine discharge static pressure vs. capacity and power draw required.

- 3) Test Range: Shut-off to a minimum of 20 percent beyond the specified design performance capacity.
 - 4) Tolerances: As specified by PTC 13 by ASME
 - 5) Generate a blower curve that shows actual flow, static pressure, brake hp, and adiabatic efficiency for each blower furnished.
 - 6) Submit blower curves, each certified by a registered Professional Engineer, to the Owner.
- c. Perform a logic test and full operational test with all systems operational on the control panel.

PART 3 EXECUTION

3.1 INSTALLATION

A. Special Techniques

1. Install the blower and accessories in accordance with the approved Shop Drawings and the manufacturer's printed instructions and recommendations.

3.2 FIELD QUALITY CONTROL

A. Field Tests and Inspections

1. Perform field testing in accordance with Section 01 60 00 – General Equipment Stipulations and the following additional requirements:
2. Final Acceptance Test
 - 1) Demonstrate blowers are properly installed and are in proper alignment.
 - 2) Demonstrate the blowers operate without overheating or overloading of any parts and without objectionable vibration.
 - a) Vibration: Within the limits of the ASME Standards or the blower manufacturer's limits, if more stringent.
 - 3) Demonstrate the blowers meet the specified Design Conditions.
 - a) Check each blower at maximum speed for a minimum of four (4) points on the blower curve for capacity, static pressure, and amperage.
 - (1) Not Acceptable: Exceeding the rated current on the motor nameplate at any point.
 - b. Furnish all labor, materials, and test apparatus necessary for conducting the field tests at no additional cost to the Owner.

B. Manufacturer Services

1. Furnish the field services of a qualified, trained, and competent manufacturer's technical representative who has knowledge of the proper installation, operation, and maintenance of the blowers in accordance with Section 01 43 33 – Manufacturer Services. Include the following site visits for each series of blowers:

Service	Number of Trips	Number of Days/Trip
Installation, Testing, Startup	1	3
Training	1	1

2. Manufacturer's Technical Representative's Minimum Responsibilities
 - a. Inspect the completed installation of each blower for conformance with manufacturer's recommended installation requirements. At a minimum, include the following:
 - 1) Check motor oil level and lubrication of seals (if applicable)
 - 2) Check power supply voltage.
 - 3) Megger for insulation breaks or moisture.
 - 4) Measure motor no-load current.
 - 5) Manually trip sensors and check complete cycle of control operation.
 - b. Supervise field test of each blower.
 - c. Supervise initial startup and operation of each blower.
 - d. Instruct Owner's personnel in proper operation and maintenance of blowers.
 - e. Prepare and certify field inspection report.

3.3 ADJUSTING

- A. After installation, align, balance, and adjust the blower and accessories as required for proper operation and proper alignment.

END OF SECTION