AlexRenew

Bid Set

Specifications

Divisions 03-46

Volume 2 of 3

Centrate Pretreatment Project

Contract 25-007

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Prepared by:

Jacobs

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END OF SECTION

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SECTION 03 01 32
REPAIR OF VERTICAL AND OVERHEAD CONCRETE SURFACES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI):
   a. 301, Specifications for Structural Concrete.
   b. 506.2, Specification for Shotcrete.
2. ASTM International (ASTM):
   a. A82/A82M, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
   b. A185/A185M, Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
   c. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   d. A706/A706M, Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
   e. C42/C42M, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
   f. C78/C78M, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
   g. C109/C109M, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens).
   h. C157/C157M, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
   i. C293/C293M, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading.
   j. C348, Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
   k. C496/C496M, Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
   l. C531, Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.
   m. C596, Standard Test Method for Drying Shrinkage of Mortar Containing Hydraulic Cement.
   n. C666/C666M, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.

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o. C882/C882M, Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
p. C1202, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.
q. C1583/C1583M, Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method).
r. D4258, Standard Practice for Surface Cleaning Concrete for Coating.
s. D4259, Standard Practice for Abrading Concrete.
t. E699, Standard Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components.

1.02 DEFINITIONS

A. Abrasive Blasting: Surface preparation method that uses compressed air intermixed with an abrasive medium to clean surface of substrate concrete, exposed steel, and steel reinforcement. Compressed air and abrasive medium is projected at high speed through a nozzle directly at the surface. Method is used to remove corrosion by-products, laitance, or other materials that may inhibit bond of repair concrete.

B. Defective Area: Surface defect such as honeycomb, rock pockets, indentations and surface voids greater than 3/16-inch deep, surface voids greater than 3/4-inch diameter, cracks in liquid containment structures and below grade habitable spaces 0.005-inch wide and wider, cracks in other structures 0.010-inch wide and wider, spalls, chips, embedded debris, sand streaks, mortar leakage from form joints, deviations in formed surface that exceed specified tolerances which include but are not limited to fins, form pop-outs, and other projections, and at exposed concrete which includes texture irregularities, stains, and other color variations that cannot be removed by cleaning.

C. High-Pressure Water Blasting: Sometimes referred to as hydro-demolition. Uses water that may contain an abrasive medium, projected under high pressure and high velocity. Used for demolition, cutting, partial or full depth removal, cleaning, scarifying, or roughening of concrete surfaces, or removing existing coatings, for preparation of substrate concrete surfaces.

D. Low-Pressure Spray Mortar: Mortar suitable to be applied by low-pressure spraying, and in small areas may be applied by hand troweling.

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E. New Concrete: Concrete less than 60 days old forming structures constructed as part of the Work.

1.03 SUBMITTALS

A. Action Submittals: Product data sheets for each material supplied.

B. Informational Submittals:

1. Repair Mortar System: Manufacturer's preparation and installation instructions.
2. Written description of equipment proposed for concrete removal and surface preparation.
3. Certificates:
   a. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, that proposed repair mortar systems are prepackaged, shrinkage compensated, specially designed for use on vertical and overhead surfaces that are exposed to weather.
   b. Mortar Manufacturer's Certificate of Proper Installation.
4. Statements of Qualification:
   a. Repair mortar system applicator.
   b. Repair mortar system manufacturer's representative.
   c. Independent Testing Laboratory.
5. Repair mortar system manufacturer's proposed modified test procedures for ASTM C109/C109M, ASTM C882/C882M, and ASTM C157/C157M test methods.
6. Field and laboratory test reports.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Repair Mortar System Applicator: For Repair System B – Low-Pressure Spray Mortar, in lieu of recognition or certification, demonstrate application of repair mortar manufacturer's system and obtain Certification of Proper Installation, in accordance with Article Manufacturer's Services.

B. Pre-repair Conference:

1. Required Meeting Attendees:
   a. Contractor.
   b. Repair Subcontractor.
   c. Engineer.

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2. Schedule and conduct prior to conducting mockups and incorporation of respective products into Project. Notify Engineer of location and time.
3. Agenda shall include, but not limited to:
    a. Review of field conditions. Conduct field observations of Work to be performed.
    b. Based on above observations, confirm material selection and make Project-specific repair method recommendations.
    c. Review proposed surface preparation, material application, consolidation, finishing, curing, and protection of repair material from weather conditions.
    d. Other specified requirements requiring coordination.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Package repair mortar system products in moisture-resistant bags, pails, or moisture-resistant bulk bags.

B. Deliver, store, and handle repair materials in accordance with manufacturer's printed instructions.

PART 2 PRODUCTS

2.01 REPAIR SYSTEM B – LOW-PRESSURE SPRAY MORTAR

A. One component, cement based, fiber reinforced, shrinkage compensated, gray in color, with a minimum 30-minute working time.

B. Cured materials mixed in accordance with manufacturer's instructions shall conform to the following criteria:

1. Compressive Strength, ASTM C109/C109M at 28 Days: 6,000 psi minimum.
2. Flexural Strength, ASTM C348 at 28 Days: 1,100 psi minimum.
3. Slant Shear Bond Strength, ASTM C882/C882M Test Method Modified with No Bonding Agent, at 28 Days: 3,000 psi minimum.
4. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 600 psi minimum.
5. Drying Shrinkage, ASTM C157/C157M Modified at 28 Days or ASTM C531: 0.1 percent maximum.
6. Chloride Ion Permeability Based on Charge Passed, ASTM C1202: 1,000 coulombs maximum.
7. System shall not produce a vapor barrier.
8. Sprayable, extremely low permeability, sulfate resistant, easy to use and requiring only addition of water.
9. Free of chlorides and other chemicals causing corrosion.

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C. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco S 488CI.
2. Sika Corp., Lyndhurst, NJ; SikaRepair 224.
3. Euclid Chemical Co., Cleveland, OH; Tamms Structural Mortar.

2.02 REPAIR SYSTEM C – POLYMER-MODIFIED REPAIR MORTAR

A. Polymer-modified, one- or two-component, cementitious based, chloride resistant, flowable, gray in color, working time of 20 minutes minimum, surface renovation mortar.

B. Cured Mortar Properties:

1. Compressive Strength, ASTM C109/C109M at 28 Days: 7,000 psi minimum.
2. Flexural Strength, ASTM C348 at 28 Days: 1,200 psi minimum.
3. Slant Shear Bond Strength, ASTM C882/C882M Test Method Modified with No Bonding Agent at 28 Days: 2,000 psi minimum.
4. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 500 psi minimum.
5. Drying Shrinkage, ASTM C596 at 28 Days: 0.12 percent maximum. Not required for small repair areas approximately 1 square foot in area or less.
6. Freeze Thaw Resistance, ASTM C666/C666M, at 300 Cycles: 90 percent RDM.
7. Chloride Ion Permeability Based on Charge Passed, ASTM C1202: 800 coulombs maximum for liquid holding and below grade repairs.

C. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco N 300CI.
2. Sika Corp., Lyndhurst, NJ; SikaTop 123 PLUS.
3. Euclid Chemical Co., Cleveland, OH; DuralTop Gel.

2.03 WATER

A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards, as specified in Section 03 30 10, Structural Concrete.

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2.04 REINFORCEMENT

A. Deformed Steel Reinforcement: Per Section 03 30 10, Structural Concrete.

2.05 EVAPORATION RETARDANT

A. As specified in Section 03 30 10, Structural Concrete.

2.06 CURING COMPOUND

A. As specified in Section 03 30 10, Structural Concrete.

PART 3 EXECUTION

3.01 GENERAL

A. New Concrete Work: Repair deficiencies in new concrete structures constructed under this Contract with applicable repair system. Refer to Section 03 30 10, Structural Concrete.

3.02 APPLICATION

A. General:

1. Repair System B: Medium to large areas and number of repair areas.
2. Repair System C: Small and limited areas and number of repair areas.

3.03 PREPARATION

A. Identify unsound and deteriorated concrete by sounding techniques, or as directed by Engineer, and review proposed extent of repair with Engineer.

B. Remove unsound, honeycombed, deteriorated, or otherwise defective areas of concrete from work areas.

1. Use 8,000 psi minimum-pressure water blasting machine as required for Site conditions.
2. Remove concrete to abrade substrate concrete surfaces to a minimum amplitude roughness of 3/16 inch measured between high and low points with a 3-foot-long straightedge, in accordance with ASTM D4259.
3. Where final surface is required to be flush with existing adjacent surface remove existing concrete depth as required for application of minimum thickness of repair mortar.

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C. Do not use power-driven jackhammers, chipping hammers, or scabblers unless water blasting is not permitted or practical because of Site conditions or may cause other damage to equipment or facilities. In such cases where chipping hammers are required, limit size of chipping hammer to 16 pounds or lighter, or use small electric chipping hammer, to reduce formation of micro-fractures in substrate concrete surface.

D. Following removal of unsound or deteriorated concrete, check substrate concrete surface by sounding techniques to identify unsound concrete remaining or resulting from use of chipping hammer.

E. Remove unsound concrete to satisfaction of Engineer.

F. Square edges of patch areas by sawing or chipping to avoid tapered shoulders or featheredges. Avoid cutting embedded steel reinforcement. Roughen polished saw-cut edge by high-pressure water blasting.

G. Remove concrete adjacent to steel reinforcement to a minimum of 1-inch clearance around steel reinforcement for application and bonding of new repair mortar to circumference of exposed steel reinforcement if one or more of the following surface conditions exist:

1. 50 percent or more of circumference around steel reinforcement is exposed during concrete removal.
2. 25 percent or more of circumference around steel reinforcement is exposed during concrete removal and corrosion is present to extent that more than 25 percent loss of section has occurred.
3. Otherwise evident that bond between existing concrete and steel reinforcement has been destroyed or has deteriorated as determined by Engineer.

H. Clean exposed steel reinforcement of loose rust and concrete splatter per recommendations of repair material manufacturer and in accordance with ASTM D4258.

I. Keep areas from which concrete has been removed free of dirt, dust, and water blasting waste slurry. Remove laitance and other bond inhibiting contaminates from prepared areas.

J. Dampen repair areas at least 6 inches beyond area to receive repair mortar for at least 24 hours to provide saturated surface dry (SSD) condition without standing water at time of application of mortar as required by and in accordance with repair mortar manufacturer’s printed instructions.

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K. Collect and dispose of spent water and concrete debris from removal operations offsite in manner and location acceptable to Owner.

3.04 PROTECTION

A. If cementitious coating or bonding agent is used, protect adjacent surfaces from over application. Promptly remove bonding agent applied beyond repair area.

B. Protect adjacent surfaces, and equipment, from being damaged by overshooting, rebound, and dust, as applicable for repair mortar system used, from low-pressure spray mortar.

3.05 REPAIR SYSTEM B – LOW-PRESSURE SPRAY MORTAR PLACEMENT

A. Mix mortar in accordance with manufacturer's printed instructions.

B. After priming prepared substrate concrete surface per manufacturer's recommendations, apply mortar by low-pressure spraying equipment, unless noted otherwise.

C. Work mortar firmly and quickly into repair area.

D. Finish repair mortar to match adjacent concrete surface.

E. Provide evaporation retardant at full strength.

F. Cure as specified in Article Curing.

3.06 REPAIR SYSTEM C – POLYMER-MODIFIED REPAIR MORTAR PLACEMENT

A. Mix mortar in accordance with manufacturer's printed instructions.

B. Bond Coat: Apply to prepared substrate concrete surface before application of mortar in accordance with repair mortar manufacturer's printed instructions. Do not apply more bond coat than can be covered with mortar before bond coat dries. Do not retemper bond coat.

C. Place mortar by hand or low-pressure spray and trowel to specified surface finish, in accordance with requirements of repair material's printed instructions.

D. Finish repair mortar to smooth even surface to match adjacent concrete surface.

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E. Cure as specified in Article Curing, and in accordance with manufacturer's printed instructions.

3.07 CURING

A. Prior to curing, apply water fog to repair mortar system in accordance with repair mortar system manufacturer's printed instructions.

B. Cure in accordance with repair mortar manufacturer's printed instructions.

C. Where permitted by repair mortar manufacturer's printed instructions, commence water curing after repair mortar system application and when curing will not cause erosion of mortar.

D. Continuously water cure repair mortar system for a period of 7 days.

E. Do not cure using curing compound or membrane, unless method is part of repair mortar system manufacturer's printed instructions and approval is obtained from Engineer.

F. Cure intermediate layers of repair mortar in accordance with repair mortar manufacturer's printed instructions.

G. Where curing compound is permitted by repair mortar system manufacturer, apply curing compound in accordance with Section 03 30 10, Structural Concrete.

3.08 FIELD QUALITY CONTROL

A. Sounding for Hollow Areas:

1. Light hammer tap repaired areas listening for hollow sound to determine areas that have not properly bonded to substrate concrete.
2. Mark hollow areas for removal and replacement.

B. Compression Strength Test:

1. Test in accordance with ASTM C109/C109M, except modified by making samples using repair mortar.
2. Obtain production samples of mixed wet mortar materials from nozzle, or mixer, during construction for compliance with Specifications for testing at 7 days, and 28 days. Alternatively, take core samples in accordance with ASTM C42/C42M from applied mortar material for testing at 7 days and 28 days.

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3. Provide a minimum of three samples for each 200 square feet of mortar repair, and a minimum of three samples in total, whichever is greater, for testing.
4. Record location where repair mortar is being applied at time production samples are obtained.

C. Direct Tension Bond Test:

1. In Situ Bond Testing: Perform tension bond test in accordance with ASTM C1583/C1583M.
2. Record locations on in situ bond tests on each type of applied repair mortar.

D. Testing laboratory retained by Owner will provide the following:

1. Compression Strength Test:
   a. Testing will follow a "modified" ASTM C109/C109M.
   b. A minimum of three production samples of mixed material will be obtained from each 200 square feet of mortar repair, and a minimum of three samples in total, whichever is greater, for testing at 7 days, and 28 days.
   c. Record location where repair mortar is being applied at time production samples are obtained.
2. Direct Tension Bond Test:
   a. Two core samples will be obtained and tested for each 2,000 square feet of repair work.
   b. Cores will be 2-1/2-inch or 3-inch diameter to a total depth equal to at least 2.5 times repair mortar thickness.
   c. Bond Strength of Repair Mortar to Substrate Concrete: 300 psi minimum in direct tension without failure or movement.
   d. Record locations of Bond Tests on each type of applied repair mortar tested.

E. Retest mortar repairs that do not meet test requirements.

F. Repair and fill holes using same repair mortar where core samples have been removed.

3.09 MORTAR REPAIR FAILED TEST

A. Remove and replace unacceptable Work.

B. Hollow Sounding Areas: Saw cut hollow sounding areas to a new square edge. Remove unsound mortar repair. Prepare substrate surface and reapply repair mortar as specified herein above.

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C. Failed Compression Strength Test: Remove affected areas of repair mortar represented by failed compression strength test results. Prepare substrate surface and reapply repair mortar as specified herein above.

D. Failed Bond Tests: Remove affected areas of repair mortar represented by failed bond test results. Prepare substrate surface and reapply repair mortar as specified herein above.

E. Retest areas where repair mortar was removed and replaced, in accordance with test requirements specified herein above.

3.10 CLEANING

A. Remove overshot low-pressure spray, Repair System B repair mortar and rebound materials as the Work proceeds. Remove waste materials, unsound material from concrete surfaces, material chipped from structure, and water used in preparation of or repair areas, finishing, and curing, and dispose offsite at an approved disposal site.

END OF SECTION

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SECTION 03 01 33
REPAIR OF HORIZONTAL CONCRETE SURFACES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO): T277, Standard Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.
2. ASTM International (ASTM):
   a. A82/A82M, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
   b. A185/A185M, Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
   c. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   d. A706/A706M, Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
   e. C42/C42M, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
   f. C78/C78M, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
   g. C109/C109M, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens).
   h. C157/C157M, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
   i. C348, Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
   j. C469, Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression.
   k. C496/C496M, Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
   l. C666/C666M, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
   m. C779/C779M, Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces.
   n. C882/C882M, Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.

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o. C928/C928M, Standard Specification for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs.
p. C1012/C1012M, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
q. C1202, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.
r. C1583/C1583M, Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method).
s. D638, Standard Test Method for Tensile Properties of Plastics.
t. D695, Standard Test Method for Compressive Properties of Rigid Plastics.
u. D4258, Standard Practice for Surface Cleaning Concrete for Coating.
v. D4259, Standard Practice for Abrading Concrete.
w. E699, Standard Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components.

1.02 DEFINITIONS

A. Abrasive Blasting: Surface preparation method that uses compressed air intermixed with an abrasive medium to clean surface of substrate concrete, exposed steel, and steel reinforcement. Compressed air and abrasive medium is projected at high speed through a nozzle directly at the surface. Method is used to remove corrosion by-products, laitance, or other materials that may inhibit bond of repair concrete.

B. Defective Area: Surface defect such as honeycomb, rock pockets, indentations, and surface voids greater than 3/16-inch deep, surface voids greater than 3/4-inch diameter, cracks in liquid containment structures and below grade habitable spaces 0.005-inch wide and wider, cracks in other structures 0.010-inch wide and wider, spalls, chips, embedded debris, sand streaks, mortar leakage from form joints, deviations in formed surface that exceed specified tolerances which include but are not limited to fins, form pop-outs, and other projections, and at exposed concrete which includes texture irregularities, stains, and other color variations that cannot be removed by cleaning.

C. High-Pressure Water Blasting (sometimes referred to as hydro-demolition): Uses water that may contain an abrasive medium, projected under high pressure and high velocity. Used for demolition, cutting, partial or full depth

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removal, cleaning, scarifying, or roughening of concrete surfaces, or removing existing coatings, for preparation of substrate concrete surfaces.

D. New Concrete: Concrete less than 60 days old forming structures constructed as part of the Work.

1.03 SUBMITTALS

A. Action Submittals: Product data sheets for each material supplied.

B. Informational Submittals:

1. Repair Mortar System: Manufacturer's preparation and installation instructions.
2. Written description of equipment proposed for concrete removal and surface preparation.
3. Certificates:
   a. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, that repair mortar systems are prepackaged, shrinkage compensated, specially designed for use on horizontal surfaces that are exposed to weather.
   b. Mortar Manufacturer's Certificate of Proper Installation.
   c. Confirmation epoxy resin bonding agents conform to ASTM C882/C882M.
4. Statements of Qualification:
   a. Repair mortar system applicator.
   b. Independent Testing Laboratory.
5. Field and laboratory test results.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Repair Mortar System Applicator: Trained and experienced applicator endorsed by repair mortar system manufacturer.

B. Pre-repair Conference:

1. Required Meeting Attendees:
   a. Contractor.
   b. Repair Subcontractor.
   c. Engineer.
2. Schedule and conduct prior to incorporation of respective products into Project. Notify Engineer of location and time.

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3. Agenda shall include, but not limited to:
   a. Review of field conditions. Conduct field observations of the Work to be performed.
   b. Based on above observations, confirm material selection and make Project specific repair method recommendations.
   c. Review proposed surface preparation, material application, consolidation, finishing, curing, and protection of repair material from weather conditions.
   d. Other specified requirements requiring coordination.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Package repair mortar system products in moisture-resistant bags, pails, or moisture-resistant bulk bags.

B. Deliver, store, and handle repair materials in accordance with manufacturer's printed instructions.

PART 2 PRODUCTS

2.01 REPAIR MORTAR SYSTEM NO. 3—SHRINKAGE COMPENSATED REPAIR MORTAR

A. One-component cement-based, flowable, shrinkage compensated repair mortar system.

B. Compressive Strength, ASTM C109/C109M:

1. 1 Day: 2,500 psi minimum.
2. 7 Days: 6,000 psi minimum.
3. 28 Days: 8,000 psi minimum.

C. Flexural Strength, ASTM C348 at 28 Days: 770 psi minimum.

D. Modulus of Elasticity, ASTM C469 at 28 Days: 5.9 by 10^6 psi minimum.

E. Slant Shear Bond Strength, ASTM C882/C882M Modified:

1. 7 Days: 2,150 psi minimum.
2. 28 Days: 3, 000 psi minimum.

F. Freeze-thaw Resistance, ASTM C666/C666M, Procedure A, at 300 Cycles: 97.0 percent RDM.

G. Chloride Ion Permeability Based on Charge Passed, ASTM C1202 at 28 Days: 650 coulombs maximum.

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H. Sulfate Resistance, ASTM C1012/C1012M after 6 Months: 0.01 percent length change maximum.

I. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco S 466 CI.
2. Euclid Chemical Co., Cleveland, OH; Eucocrete Supreme.

2.02 WATER

A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards, as specified in Section 03 30 10, Structural Concrete.

2.03 REINFORCEMENT

A. Deformed Steel reinforcement: Per Section 03 30 10, Structural Concrete.

2.04 EVAPORATION RETARDANT

A. As specified in Section 03 30 10, Structural Concrete.

2.05 CURING COMPOUND

A. As specified in Section 03 30 10, Structural Concrete.

PART 3 EXECUTION

3.01 GENERAL

A. New Concrete Work: Repair deficiencies in new concrete structures constructed under this Contract with applicable repair system.

3.02 APPLICATION

A. General: Repair Mortar System No. 3: Patches, joints, or overlays 1 inch thick or greater. Return to service in 7 days or more.

3.03 PREPARATION

A. Identify unsound and deteriorated concrete by sounding techniques, or as directed by Engineer. Review proposed extent of repair with Engineer.

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B. Remove unsound, deteriorated, or otherwise defective areas of concrete from Work areas.

1. Use 8,000 psi minimum high-pressure water machine, as appropriate to suit Site conditions.
2. Remove concrete to abrade substrate concrete surface to a minimum amplitude roughness of 3/16 inch measured between high and low points with a 3-foot-long straightedge, in accordance with ASTM D4259.
3. Where final surface is required to be flush with existing adjacent surface, remove existing concrete depth as required for application of minimum thickness of repair mortar.

C. Do not use power-driven jackhammers, chipping hammers, scabblers, or scarifiers unless water blasting is not permitted or practical because of Site conditions or may cause other damage to equipment or facilities. In such cases where chipping hammers are required, limit size of chipping hammer to 16 pounds or lighter, or use small electric chipping hammer, to reduce formation of micro-fractures in substrate concrete surface.

D. Following removal of unsound or deteriorated concrete, check substrate concrete surface by sounding techniques to identify unsound concrete remaining or resulting from use of chipping hammer.

E. Remove unsound concrete to satisfaction of Engineer.

F. Square edges of patch areas by sawing or chipping to avoid tapered shoulders or featheredges. Avoid cutting embedded steel reinforcement. Roughen polished saw-cut edge by high-pressure water blasting.

G. Remove concrete adjacent to steel reinforcement to a minimum of 1-inch clearance around steel reinforcement for application and bonding of new repair mortar to entire circumference of exposed steel reinforcement if one or more of the following surface conditions exist:

1. 50 percent or more of circumference around steel reinforcement is exposed during concrete removal.
2. 25 percent or more of circumference around steel reinforcement is exposed during concrete removal and corrosion is present to extent that more than 25 percent loss of section has occurred.
3. Otherwise evident that bond between existing concrete and steel reinforcement has been destroyed or has deteriorated as determined by Engineer.

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H. Clean exposed steel reinforcement of loose rust and concrete splatter per recommendations of repair material manufacturer and in accordance with ASTM D4258.

I. Keep areas from which concrete has been removed free of dirt, dust, and water blasting waste slurry. Remove laitance and other bond inhibiting contaminates from prepared areas.

J. Preparation of Substrate Concrete Surface in Areas to Receive Repair Mortar System No. 3: Dampen repair areas at least 6 inches beyond area to receive repair mortar for at least 24 hours to provide saturated surface dry (SSD) condition without standing water at time of application of mortar, as required by and in accordance with repair mortar manufacturer's printed instructions.

K. Collect and dispose of spent water and concrete debris from removal operations offsite in manner and location acceptable to Owner.

3.04 PROTECTION

A. If cementitious coating or bonding agent is used, protect adjacent surfaces from over application. Promptly remove bonding agent applied beyond repair area.

B. Protect adjacent surfaces, and equipment from spillage of repair mortar and dust, as applicable for repair mortar system used.

3.05 PLACEMENT

A. Repair Mortar System Nos. 3:

1. Remove standing and free water from prepared area.
2. Apply bond scrub coat of mortar to prepared surface in accordance with manufacturer's instructions. Do not apply more scrub coat of mortar than can be covered with repair mortar before scrub coat begins drying.
3. Immediately place mixed repair mortar into prepared area from one side to the other side.
4. Work material firmly into bottom and sides of patch to ensure a good continuous bond.
5. Level repair mortar and screed to elevation of existing concrete.
6. Finish to same texture as existing concrete around patch.

3.06 FINISHING

A. Spray full strength evaporation retardant on fresh concrete to prevent rapid drying during hot and windy weather.

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3.07 CURING

A. Repair Mortar System No. 3: Apply curing compound in accordance with Section 03 30 10, Structural Concrete.

3.08 FIELD QUALITY CONTROL

A. Sounding for Hollow Areas:

1. Chain drag or light hammer tap repaired areas listening for hollow sound to determine areas that have not properly bonded to substrate concrete.
2. Mark hollow areas for removal and replacement.

B. Compression Strength Test:

1. Test in accordance with ASTM C109/C109M, except modified by making samples using repair mortar.
2. Obtain production samples of mixed materials from mixer during construction for compliance with Specifications.
3. Provide minimum of three samples for each 200 square feet of mortar repair, and a minimum of three samples in total, whichever is greater for testing.
4. Record location where repair mortar is being applied at time production samples are obtained.

C. Direct Tension Bond Test:

1. In Situ Bond Testing: Perform tension bond test in accordance with ASTM C1583/C1583M.
2. Record locations on in situ bond tests on each type of applied repair mortar.

D. Testing laboratory retained by Owner will provide the following:

1. Compression Strength Test:
   a. Testing will follow a “modified” ASTM C109/C109M.
   b. A minimum of three production samples of mixed material will be obtained from each 200 square feet of mortar repair, and a minimum of three samples in total, whichever is greater, for testing at 7 days, and 28 days.
   c. Record location where repair mortar is being applied at time production samples are obtained.
2. Direct Tension Bond Test:

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a. Two core samples will be obtained and tested for each 2,000 square feet of repair work.
b. Cores will be 2-1/2-inch or 3-inch diameter to a total depth equal to at least 2.5 times repair mortar thickness.
c. Bond Strength of Repair Mortar to Substrate Concrete: 300 psi minimum in direct tension without failure or movement.
d. Record locations of bond tests on each type of applied repair mortar tested.

E. Retest mortar repairs that do not meet test requirements.

F. Repair and fill holes using same repair mortar where core samples have been removed.

3.09 MORTAR REPAIR FAILED TEST

A. Remove and replace unacceptable Work.

B. Hollow Sounding Areas: Saw cut hollow sounding areas to a new square edge, remove unsound mortar repair. Prepare substrate surface and reapply repair mortar as specified herein above.

C. Failed Compression Strength Test: Remove affected areas of repair mortar represented by failed compression strength test results. Prepare substrate surface and reapply repair mortar as specified herein above.

D. Failed Bond Tests: Remove affected areas of repair mortar represented by failed bond test results. Prepare substrate surface and reapply repair mortar as specified herein above.

E. Retest areas where repair mortar was removed and replaced, in accordance with test requirements specified herein above.

3.10 MANUFACTURERS' SERVICES

A. Provide mortar manufacturer's representative at Site to advice on product selection, review acceptability of surface preparation, mixing and installation assistance, inspection, and Certification of Proper Installation.

3.11 CLEANING

A. Remove excess repair mortar materials as the Work proceeds. Remove waste materials, unsound material from concrete surfaces, material chipped from structure, and water used in preparation of repair areas, finishing, and curing, and dispose offsite at approved disposal site.

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END OF SECTION

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SECTION 03 30 10
STRUCTURAL CONCRETE

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI):
   a. 117, Specifications for Tolerances for Concrete Construction and Materials.
   b. 301, Specifications for Structural Concrete.
   c. 305.1, Standard Specification for Hot Weather Concreting.
   d. 306.1, Standard Specification for Cold Weather Concreting.
   e. 318, Building Code Requirements for Structural Concrete.
   f. SP-66, Detailing Manual.
2. ASTM International (ASTM):
   a. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   b. C31/C31M, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   c. C33, Standard Specification for Concrete Aggregates.
   d. C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   e. C88, Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
   f. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   g. C143/C143M, Standard Test Method for Slump of Hydraulic-Cement Concrete.
   h. C150, Standard Specification for Portland Cement.
   i. C192/C192M, Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.
   j. C227, Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method).
   k. C231, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
   l. C260, Standard Specification for Air-Entraining Admixtures for Concrete.
   m. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
   n. C311, Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland Cement Concrete.

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o. C452, Standard Test Method for Potential Expansion of Portland-Cement Mortars Exposed to Sulfate.
p. C494/C494M, Standard Specification for Chemical Admixtures for Concrete.
q. C595, Standard Specification for Blended Hydraulic Cements.
r. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
s. C989, Standard Specification for Slag Cement for Use in Concrete and Mortars.
t. C1012, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
u. C1157, Standard Performance Specification for Hydraulic Cement.
v. C1218/C1218M, Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.
w. C1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).
x. C1293, Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction.
y. C1315, Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.
z. C1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method).
aa. C1602/C1602M, Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.
bb. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
cc. D1751, Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).

3. Concrete Reinforcing Steel Institute (CRSI):
   a. Manual of Standard Practice.
   b. Recommended Practice for Placing Reinforcing Bars.
4. National Ready Mixed Concrete Association (NRMCA).

1.02 FORMWORK DESIGN REQUIREMENTS

A. Design formwork in accordance with requirements of ACI 301 to provide specified concrete finishes.

B. Joints in forms shall not leak concrete mortar.

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C. Limit panel deflection to 1/240th of each component span to achieve tolerances specified.

1.03 SUBMITTALS

A. Action Submittals:

1. Formwork and Formwork Accessories: Unless otherwise specified, conform to requirements of ACI 301.
2. Reinforcing steel prepared in accordance with CRSI Manual of Standard Practice and ACI SP-66 Detailing Manual:
    a. Bending lists.
    b. Placing drawings.
3. Mix Designs:
    a. Concrete mix designs shall contain proportions of materials and admixtures to be used on Project, signed by mix designer.
    b. Documentation of average strength for each proposed mix design in accordance with ACI 301.
    c. Letter of Certification that Concrete Producer has verified compatibility of constituent materials in design mix.
    d. Test Reports:
        1) Supplementary Cementitious Materials: Chemical analysis report and report of other specified test analyses.
        2) Water-Soluble Chloride-Ion Content in Hardened Concrete:
            a) Supplier’s Certificate of Compliance that each admixture does not include any intentionally added chlorides and/or that their chloride content does not exceed trace amounts.
            b) Verification that potable water is used in the concrete mix or test data documenting the chloride content of the water.
            c) Letter from the concrete supplier stating that fine and coarse aggregates are from sources that are not known to be susceptible to chlorides in the aggregates.
    e. Cementitious Materials Manufacturer’s Letter of Certification and as follows:
        1) Fly Ash: Report of specified test analyses.
    f. Aggregates:
        1) Percent of fine aggregate weight to total aggregate weight.
        2) Deleterious substances in fine aggregate.
            a) Clays and friable.
            b) Percent passing No. 200 sieve.
            c) Percent of coal and lignite in fine aggregate.
        3) Deleterious substances in coarse aggregate.

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4) Manufacturer's letter of certification for specified class designation.
5) Waterstop installation instructions.
6) Test Reports:
a) Fine and coarse aggregate soundness in accordance with ASTM C33 and ASTM C88 using sodium sulfate solution.
b) Alkali Aggregate Reactivity: Aggregate shall be classified as nonpotentially reactive in accordance with Article Concrete, paragraph Mix Design. Include documentation of test results in accordance with applicable standards.

g. Admixtures:
1) Manufacturer's catalog cut sheets and product data sheets for each admixture used in proposed mix designs.
2) Manufacturer's letter of certification.

4. Product Data: Specified ancillary materials.
5. Proposed curing methods.
6. Detailed plan for cold weather curing and protection of concrete placed and cured in weather below 40 degrees F or near 40 degrees F and falling. The details shall include, but not be limited to, the following:
a. Procedures for protecting the subgrade from frost and the accumulation of ice or snow on reinforcement and other metallic embeds or forms prior to placement.
b. Methods for temperature protection during placement.
c. Types of covering, insulation, housing, or heating to be provided.
d. Curing methods to be used during and following the protection period.
e. Use of strength accelerating admixtures.
f. Methods for verification of in-place strength.
g. Documentation of embeds that must be at a temperature above freezing prior to placement of concrete.
h. Procedures for measuring and recording concrete temperatures.
i. Procedures for preventing drying during dry, windy conditions.
7. Detailed plan for hot weather placements, including curing and protection for concrete placed in ambient temperatures over 80 degrees F.
a. Procedures for measuring and recording temperatures of reinforcement and other embedded items prior to concrete placement.
b. Use of retarding admixture.
c. Methods for controlling temperature of reinforcement and other embedded items and concrete materials before and during placement.

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d. Type of shading and wind protection to be provided.
e. Curing methods.
f. Procedures for measuring and recording concrete temperatures.
g. Procedures for preventing drying during dry, windy conditions.

B. Informational Submittals:

1. Preinstallation conference minutes.
2. Manufacturers' Letter of Certification:
   a. Portland cement.
   b. Fly ash.
   c. Aggregates.
   d. Admixtures.
   e. Bonding agent.
   f. Bond breaker.
3. Manufacturer's application instructions for bonding agent, bond breaker, and curing compound.
4. Statement of Qualification:
   a. Batch Plant: Certification.
   b. Mix designer.
   c. Testing agency.
5. Concrete Delivery Tickets:
   a. For each batch of concrete before unloading at Site.
   b. In accordance with ASTM C94/C94M, including requirements 14.2.1. through 14.2.10.
   c. Indicate amount of mixing water withheld, and maximum amount that may be permitted to be added at Project site.
6. Field test reports.

1.04 QUALITY ASSURANCE

A. Concrete construction shall conform to requirements of ACI 117 and ACI 301, except as modified herein.

B. 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. Requirement may be waived if individual is Contractor's Licensed Design Engineer.

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3. Testing Agency: Unless otherwise permitted, an independent agency, acceptable to authorities having jurisdiction, qualified according to ASTM C1077 and ASTM E329 for testing indicated, as documented according to ASTM E548.
    a. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-01 or an equivalent certification program.
    b. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician - Grade I. Testing Agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing.

C. Preinstallation Conference:

1. Required Meeting Attendees:
    a. Contractor, including pumping, placing and finishing, and curing subcontractors.
    b. Ready-mix producer.
    c. Testing and sampling personnel.
    d. Engineer’s representatives.
    e. Owner’s Project Manager.
2. Schedule and conduct prior to incorporation of respective products into Project. Notify Engineer of location and time.
3. Agenda shall include:
    a. Admixture types, dosage, performance, and redosing at Site.
    b. Mix designs, test of mixes, and submittals.
    c. Concrete placement schedule and sequencing.
    d. Placement methods, techniques, equipment, consolidation, and form pressures.
    e. Slump and placement time to maintain slump.
    f. Finish, curing, and water retention.
    g. Hot weather and cold weather concreting plans.
    h. Protection procedures for weather conditions.
    i. Other specified requirements requiring coordination.
4. Submit conference minutes.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Unload, store, and handle bars in accordance with CRSI publication “Placing Reinforcing Bars.”

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PART 2 PRODUCTS

2.01 GENERAL

A. Products shall be in accordance with requirements of ACI 301 unless otherwise noted.

2.02 FORMWORK

A. Form Materials:

1. For exposed areas, use hard plastic finished plywood overlaid waterproof particle board, or steel in “new and undamaged” condition, of sufficient strength and surface smoothness to produce specified finish.
2. For unexposed areas, use new shiplap or plywood.
3. Earth cuts may be used for forming footings.

B. Beveled Edge Corner Strips: Nonabsorbent material, compatible with form surface, fully sealed on all sides prohibiting loss of paste or water between the two surfaces.

C. Form Ties:

1. Material: Steel.
2. Spreader Inserts:
   a. Conical or spherical type.
   b. Design to maintain positive contact with forming material.
   c. Furnish units that will leave no metal closer than 1-1/2 inches to concrete surface when forms, inserts, and tie ends are removed.
3. Wire ties not permitted.
4. Waterstop Ties: For water-holding structures 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 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.

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2.03 CONCRETE

A. Materials: Unless otherwise specified, in accordance with ACI 301.

1. Cementitious Materials:
   a. Cement:
      1) Portland Cement: Unless otherwise specified, portland cement shall conform to the requirements of ASTM C150.
      2) Blended Hydraulic Cement:
         a) Unless otherwise specified, blended hydraulic cements shall conform to the requirements of ASTM C595.
         b) Portland cement used in blended hydraulic cement shall conform to the requirements of ASTM C150.
      3) Furnish from one source.
   b. Supplementary Cementitious Materials (SCM):
      1) Fly Ash (Pozzolan): Class F and Class C fly ash in accordance with ASTM C618, except as modified herein:
         a) ASTM C618, Table 1, Loss on Ignition: Maximum 3 percent.
         b) ASTM C618, Table 2, Water Requirement: Maximum 100 percent of control.
         c) ASTM C618, Table 3, Expansion of Test Mixture. Results shall be evaluated using either Procedure A or Procedure B and as follows:
            (1) Procedure A after 6-month sulfate exposure, maximum 0.10 percent.
            (2) Procedure B, expansion of test mixture as a percentage of sulfate resistance cement control, after at least 6-month exposure, maximum 100 percent.
         d) Where fly ash is specified to be used with portland cement, fly ash shall meet one of the following requirements:
            (1) CaO: Maximum 15 percent.
            (2) Test cementitious materials as follows:
               (a) In accordance with ASTM C1012.
               (b) 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.

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(c) Conduct tests using proposed fly ash and cement samples together with control samples using Type II cement without fly ash.

2. Aggregates: Unless otherwise permitted, furnish from one source for each aggregate type used in a mix design.
   a. Normal-Weight Aggregates:
      1) In accordance with ASTM C33, except as modified herein.
         a) Class Designation: 4S unless otherwise specified. Free from deleterious coatings and substances in accordance with ASTM C33, except as modified herein.
      2) Free of materials and aggregate types causing popouts, discoloration, staining, or other defects on surface of concrete.
      3) Alkali Silica Reactivity: See paragraph Mix Design.
      4) Aggregate Soundness: Test for fine and coarse aggregates in accordance with ASTM C33 and ASTM C88 using sodium sulfate solution.
   b. Fine Aggregates:
      1) Clean, sharp, natural sand.
      2) ASTM C33.
      3) Limit deleterious substances in accordance with ASTM C33, Table 1 and as follows:
         a) Limit material finer than 75-µm (No. 200) sieve to 3 percent mass of total sample.
         b) Limit coal and lignite to 1 percent.
   c. Coarse Aggregate:
      1) 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).
      2) Limit deleterious substances in accordance with ASTM C33, Table 3 for specified class designation.
3. Admixtures: Unless otherwise permitted, furnish from one Manufacturer.
   a. Characteristics:
      1) Compatible with other constituents in mix.
      2) Shall contain at most, only trace amount chlorides in solution.
      3) Furnish type of admixture as recommended by Manufacturer for anticipated temperature ranges.
   b. Air-Entraining Admixture: ASTM C260.

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c. Water-Reducing Admixture: ASTM C494/C494M, Type A or Type D.
d. Retarding Admixture: ASTM C494/C494M, Type B.
e. High Range Water-Reducing Admixture: ASTM C494/C494M, Type F or G.

4. Water and Ice: Mixing water for concrete and water used to make ice shall be potable water unless alternative sources of water are permitted.
   a. Water from alternative sources shall comply with requirements of ASTM C1602/C1602M, and shall contain less than:
      1) 1,000 ppm of chlorides.
      2) 3,000 ppm sulfate as SO_4.
      3) 600 ppm alkalis as (Na_2O + 0.658 K_2O).
      4) Total solids by mass less than 50,000 ppm.

B. Mix Design:

1. General:
   a. See Supplement at the end of this section for mix design requirements for each class of concrete used on Project.
   b. Prepare design mixtures for each type and strength of concrete, selecting and proportioning ingredients in accordance with requirements of ACI 301, unless otherwise specified.
   c. Where multiple requirements provide different limits, the limit that provides the most durable concrete shall be used.
   d. Selection of constituent materials and products in mix design are optional unless otherwise specified.
   e. Use water-reducing admixture and/or high-range water-reducing admixture to achieve fresh properties that facilitate handling, placing, and consolidating of concrete, and specified hardened properties.
   f. Use water-reducing and retarding admixture when anticipated high temperatures, low humidity, or other adverse placement conditions can adversely affect the fresh properties of the concrete.
   g. Unless otherwise permitted, use water-reducing admixture or water-reducing admixture and high-range water-reducing admixture in pumped concrete.
   h. Unless otherwise specified, desired fresh properties of concrete shall be determined by Contractor and coordinated with concrete producer. Fresh properties of concrete shall remain stable to the satisfaction of the Contractor, for duration of placement and consolidation, and shall remain in conformance with requirements of Contract Documents.

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2. Potential Alkali-Aggregate Reactivity of Concrete:
   a. Do not use aggregates known to be susceptible to alkali-carbonate reaction (ACR).
   b. Aggregates shall have been tested to determine potential alkali-aggregate reactivity in concrete in accordance with ASTM C1260 or ASTM C1567.
      1) Aggregates that indicate expansion greater than 0.10 percent at 16 days after casting shall not be used unless they have been shown to be nondeleteriously reactive in accordance with ASTM C227 or ASTM C1293, with less than 0.04 percent expansion at 2 years for combinations with pozzolans.
      2) Alkali content of cement used in proposed concrete mixture shall not be greater than alkali content of cement used in test for potential alkali-aggregate reactivity.
      3) Use low alkali cement or incorporate pozzolans into the concrete mixture as necessary. Alternately, a chemical inhibitor such as a lithium based admixture may be proposed. Submit documentation of control of alkali-aggregate reactivity for proposed admixtures.
3. Proportions:
   a. Design mix to meet aesthetic, durability, and strength requirements.
   b. Where fly ash is included in mix, minimum fly ash content shall be a minimum of 15 percent and maximum of 30 percent of weight of total cementitious materials.
4. Slump Range at Site:
   a. Unless otherwise permitted, target slump value is 4 inches at point of delivery, for concrete without high range water reducing admixture.
   b. Mixes that include a high range water reducing admixture, concrete shall have a minimum slump of 2 inches prior to the addition of the high range water reducing admixture. Slump shall be 8 inches maximum at the point of delivery, for concrete with a high range water reducing admixture.
   c. Slump tolerance shall meet the requirements of ACI 117.
5. Combined Aggregate Gradation:
   a. Combined Gradation Limits: Fine aggregate shall be in the range of 36 to 40 percent of total aggregate weight.

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C. Concrete Mixing:

1. General: In accordance with ACI 301, except as modified herein.
2. Concrete Mix Temperatures: As shown below for various stages of mixing and placing:

Concrete Temperatures				
	Concrete Member Size, Minimum Dimension			
Ambient Air Temperature	<12"	12"-36"	36"-72"	>72"
Minimum concrete temperature as mixed for indicated air temperature:				
Above 30 deg F	60 deg F	55 deg F	50 deg F	45 deg F
0 to 30 deg F	65 deg F	60 deg F	55 deg F	50 deg F
Below 0 deg F	70 deg F	65 deg F	60 deg F	55 deg F
Maximum allowable gradual temperature drop in first 24 hours after curing period and after end of protection:				
	50 deg F	40 deg F	30 deg F	20 deg F

3. For every truck, test slump of samples taken in accordance with 12.5.1 of ASTM C94. Where specified slump is more than 4 inches, and if slump tests differ by more than 2 inches, discontinue use of truck mixer unless causing condition is corrected and satisfactory performance is verified by additional slump tests.

2.04 REINFORCING STEEL

A. Deformed Steel Reinforcing Bars:

1. ASTM A615/A615M or ASTM A706/A706M, Grade 60. Welding of reinforcing bars is not permitted.
2. ASTM A767/767M, Grade 60, for galvanized bars at control joints.

B. Fabrication: Follow CRSI Manual of Standard Practice.

2.05 ANCILLARY MATERIALS

A. Premolded Joint Filler: Bituminous Type: ASTM D994 or ASTM D1751.

B. Nails: Galvanized, as required for securing premolded joint filler.

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C. Bonding Agent:

1. Unless otherwise specified, provide two-component epoxy.
2. Consult Manufacturer for surface finish, pot life, set time, vertical or horizontal application, and forming restrictions.
3. Manufacturers and Products:
   a. BASF Building Systems Inc., Shakopee, MN; Concresive Series.
   b. Euclid Chemical Co., Cleveland, OH; Euco Epoxy System.
   c. Sika Chemical Corp., Lyndhurst, NJ; Sikadur 32.

D. Bond Breaker: Nonstaining type, providing positive bond prevention.

1. Manufacturers and Products:
   a. Dayton Superior Corporation, Kansas City, KS; EDOCO Clean Lift Bond Breaker.
   b. Nox-Crete Products Group, Omaha, NE; Silcoseal Select.

E. Tie Wire:

1. Black, soft-annealed 16-gauge wire.
2. Nylon-, epoxy-, or plastic-coated wire.

F. Bar Supports and Spacers:

1. Use precast concrete bar supports and side form spacers, unless noted otherwise. Do not use other types of supports or spacers.
2. Bar supports shall have sufficient strength and stiffness to carry loads without failure, displacement, or significant deformation. Space bar supports so minimum concrete cover is maintained for reinforcing between supports.

G. Evaporation Retardant:

1. Optional: Fluorescent color tint that disappears completely upon drying.
2. Manufacturers and Products:
   a. Master Builders Co., Cleveland, OH; Confilm.
   b. Euclid Chemical Co., Cleveland, OH; Eucobar.

H. Curing Compound:

1. Water based, high solids content nonyellowing curing compound meeting requirements of ASTM C309 except as noted below, or ASTM C1315.
   a. Moisture Loss: 0.40 kg per square meter per 72 hours maximum.

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b. Capable of meeting moisture retention at Manufacturer's specified application rate.

2. Manufacturers and Products:
   a. BASF, Shakopee, MN; Masterkure.
   b. Euclid Chemical Co., Cleveland, OH; Super Diamond Clear VOX.
   c. WR Meadows, Inc., Hampshire, IL; VOCOMP-30.
   d. Vexcon Chemical, Inc.; Philadelphia, PA; Starseal 1315.
3. Dayton Superior; Safe Cure and Seal 30 Percent.

I. Nonshrink Grout:

1. Nonmetallic, nongas-liberating.
2. Prepackaged natural aggregate grout requiring only the addition of water.
3. Aggregate shall show no segregation or settlement at fluid consistency at specified times or temperatures.
4. Minimum strength of fluid grout, 3,500 psi at 1 day, 4,500 psi at 3 days, and 7,500 psi at 28 days.
5. Manufacturers and Products:
   a. BASF Building Systems, Inc., Shakopee, MN; Master Flow 928.
   b. Five Star Products Inc., Fairfield, CT; Five Star Fluid Grout 100.
   c. Euclid Chemical Co., Cleveland, OH; Hi Flow Grout.
   d. Dayton Superior Corp., Kansas City, KS; Sure Grip High Performance Grout.
   e. No "Or-equal" is acceptable.

J. Hydrophilic Waterstop:

1. For use at construction joints only, where new concrete is placed against existing concrete and as shown on Drawings.
2. Material shall be a nonbentonite hydrophilic rubber compound.
3. Manufacturers and Products:
   a. Where Waterstop Will Have 2 to 4 Inches of Concrete Cover:
      1) Greenstreak Plastic Products, St. Louis, MO; Hydrotite CJ-1020 2K with Leakmaster LV-1 adhesive and sealant.
      2) Adeka Ultra Seal, JLM Associates, Spearfish, SD; KBA-1510FP with 3M-2141 adhesive and P-201 sealant.
   b. Where Waterstop Will Have More Than 4 Inches of Concrete Cover:
      1) Greenstreak Plastic Products, St. Louis, MO; Hydrotite CJ-1020-2K with Leakmaster LV-1 adhesive and sealant.
      2) Adeka Ultra Seal, JLM Associates, Spearfish, SD; MC-2010MN with 3M-2141 adhesive and P-201 sealant.

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PART 3 EXECUTION

3.01 GENERAL

A. Execution shall be in accordance with requirements of ACI 301 unless otherwise noted.

3.02 FORMWORK

A. Form Construction:

1. Construct forms and provide smooth form finish in accordance with ACI 301.
2. Form 3/4-inch bevels at concrete edges, unless otherwise shown.
3. Make joints tight to prevent escape of mortar and to avoid formation of fins.
4. Brace as required to prevent distortion during concrete placement.
5. On exposed surfaces locate form ties in uniform pattern or as shown.
6. Construct so ties remain embedded in the member with no metal within 1 inch of concrete surface when forms, inserts, and tie ends are removed.

B. Form Removal:

1. Nonsupporting forms (walls and similar parts of Work) may be removed after cumulatively curing at not less than 50 degrees F for 24 hours from time of concrete placement if:
   a. Concrete is sufficiently hard so as not to sustain damage by form removal operations.
   b. Curing and protection operations are maintained.
2. Remove forms with care to prevent scarring and damaging the surface.
3. Prior to form removal, provide thermal protection for concrete being placed under the requirements of cold weather concreting.

3.03 PLACING REINFORCING STEEL

A. Unless otherwise specified, place reinforcing steel in accordance with CRSI Recommended Practice for Placing Reinforcing Bars.

B. Splices and Laps:

1. Top Bars: Horizontal bars placed such that 12 inches of fresh concrete is cast below in single placement.

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2. Lap Splice Reinforcing: Splices are to be Class B lap splices for reinforcing bars in tension, as defined in ACI 318.
3. Tie splices with 18-gauge annealed wire as specified in CRSI Standard.

3.04 INSTALLATION OF HYDROPHILIC WATERSTOP

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

B. Center waterstop in slab or wall, with minimum of 2 inches of concrete cover over waterstop. When structure has two layers of reinforcing steel, locate centered between layers of steel or as shown.

C. Apply adhesive to concrete surface and allow to dry for specified time before applying waterstop strip.

D. Butt ends of waterstop strip together at splices and corners and join with sealant.

E. Verify that waterstop is anchored firmly in place before placing concrete. Do not allow vibrator to come into contact with waterstop.

3.05 PLACING CONCRETE

A. Inspection: Notify Engineer at least 1 full working day in advance before starting to place concrete.

B. Prior to placing concrete, remove water from excavation and debris and foreign material from forms. Check reinforcing steel for proper placement and correct discrepancies.

C. Before depositing new concrete on old concrete, clean surface using sandblast or bushhammer or other mechanical means to obtain a 1/4-inch rough profile, and pour a cement-sand grout to minimum depth of 1/2 inch over surface. Proportion 1 part cement to 2.5 parts sand by weight.

D. Place concrete as soon as possible after leaving mixer, without segregation or loss of ingredients, without splashing forms or steel above, and in layers not over 1-1/2 feet deep, except for slabs which shall be placed full depth. Place and consolidate successive layers prior to initial set of first layer to prevent cold joints.

E. Use placement devices, for example, chutes, pouring spouts, and pumps as required to prevent segregation.

F. Vertical Free Fall Drop to Final Placement: 5 feet in forms 8 inches or less wide and 8 feet in forms wider than 8 inches, except as specified.

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G. For placements where drops are greater than specified, use placement device such that free fall below placement device conforms to required value.

1. Limit free fall to prevent segregation caused by aggregates hitting reinforcing steel.

H. Provide sufficient illumination in the interior of forms so concrete deposition is visible, permitting confirmation of consolidation quality.

I. If reinforcement is in direct sunlight or is more than 20 degrees F higher in temperature than concrete temperature before placement, wet reinforcement with water fog spray before placing concrete to cool reinforcement.

J. Trowel and round off top exposed edges of walls with 1/4-inch radius steel edging tool.

K. Do not use aluminum conveying devices.

L. Chutes:

1. Design and arrange ends of chutes, hopper gates, and other points of concrete discharge throughout conveying, hoisting, and placing system for concrete to pass without becoming segregated.
2. Do not use chutes longer than 50 feet.
3. Minimum Slopes of Chutes: Angled to allow concrete to readily flow without segregation.

M. Pumping of Concrete:

1. Provide standby pump, conveyor system, crane and concrete bucket, or other system onsite during pumping, for adequate redundancy to assure completion of concrete placement without cold joints in case of primary placing Equipment breakdown.
2. Minimum Pump Hose (Conduit) Diameter: 4 inches.
3. Replace pumping Equipment and hoses (conduits) that are not functioning properly.

N. Retempering: Not permitted for concrete where cement has partially hydrated.

O. Maximum Size of Concrete Placements:

1. Limit size of each placement to allow for strength gain and volume change as a result of shrinkage.
2. Locate control joints and construction joints where shown.

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3. Construction Joints: Locate construction joints as shown or where approved in the joint location submittal.

P. Minimum Time between Adjacent Placements:

1. Construction or Control Joints: 10 days.

3.06 CONSOLIDATION AND VISUAL OBSERVATION

A. Consolidation Equipment and Methods: ACI 301.

B. Provide at least one standby vibrator in operable condition at placement Site prior to placing concrete.

C. Vibrate concrete in vicinity of joints to obtain impervious concrete.

3.07 HOT WEATHER

A. Prepare ingredients, mix, place, cure, and protect in accordance with ACI 305.1.

B. Maintain concrete temperature below 90 degrees F at time of placement, or furnish test data or provide other proof that admixtures and mix ingredients do not produce flash set plastic shrinkage, or cracking as a result of heat of hydration. Cool ingredients before mixing to maintain fresh concrete temperatures as specified or less.

C. Provide for windbreaks, shading, fog spraying, sprinkling, ice, wet cover, or other means as necessary to maintain concrete at or below specified temperature.

D. Prevent differential temperature between reinforcing steel and concrete.

E. Provide for windbreaks, shading, fog spraying, sprinkling, ice, wet cover, or other means as necessary to maintain concrete at or below specified temperature.

F. Use evaporation retardant when concrete is exposed to drying conditions because of high concrete or ambient temperatures, low humidity, or high winds.

3.08 COLD WEATHER PLACEMENT

A. In accordance with ACI 306.1 and ACI 301.

B. Do not place concrete when ambient temperature is below 40 degrees F or approaching 40 degrees F and falling, without approved thermal protection.

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C. Do not place concrete over frozen earth or against surfaces with frost or ice present. Frozen earth must be thawed to the acceptance of Geotechnical Engineer.

D. Do not place concrete against reinforcement or other metallic embedments if temperature of these elements, is lower than 32 degrees F.

E. Document embedded items that must be at a temperature above freezing prior to placement of concrete.

F. Provide heated enclosures when air temperatures are below 40 degrees F.

G. Maintain surface temperature of concrete above 40 degrees F and cure concrete as specified, for minimum of 7 days.

H. Provide maximum and minimum thermometers placed on concrete surfaces spaced throughout Work to allow monitoring of concrete surface temperatures representative of Work.

I. External Heating Units:

1. Vent heating units to atmosphere and do not locally heat or dry concrete. Where water cure is specified, maintain wet condition.
2. Do not exhaust heater flue gases (causes concrete carbonation as a result of concentrated carbon dioxide) directly into enclosed area.

J. Maintain surface temperature of concrete above 40 degrees F and cure concrete for minimum of 7 days.

3.09 FINISHING

A. Floor Slabs and Equipment Pads:

1. Screed surfaces to true level planes.
2. After initial water has been absorbed, float with wood float and trowel with steel trowel to smooth finish free from trowel marks.
3. Do not absorb wet spots with neat cement.

B. Tolerances: Floors shall not vary from level or true plane more than 1/4 inch in 10 feet when measured with a straightedge.

C. Exterior Slabs and Equipment Pads:

1. Bull float with wood float, wood trowel, and lightly trowel with steel trowel.
2. Finish with broom to obtain nonskid surface.

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3. Finish exposed edges with steel edging tool.
4. Mark sidewalks transversely at 5-foot intervals with jointing tool.

3.10 PROTECTION AND CURING

A. Protect fresh concrete from direct rays of sunlight, drying winds, and wash by rain.

B. Keep concrete slabs continuously wet for a 7-day period. Intermittent wetting is not acceptable.

C. Use curing compound only where approved by Engineer. Use only 7-day continuous water curing where additional finishes such as sealers, hardeners, painting, or other special coatings will be applied.

D. Cure formed surfaces with curing compound applied in accordance with Manufacturer's directions as soon as forms are removed, and finishing is completed.

E. Remove and replace concrete damaged by freezing.

3.11 NONSHRINK GROUT

A. General: Mix, place, and cure nonshrink grout in accordance with grout Manufacturer's written instructions.

B. Form Tie: Provide nonshrink grout, fill space with dry pack dense grout hammered in with steel tool and hammer.

C. Grouting Machinery Foundations:

1. Block out original concrete or finish off at distance shown below bottom of machinery base with grout. Prepare concrete surface by sandblasting, chipping, or by mechanical means to remove any soft material.
2. Set machinery in position and wedge to elevation with steel wedges, or use cast-in leveling bolts.
3. Form with watertight forms at least 2 inches higher than bottom of plate.
4. Fill space between bottom of machinery base and original concrete in accordance with Manufacturer's written instructions.

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3.12 FIELD QUALITY CONTROL

A. General:

1. Provide adequate facilities for safe storage and proper curing of concrete test cylinders onsite for first 24 hours, and for additional time as may be required before transporting to test lab.
2. Provide concrete for testing of slump, air content, and for making cylinders from the point of discharge into forms. When concrete is pumped, Samples used shall be taken from discharge end of pump hose.
3. Evaluation will be in accordance with ACI 301 and Specifications.
4. Specimens shall be made, cured, and tested in accordance with ASTM C31/C31M and ASTM C39/C39M.
5. Frequency of testing may be changed at discretion of Engineer.
6. Pumped Concrete: Take concrete samples for slump (ASTM C143/C143M) and test cylinders (ASTM C31/C31M and ASTM C39/C39M) at placement (discharge) end of line.
7. Reject concrete represented by cylinders failing to meet strength and air content specified.

B. Concrete Strength Test:

1. Unless otherwise specified, test one set of specimens at age of 7 days for information, one set of specimens at age of 28 days for acceptance, and one set of specimens at age of 56 days for acceptance. Should results of 28-day tests meet specified requirement for 56-day strength, 56-day tests will not be required.
2. A set of specimens shall consist of two 6 inch diameter by 12 inch cylinders, or when permitted three 4 inch diameter by 8 inch cylinders.
3. Provide a minimum of one spare cylinder per sample. Spare cylinder shall be tested as directed by Engineer.

C. High Range Water Reducer (Superplasticizer) Admixture Segregation Test: Test each truck prior to use on job.

1. Segregation Test Objective: Concrete with 4-inch to 8-inch slump must stay together when slumped. Segregation is assumed to cause mortar to flow out of mix even though aggregate may stay piled enough to meet slump test.
2. Test Procedure: Make slump test and check for excessive slump and observe to see if mortar or moisture flows from slumped concrete.
3. Reject concrete if mortar or moisture separates and flows out of mix.

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D. Cold Weather Placement Tests:

1. During cold weather concreting, cast cylinders for field curing as follows. Use method that will produce greater number of specimens:
   a. Six extra test cylinders from last 100 cubic yards of concrete.
   b. Minimum three specimens for each 2 hours of placing time or for each 100 cubic yards.
2. These specimens shall be in addition to those cast for lab testing.
3. Protect test cylinders from weather until they can be placed under same protection provided for concrete of structure that they represent.
4. Keep field test cylinders in same protective environment as parts of structure they represent to determine if specified strength has been obtained.
5. Test cylinders in accordance with applicable sections of ASTM C31/ C31M and ASTM C39/C39M.
6. Use test results to determine specified strength gain prior to falsework removal.

E. Tolerances:

1. Slab Finish Tolerances and Slope Tolerances:
   a. Floor flatness measurements shall be made day after floor is finished and before shoring is removed to eliminate effects of shrinkage, curing, and deflection.
   b. Support 10-foot-long straightedge at each end with steel gauge blocks of thicknesses equal to specified tolerance.
2. Compliance with designated limits in four of five consecutive measurements is satisfactory, unless defective conditions are observed.

3.13 MANUFACTURER'S SERVICES

A. Provide the following representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection, and certification of proper installation for concrete ingredients, mix design, mixing, and placement.

1. Concrete Producer Representative:
   a. Observe how concrete mixes are performing.
   b. Be present during first placement of each type of concrete mix.
   c. Assist with concrete mix design, performance, placement, weather problems, and problems as may occur with concrete mix throughout Project, including instructions for redosing.
   d. Establish control limits on concrete mix designs.

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e. Provide Equipment for control of concrete redosing for air entrainment or high range water reducing admixture (superplasticizers) at Site to maintain proper slump and air content if so needed.

3.14 SUPPLEMENTS

A. Requirements of concrete mix designs following "End of Section," are part of this Specification and supplement requirements of Part 1 through Part 3 of this section:

1. Concrete Mix Design, Class 4500F2S1P2C1.

END OF SECTION

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CONCRETE MIX DESIGN, CLASS 4500F2S1P2C1

A. Locations where mix shall be used: Typical, unless otherwise specified.

B. Exposure Categories and Classifications: F2S1P2C1.

C. Mix Properties:

1. Minimum concrete compressive strength (f'c) shall be 4,000 psi at 28 days and 4,500 psi at 56 days.
2. Limit water to cementitious materials ratio (W/Cm) in mix design to maximum value of 0.42.
3. Air-entraining admixtures are prohibited in concrete mixtures and total air content shall not be greater than 3 percent, for the following:
   a. Slabs to receive a hard-troweled finish.
4. Unless otherwise specified, provide air content based on the nominal maximum size of aggregate as follows:

Nominal Maximum Aggregate Size in.‡	**Air Content (%)***
3/4	6.0
1	6.0
1-1/2	5.5
‡See ASTM C33/C33M for tolerance on oversize for various nominal maximum size designations. *Tolerance of air content is plus or minus1-1/2 percent.	

5. Limit supplementary cementitious materials measured as a percent of weight of total cementitious materials in mix design, as follows:
   a. Fly Ash and other Pozzolans: Maximum 30 percent.
6. Provide cementitious materials in accordance with one of the following:
   a. ASTM C150 Type II. Inclusion of supplementary cementitious materials in design mix is optional.
   b. ASTM C150 Types Other Than II plus supplementary cementitious materials in accordance with one of the following:
      1) Tricalcium Aluminate Content of Total Cementitious Materials: Maximum 8 percent by weight.
      2) Provide documentation of test results in accordance with ASTM C1012, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.

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c. ASTM C595 Types IP or IS (less than 70), tested to comply with moderate sulfate resistance option (MS).
   1) Provide documentation of test results in accordance with ASTM C1012, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.

7. Minimum cementitious materials content in mix design shall be as follows:
   a. 515 pounds per cubic yard for concrete with 1-1/2-inch nominal maximum size aggregate.
   b. 535 pounds per cubic yard for 1-inch nominal maximum size aggregate.
   c. 560 pounds per cubic yard for 3/4-inch nominal maximum size aggregate.
8. Limit cementitious materials content to 100 pounds per cubic yard greater than specified minimum cementitious materials content in mix design.
9. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent, unless otherwise specified. Limits are stated in terms of chloride ions in percent by weight of cement.
   a. Provide documentation from concrete tested in accordance with ASTM C1218 at an age between 28 and 42 days.

D. Refer to Part 1 through Part 3 of this section for additional requirements.

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SECTION 03 63 00
CONCRETE DOWELING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American National Standards Institute (ANSI).
2. ASTM International (ASTM):
   a. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
   b. E488, Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements.
3. International Code Council (ICC):
   a. 2021 International Building Code (IBC).
   b. Evaluation Services Reports.

1.02 DEFINITIONS

A. ICC Evaluation Services Report: Published by ICC for products provided by concrete adhesive anchor manufacturers.

B. Special Inspection: As defined in the ICC IBC and indicated on the Statement of Special Inspection (Plan) on the Drawings.

1.03 SUBMITTALS

A. Action Submittals:

1. Product Data: Manufacturer’s catalog information.

B. Informational Submittals:

1. Manufacturer’s instructions for preparation, placement, drilling of holes, installation of anchors and adhesive, and handling of cartridges, nozzles, and equipment.
2. Manufacturer’s written letter of certification identifying installer’s qualifications to install products.
3. ICC Evaluation Services Report: Specific to proposed doweling system manufacturer.

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1.04 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer: At least three similar projects with same products within last 3 years.
2. Installer: Trained and certified by manufacturer.

1.05 DELIVERY, STORAGE, AND HANDLING

A. 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.

B. Store adhesive components in accordance with manufacturer's written instructions.

C. Dispose of when:

1. Shelf life has expired.
2. Stored other than per manufacturer's instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Adhesive:

1. Approved by an ICC Evaluation Services Report for conformance to 2021 IBC requirements for doweling of steel reinforcing bars in cracked concrete.
2. Suitable for long-term loads as well as for wind and seismic loads.
3. Meet requirements of ASTM C881/C881M.
4. Two-component, insensitive to moisture, designed to be used in adverse freeze/thaw environments.
5. Disposable, Self-Contained Cartridge System:
   a. Capable of dispensing both components in proper mixing ratio.
   b. Fit into manually or pneumatically operated caulking gun.
6. Mixed Adhesive: Nonsag, light paste consistency with ability to remain in a 1-inch diameter overhead drilled hole without runout.
7. Manufacturers and Products:
   a. Hilti, Inc., Tulsa, OK; HIT-RE 500 V3 (ESR-3814) or HIT HY 200 (ESR 3187) Adhesive Anchors.
   b. Powers Fasteners, Brewster, NY; Power PURE110+ Epoxy Adhesive Anchor System (ESR-3298).

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c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; SET-XP Epoxy Adhesive Anchors (ESR-2508).

B. Mixing Nozzles: Disposable, manufactured in several sizes to accommodate size of reinforcing dowels.

C. Reinforcing Dowels: As specified in Section 03 30 10, Structural Concrete.

PART 3 EXECUTION

3.01 INSTALLATION

A. Drilling Equipment:

1. Drilling Hammers for Dowel Holes:
   a. Electric or pneumatic rotary type with medium or light impact.
   b. Hollow drills with flushing air systems are preferred.
2. Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking and concrete spalling during drilling process.

B. Hole Diameter: Use drill bit diameter meeting ICC Evaluation Services Report requirements and as recommended by manufacturer.

C. Obstructions in Drill Path: When existing steel reinforcement is encountered during drilling, obtain Engineer approval for proposed fix.

D. Doweling:

1. Install per details shown on Drawings and in accordance with adhesive manufacturer's instructions.
2. Bent Bar Dowels: Where edge distances are critical and intersection with steel reinforcement or other obstruction is likely, slant drill to address edge distance or to clear obstruction. If drill must be slanted more than indicated in the manufacturer's installation instructions to clear obstruction, notify Engineer for direction on how to proceed.

E. Adhesive:

1. Install in accordance with written manufacturer's instructions.
2. Dispense components through specially designed static mixing nozzle that thoroughly mixes components and places mixed adhesive at base of predrilled hole.

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3.02 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Proof Loading:

1. To be performed where continuous inspection of concrete dowels is required.
2. Testing will be performed by Owner's Independent Testing Agency.
3. Proof loading to be performed only after adhesive has achieved proper cure per manufacturer's requirements.
4. Testing will be conducted on minimum of 10 percent of installed dowels, with a minimum of two tension tests. A minimum of two cartridges per box or packaging unit will be tested.
5. Testing will be conducted in accordance with ASTM E488 and as follows:
    a. Performance of a static tension test of each test dowel.
    b. Test apparatus reaction base will not interfere with bond failure of dowel but will preclude a concrete pullout cone failure.
    c. Each test dowel will be tested at a proof load equal to the lesser of 80 percent of the yield strength of the dowel bar or 50 percent of calculated ultimate load based on adhesive bond strength.
    d. Test load to be maintained for a minimum of 30 seconds without visible signs of movement of dowel or drop in gauge reading.
6. Failure of dowel bar or failure within base concrete will cause dowel to be rejected. For each rejected dowel, two additional dowels will be tested. Replace rejected dowels as approved by Engineer.

B. Testing of Automatic Metering and Mixing Devices:

1. Test for Proper Ratio:
    a. Retain small amount of dispensed adhesive for inspection after each time pump is refilled.
    b. Check samples for color change.
    c. Should change in color occur, follow manufacturer's service instructions to obtain proper operation.
2. Frequency of Tests: Make full ratio check after each 100 gallons of adhesive is dispensed or if color of mixed adhesive becomes noticeably darker or lighter.
3. Ratio Check Procedure:
    a. Disconnect dispensing head behind ON/OFF valve.
    b. Place volume containers of required proportions under "B" and "A" component hose ends.
    c. Actuate pump.
    d. Both cups should fill in an equal time to proper volume, thereby verifying proportion ratio by volume.

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e. Document timing and results of each ratio check procedure.

C. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspection (Plan) on Drawings. Contractor responsibilities and related information on special inspection and testing are included in Section 01 45 33, Special Inspection, Observation, and Testing.

1. Special inspection will be performed by the Special Inspector in accordance with ICC ESR requirements and as specified in Section 01 45 33, Special Inspection, Observation, and Testing.
2. Continuous inspection required where noted on Drawings and where concrete dowels are installed in overhead applications.
3. Periodic inspection required where continuous inspection is not specified.
4. Special Inspector will observe installation in accordance with requirements of the ICC Evaluation Services Report and will submit report including the following:
   a. Product Description: Product name, rod diameter, and length.
   b. Drill bit compliance.
   c. Hole diameter, diameter, and depth and cleanliness.
   d. Adhesive expiration date.
5. Verification of dowel installation in accordance with manufacturer's published instructions.

END OF SECTION

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SECTION 05 05 19
POST-INSTALLED ANCHORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI):
   a. 318, Building Code Requirements for Structural Concrete.
   b. 355.2, Qualification of Post-Installed Mechanical Anchors in Concrete.
   c. 355.4, Qualification of Post-Installed Adhesive Anchors in Concrete.
2. American Iron and Steel Institute (AISI): Stainless Steel Type 316.
3. American National Standards Institute (ANSI).
4. ASTM International (ASTM):
   a. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   b. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
   c. A194/A194M, Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   d. E488/E488M, Standard Test Methods for Strength of Anchors in Concrete Elements.
   e. F436/F436M, Standard Specification for Hardened Steel Washers.
   f. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   g. F594, Standard Specification for Stainless Steel Nuts.
   h. F1554, Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.
5. International Association of Plumbing and Mechanical Officials Uniform ES (IAPMO-UES): Evaluation Reports for Concrete and Masonry Anchors.
6. International Code Council Evaluation Service (ICC-ES):
   a. Evaluation Reports for Concrete and Masonry Anchors.
   b. AC193, Acceptance Criteria for Mechanical Anchors in Concrete Elements.

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c. AC308, Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements. Evaluation Reports for Concrete and Masonry Anchors.

7. Specialty Steel Industry of North America (SSINA):
   a. Specifications for Stainless Steel.
   b. Design Guidelines for the Selection and Use of Stainless Steel.
   c. Stainless Steel Fabrication.
   d. Stainless Steel Fasteners.

1.02 DEFINITIONS

A. Corrosive Area: Containment area or area exposed to delivery, storage, transfer, or use of chemicals.

B. Exterior Area: Location not protected from weather by a building or other enclosed structure to include buried roof structures.

C. Interior Dry Area: Location inside building or structure where floor is not subject to liquid spills or wash down, and where wall or roof slab is not common to a water-holding or earth-retaining structure.

D. Interior Wet Area: Location inside building or structure where floor is sloped to floor drains or gutters and is subject to liquid spills or wash down, or where wall, floor, or roof slab is common to a water-holding or earth-retaining structure.

E. 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.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Specific instructions for concrete anchor installation, including drilled hole size and depth, preparation, placement, procedures, and instructions for safe handling of anchoring systems.

B. Informational Submittals:

1. Concrete Anchors:
   a. Manufacturer’s product description and installation instructions.
   b. Current ICC-ES or IAPMO-UES Report for each type of post-installed anchor to be used.

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c. Adhesive Anchor Installer Certification.

2. Passivation method for stainless steel members.
3. Hot-Dip Galvanizing: Certificate of Compliance signed by galvanizer, with description of material processed and ASTM standard used for coating.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Installers of adhesive anchors horizontally or upwardly inclined to support sustained tension loads shall be certified by an applicable certification program. Certification shall include written and performance tests in accordance with the ACI/CRSI Adhesive Installer Certification Program or equivalent.
2. Galvanized Coating Applicator: Company specializing in hot-dip galvanizing after fabrication and following procedures of Quality Assurance Manual of the American Galvanizers Association.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Package stainless steel items in a manner to provide protection from carbon impregnation.

B. Protect hot-dip galvanized finishes from damage because of metal banding and rough handling.

PART 2 PRODUCTS

2.01 GENERAL

A. Unless otherwise indicated, meet the following requirements:

Item	ASTM Reference
Stainless Steel:	
Threaded Rods	F593, AISI Type 316, Condition CW
Nuts*	F594, AISI Type 316, Condition CW
Carbon Steel:	
Threaded Rods	F1554, Grade 36
Flat and Beveled Washers (Hardened)	F436/F436M

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Item	ASTM Reference
Nuts*	A194/A194M, Grade 2H
Galvanized Steel:	
All	A153/A153M
*Nuts of other grades and styles having specified proof load stresses greater than specified grade and style are also suitable. Nuts must have specified proof load stresses equal to or greater than minimum tensile strength of specified threaded rod.	

B. Bolts, Washers, and Nuts: Use stainless steel, hot-dip galvanized steel, and zinc-plated steel material types as indicated in Fastener Schedule at end of this section.

2.02 POST-INSTALLED CONCRETE 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. Post-installed anchor systems used in concrete shall be approved by ICC Evaluation Services Report or equivalent for use in cracked concrete and for short-term and long-term loads including wind and earthquake.
3. Mechanical Anchors: Comply with the requirements of ICC-ES AC193 or ACI 355.2.
4. Adhesive Anchors: Comply with the requirements of ICC-ES AC308 or ACI 355.4.

B. Torque-Controlled Expansion Anchors (Wedge Anchors):

1. Manufacturers and Products:
   a. Hilti, Inc., Tulsa, OK; KWIK Bolt-TZ2 Expansion Anchor Safe Set System with hollow drill bit and vacuum and SI-AT-A22 tool with adaptive torque for applicable sizes (ESR-4266).
   b. DeWalt/Powers Fasteners, Brewster, NY; Power-Stud +SD1, +SD2, +SD4, or +SD6 Anchors (ESR-2502 and ESR-2818).
   c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Strong-Bolt 2 Anchors (ESR-1771 and ESR-3037).

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C. Adhesive Anchors:

1. Threaded Rod:
   a. Diameter as shown on the Drawings.
   b. Length as required to provide minimum depth of embedment indicated and thread projection required.
   c. Clean and free of grease, oil, or other deleterious material.
2. Adhesive:
   a. Two-component, insensitive to moisture, designed to be used in adverse freeze/thaw environments.
   b. Cure Temperature, Pot Life, and Workability: Compatible for intended use and anticipated environmental conditions.
3. Packaging and Storage:
   a. Disposable, self-contained system capable of dispensing both components in proper mixing ratio and fitting into a manually or pneumatically operated caulking gun.
   b. Store adhesive on pallets or shelving in a covered storage area.
   c. Package Markings: Include manufacturer's name, product name, batch number, 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., Tulsa, OK; HIT Doweling Anchor System, HIT-HY 200 V3 Safe Set System with HAS threaded rod (ESR-4868), HIT RE 500 V3 Safe Set System with HAS threaded rod (ESR-3814), or HIT-RE 500 V3 Safe Set System with Hilti Roughening Tool (HIT RT) with HAS threaded rod (ESR-3814) for diamond cored holes.
   b. Simpson Strong-Tie Co., Inc., Pleasanton, CA; SET-3G Epoxy Adhesive Anchors. (ESR-4057).
   c. DeWalt/Powers Fasteners, Brewster NY; Pure 220+ Epoxy adhesive anchor system with Dust X+ System (ESR-5144).

D. Adhesive Threaded Inserts:

1. Type 316 stainless steel, internally threaded inserts.
2. Manufacturer and Product: Hilti, Inc., Tulsa, OK; HIS-RN Insert with HIT-RE 500-V3 or HIT-HY 200 adhesive.

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PART 3 EXECUTION

3.01 CONCRETE ANCHORS

A. Begin installation only after concrete to receive anchors is a minimum of 21 days old or has attained design strength whichever requires a longer duration.

B. Locate existing reinforcing with ground penetrating radar or other method approved by the Engineer prior to drilling. Coordinate with the Engineer to adjust anchor locations where installation would result in hitting reinforcing.

C. Install in accordance with written manufacturer's instructions.

D. Provide minimum embedment, edge distance, and spacing as indicated on the Drawings.

E. Use only drill type, bit type, and diameter recommended by anchor manufacturer. Use rotary hammer drill unless otherwise approved by the Engineer. Core drilling may only be used if specifically allowed by the Engineer.

F. Clean hole of debris and dust per manufacturer's requirements.

G. When unidentified embedded steel, rebar, or other obstruction is encountered in drill path, slant drill to clear obstruction. If drill must be slanted more than indicated in manufacturer's installation instructions to clear obstruction, notify the Engineer for direction on how to proceed.

H. Adhesive Anchors:

1. Unless otherwise approved by the Engineer and adhesive manufacturer:
   a. Do not install adhesive anchors when temperature of concrete is below 40 degrees F or above 100 degrees F.
   b. Do not install prior to concrete attaining an age of 21 days.
   c. Remove any standing water from hole with oil-free compressed air. Inside surface of hole shall be dry.
   d. Do not disturb anchor during recommended curing time.
   e. Do not exceed maximum torque as specified in manufacturer's instructions.
2. Prestressed Concrete: Do not use drilled-in anchors in prestressed or post-tensioned concrete members without the Engineer's prior approval unless specifically shown on the Drawings.

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3.02 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan as shown on the Drawings. The Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.

B. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01 45 16, Contractor Quality Control.

3.03 MANUFACTURER'S SERVICES

A. Adhesive and Mechanical Anchors: Conduct Site training of installation personnel for proper installation, handling, and storage of adhesive anchor system. Notify the Engineer of time and place for sessions.

3.04 FASTENER SCHEDULE

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

Service Use and Location	**Product**	**Remarks**
1. Post-Installed Anchors for Metal Components to Cast-in-Place Concrete (such as, Ladders, Handrail Posts, Electrical Panels, Platforms, and Equipment)		
Interior Dry Areas	Anchor material type to match material being anchored (for example, stainless steel anchors to anchor stainless steel equipment, zinc-plated anchors to anchor painted equipment, galvanized anchors to anchor galvanized equipment).	Verify product acceptability and manufacturer's requirements if anchor installation will occur in an overhead application.

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Service Use and Location	Product	Remarks
Submerged, Exterior, Interior Wet, and Corrosive Areas	Stainless steel adhesive anchors	Verify product acceptability and manufacturer's requirements if anchor installation will occur in an overhead application.
4. All Others		
All service uses and locations	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

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SECTION 05 05 23
WELDING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
   a. BPVC SEC V, Nondestructive Examination.
   b. BPVC SEC IX, Welding and Brazing Qualifications.
2. American Society of Nondestructive Testing (ASNT): SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing.
3. ASTM International (ASTM): A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products.
4. American Welding Society (AWS):
   a. A2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination.
   b. A3.0, Standard Welding Terms and Definitions.
   c. D1.1/D1.1M, Structural Welding Code—Steel.
   d. D1.8/D1.8M, Structural Welding Code—Seismic Supplement.
   e. D1.2/D1.2M, Structural Welding Code—Aluminum.
   f. D1.3/1.3M, Structural Welding Code—Sheet Steel.
   g. D1.4/D1.4M, Structural Welding Code—Reinforcing Steel.
   h. D1.6/D1.6M, Structural Welding Code—Stainless Steel.
   i. QC1, Standard for AWS Certification of Welding Inspectors.

1.02 DEFINITIONS

A. CJP: Complete Joint Penetration.

B. CWI: Certified Welding Inspector.

1. Contractor’s Welding Inspector: Contractor’s CWI acts for, and on behalf of, the Contractor for all inspection and quality matters within the scope of the Contract Documents. Contractor is required to provide a welding inspector to oversee welding operations and be responsible for visual inspection and necessary correction of all deficiencies in materials and workmanship required to meet referenced welding codes. This type of Quality Control Inspection is not classified as Special Inspection.

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2. Verification Inspector: This independent inspection is the prerogative of the Owner, who may employ their own, independent CWI, or waive this supplementary, independent CWI inspection.

C. MT: Magnetic Particle Testing.

D. NDE: Nondestructive Examination.

E. NDT: Nondestructive Testing.

F. PJP: Partial Joint Penetration.

G. PQR: Procedure Qualification Record.

H. PT: Liquid Penetrant Testing.

I. Special Inspection: Nondestructive weld examination including MT, PT, UT, and RT.

1. Special Inspection personnel report to, and are retained by the Owner, except as noted below:
   a. Contractor and fabricator are required to complete nondestructive weld examinations for welded steel tanks, welded steel pipe, and process piping.
2. See additional requirements in Section 01 45 33, Special Inspection, Observation, and Testing.

J. RT: Radiographic Testing.

K. UT: Ultrasonic Testing.

L. VT: Visual Inspection/Testing.

M. WPQ: Welder/Welding Operator Performance Qualification Record.

N. WPS: Welding Procedure Specification.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Shop and field WPSs and PQRs.
   b. NDT procedure specifications prepared in accordance with ASME BPVC SEC V.

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c. Welding Data (Shop and Field): Submit welding data together with Shop Drawings as a complete package.
   1) Show on Shop Drawings, or on a weld map, complete information regarding base metal ASTM specifications, and location, type, size, and length of welds.
   2) Identify WPS to be used, and NDE requirements in tail of welding symbol.
   3) Clearly distinguish between shop and field welds.
   4) Indicate, by welding symbols or sketches, details of welded joints and preparation of base metal. Provide complete joint welding details showing bevels, groove angles, and root openings for welds.
   5) Welding and NDE Symbols shall be in accordance with AWS A2.4. Welding terms and definitions shall comply with AWS A3.0.

B. Informational Submittals:

1. WPQs.
2. CWI credentials.
3. Testing agency NDE inspector credentials.
4. CWI visual inspection (VT) reports.
5. Welding Documentation: Submit on forms provided in referenced welding codes.

1.04 QUALIFICATIONS

A. WPSs: In accordance with AWS D1.1/D1.1M (Annex J Forms) for shop or field welding; or ASME BPVC SEC IX (Forms QW-482 and QW-483) for shop welding only.

B. WPQs: In accordance with AWS D1.1/D1.1M (Annex J Forms); or ASME BPVC SEC IX (Form QW-484).

C. CWI: Certified in accordance with AWS QC1 and having prior experience with specified welding codes. Alternate welding inspector qualifications require prior approval by Engineer.

D. Testing Agency: Personnel performing tests shall be NDT Level II certified in accordance with ASNT SNT-TC-1A.

1.05 SEQUENCING AND SCHEDULING

A. Unless otherwise specified, Submittals required in this section shall be submitted and approved prior to commencement of welding operations.

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PART 2 PRODUCTS

2.01 SOURCE QUALITY CONTROL

A. Contractor's CWI shall be present whenever shop welding is performed. CWI shall perform inspection at suitable intervals, prior to assembly, during assembly, during welding, and after welding. CWI shall perform inspections as required in AWS D1.1/D1.1M or referenced welding code and as follows:

1. Verify conformance of specified job materials and proper storage.
2. Monitor conformance with approved WPSs.
3. Monitor welder performance and conformance with approved WPQs.
4. Inspect weld joint fit-up and perform in-process inspections.
5. Provide 100 percent visual inspection of completed welds.
6. Coordinate with nondestructive testing personnel and review NDE results.
7. Maintain records and prepare reports documenting results of CWI VT and required NDE complies with the Work and referenced welding codes.

PART 3 EXECUTION

3.01 GENERAL

A. Welding and Fabrication by Welding: Conform to governing welding codes referenced in attached Welding and Nondestructive Testing Table.

3.02 NONDESTRUCTIVE WELD TESTING REQUIREMENTS

A. Quality Control Inspection:

1. All Welds: 100 percent VT by Contractor's CWI.
2. Acceptance Criteria:
   a. Structural Pipe and Tubing: AWS D1.1/D1.1M, Paragraph 10.24.
   b. All Other Structural Steel: AWS D1.1/D1.1M, Paragraph 8.9, Visual Inspection, Statically Loaded Nontubular Connections.
   c. Stud Connections: AWS D1.1/D1.1M, Paragraph 9.8.1.

B. Nondestructive Testing Requirements:

1. NDT frequency shall be as specified below, as required by referenced fabrication or welding codes, or as specified in the attached table. In case there is a conflict, the higher frequency level of NDT shall apply.

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a. Nontubular Connections:
   1) CJP Butt Joint Groove Welds: 10 percent random RT. Use UT for CJP butt joint groove welds that cannot be readily radiographed.
   2) All Other CJP Groove Welds: 10 percent random UT.
   3) Fillet Welds and PJP Groove Welds: 10 percent random PT or MT.

b. Tubular Connections:
   1) CJP butt joint groove welds made from one side without backing:100 percent RT or UT in accordance with AWS D1.1/D1.1M, Paragraph 10.25.2 requirements.
   2) CJP Butt Joint Groove Welds made with back-gouging: 10 percent random RT.
   3) CJP Butt Joint Groove Welds made with backing and other butt joint groove welds that cannot be readily radiographed: 10 percent random UT.
   4) All Other CJP Groove Welds: 10 percent random UT.
   5) Fillet Welds and PJP Groove Welds: 10 percent random PT or MT.

2. NDT Procedures and Acceptance Criteria:
   a. Nontubular Connections:
      1) RT: Perform in accordance with AWS D1.1/D1.1M, Clause 8, Part E. Acceptance criteria per AWS D1.1/D1.1M, Paragraph 8.12.1.
      2) UT: Perform in accordance with AWS D1.1/D1.1M, Clause 8, Part F. Acceptance criteria per AWS D1.1/D1.1M, Paragraph 8.13.1.
      3) PT and MT:
         a) Perform on fillet and PJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 8.14.4 and Paragraph 8.14.5.
         b) Acceptance criteria per AWS D1.1/D1.1M, Paragraph 8.9, Visual Inspection, Statically Loaded Nontubular Connections.
   b. Tubular Connections:
      1) RT: Comply with requirements for Nontubular Connections and additional requirements of AWS D1.1/D1.1M, Clause 10, Paragraph 10.27, and Paragraph 10.28.
      2) UT: Comply with requirements for Nontubular Connections and additional requirements of AWS D1.1/D1.1M, Clause 10, Paragraph 10.26, and Paragraph 10.29.

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3) PT and MT:
   a) Perform on fillet and PJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 8.14.4 and Paragraph 8.14.5.
   b) Acceptance criteria per AWS D1.1/D1.1M, Paragraph 10.24.

3.03 FIELD QUALITY CONTROL

A. The Contractor's CWI shall be present whenever field welding is being done and shall perform inspection, at suitable intervals, prior to assembly, during assembly, during welding, and after welding. CWI shall perform inspections as required in AWS D1.1/D1.1M or referenced welding code and as follows:

1. Verify conformance of specified job materials and proper storage.
2. Monitor conformance with approved WPS.
3. Monitor welder performance and conformance with approved WPQs.
4. Inspect weld joint fit-up and perform in-process inspection.
5. Provide 100 percent visual inspection of all welds in accordance with Paragraph Quality Control Inspection.
6. Coordinate with nondestructive testing personnel and review test results.
7. Maintain records and prepare reports confirming results of inspection and testing comply with the Work.

3.04 WELD DEFECT REPAIR

A. Repair and retest rejectable weld defects until sound weld metal have been deposited in accordance with appropriate welding codes.

3.05 SUPPLEMENT

A. The supplement listed below, following "End of Section," is part of this specification.

1. Welding and Nondestructive Testing Table.

END OF SECTION

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Welding and Nondestructive Testing						
Specification Section	**Governing Welding Codes or Standards**	**Submit WPS**	**Submit WPQ**	**Onsite CWI Required?**	**Submit Written NDT Procedure Specifications**	**NDT Requirements**
05 12 00 Structural Steel Framing	AWS D1.1/D1.1M, Structural Welding Code—Steel	Yes	Yes	Yes	Yes	100% VT and 10% UT or RT of all groove-and-butt joint welds; 10% MT of all fillet welds; also see Section 05 12 00
05 50 00 Metal Fabrications	AWS D1.1/D1.1M, Structural Welding Code–Steel or AWS D1.2/D1.2M, Structural Welding Code—Aluminum or AWS D1.6/D1.6M, Structural Welding Code—Stainless Steel	Yes	Yes	Yes	Yes	100% VT; also see Section 05 50 00
05 52 16 Aluminum Railings	AWS D1.1/D1.1M, Structural Welding Code—Steel or AWS D1.2/D1.2M, Structural Welding Code—Aluminum	No	No	No	No	100% VT; also see Section 05 52 16

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SECTION 05 12 00
STRUCTURAL STEEL FRAMING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Galvanizers Association (AGA): Quality Assurance Manual.
2. American Institute of Steel Construction (AISC):
   a. 207, Standard for Certification Programs.
   b. 303, Code of Standard Practices for Steel Buildings and Bridges.
   c. 325, Steel Construction Manual.
   d. 326, Detailing for Steel Construction.
   e. 341, Seismic Provisions for Structural Steel Buildings.
   f. 360, Specification for Structural Steel Buildings.
   g. 420, Certification Standard for Shop Application of Complex Protective Coating Systems.
3. American Welding Society (AWS):
   a. D1.1/D1.1M, Structural Welding Code—Steel.
   b. D1.8/D1.8M, Structural Welding Code—Seismic Supplement.
4. ASTM International (ASTM):
   a. A6/A6M, Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling.
   b. A36/A36M, Standard Specification for Carbon Structural Steel.
   c. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
   d. A123/123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   e. A143/A143M, Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.
   f. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   g. A384/A384M, Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.
   h. A385/A385M, Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip).
   i. A500/A500M, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.

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j. A563, Standard Specification for Carbons and Alloy Steel Nuts.
k. A572/A572M, Standard Specification for High-Strength Low Alloy Columbium-Vanadium Structural Steel.
l. A780/A780M, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
m. A992/A992M, Standard Specification for Structural Steel Shapes.
n. A1065/1065M, Standard Specification for Cold-Formed Electric Fusion (Arc) Welded High-Strength Low-Allow Structural Tubing in Shapes with 50 ksi [345 MPa] Minimum Yield Point.
o. A1085/A1085M, Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS).
p. B695, Standard Specification for Coatings of Zinc Mechanically Deposited on Iron and Steel.
q. D6386, Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Painting.
r. D7803, Standard Practice for Preparation of Zinc (Hot-Dip Galvanized) Coated Iron and Steel Product and Hardware Surfaces for Powder Coating.
s. F436, Standard Specification for Hardened Steel Washers.
t. F959, Standard Specification for Compressible-Washer-Type Direct Tension Indicators for Use with Structural Fasteners.
u. F1136, Standard Specification for Zinc/Aluminum Corrosion Protective Coatings for Fasteners.
v. F3125, Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi (830 MPa) and 150 ksi (1040 MPa) Minimum Tensile Strength, Inch and Metric Dimensions.
w. F3148, Standard Specification for High Strength Structural Bolt Assemblies, Steel and Alloy Steel, Heat Treated, 144 ksi Minimum Tensile Strength, Inch Dimensions.

5. Occupational Safety and Health Administration (OSHA).
6. Research Council on Structural Connections (RCSC): Specification for Structural Joints using High-Strength Bolts.

1.02 SUBMITTALS

A. Action Submittals:

1. Provide Shop Drawing details showing:
   a. Erection plans.
   b. Members, including piece numbers, sizes, grades, dimensions, cambers, and connection details.
   c. Anchor bolt layouts.

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d. Hardened washer details.
e. Connection material specifications.
f. Indicate type, size, and length of bolts.
g. Joint details for complete penetration welds.
h. Indicate welds by standard AWS symbols, distinguishing between shop and field welds and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain.

2. Product specifications, including primer and other coatings.
3. Identify pretensioned and slip-critical high strength bolted connections.
4. Locations of Class A, or higher, faying surfaces.
5. Weld access hole dimensions, surface profile, and finish requirements.
6. Location of demand critical shop welds.
7. Locations and dimensions of protected zones.
8. Gusset plates drawn to scale when they are detailed to accommodate inelastic rotation.
9. Nondestructive testing (NDT) where performed by the fabricator.
10. Welding requirements as specified in AISC 341 Appendix W, Section W2.2 or AWS D1.8/D1.8M.

B. Informational Submittals:

1. Name and address of manufacturer(s).
2. Mill Certificates of tests made in accordance with ASTM A6/A6M.
3. Manufacturers' testing procedures and standards.
4. Preparation and installation or application instructions, as appropriate.
5. Proposed method to resolve misalignment between anchor bolts and bolt holes in steel members.
6. High-Strength Bolts:
   a. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, that products meet specified chemical and mechanical requirements.
   b. Manufacturer's inspection test report results for production lot(s) furnished to include:
      1) Tensile strength.
      2) Yield strength.
      3) Reduction of area.
      4) Elongation and hardness.

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c. Certified Mill Test Reports for Bolts and Nuts:
   1) Name and address of manufacturer.
   2) Bolts correctly marked.
   3) Marked bolts and nuts used in required mill tests and manufacturer's inspection tests.

7. Direct Tension Indicators (DTIs): Manufacturer's test report meeting requirements of ASTM F959.
8. Twist-Off-Type Tension-Control (TC) Bolts: Manufacturer's test report meeting requirements of ASTM F3125 Grade F1852.
9. Welding Procedures, Qualifications, and Inspection Reports: As specified in Section 05 05 23, Welding.
10. Hot-Dip Galvanizing: Certificate of compliance signed by galvanizer with description of material processed and ASTM standard used for coating.
11. AISC Quality Certification: AISC certificate showing name and address of certified firm, effective date, and category of certification; or, for erectors, documentation of similar project experience to include project name, location, date of completion, and name and phone number of owner's contact person.
12. Charpy V-notch test results.
13. Nondestructive Testing (NDT) report.

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Welding qualifications as specified in Section 05 05 23, Welding.
2. Galvanized Coating Applicator: Company specializing in hot-dip galvanizing after fabrication and following procedures of AGA's Quality Assurance Manual.

B. Certifications: Mill identification marks, heat number, size of section, and length in accordance with ASTM A6/A6M.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Load structural members in such a manner that they will be transported and unloaded without damage to coatings and without being excessively stressed, deformed, or otherwise damaged.

B. Storage:

1. Store materials to permit easy access for inspection and identification. Store in a dry area and keep steel members off ground and spaced by

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using pallets, dunnage, or other supports and spacers. Protect steel members and packaged materials from corrosion and deterioration.

a. Do not store materials in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials as directed.

2. Store fasteners in a protected place in sealed containers with manufacturer's labels intact.

a. Fasteners may be repackaged provided testing and inspecting agency observes repackaging and sealing of containers.

b. Clean and lubricate bolts and nuts that become dry or rusty before use.

c. Comply with manufacturer's written recommendations for cleaning and lubricating fasteners and for retesting fasteners after lubrication.

C. Handle materials to avoid distortion or damage to members or supporting structures.

PART 2 PRODUCTS

2.01 MATERIALS

A. Recycled Content of Steel Products:

1. Provide products with an average recycled content of steel products so postconsumer recycled content plus one-half of preconsumer recycled content is not less than the following:

a. W-Shapes: 60 percent.

b. Channels, Angles, S-Shapes: 60 percent.

c. Plate and Bar: 25 percent.

d. Cold-Formed Hollow Structural Sections: 25 percent.

e. All Other Steel Materials: 25 percent.

B. Rolled Plates, Shapes except W-Shapes and Bars: ASTM A572/A572M Grade 50 unless indicated otherwise.

C. W-Shapes: ASTM A992/A992M, unless indicated otherwise on Drawings.

D. Steel Pipe: ASTM A53/A53M, Grade B.

E. Round Hollow Structural Sections (HSS): ASTM A500/A500M, Grade C (Fy equals 46 ksi).

F. Square and Rectangular Hollow Structural Sections (HSS): ASTM A500/A500M, Grade C (Fy equals 50 ksi).

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G. For hot-dip galvanized steel that is exposed to view and does not receive paint, limit combined phosphorus and silicon content to 0.04 percent. For steels that require a minimum of 0.15 percent silicon, such as plates over 1-1/2-inches thick for ASTM A36/A36M and ASTM A572/A572M steels, limit maximum silicon content to 0.21 percent and phosphorous content to 0.03 percent.

2.02 FASTENERS

A. Anchor Bolts: As specified in Section 05 50 00, Metal Fabrications.

B. Post-Installed Anchors: As specified in Section 05 05 19, Post-Installed Anchors.

C. High-Strength Bolts:

1. ASTM F3125 Grade A325, Type 1, hot-dip galvanized.
2. Bolt Length and Thread Length: As required for connection type shown, with hardened washers as required.

D. Direct Tension Indicators (DTIs) or Load Indicator Washers:

1. ASTM F959, coating type to match bolt finish.
2. Type A325 or Type A490, to match bolt grade.
3. Manufacturers and Products:
   a. TurnaSure LLC, Langhorne, PA; DTIs.
   b. Applied Bolting Technology Products, Ludlow, VT; DTIs, regular or Squirter type.

E. Nuts: ASTM A563, type to match bolt type and finish.

F. Hardened Steel Flat and Beveled Washers: ASTM F436, type to match bolt finish.

G. Stud Shear Connectors: As specified in Section 05 50 00, Metal Fabrications.

2.03 ANCILLARY MATERIALS

A. Surface Preparation and Primer: As specified in Section 09 90 00, Painting and Coating.

B. Grout: As specified in Section 03 30 10, Structural Concrete.

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2.04 FABRICATION

A. General:

1. Fabricate as shown and in accordance with AISC 360 and AISC 303.
2. Columns: Full-length members without splices, unless shown otherwise or approved by Engineer.
3. Mark and match mark materials for field assembly.
4. Complete assembly, including bolting and welding of units, before start of finishing operations.
5. Fabricate to agree with field measurements.
6. Fabricate beams with rolling camber up.
7. Sheared and flame-cut edges shall be free from rough corners and projections.

B. Connections:

1. Shop Connections: Weld or bolt as shown on Drawings.
2. Meet requirements of AISC 325 for bolted double-angle shear connections, unless indicated otherwise.
3. Meet OSHA requirements for one independent bolt at beams framing into column web connections.
4. Provide oversized holes for anchor bolts in column baseplate in accordance with AISC 325, unless indicated otherwise.

C. Welded Construction:

1. As specified in Section 05 05 23, Welding.
2. Groove and Butt Joint Welds: Complete penetration, unless otherwise indicated.

D. Interface with Other Work:

1. Holes:
   a. As necessary or as indicated for securing other Work to structural steel framing, and for passage of other Work through steel framing members shall be approved by Engineer.
   b. No flame-cut holes are permitted without prior approval of Engineer.
2. Weld threaded nuts to framing members, and other specialty items to receive other Work.

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2.05 FINISHES

A. Shop Paint Primer:

1. Surface Preparation and painting as specified in Section 09 90 00, Painting and Coating.
2. Do not shop prime the following surfaces, unless indicated otherwise:
   a. Within 2 inches of field-welded connections.
   b. Steel members to be completely encased in reinforced concrete or coated with cementitious fireproofing.
3. Apply shop primer to top flange surfaces of composite steel beams, unless indicated otherwise.

B. Galvanizing:

1. Fabricate steel to be galvanized in accordance with ASTM A143/A143M, ASTM A384/A384M, and ASTM A385/A385M. Avoid fabrication techniques that could cause distortion or embrittlement of steel.
2. Surfaces of hot-dip galvanized iron and steel that will receive an application of powder coating materials, shall be prepared in accordance with ASTM D7803.
3. Surfaces of hot-dip galvanized iron and steel that will be painted, shall be prepared in accordance with ASTM D6386.
4. Remove welding slag, splatter, burrs, grease, oil, paint, lacquer, and other deleterious material prior to delivery for galvanizing.
5. Remove, by blast cleaning or other methods, surface contaminants and coatings not removable by normal chemical cleaning process in galvanizing operation.
6. Hot-dip galvanize steel members, fabrications, and assemblies after fabrication in accordance with ASTM A123/A123M.
7. Hot-dip galvanize ASTM F3125 Grade A325 bolts, nuts, washers, and hardware components in accordance with ASTM A153/A153M. Oversize holes to allow for zinc alloy growth. Shop-assemble bolts, nuts, and washers with special lubricant and test in accordance with ASTM F3125 and ASTM A563.
8. Mechanically zinc coat ASTM F3125 Grade F1852 twist-of-type tension-control (TC) bolts, nuts, and washers in accordance with ASTM F3125 and ASTM B695, Class 50.
9. Coat ASTM F3125 Grade F2280 twist-off-type tension-control (TC) bolts, nuts, and washers in accordance with ASTM F1136.
10. Galvanize components of bolted assemblies separately before assembly.

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2.06 SOURCE QUALITY CONTROL

A. Welding:

1. Contractor's Certified Welding Inspector (CWI): Inspect and test fabrication welds as specified in Section 05 05 23, Welding.
2. Visually inspect fabrication welds in accordance with AWS D1.1/D1.1M, Section 6 and Table 6.1, Visual Inspection Acceptance Criteria.
3. An independent testing agency will be retained by Owner to perform the inspection and testing of fabrication welds as specified in Section 05 05 23, Welding.
4. Repair and retest defective welds as specified in Section 05 05 23, Welding.

B. Special inspection of fabrication process and shop welding will be provided by Owner as indicated on Drawings.

C. 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

3.01 ERECTION

A. General:

1. Meet requirements of AISC 360 and AISC 303, with exceptions as specified.
2. Install Contractor-designed temporary construction bracing to provide necessary support until components are in place and construction is complete.
3. Provide additional field connection material as required by AISC 303.
4. Splice members only where indicated and accepted on Shop Drawings.

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B. Field Assembly:

1. Clean bearing surfaces and other surfaces that will be in permanent contact before assembly.
2. Set structural frames accurately to lines and elevations shown.
3. Align and adjust various members forming a part of a complete frame or structure before permanently fastening.
4. Level and plumb individual members of structure within tolerances shown in AISC 303.
5. Establish required leveling and plumbing measurements on mean operating temperature of structure. Make allowances for difference between temperature at time of erection and mean temperature at which structure will be completed and in service.
6. Perform necessary adjustments to compensate for minor discrepancies in elevations and alignment.

C. Setting Baseplates and Bearing Plates:

1. Clean concrete and masonry bearing surfaces of bond reducing materials and roughen to improve bond to surfaces.
2. Clean bottom surface of baseplates and bearing plates.
3. Set loose and attached baseplates and bearing plates for structural members on wedges, shims, leveling nuts, or other adjustable devices. Use leveling plates where indicated.
4. Tighten anchor bolts after supported members have been positioned and plumbed. Do not remove wedges or shims, but if protruding, cut off flush with edge of base or bearing plate prior to placing grout. Weld plate washer to baseplate where indicated.
5. Grout Under Baseplate: As specified in Section 03 30 10, Structural Concrete, prior to placing loads on structure.

D. Anchor Bolts:

1. Coordinate installation of anchor bolts and other connectors required for securing structural steel to in-place work.
2. Provide templates and other devices for presetting bolts and other anchors to accurate locations.
3. Projection of anchor bolts beyond face of concrete and threaded length shall be adequate to allow for full engagement of threads of hold-down nuts, adjustment of leveling nuts, washer thicknesses, and construction tolerances, unless indicated otherwise.
4. Placement Tolerances:
   a. As required by AISC 303, unless indicated otherwise.

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b. Embedded anchor bolts shall not vary from dimensions shown on Drawings by more than the following:
   1) Center-to-Center of Any Two Bolts Within an Anchor Group: 1/8 inch.
   2) Center-to-Center of Adjacent Anchor Bolt Groups: 1/4 inch.
   3) Variation from Perpendicular to Theoretical Bearing Surface: 1:50.

E. Connections:

1. High-Strength Bolted:
   a. Tighten in accordance with RCSC Specification for Structural Joints Using High-Strength Bolts.
   b. Pretension all bolts unless noted otherwise on Drawings.
   c. Hardened Washers:
      1) Provide at locations required by Washer Requirements section of RCSC Specification for Structural Joints Using High Strength Bolts, to include pretensioned and slip critical connections using slotted or oversized holes or F3125 Grade A490 bolts.
      2) Use beveled style and extra thickness where required by RCSC Specification.
      3) Use square or rectangular beveled washers at inner flange surfaces of American Standard beams and channels.
      4) Do not substitute DTIs for hardened flat washers required at slotted and oversize holes.
   d. For snug-tightened connections (N, X), tighten to snug tight condition. Use hardened washer over slotted or oversize holes in outer plies.
2. Pretensioned Bolted:
   a. Use DTIs or twist-off-type tension-control (TC) bolts at slip critical (SC) and pretensioned bearing-type connections.
   b. DTIs:
      1) Position within bolted assembly in accordance with ASTM F959.
      2) Install bolts, with DTIs plus hardened washers as required, in holes of assembly and tighten until plies are in firm contact and fasteners are uniformly snug tight.
   c. Final tightening bolts begin at most rigid part of bolted connection and progress toward free edges until final twist-off-type tension-control (TC) bolts or until DTIs have been compressed to an average gap equal to or less than shown in ASTM F959, Table 2.

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3. Welded:
    a. As specified in Section 05 05 23, Welding.
    b. Groove and Butt Joint Welds: Complete penetration, unless otherwise indicated.

3.02 MISFITS

A. At Bolted Connections:

1. Immediately notify Engineer for approval of one of the following methods of correction:
    a. Ream holes that must be enlarged to admit bolts and use oversized bolts.
    b. Plug weld misaligned holes and redrill holes to admit standard size bolts.
    c. Drill additional holes in connection, conforming to AISC for bolt spacing and end and edge distances, and add additional bolts.
    d. Reject member containing misfit, incorrect sized, or misaligned holes and fabricate new member to ensure proper fit.
2. Do not enlarge incorrectly sized or misaligned holes in members by burning or by use of drift pins.

B. At Anchor Bolts:

1. Resolve misalignments between anchor bolts and bolt holes in steel members in accordance with approved Shop Drawing.
2. Do not flame cut to enlarge holes without prior approval of Engineer.

C. Gas Cutting:

1. Do not use gas cutting torches in field for correcting fabrication errors in structural framing.
2. Secondary members not under stress and concealed in finished structure may be corrected by gas cutting torches, if approved by Engineer.
3. Finish flame-cut sections equivalent to sheared and punched appearance.

3.03 REPAIR AND CLEANING

A. Clean shop primer from field welds, bolted connections, and abraded areas immediately after erection.

B. Remove and grind smooth tack welds, fit-up-lugs, and weld runoff tabs.

C. Remove weld back-up bars and grind smooth where indicated on Drawings.

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D. Apply touchup paint primer by brush or spray of same thickness and material as that used in shop application and as specified in Section 09 90 00, Painting and Coating.

E. Hot-Dip Galvanized Coating Repair:

1. Conform to ASTM A780/A780M.
2. For minor repairs at abraded areas, use sprayed zinc conforming to ASTM A780/A780M.
3. For flame cut or welded areas, use zinc-based solder, or zinc sticks, conforming to ASTM A780/A780M.
4. Use magnetic gauge to determine thickness is equal to or greater than base galvanized coating.

3.04 FIELD FINISH

A. Field finish in accordance with Section 09 90 00, Painting and Coating.

3.05 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in Statement of Special Inspections Plan on Drawings. Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.

B. High-Strength Bolted Connections:

1. An independent testing agency will be retained by Owner to perform the following inspection and testing in accordance with the RCSC Specification for Structural Joints Using High-Strength Bolts:
   a. Marking identification and conformance to ASTM standards.
   b. Alignment of bolt holes.
   c. Placement, type, and thickness of hardened washers.
   d. Tightening of bolts.
2. Snug-Tightened Connections (N, X): Snug tight condition with plies of joint in firm contact.
3. Preinstallation Test:
   a. Conduct test in accordance with Specification for Structural Joints Using ASTM F3125 Grade A325 or Grade A490 bolts prior to using bolt tension measuring device.
   b. Select representative sample of not less than three bolts of each diameter, length, and grade.
   c. Include DTIs and flat hardened washers as required to match actual connection assembly.

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4. Nondestructive Testing (NDT): Inspect bolted connections and perform corrections as required to meet code acceptance criteria per RCSC Specification for Structural Joints Using High-Strength Bolts.
5. Defective Connections: Correct and reinspect defective and improperly tightened high strength bolted connections. Retest pretensioned bolts as necessary to demonstrate compliance of completed work.

C. Welding:

1. Contractor's Certified Welding Inspector (CWI): Inspect and test field welds as specified in Section 05 05 23, Welding.
2. Visually inspect field welds in accordance with AWS D1.1/D1.1M, Section 6 and Table 6.1, Visual Inspection Acceptance Criteria.
3. An independent testing agency will be retained by Owner to perform inspection and testing of field welds as specified in Section 05 05 23, Welding.
4. Repair and retest defective welds as specified in Section 05 05 23, Welding.

D. Special inspection will be provided by Owner as indicated on Drawings.

E. Stud Shear Connectors: Inspect and test stud shear connectors as specified in Section 05 50 00, Metal Fabrications.

END OF SECTION

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SECTION 05 50 00
METAL FABRICATIONS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. The Aluminum Association, Inc. (AA): The Aluminum Design Manual.
2. American Galvanizers Association (AGA):
   a. Inspection of Hot-Dip Galvanized Steel Products.
   b. Quality Assurance Manual.
3. American Iron and Steel Institute (AISI): Stainless Steel Types.
4. American Ladder Institute (ALI): A14.3, Ladders - Fixed - Safety Requirements.
5. American National Standards Institute (ANSI).
6. American Society of Safety Engineers (ASSE): A10.11, Safety Requirements for Personnel and Debris Nets.
7. American Welding Society (AWS):
   a. D1.1/D1.1M, Structural Welding Code - Steel.
   b. D1.2/D1.2M, Structural Welding Code - Aluminum.
   c. D1.6/D1.6M, Structural Welding Code - Stainless Steel.
8. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A48/A48M, Specification for Gray Iron Castings.
   c. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   d. A108, Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.
   e. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   f. A143/A143M, Standard for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.
   g. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   h. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   i. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.

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j. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
k. A276, Standard Specification for Stainless Steel Bars and Shapes.
l. A283/A283M, Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
m. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
n. A325, Standard Specification for Structural Bolts, Steel, Heat Treated 120/105 ksi Minimum Tensile Strength.
o. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
p. A384/A384M, Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.
q. A385/A385M, Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip).
r. A489, Standard Specification for Carbon Steel Lifting Eyes.
s. A500/A500M, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
t. A501, Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
u. A563, Standard Specification for Carbon and Alloy Steel Nuts.
v. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
w. A780/A780, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
x. A786/A786M, Standard Specification for Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy, and Alloy Steel Floor Plates.
y. A793, Standard Specification for Rolled Floor Plate, Stainless Steel.
z. A967, Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
aa. A992/A992M, Standard Specification for Structural Steel Shapes.
bb. A1085, Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS).
cc. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
dd. B308/B308M, Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.

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ee. B429/B429M, Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
ff. B632/B632M, Standard Specification for Aluminum-Alloy Rolled Tread Plate.
gg. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
hh. D1056, Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber.
ii. F436, Standard Specification for Hardened Steel Washers.
jj. F468, Standard Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use.
kk. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
ll. F594, Standard Specification for Stainless Steel Nuts.
mm. F844, Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use.
nn. F1554, Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.

9. Occupational Safety and Health Administration (OSHA):
   a. 29 CFR 1910.27, Fixed Ladders.
   b. 29 CFR 1926.105, Safety Nets.
   c. 29 CFR 1926.502, Fall Protection Systems Criteria and Practices.
10. Specialty Steel Industry of North America (SSINA):
   a. Specifications for Stainless Steel.
   b. Design Guidelines for the Selection and Use of Stainless Steel.
   c. Stainless Steel Fabrication.
   d. Stainless Steel Fasteners.

1.02 DEFINITIONS

A. Anchor Bolt: Cast-in-place anchor; concrete or masonry.

B. Corrosive Area: Containment area or area exposed to delivery, storage, transfer, or use of chemicals. Corrosive area includes areas exposed to corrosive atmosphere such as hydrogen sulfide from wastewater.

C. Exterior Area: Location not protected from weather by building or other enclosed structure.

D. 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 a water-holding or earth-retaining structure.

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E. 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.

F. Submerged: Location at or below top of wall of open water-holding structure, such as basin or channel, or wall, ceiling or floor surface inside a covered water-holding structure, or exterior belowgrade wall or roof surface of water-holding structure, open or covered.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Metal fabrications, including welding and fastener information.
2. Samples: Color samples of abrasive stair nosings.

B. Informational Submittals:

1. U-Channel Concrete Inserts:
   a. Manufacturer’s product description.
   b. Allowable load tables.
2. Pre-engineered Ladders: Letter of certification that ladder meets OSHA 29 CFR 1910.27 requirements.
3. Passivation method for stainless steel members.
4. Galvanized coating applicator qualifications.
5. Hot-Dip Galvanizing: Certificate of compliance signed by galvanizer, with description of material processed and ASTM standard used for coating.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Galvanized Coating Applicator: Company specializing in hot-dip galvanizing after fabrication and following procedures of Quality Assurance Manual of the American Galvanizers Association.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Insofar as practical, factory assemble specified items. Package assemblies, which have to be shipped unassembled to protect materials from damage and tag to facilitate identification and field assembly.

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B. Package stainless steel items to provide protection from carbon impregnation.

C. Protect painted coatings and hot-dip galvanized finishes from damage as a result of metal banding and rough handling. Use padded slings and straps.

D. Store fabricated items in dry area, not in direct contact with ground.

1.06 SPECIAL GUARANTEE

A. Manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at option of Owner, removal and replacement of floor hatches found defective during a period of 5 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in General Conditions.

PART 2 PRODUCTS

2.01 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 ASTM A36/A36M steel), limit maximum silicon content to 0.21 percent and phosphorous content to 0.03 percent.

B. Unless otherwise indicated, meet the following requirements:

Item	ASTM Reference
Steel Wide Flange Shapes	A992/992M
Other Steel Shapes and Plates	A36/A36M or A572/A572M, Grade 50 or A992/A992M for other steel shapes
Steel Pipe	A500, Grade B
Hollow Structural Sections (HSS)	A500/A500M, Grade C
Aluminum:	
Aluminum Plates	B209, Alloy y6061-T6
Aluminum Structural Shapes	B308/B308M, Alloy 6061-T6

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Item	ASTM Reference
Stainless Steel:	
Bars and Angles	A276, AISI Type 316 (316L for welded connections)
Shapes	A276, AISI Type 304 (304L for welded connections)
Steel Plate, Sheet, and Strip	A240/A240M, AISI Type 316 (316L for welded connections)
Bolts, Threaded Rods, Anchor Bolts, and Anchor Studs	F593, AISI Type 316, Group 2, Condition SH
Nuts	F594, AISI Type 316, Condition CW
Steel Bolts and Nuts:	
Carbon Steel	A307 bolts, with A563 nuts
High-Strength	A325, Type 1 bolts, with A563 nuts
Anchor Bolts and Rods	F1554, Grade 36 with weldability 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
Aluminum Bolts and Nuts	F468, Alloy 2024-T4
Cast Iron	A48/A48M, Class 35

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C. Bolts, Washers, and Nuts: Use stainless steel, hot-dip galvanized steel, zinc-plated steel, and aluminum material types as indicated in Fastener Schedule at end of this section.

2.02 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.
2. Fabricated Steel: ASTM A36/A36M.

2.03 POST-INSTALLED CONCRETE ANCHORS

A. See Section 05 05 19, Post-Installed Anchors.

2.04 STUD SHEAR CONNECTORS

A. Headed anchor studs (HAS), or threaded anchor studs (TAS),or stud shear connectors, 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, FabriSteel Co., Elyria, OH.
2. Stud Welding Associates, Inc., Elyria, OH.

2.05 STEEL LINTELS AND SHELF ANGLES

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

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2.06 SIDEWALK DOORS

A. Load Capacity: 300 psf with maximum deflection of 1/150th of span.

B. Component Fabrication:

1. Access Door Leaf(s): 1/4-inch aluminum diamond pattern plate. Provide stainless steel safety chain and attachments for end of double-leaf door assembly when open.
2. Channel Frame: 1/4-inch-thick extruded aluminum trough frame with continuous anchor flange around perimeter. Weld 1-1/2-inch diameter drain coupling, and drain pipe, to frame trough at front right corner, unless indicated otherwise on Drawings.
3. Safety Grate: Aluminum grating with 300 psf live load capacity, 5-inch by 5-inch grate openings, permanent hinging system that locks grate in 90-degree position, and opening arm with vinyl grip handle and locking device.

C. Door Hardware:

1. Hinges: Heavy-duty brass or stainless steel with stainless steel pins through-bolted to cover plate with tamper-proof stainless steel bolts flush with top of cover and to outside leg of channel frame with stainless steel bolts and locknuts.
2. Lifting Mechanism: Stainless steel compression lift springs enclosed in telescoping vertical housing or stainless steel torsion lift springs.
3. Hold-Open Arm:
   a. Locks automatically in open position.
   b. Disengages with slight pull on vinyl grip with one hand.
   c. Door can be easily closed with one hand by pulling forward and down on vinyl grip.
4. Snap Lock:
   a. Stainless steel snap lock mounted on bottom of door leaf with removable topside key wrench and inside fixed lever handle.
   b. Threaded plug for flush outside surface with key wrench removed.

D. Aluminum: Mill finished with protective coating applied to surfaces to be in contact with concrete, as specified in Section 09 90 00, Painting and Coating.

E. Manufacturers and Products:

1. Bilco Co., New Haven, CT; J Series.
2. Nystrom Products Co., Minneapolis, MN; FG Series.
3. U.S.F. Fabrication, Hialeah, FL; T Series.
4. ITT Flygt Corporation, Trumbull, CT; FDRN Series.

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5. Thompson Fabricating Co., Birmingham, AL; TE Series.
6. Halliday Products, Orlando, FL; WS Series.

2.07 ACCESSORIES

A. Antiseizing Lubricant for Stainless Steel Threaded Connections:

1. Suitable for potable water supply.
2. Resists washout.
3. Manufacturers and Products:
   a. Bostik, Middleton, MA; Neverseez.
   b. Saf-T-Eze Div., STL Corp., Lombard, IL; Anti-Seize.

2.08 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 to between 0.15 percent and 0.25 percent.
3. Fabricate aluminum in accordance with AA Specifications 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 shall be free from twisting or distortion caused by improper welding techniques.
3. Steel: Meet fabrication requirements of AWS D1.1/D1.1M, Section 5.
4. Aluminum: Meet requirements of AWS D1.2/D1.2M.
5. Stainless Steel: Meet requirements of AWS D1.6/D1.6M.

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6. Welded Anchor Studs: Prepare surface to be welded and weld with stud welding gun in accordance with AWS D1.1/D1.1M, Section 7, and manufacturer's instructions.
7. Complete welding before applying finish.

D. Painting:

1. Shop prime with rust-inhibitive primer as specified in Section 09 90 00, Painting and Coating, 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 90 00, Painting and Coating, unless indicated otherwise.
3. Do not apply protective coating to galvanized steel anchor bolts or galvanized steel welded anchor studs, unless indicated otherwise.

E. Galvanizing:

1. Fabricate steel to be galvanized in accordance with ASTM A143/A143M, ASTM A384/A384M, and ASTM A385/A385M. 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/A385M.
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 A123/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. Galvanized steel sheets in accordance with ASTM A653/A653M.
8. Galvanize components of bolted assemblies separately before assembly. Galvanizing of tapped holes is not required.

F. Electrolytic Protection: 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 90 00, Painting and Coating, unless indicated otherwise.

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G. Watertight Seal: Where required or shown, furnish neoprene gasket of a type that is satisfactory for use in contact with sewage. Cover full bearing surfaces.

H. Fitting: Where movement of fabrications is required or shown, cut, fit, and align items for smooth operation. Make corners square and opposite sides parallel.

I. Accessories: Furnish as required for a complete installation. Fasten by welding or with stainless steel bolts or screws.

2.09 SOURCE QUALITY CONTROL

A. Visually inspect all fabrication welds and correct deficiencies.

1. Steel: AWS D1.1/D1.1M, Section 6 and Table 6.1, Visual Inspection Acceptance Criteria.
2. Aluminum: AWS D1.2/D1.2M.
3. Stainless Steel: AWS D1.6/D1.6M.

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

3.01 INSTALLATION OF METAL FABRICATIONS

A. General:

1. Install metal fabrications plumb and level, accurately fitted, free from distortion or defects.
2. Install rigid, substantial, and neat in appearance.
3. Install manufactured products in accordance with manufacturer’s recommendations.
4. Obtain Engineer approval prior to field cutting steel members or making adjustments not scheduled.

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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. Fabrication, mechanical connections, and welded construction shall be in accordance with the AA Aluminum Design Manual.

C. Steel Lintels and Shelf Angles: Provide as required for support of masonry and other construction not attached to structural steel framing, unless otherwise shown on Drawings.

3.02 CAST-IN-PLACE ANCHOR BOLTS

A. Locate and hold anchor bolts in place with templates at 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: 1/2-inch diameter by 12 inches long, unless otherwise shown.

3.03 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 90 00, Painting and Coating, unless indicated otherwise.
2. Do not apply protective coating to galvanized steel anchor bolts or galvanized steel welded anchor studs, unless indicated otherwise.
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. Titanium: Where titanium equipment is in contact with concrete or dissimilar metal, provide full-face neoprene insulation gasket, 3/32-inch minimum thickness and 70-durometer hardness.

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C. 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 using cleaning and passivation methods 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 surfaces for compliance.

3.04 PAINTING

A. Painted Galvanized Surfaces: Prepare as specified in Section 09 90 00, Painting and Coating.

B. Repair of Damaged Hot-Dip Galvanized Coating:

1. Conform to ASTM A780/A780M.
2. For minor repairs at abraded areas, use sprayed zinc conforming to ASTM A780/A780M.
3. For flame cut or welded areas, use zinc-based solder, or zinc sticks, conforming to ASTM A780/A780M.
4. Use magnetic gauge to determine thickness is equal to or greater than base galvanized coating.

C. Field Painting of Shop Primed Surfaces: Prepare surfaces and field finish in accordance with Section 09 90 00, Painting and Coating.

3.05 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance:

1. In accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan on Drawings.
2. Contractor responsibilities and related information on special inspection, observation, and testing are included in Section 01 45 33, Special Inspection, Observation, and Testing.

B. Contractor-Furnished Quality Control: Manufacturer’s Certificate of Compliance per Section 01 61 00, Common Product Requirements, for test results, or calculations, or drawings that ensure material and equipment design and design criteria meet requirements of Section 01 61 00, Common Product Requirements and Section 01 88 15, Anchorage and Bracing.

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C. Stud Shear Connectors:

1. At start of each production period, conduct the following test to determine proper generator, control unit, and stud welding gun settings, in accordance with AWS D1.1/D1.1M, 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) studs per AWS D1.1/D1.1M, 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 weld does not exhibit full 360-degree flash or that stud has been repaired by welding, conduct the following test in accordance with AWS D1.1/D1.1M, Chapter 7:
   a. Bend HAS studs or stud shear connectors approximately 15 degrees from vertical, away from missing portion of flash. For TAS studs, torque test per AWS D1.1/D1.1M, 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 shall be provided by Owner where indicated in Statement of Special Inspections Plan on Drawings.

3.06 FASTENER SCHEDULE

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

Service Use and Location	**Product**	**Remarks**
1. Anchor Bolts Cast Into Concrete for Structural Steel, Metal Fabrications and Castings		
Interior Dry Areas	Plain uncoated 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 90 00, Painting and Coating

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Service Use and Location	Product	Remarks
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 90 00, Painting and Coating
3. Post-Installed Anchors: See Section 05 05 19, Post-Installed Anchors		
5. Connections for Structural Steel Framing		
Exterior and Interior Wet and Dry Areas	High-strength steel bolted connections	Use hot-dipped galvanized high-strength bolted connections for galvanized steel framing members.
7. Connections of Aluminum Components		
Submerged, Exterior and Interior Wet and Dry Areas	Stainless steel bolted connections, unless otherwise specified with equipment	
8. All Others		
Exterior and Interior Wet and Dry Areas	Stainless steel fasteners	

B. Antiseizing Lubricant: Use on stainless steel threads.

END OF SECTION

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SECTION 05 52 16
ALUMINUM RAILINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Aluminum Association, Incorporated (AA): DAF45, Designation System for Aluminum Finishes.
2. American Concrete Institute (ACI) 318, Building Code Requirements for Structural Concrete.
3. American Iron and Steel Institute (AISI).
4. ASTM International (ASTM):
    a. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
    b. A194/A194M, Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
    c. E894, Standard Test Method for Anchorage of Permanent Metal Railing Systems and Rails for Buildings.
    d. E935, Standard Test Methods for Performance of Permanent Metal Railing Systems and Rails for Buildings.
    e. E985, Standard Specification for Permanent Metal Railing Systems and Rails for Buildings.
5. International Code Council (ICC): International Building Code (IBC).
6. Occupational Safety and Health Act (OSHA): 29 CFR 1910, Code of Federal Regulations.

1.02 DEFINITIONS

A. ICC Evaluation Services Report: ICC report on evaluation of manufactured concrete anchor systems.

B. Railings: This term includes guardrail systems, handrail systems, platform railing systems, ramp-rail systems, and stair-rail systems. Railings may be comprised of a framework of vertical, horizontal, or inclined members, grillwork or panels, accessories, or combination thereof.

C. Special Inspection: As defined by the ICC IBC.

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D. Toeboards: Vertical barrier at floor level usually erected on railings along exposed edges of floor or wall openings, platforms, or ramps to prevent miscellaneous items from falling through.

1.03 DESIGN REQUIREMENTS

A. Structural Performance of Railing Systems: Design, test, fabricate, and install railings to withstand the following structural loads without exceeding allowable design working stress or allowable deflection. Apply each load to produce maximum stress and deflection in railing system components.

1. Top Rail: Capable of withstanding the following load cases applied:
   a. Concentrated load of 200 pounds applied at any point and in any direction in accordance with ICC IBC and OSHA.
   b. Uniform load of 50 pounds per linear foot applied in any direction in accordance with ICC IBC.
   c. Concentrated load need not be assumed to act concurrently with uniform loads in accordance with ICC IBC.
2. Toeboard: Capable of withstanding, without failure, force of at least 50 pounds applied in downward or outward direction at any point along toeboard.
3. Calculated lateral deflection at top of posts shall not exceed 1 inch.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Project-specific scaled plans and elevations of railings and detail drawings. Include railing profiles, sizes, connections, anchorage, size and type of fasteners, and accessories.
   b. Manufacturer’s literature and catalog data of railing and components.
   c. Design Data: Calculations or test data using specified design performance loads and including the following:
      1) Bending stress in, and deflection of, posts in accordance with ASTM E985 as modified herein.
      2) Design of post base connection.
      3) Documentation that concrete anchors have been designed in accordance with one of the following:
         a) ACI 318, Chapter 17.
         b) ICC Evaluation Services Report for selected anchor.

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B. Informational Submittals:

1. Manufacturer's assembly and installation instructions.
2. Special Inspection: Manufacturer's instructions for Special Inspection of post-installed anchors.
3. Test Reports: Test data may supplement load calculations providing data covers complete railing system, including anchorage:
    a. Test data for railing and components showing load and deflection as a result of load, in enough detail to prove railing is strong enough and satisfies national, state, local standards, regulations, code requirements, and OSHA 29 CFR 1910, using design loads specified. Include test data for the following:
        1) Railing and post connections.
        2) Railing wall connections.
        3) Railing expansion joint connections.
    b. Testing of anchorages shall be in accordance with ASTM E894 and ASTM E935 using applied loads in accordance with ICC IBC.
    c. Deflection Criteria: In accordance with ASTM E985 and design loads specified, except as follows: maximum calculated lateral deflection at top of posts shall not exceed 1 inch.
    d. Aluminum Rail Piping: Test data showing yield strength of pipe as delivered equals or exceeds specified values.
4. Manufacturer's written recommendations describing procedures for maintaining railings including cleaning materials, application methods, and precautions to be taken in use of cleaning materials.

1.05 QUALITY ASSURANCE

A. Qualifications: Calculations required for design data shall be stamped by a registered civil or structural engineer licensed in state where Project will be constructed.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Package and wrap railings to prevent scratching and denting during shipment, storage, and installation. Maintain protective wrapping to extent possible until railing is completely installed.

B. Delivery:

1. Shop assemble into practical modules of lengths not exceeding 24 feet for shipment.
2. Deliver toeboards loose for field assembly.
3. Deliver clear anodized railing pipe and posts with protective plastic wrap.

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1.07 ENVIRONMENTAL REQUIREMENTS

A. Thermal Movements: Allow for thermal movement resulting from the following maximum range in ambient temperature in design, fabrication, and installation of railings to prevent buckling, opening up of joints, over stressing of components, connections and other detrimental effects. Base design calculation on actual surface temperature of material as a result of both solar heat gain and nighttime sky heat loss. Temperature change is difference between high or low temperature and installation temperature.

1. Temperature Change Range: 70 degrees F, ambient; 100 degrees F, material surfaces.

PART 2 PRODUCTS

2.01 ALUMINUM RAILINGS

A. General:

1. Furnish pre-engineered and prefabricated railing systems as shown on Drawings.
2. Railing systems using pop rivets or glued railing construction are not permitted.
3. Sand cast accessories and components are not permitted.
4. Fasteners shall be AISI Type 316 stainless steel, unless otherwise noted.

B. Rails, Posts, and Formed Elbows:

1. Extruded Alloy 6105-T5, 6061-T6, or equivalent.
2. Tensile Strength: 38,000 psi, minimum.
3. Yield Strength: 35,000 psi, minimum.
4. Nominal Wall Thickness: 0.145 inch, minimum.
5. Posts and railings shall be nominal 1-1/2-inch diameter (1.90-inch outside diameter).

C. Accessories:

1. Fittings and Accessories:
   a. Extruded, machined bar stock, permanent mold castings, or die castings of sufficient strength to meet load requirements.
   b. Gauge metal components are not acceptable for load-resisting components.
   c. Fittings shall match color of pipe in railings.

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2. Miscellaneous Extruded Aluminum Parts: Alloy 6063-T6, Alloy 6061-T6, or Alloy 6105 T5 aluminum, or equivalent, and of adequate strength for all loads.
3. Castings for Railings:
   a. Cast Al-mag with sufficient strength to meet load and test requirements.
   b. Anodizable grade finish with excellent resistance to corrosion when subjected to exposure of sodium chloride solution intermittent spray and immersion.
4. Post Anchorages:
   a. Refer to standard details for types of post anchorages and minimum requirements.
   b. Bolts at anchorages shall be minimum 1/2-inch diameter.
5. Wall Brackets: Adjustable wall fitting, with provision for minimum three 3/8-inch diameter AISI Type 304 or Type 316 stainless steel bolts or concrete anchors.
6. Rail Terminals (including Wall Returns): Aluminum wall fitting with provision for three 3/8-inch Type 304 fasteners.
7. Toeboards:
   a. Molded or extruded Alloy 6063-T6 or Alloy 6061-T6 aluminum.
   b. Provide slotted holes for expansion and contraction where required.

D. Finishes:

1. Pipe and Post: In accordance with AA DAF45, designation AA-M32-C22-A41.
2. Cast Fittings and Toeboards: In accordance with AA DAF45, designation AA-M10-C22-A41.

2.02 ANCHOR BOLTS, FASTENERS, AND CONCRETE ANCHORS

A. Locknuts, Washers, and Screws:

1. Elastic Locknuts, Steel Flat Washers, Round Head Machine Screws (RHMS): AISI Type 316 stainless steel.
2. Flat Washers: Molded nylon.

B. Bolts and Nuts for Bolting Railing to Metal Beams: ASTM A193/A193M and ASTM A194/A194M, Type 316 stainless steel.

C. Concrete Anchors:

1. Stainless steel, AISI Type 316.
2. Post-installed anchors in accordance with Section 05 05 19, Post-installed Anchors, unless otherwise specified herein.

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3. Bolt Diameter: 1/2-inch, minimum.

2.03 FABRICATION

A. Shop Assembly:

1. Post Spacing: Maximum 6-foot horizontal spacing.
2. Railing Posts Bolted to Metal or Concrete:
   a. In lieu of field cutting, provide approved fitting with sufficient post overlap, containing provisions for vertical adjustment.
   b. Field fit-up is required.
3. Free of burrs, nicks, and sharp edges when fabrication is complete.
4. Welding is not permitted.

B. Shop/Factory Finishing:

1. Use same alloy for uniform appearance throughout fabrication for railings.
2. Railing and Post Fittings: Match fittings with color of pipe in railing.

C. Shop Assembly:

1. Shop assemble rails, posts, and formed elbows with a close tolerance for tight fit.
2. Fit dowels tightly inside posts.

D. Repair of Defective Work: Remove stains and replace defective Work.

PART 3 EXECUTION

3.01 GENERAL

A. Field fabrication of aluminum railing systems is not permitted.

B. Where required, provide railing posts longer than needed and field cut to exact dimensions required in order to satisfy vertical variations on actual structure.

C. Install railing with base that provides plus or minus 1/4-inch vertical adjustment inside base fitting. If adjustment is required in field and exceeds plus or minus 1/4-inch, reduce post length not to exceed beyond bottom of lowest setscrew or bolt in base fitting.

D. Modification to supporting structure is not permitted where railing is to be attached.

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E. Protection from Entrapped Water:

1. Make provisions in exterior and interior installations subject to high humidity to drain water from railing system.
2. For posts mounted in concrete, bends, and elbows occurring at low points, drill weep holes of 1/4-inch diameter at lowest possible elevations, one hole per post or rail. Drill hole in plane of rail.

3.02 RAILING INSTALLATION

A. Assembly and Installation: Perform in accordance with manufacturer's written recommendations for installation.

B. Expansion Joints:

1. Maximum intervals of 54 feet on center and at structural joints.
2. Slip joint with internal sleeve extending 2 inches beyond each side of joint. Provide 1/2-inch slip joint gap to allow for expansion.
3. Fasten to one side using 3/8-inch diameter setscrew. Place setscrew at bottom of pipe.
4. Locate joints within 12 inches of posts. Locate expansion joints in rails that span expansion joints in structural walls and floors supporting the posts.

C. Posts and Rails:

1. Surface Mounted Posts:
   a. Bolt post baseplate connectors firmly in place.
   b. Shims, wedges, grout, and similar devices for railing post alignment not permitted.
2. Set posts plumb and aligned to within 1/8 inch in 12 feet.
3. Set rails horizontal or parallel to slope of steps to within 1/8 inch in 12 feet.
4. Install posts and rails in same plane.
5. Remove projections or irregularities and provide a smooth surface for sliding hands continuously along top rail.
6. Use offset rail for use on stairs and platforms if post is attached to web of stringers or structural platform supports.
7. Support 1-1/2-inch rails directly above stairway stringers with offset fittings.

D. Wall Brackets:

1. Support wall rails on brackets spaced maximum 5 feet on centers as measured on the horizontal projection.

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E. Toeboard:

1. Provide at railings, except where 4-inch or higher concrete curbs are installed, at gates, or at stairways unless shown otherwise.
2. Accurately measure in field for correct length; after railing post installation cut and secure to posts.
3. Dimension between bottom of toeboard and walking surface not to exceed 1/4 inch.
4. Install plumb and aligned to within 1/8 inch in 12 feet.
5. Attach toeboards to posts via clamp that complies with design requirements while facilitating expansion and contraction. Do not screw directly to post or base.

3.03 FIELD FINISHING

A. Corrosion Protection: Prevent galvanic action and other forms of corrosion caused from direct contact with concrete and dissimilar metals by coating metal surfaces as specified in Section 09 90 00, Painting and Coating.

3.04 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Post-installed anchors supporting railing systems require special inspection.

B. Owner-Furnished Quality Assurance, in accordance with ICC IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan on Drawings. Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.

3.05 CLEANING

A. Wash railing system thoroughly using clean water and soap. Rinse with clean water.

B. Do not use acid solution, steel wool, or other harsh abrasive.

C. If stain remains after washing, restore in accordance with railing manufacturer’s recommendations or replace stained railings.

END OF SECTION

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SECTION 09 90 00
PAINTING AND COATING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA):
   a. C203, Coal-Tar Protective Coatings and Linings for Steel Water Pipelines—Enamel and Tape—Hot-Applied.
   b. C209, Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
   c. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
   d. C214, Tape Coating Systems for the Exterior of Steel Water Pipelines.
2. Environmental Protection Agency (EPA).
3. NACE International (NACE): SP0188, Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
4. NSF International (NSF): 61, Drinking Water System Components - Health Effects.
5. Occupational Safety and Health Act (OSHA).
6. Research Council on Structural Connections (RCSC): Specification for Structural Joints using High-Strength Bolts.
7. The Society for Protective Coatings (SSPC):
   a. PA 2, Procedure for Determining Conformance to Dry Coating Thickness Requirements.
   b. PA 10, Guide to Safety and Health Requirements for Industrial Painting Projects.
   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 16, Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.
   l. SP 13, Surface Preparation of Concrete.

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m. Guide 15, Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates.

1.02 DEFINITIONS

A. Terms used in this section:

1. Coverage: Total minimum dry film thickness in mils or square feet per gallon.
2. FRP: Fiberglass Reinforced Plastic.
3. HCl: Hydrochloric Acid.
4. MDFT: Minimum Dry Film Thickness, mils.
5. MDFTPC: Minimum Dry Film Thickness per Coat, mils.
6. Mil: Thousandth of an inch.
7. PDS: Product Data Sheet.
8. PSDS: Paint System Data Sheet.
9. PVC: Polyvinyl Chloride.
10. SFPG: Square Feet per Gallon.
11. SFPGPC: Square Feet per Gallon per Coat.
12. SP: Surface Preparation.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Data Sheets:
      1) 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.
      2) For each paint system, furnish a Paint System Data Sheet (PSDS). The PSDS form is appended to the end of this section.
      3) Technical and performance information that demonstrates compliance with specification.
      4) Furnish copies of paint system submittals to the coating applicator.
      5) Indiscriminate submittal of only manufacturer’s literature is not acceptable.
   b. Detailed chemical and gradation analysis for each proposed abrasive material.

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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 by 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, finishes, and textures are approved.
            c) Approved samples to be the quality standard for final finishes.

B. Informational Submittals:

1. Applicator's Qualification: List of references substantiating experience.
2. Coating manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services.
3. Factory Applied Coatings: Manufacturer's certification stating factory applied coating system meets or exceeds requirements specified.
4. Manufacturer's written verification that submitted material is suitable for the intended use.
5. Coating for Faying Surfaces: Manufacturer's test results that show the proposed coating meets the slip resistance requirements of the AISC Specification for Structural Joints using ASTM A325 or ASTM A490 bolts.
6. If the manufacturer of finish coating differs from that of shop primer, provide finish coating manufacturer's written confirmation that materials are compatible.
7. Manufacturer's written instructions and special details for applying each type of paint.

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1.04 QUALITY ASSURANCE

A. Applicator Qualifications: Minimum 5 years' experience in application of specified products.

B. 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 10.
   c. Federal, state, and local agencies having jurisdiction.

C. Mockup:

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 shall serve as a standard for similar work throughout the Project.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Shipping:

1. Where precoated items are to be shipped to the Site, protect coating from damage. Batten coated items to prevent abrasion.
2. Protect shop painted surfaces during shipment and handling by suitable provisions including padding, blocking, and use of canvas or nylon slings.

B. Storage:

1. Store products in a protected area that is heated or cooled to maintain temperatures within the range recommended by paint manufacturer.
2. Primed surfaces shall not be exposed to weather for more than 2 months before being topcoated, or less time if recommended by coating manufacturer.

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1.06 PROJECT CONDITIONS

A. Environmental Requirements:

1. Do not apply paint in temperatures or moisture conditions outside of manufacturer's recommended maximum or minimum allowable.
2. Do not perform final abrasive blast cleaning whenever relative humidity exceeds 85 percent, or whenever surface temperature is less than 5 degrees F above dew point of ambient air.

B. Status of Existing Coatings: The following information on existing coatings or substrate conditions is provided for information only, and is generally believed to be accurate, but is not guaranteed. Perform tests as required to verify applicability of this information to the Work.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Nationally recognized manufacturers of paints and protective coatings who are regularly engaged in the production of such materials for essentially identical service conditions.

B. Minimum of 5 years' verifiable experience in manufacture of specified product.

C. Each of the following manufacturers is capable of supplying most of the products specified herein:

1. Tnemec Coatings.
2. Sherwin Williams.
3. Carboline Coatings Company.

2.02 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.

2.03 PAINT MATERIALS

A. General:

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

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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:

Product	Definition
Acrylic Latex	Single-component, finish as required
Acrylic Latex (Flat)	Flat latex
Acrylic Sealer	Clear acrylic
Alkyd (Semigloss)	Semigloss alkyd
Alkyd Enamel	Optimum quality, gloss or semigloss finish as required, medium long oil
Alkyd Wood Primer	Flat alkyd
Bituminous Paint	Single-component, coal-tar pitch based
Block Filler	Primer-sealer designed for rough masonry surfaces, 100% acrylic emulsion
Coal-Tar Epoxy	Amine, polyamide, or phenolic epoxy type 70% volume solids minimum, suitable for immersion service
DTM Acrylic Primer	Surface tolerant, direct-to-metal water borne acrylic primer
DTM Acrylic Finish	Surface tolerant, direct-to-metal water borne acrylic finish coat
Elastomeric Polyurethane	100% solids, plural component, spray applied, high build, elastomeric polyurethane coating, suitable for the intended service
Epoxy Filler/Surfacer	100% solids epoxy trowel grade filler and surfacer, nonshrinking, suitable for application to concrete and masonry. Approved for potable water contact and conforming to NSF 61, where required
Epoxy Nonskid (Aggregated)	Polyamidoamine or amine converted epoxies aggregated; aggregate may be packaged separately

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Product	Definition
Epoxy Primer—Ferrous Metal	Anticorrosive, converted epoxy primer containing rust-inhibitive pigments
Epoxy Primer—Other	Epoxy primer, high-build, as recommended by coating manufacturer for specific galvanized metal, copper, or nonferrous metal alloy to be coated
Fusion Bonded Coating	100% solids, thermosetting, fusion bonded, dry powder epoxy, suitable for the intended service
TFE Lube or Grease Lube	Tetrafluoroethylene, liquid coating, or open gear grease as supplied by McMaster-Carr Supply Corporation, Elmhurst, IL
High Build Epoxy	Polyamidoamine epoxy, minimum 69% volume solids, capability of 4 to 8 MDFT per coat
Inorganic Zinc Primer	Solvent or water based, having 85% metallic zinc content in the dry film; follow manufacturer's recommendation for topcoating
Latex Primer Sealer	Waterborne vinyl acrylic primer/sealer for interior gypsum board and plaster. Capable of providing uniform seal and suitable for use with specified finish coats
NSF Epoxy	Polyamidoamine epoxy, approved for potable water contact and conforming to NSF 61
Epoxy, High Solids	Polyamidoamine epoxy, 80% volume solids, minimum, suitable for immersion service
Polyurethane Enamel	Two-component, aliphatic or acrylic based polyurethane; high gloss finish
Organic Zinc Rich Primer	Epoxy or moisture cured urethane with 85-percent zinc content in the dry film, meeting the requirements of RCSC Specification for Structural Joints using High Strength Bolts, Class A or Class B, as required.
Rust-Inhibitive Primer	Single-package steel primers with anticorrosive pigment loading
Sanding Sealer	Co-polymer oil, clear, dull luster
Silicone/Silicone Acrylic	Elevated temperature silicone or silicone/acrylic based
Stain, Concrete	Acrylic, water repellant, penetrating stain

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Product	Definition
Stain, Wood	Satin luster, linseed oil, solid or transparent as required
Varnish	Nonpigmented vehicle based on a variety of resins (alkyd, phenolic, urethane) in gloss, semigloss, or flat finishes, as required
Water Base Epoxy	Two-component, polyamide epoxy emulsion, finish as required

2.04 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 and for painting other small areas.
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 might be affected by presence of hydrogen sulfide or other gas likely to be present at Site.

2.05 SHOP FINISHES

A. Shop Blast Cleaning: Reference Paragraph, Shop Coating Requirements.

B. Surface Preparation: Provide Engineer minimum 7 days' advance notice to start of shop surface preparation work and coating application work.

C. Shop Coating Requirements:

1. When required by equipment specifications, such equipment shall be primed and finish coated in shop by manufacturer and touched up in field with identical material after installation.
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, tie-coat shall be surface tolerant epoxy as recommended by

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manufacturer of specified field finish coat. Coordinate details of equipment manufacturer's standard coating with field coating manufacturer.

D. Pipe:

1. Ductile Iron Pipe:
   a. Use SSPC standards as a guide for desired prepared surface. Follow recommendations of pipe and coating manufacturers for means and methods to achieve SSPC-equivalent surface.
   b. The surface preparation and application of the primer shall be performed by pipe manufacturer.
   c. For high performance (epoxy) coatings, follow additional recommendations of pipe and coating manufacturers.
   d. Prior to blast cleaning, grind smooth surface imperfections, including, but not limited to delaminating metal or oxide layers.
2. Steel Pipe:
   a. Surface preparation and application of primer shall be performed by pipe manufacturer.
   b. For pipe with epoxy lining, do not place end cap seals until pipe lining material has sufficiently dried.

PART 3 EXECUTION

3.01 GENERAL

A. Provide Engineer minimum 7 days' advance notice to start of field surface preparation work and coating application work.

B. Perform the Work only in presence of Engineer, unless Engineer grants prior approval to perform the Work in Engineer's absence.

C. Schedule inspection of cleaned surfaces and all coats prior to succeeding coat in advance with Engineer.

3.02 EXAMINATION

A. Factory Finished Items:

1. Schedule inspection with Engineer before repairing damaged factory-finished items delivered to Site.
2. Repair abraded or otherwise damaged areas on factory-finished items as recommended by coating manufacturer. Carefully blend repaired areas into original finish. If required to match colors, provide full finish coat in field.

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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. The more stringent requirements shall apply.

3.03 PROTECTION OF ITEMS NOT TO BE PAINTED

A. 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.

B. Provide drop cloths to prevent paint materials from falling on or marring adjacent surfaces.

C. Protect working parts of mechanical and electrical equipment from damage during surface preparation and painting process.

D. Mask openings in motors to prevent paint and other materials from entering.

E. Protect surfaces adjacent to or downwind of Work area from overspray.

3.04 SURFACE PREPARATION

A. Field Abrasive Blasting:

1. Perform blasting for items and equipment where specified and as required to restore damaged surfaces previously shop or field blasted and primed or coated.
2. Refer to coating systems for degree of abrasive blasting required.
3. Where the specified degree of surface preparation differs from manufacturer’s recommendations, the more stringent shall apply.

B. Metal Surface Preparation:

1. Where indicated, meet requirements of SSPC Specifications summarized below:
    a. SP 1, Solvent Cleaning: Removal of visible oil, grease, soil, drawing and cutting compounds, and other soluble contaminants by cleaning with solvent.
    b. SP 2, Hand Tool Cleaning: Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, using nonpower hand tools.

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c. SP 3, Power Tool Cleaning: Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, using power-assisted hand tools.
d. SP 5, White Metal Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter by blast cleaning.
e. SP 6, Commercial Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter, except for random staining limited to no more than 33 percent of each unit area of surface which may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coatings.
f. SP 7, Brush-Off Blast Cleaning: Removal of visible rust, oil, grease, soil, dust, loose mill scale, loose rust, and loose coatings. Tightly adherent mill scale, rust, and coating may remain on surface.
g. SP 10, Near-White Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter, except for random staining limited to no more than 5 percent of each unit area of surface which may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coatings.
h. SP 11, Power Tool Cleaning to Bare Metal: Removal of visible oil, grease, dirt, dust, mill scale, rust, paint, oxide, corrosion products, and other foreign matter using power-assisted hand tools capable of producing suitable surface profile. Slight residues of rust and paint may be left in lower portion of pits if original surface is pitted.
i. SP-16, Brush Blasting of Non-Ferrous Metals: A brush-off blast cleaned non-ferrous metal surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, metal oxides (corrosion products), and other foreign matter. Intact, tightly adherent coating is permitted to remain. A coating is considered tightly adherent if it cannot be removed by lifting with a dull putty knife. Bare metal substrates shall have a minimum profile of 19 micrometers (0.75 mil).

2. The words “solvent cleaning”, “hand tool cleaning”, “wire brushing”, and “blast cleaning”, or similar words of equal intent in these Specifications or in paint manufacturer’s specification refer to the applicable SSPC Specification.
3. Where OSHA or EPA regulations preclude standard abrasive blast cleaning, wet or vacu-blast methods may be required. Coating

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manufacturers' recommendations for wet blast additives and first coat application shall apply.

4. Ductile Iron Pipe Supplied with Asphaltic Varnish Finish: Remove asphaltic varnish finish prior to performing specified surface preparation.
5. Hand tool clean areas that cannot be cleaned by power tool cleaning.
6. Round or chamfer sharp edges and grind smooth burrs, jagged edges, and surface defects.
7. Welds and Adjacent Areas:
    a. Prepare such that there is:
        1) No undercutting or reverse ridges on weld bead.
        2) No weld spatter on or adjacent to weld or any area to be painted.
        3) No sharp peaks or ridges along weld bead.
    b. Grind embedded pieces of electrode or wire flush with adjacent surface of weld bead.
8. Preblast Cleaning Requirements:
    a. Remove oil, grease, welding fluxes, and other surface contaminants prior to blast cleaning.
    b. Cleaning Methods: Steam, open flame, hot water, or cold water with appropriate detergent additives followed with clean water rinsing.
    c. Clean small isolated areas as above or solvent clean with suitable solvent and clean cloth.
9. Blast Cleaning Requirements:
    a. Type of Equipment and Speed of Travel: Design to obtain specified degree of cleanliness. Minimum surface preparation is as specified herein and takes precedence over coating manufacturer's recommendations.
    b. Select type and size of abrasive to produce surface profile that meets coating manufacturer's recommendations for particular primer to be used.
    c. Use only dry blast cleaning methods.
    d. Do not reuse abrasive, except for designed recyclable systems.
    e. Meet applicable federal, state, and local air pollution and environmental control regulations for blast cleaning, confined space entry (if required), and disposition of spent aggregate and debris.
10. Post-Blast Cleaning and Other Cleaning Requirements:
    a. Clean surfaces of dust and residual particles from cleaning operations by dry (no oil or water vapor) air blast cleaning or other method prior to painting. Vacuum clean enclosed areas and

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other areas where dust settling is a problem and wipe with a tack cloth.

b. Paint surfaces the same day they are blasted. Reblast surfaces that have started to rust before they are painted.

C. Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation:

1. Remove soil, cement spatter, and other surface dirt with appropriate hand or power tools.
2. Brush blast in accordance with SSPC SP 16.
3. Obtain and follow coating manufacturer's recommendations for additional preparation that may be required.

D. Concrete Surface Preparation:

1. Do not begin until 30 days after concrete has been placed.
2. Meet requirements of SSPC SP 13.
3. Remove grease, oil, dirt, salts or other chemicals, loose materials, or other foreign matter by solvent, detergent, or other suitable cleaning methods.
4. Brush-off blast clean to remove loose concrete and laitance, and provide a tooth for binding. Upon approval by Engineer, surface may be cleaned by acid etching method. Approval is subject to producing desired profile equivalent to No. 80 grit flint sandpaper. Acid etching of vertical or overhead surfaces shall not be allowed.
5. Secure coating manufacturer's recommendations for additional preparation, if required, for excessive bug holes exposed after blasting.
6. Unless otherwise required for proper adhesion, ensure surfaces are dry prior to painting.

E. Plastic and FRP Surface Preparation:

1. Hand sand plastic surfaces to be coated with medium grit sandpaper to provide tooth for coating system.
2. Large areas may be power sanded, or brush-off blasted, provided sufficient controls are employed so surface is roughened without removing excess material.

F. Masonry Surface Preparation:

1. Complete and cure masonry construction for 14 days or more before starting surface preparation work.
2. Remove oil, grease, dirt, salts or other chemicals, loose materials, or other foreign matter by solvent, detergent washing, or other suitable cleaning methods.

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3. Clean masonry surfaces of mortar and grout spillage and other surface deposits using one of the following:
    a. Nonmetallic fiber brushes and commercial muriatic acid followed by rinsing with clean water.
    b. Brush-off blasting.
    c. Water blasting.
4. Do not damage masonry mortar joints or adjacent surfaces.
5. Leave surfaces clean and, unless otherwise required for proper adhesion, dry prior to painting.
6. Masonry Surfaces to be Painted: Uniform texture and free of surface imperfections that would impair intended finished appearance.
7. Masonry Surfaces to be Clear Coated: Free of discolorations and uniform in texture after cleaning.

G. Wood Surface Preparation:

1. Replace damaged wood surfaces or repair in a manner acceptable to Engineer prior to start of surface preparation.
2. Solvent clean (mineral spirits) knots and other resinous areas and coat with shellac or other knot sealer, prior to painting. Remove pitch by scraping and wipe clean with mineral spirits or turpentine prior to applying knot sealer.
3. Round sharp edges by light sanding prior to priming.
4. Filler:
    a. Synthetic-based wood putty approved by paint manufacturer for paint system.
    b. For natural finishes, color of wood putty shall match color of finished wood.
    c. Fill holes, cracks, and other surface irregularities flush with surrounding surface and sand smooth.
    d. Apply putty before or after prime coat, depending on compatibility and putty manufacturer’s recommendations.
    e. Use cellulose type putty for stained wood surfaces.
5. Ensure surfaces are clean and dry prior to painting.

H. Gypsum Board Surface Preparation: Typically, new gypsum board surfaces need no special preparation before painting.

1. Surface Finish: Dry, free of dust, dirt, powdery residue, grease, oil, or any other contaminants.

I. Existing Painted Surfaces to be Repainted Surface Preparation:

1. Detergent wash and freshwater rinse.

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2. Clean loose, abraded, or damaged coatings to substrate by hand or power tool, SP 2 or SP 3.
3. Feather surrounding intact coating.
4. Apply one spot coat of specified primer to bare areas, overlapping prepared existing coating.
5. Apply one full finish coat of specified primer to entire surface.
6. If an aged, plural-component material is to be topcoated, contact coating manufacturer for additional surface preparation requirements.
7. Application of Cosmetic Coat:
   a. It is assumed that existing coatings have oxidized sufficiently to prevent lifting or peeling when overcoated with paints specified.
   b. Check compatibility by application to a small area prior to starting painting.
   c. If lifting or other problems occur, request disposition from Engineer.
8. Perform blasting as required to restore damaged surfaces. Materials, equipment, procedures shall meet requirements of SSPC.

3.05 SURFACE CLEANING

A. Brush-off Blast Cleaning:

1. Equipment, procedure, and degree of cleaning shall meet requirements of SSPC SP 7.
2. Abrasive: Either wet or dry blasting sand, grit, or nutshell.
3. Select various surface preparation parameters, such as size and hardness of abrasive, nozzle size, air pressure, and nozzle distance from surface such that surface is cleaned without pitting, chipping, or other damage.
4. Verify parameter selection by blast cleaning a trial area that will not be exposed to view.
5. Engineer will review acceptable trial blast cleaned area and use area as a representative sample of surface preparation.
6. Repair or replace surface damaged by blast cleaning.

B. Acid Etching:

1. After precleaning, spread the following solution by brush or plastic sprinkling can: One part commercial muriatic acid reduced by two parts water by volume. Adding acid to water in these proportions gives an approximate 10 percent solution of HCl.
2. Application:
   a. Rate: Approximately 2 gallons per 100 square feet.
   b. Work acid solution into surface by hard-bristled brushes or brooms until complete wetting and coverage is obtained.

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c. Acid will react vigorously for a few minutes, during which time brushing shall be continued.
d. After bubbling subsides (10 minutes), hose down remaining slurry with high pressure clean water.
e. Rinse immediately to avoid formation on the surface of salts that are difficult to remove.
f. Thoroughly rinse to remove any residual acid surface condition that may impair adhesion.

3. Ensure surface is completely dry before application of coating.
4. Apply acid etching to obtain a “grit sandpaper” surface profile. If not, repeat treatment.

C. Solvent Cleaning:

1. Consists of removal of foreign matter such as oil, grease, soil, drawing and cutting compounds, and any other surface contaminants by using solvents, emulsions, cleaning compounds, steam cleaning, or similar materials and methods that involve a solvent or cleaning action.
2. Meet requirements of SSPC SP 1.

3.06 APPLICATION

A. General:

1. The intention of these Specifications is for existing and new, interior and exterior masonry, concrete, and metal, surfaces to be painted, whether specifically mentioned or not, except as specified otherwise. Do not paint exterior concrete surfaces, unless specifically indicated.
2. Extent of Coating (Immersion): Coatings shall be applied to internal vessel and pipe surfaces, nozzle bores, flange gasket sealing surfaces, carbon steel internals, and stainless steel internals, unless otherwise specified.
3. For coatings subject to immersion, obtain full cure for completed system. Consult coatings manufacturer’s written instructions for these requirements. Do not immerse coating until completion of curing cycle.
4. Apply coatings in accordance with these Specifications and paint manufacturers’ printed recommendations and special details. The more stringent requirements shall apply. Allow sufficient time between coats to assure thorough drying of previously applied paint.
5. Sand wood lightly between coats to achieve required finish.
6. Vacuum clean surfaces free of loose particles. Use tack cloth just prior to applying next coat.
7. Fusion Bonded Coatings Method Application: Electrostatic, fluidized bed, or flocking.

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8. Coat units or surfaces to be bolted together or joined closely to structures or to one another prior to assembly or installation.
9. Water-Resistant Gypsum Board: Use only solvent type paints and coatings.
10. On pipelines, terminate coatings along pipe runs to 1 inch inside pipe penetrations.
11. Keep paint materials sealed when not in use.
12. Where more than one coat is applied within a given system, alternate colors to provide a visual reference showing required number of coats have been applied.

B. Galvanized Metal, Copper, and Nonferrous Metal Alloys:

1. Concealed galvanized, copper, and nonferrous metal alloy surfaces (behind building panels or walls) do not require painting, unless specifically indicated herein.
2. Prepare surface and apply primer in accordance with System No. 10 specification.
3. Apply intermediate and finish coats of the coating system appropriate for the exposure.

C. Porous Surfaces, Such as Concrete and Masonry:

1. Filler/Surfacer: Use coating manufacturer's recommended product to fill air holes, bug holes, and other surface voids or defects.
2. Prime Coat: May be thinned to provide maximum penetration and adhesion.
    a. Type and Amount of Thinning: Determined by paint manufacturer and dependent on surface density and type of coating.
3. Surface Specified to Receive Water Base Coating: Damp, but free of running water, just prior to application of coating.

D. Film Thickness and Coverage:

1. Number of Coats:
    a. Minimum required without regard to coating thickness.
    b. Additional coats may be required to obtain minimum required paint thickness, depending on method of application, differences in manufacturers' products, and atmospheric conditions.
2. Application Thickness:
    a. Do not exceed coating manufacturer's recommendations.
    b. Measure using a wet film thickness gauge to ensure proper coating thickness during application.

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3. Film Thickness Measurements and Electrical Inspection of Coated Surfaces:
   a. Perform with properly calibrated instruments.
   b. Recoat and repair as necessary for compliance with specification.
   c. Coats are subject to inspection by Engineer and coating manufacturer's representative.
4. Visually inspect concrete, masonry, nonferrous metal, plastic, and wood surfaces to ensure proper and complete coverage has been attained.
5. Give particular attention to edges, angles, flanges, and other similar areas, where insufficient film thicknesses are likely to be present, and ensure proper millage in these areas.
6. Apply additional coats as required to achieve complete hiding of underlying coats. Hiding shall be so complete that additional coats would not increase the hiding.

3.07 PROTECTIVE COATINGS SYSTEMS AND APPLICATION SCHEDULE

A. Unless otherwise shown or specified, paint surfaces in accordance with the following application schedule. In the event of discrepancies or omissions in the following, request clarification from Engineer before starting work in question.

B. As shown in Finish Schedule on Drawings.

C. System No. 2 Submerged Metal—Domestic Sewage:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 5, White Metal Blast Cleaning	Prime in accordance with manufacturer's recommendations	
	Coal-Tar Epoxy -OR- High Build Epoxy	2 coats, 16 MDFT 2 coats, 16 MDFT

1. Use on the following items or areas:
   a. Metal surfaces below a plane 1 foot above maximum liquid surface, metal surfaces above maximum liquid surface that are a part of immersed equipment, concrete embedded surfaces of metallic items, such as wall pipes, pipes, pipe sleeves, and structural steel.

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D. System No. 5 Exposed Metal—Mildly Corrosive:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Epoxy Primer—Ferrous Metal	1 coat, 2.5 MDFT
	Polyurethane Enamel	1 coat, 3 MDFT

1. Use on the following items or areas:
   a. Exposed metal surfaces, new and existing located inside or outside of structures and exposed to weather or in a highly humid atmosphere, such as pipe galleries and similar areas

E. System No. 6 Exposed Metal—Atmospheric:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 6, Commercial Blast Cleaning	Rust-Inhibitive Primer	1 coat, 2 MDFT
	Alkyd Enamel	2 coats, 4 MDFT

1. Use on the following items or areas:
   a. Exposed metal surfaces, new and existing located inside or outside of structures or exposed to weather, including vents, louvers, exterior metal ductwork, flashing, sheet metalwork and miscellaneous architectural metal trim.
   b. Apply surface preparation and primer to surfaces prior to installation. Finish coats need only be applied to surfaces exposed after completion of construction.

F. System No. 18a Concrete Exposed Metal Repair Coating—Potable Water and Non-Submerged:

Surface Prep.	Paint Material	Min. Coats, Cover
Brush blast concrete in accordance with Paragraph Concrete Surface Preparation; blast exposed reinforcing steel to Near White Metal, SSPC SP10. See Note 1	NSF Epoxy; finish color white	2 coats, 4 MDFTPC, see Note 2.

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Surface Prep.	Paint Material	Min. Coats, Cover
Note 1. Surface Preparation Alternative: Mechanical abrade concrete surfaces to meet International Concrete Restoration Association standard 37/32, Concrete Surface Profile No. 3. Mechanically abrade exposed ends of reinforcing steel in accordance with SSPC SP-11. Note 2. Brush out surface voids and irregularities to provide a monolithic film.		

1. Use this system:
   a. On saw-cut concrete surfaces that will not receive new concrete to cover exposed ends of rebar and metal embeds. Or alternately, where approved, over ends of and minimum 2 inches around ends of exposed metal and rebar in lieu of entire surface.

G. System No. 19a Concrete Exposed Metal Repair Coating—Wastewater:

Surface Prep.	Paint Material	Min. Coats, Cover
Brush blast concrete in accordance with Paragraph Concrete Surface Preparation; blast exposed reinforcing steel to Near White Metal, SSPC SP10. See Note 1.	Amine-cured epoxy, suitable for exposure to primary wastewater, finish color gray.	2 coats, 8 MDFTPC, see Note 2.
Note 1. Surface Preparation Alternative: Mechanical abrade concrete surfaces to meet International Concrete Restoration Association standard 37/32, Concrete Surface Profile No. 3. Mechanically abrade exposed ends of reinforcing steel in accordance with SSPC SP-11. Note 2. Brush out surface voids and irregularities to provide a monolithic film.		

1. On saw-cut concrete surfaces that will not receive new concrete to cover exposed ends of rebar and metal embeds. Or alternately, where approved, over ends of and minimum two inches around ends of exposed metal and rebar in lieu of entire surface.

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H. System No. 25 Exposed FRP, PVC, CPVC:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Plastic and FRP Surface Preparation	Acrylic Latex Semigloss	2 coats, 320 SFPGPC

1. Use on the following items or areas:
   a. All new and existing exposed-to-view PVC and CPVC surfaces, FRP, and other plastic surfaces without integral UV-resistant gel coat.

I. System No. 27 Aluminum and Dissimilar Metal Insulation:

Surface Prep.	**Paint Material**	**Min. Coats, Cover**
Solvent Clean (SP 1)	Prime in accordance with manufacturer's recommendations	
	Bituminous Paint	1 coat, 10 MDFT

1. Use on aluminum surfaces embedded or in contact with concrete.

3.08 ARCHITECTURAL PAINT SYSTEMS AND APPLICATION SCHEDULE

A. Unless otherwise shown or specified, paint surfaces in accordance with the following application schedule. In the event of discrepancies or omissions in the following, request clarification from Engineer before starting work in question.

B. System No. 106 Galvanized Metal:

Surface Prep.	**Paint Material**	**Min. Coats, Cover**
In accordance with Paragraph Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation	Manufacturer's Recommended Primer	1 coat, as recommended by manufacturer
	Alkyd Enamel (Semigloss)	2 coats, 4 MDFT

1. Use on the following items or areas:
   a. New structural support beams and columns, interior.

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3.09 COLORS

A. Provide as designated herein and shown in Piping Schedule.

B. Proprietary identification of colors is for identification only. Selected manufacturer may supply matches.

C. Equipment Colors:

1. Equipment includes the machinery or vessel itself plus the structural supports and fasteners and attached electrical conduits.
2. Paint equipment and piping one color as selected.
3. Paint nonsubmerged portions of equipment the same color as the piping it serves, except as itemized below:
   a. Dangerous Parts of Equipment and Machinery: OSHA Orange.
   b. Fire Protection Equipment and Apparatus: OSHA Red.
   c. Radiation Hazards: OSHA Purple.
   d. Physical hazards in normal operating area and energy lockout devices, including, but not limited to, electrical disconnects for equipment and equipment isolation valves in air and liquid lines under pressure: OSHA Yellow.

D. Pipe Identification Painting:

1. Color code nonsubmerged metal piping, except electrical conduit. Paint fittings and valves the same color as pipe, except equipment isolation valves.
2. Pipe Color Coding: In accordance with Piping Schedule.
3. On exposed stainless steel piping, apply color 24 inches in length along pipe axis at connections to equipment, valves, or branch fittings, at wall boundaries, and at intervals along piping not greater than 9 feet on center.
4. Pipe Supports: Painted light gray, as approved by Owner.

3.10 FIELD QUALITY CONTROL

A. Testing Equipment:

1. Provide calibrated electronic type dry film thickness gauge to test coating thickness specified in mils.
2. Provide low-voltage wet sponge electrical holiday detector to test completed coating systems, 20 mils dry film thickness or less, except zinc primer, high-build elastomeric coatings, and galvanizing, for pinholes, holidays, and discontinuities, as manufactured by Tinker and Rasor, San Gabriel, CA, Model M-1.

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3. Provide high-voltage spark tester to test completed coating systems in excess of 20 mils dry film thickness. Unit as recommended by coating manufacturer.

B. Testing:

1. Thickness and Continuity Testing:
   a. Measure coating thickness specified in mils with a 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 SP0188.
   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 SP0188.
   d. After repaired and recoated areas have dried sufficiently, retest each repaired area. Final tests may also be conducted by Engineer.

C. 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.

D. 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.

E. Damaged Coatings, Pinholes, and Holidays:

1. Hand or power sand visible areas of chipped, peeled, or abraded paint, and feather edges. Follow with primer and finish coat. Depending on extent of repair and appearance, a finish sanding and topcoat may be required.
2. Remove rust and contaminants from metal surface. Provide surface cleanliness and profile in accordance with surface preparation requirements for specified paint system.

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3. Feather edges and repair in accordance with recommendations of paint manufacturer.
4. Apply finish coats, including touchup and damage-repair coats in a manner that will present a uniform texture and color-matched appearance.

3.11 MANUFACTURER'S SERVICES

A. In accordance with Section 01 43 33, Manufacturers' Field Services, coating manufacturer's representative shall be present at Site as follows:

1. On first day of application of any coating system.
2. A minimum of two additional Site inspection visits, each for a minimum of 4 hours, in order to provide Manufacturer's Certificate of Proper Installation.
3. As required to resolve field problems attributable to or associated with manufacturer's product.
4. To verify full cure of coating prior to coated surfaces being placed into immersion service.

3.12 CLEANUP

A. Place cloths and waste that might constitute a fire hazard in closed metal containers or destroy at end of each day.

B. Upon completion of the Work, remove staging, scaffolding, and containers from Site or destroy in a legal manner.

C. Remove paint spots, oil, or stains upon adjacent surfaces and floors and leave entire job clean.

3.13 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are part of this specification:

1. Paint System Data Sheet (PSDS)
2. Product Data Sheet (PDS).

END OF SECTION

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

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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 recommendations 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.

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SECTION 10 14 00
SIGNAGE

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Society of Mechanical Engineers (ASME): A13.1, Scheme for the Identification of Piping Systems.
2. ASTM International (ASTM):
   a. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
   b. D709, Standard Specification for Laminated Thermosetting Materials.
3. The Chlorine Institute, Inc.: WC-1, Wall Chart: Handling Chlorine Cylinders and Ton Containers.
4. National Fire Protection Association (NFPA):
   a. 704, Standard System for the Identification of the Hazards of Materials for Emergency Response.
   b. HAZ-01, Fire Protection Guide to Hazardous Materials.
5. Occupational Safety and Health Act (OSHA).

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Drawings showing layouts, actual letter sizes and styles, and Project-specific mounting details.
   b. Manufacturer’s literature showing letter sizes and styles, sign materials, and standard mounting details.
2. Samples: One full size for each type of nameplate, sign, and label specified.

B. Informational Submittals: Manufacturer’s installation instructions.

PART 2 PRODUCTS

2.01 GENERAL

A. Meet requirements of Occupational Safety and Health Act (OSHA).

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2.02 DOOR NAMEPLATES

A. Material: Plastic with square corners.

B. Thickness:1/8 inch.

C. Height: 2 inches.

D. Finish: Nondirectional matte.

E. Background: Matching other existing door nameplates in Building G/2.

F. Letters: Raised.

1. Size: 1-inch high.
2. Color: White.
3. Style: Matching other existing door nameplates in Building 69.
4. Braille Text: Domed or rounded as required by ADA regulations, with 3/8-inch minimum clearance on all sides.

G. Manufacturers and Products:

1. Best Sign Systems, Montrose, CO; Graphic Blast.
2. Andco Industries Corp., Greensboro, NC; 1400 series.

2.03 SIGNS

A. Plastic Sign (Type A):

1. Exterior: Laminated plastic subsurface image type, 3/16-inch-thick with high-gloss finish.
2. Interior: Plastic, 1/8-inch-thick with nondirectional matte finish and raised letters.
3. Rounded corners.

B. Fiberglass Sign (Type C):

1. Material: Three-ply laminated fiberglass, minimum 1/8-inch-thick, with contrasting color core message layer between two clear weather-resistant surface layers.
2. Manufacturers:
   a. Best Sign Systems.
   b. Brady Signmark.

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C. Hazardous Material Sign (Type H):

1. Conform to NFPA 704 and NFPA HAZ-01.
2. Material: Fiberglass 1/8-inch-thick.
3. Background, Letters, and Numbers: Die-cut vinyl with pressure sensitive adhesive.
4. Manufacturers:
    a. Brady Signmark.
    b. Emed Co., Inc.

2.04 IDENTIFICATION LABELS

A. Pipe Labels:

1. Labels:
    a. Snap-on, reversible type with lettering and directional arrows, sized for outside diameter of pipe and insulation.
    b. Provided with ties or straps for pipes of 6 inches and over diameter.
    c. Designed to firmly grip pipe so labels remain fixed in vertical pipe runs.
2. Material: Heavy-duty vinyl or polyester, suitable for exterior use, long lasting, and resistance to moisture, grease, and oils.
3. Letters and Arrows: Black on OSHA safety yellow background.
4. Color Field and Letter Height: Meet ASME A13.1.
5. Message: Piping system name as indicated on Piping Schedule.
6. Manufacturers and Products:
    a. Brady Signmark; B-915 Brady Snap-On and Strap-On Pipe Markers.
    b. Seton Identification Products; Ultra-mark Pipe Markers.

B. Equipment Labels:

1. Applies to equipment with assigned tag numbers, where specified.
2. Letters: Black bold face, 3/4 inch minimum high.
3. Background: OSHA safety yellow.
4. Materials:
    a. Aluminum or stainless steel with a baked-on finish suitable for use on wet, oily, exposed, abrasive, and corrosive areas.
5. Furnish 1-inch margin with holes at each end of label, for mounting. On fiberglass labels, furnish grommets at each hole.

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6. Size:
    a. 2 inches minimum and 3 inches maximum high, by 14 inches minimum and 18 inches maximum long.
    b. Furnish same size base dimensions for all labels.
7. Message: Equipment names and tag numbers as used in sections where equipment is specified.
8. Manufacturers:
    a. Brady Signmark.
    b. Seton Identification Products.

2.05 ANCILLARY MATERIALS

A. Fasteners: Stainless steel screws or bolts of appropriate sizes.

B. Pipe Posts: 2-1/2-inch galvanized steel pipe meeting ASTM A53, Type S, Grade B.

C. Chain: Type 304 stainless steel, No. 16 single jack chain or No. 2 double loop coil chain.

D. Manufacturer’s standard brackets for wall mounting of two-sided exit signs.

PART 3 EXECUTION

3.01 INSTALLATION—GENERAL

A. In accordance with manufacturer’s recommendations.

B. Mount securely, plumb, and level.

C. All signs to be located as directed by the Owner or Engineer.

3.02 DOOR NAMEPLATES AND PICTORIAL SYMBOLS

A. Attach to doors or walls adjacent to doors with self-sticking removable adhesive. See: Door Nameplate Schedule for locations and messages.

B. Mount with bottom of nameplate at 5 feet 6 inches above floor.

3.03 SIGNS

A. General:

1. Fasten to walls or posts or hang as scheduled.
2. Anchor in place for easy removal and reinstallation with ordinary hand tools.

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B. Information and Safety Signs:

1. Install facing traffic. Locate for high visibility with minimum restriction of working area around walkways and equipment.
2. Install as scheduled.
3. Removable with ordinary hand tools without leaving scars on structure or equipment.

C. Hazardous Material Sign:

1. Install where required by NFPA No. 704 and IFC, Chapter 27.
2. Install at entrances to spaces where hazardous materials are stored, dispensed, used, or handled, and on sides of stationary tanks.
3. Specific Materials:

Sign Schedule—Hazardous Material Signs

Mark	Material	Health Hazard (Blue)	Flammability Hazard (Red)	Instability Hazard (Yellow)	Special Hazard (White)	Location	Mounting Method	Height to Top
H-1	Sodium Hydroxide (10-30% solution)	3	0	0	COR	Wall	Bolts	5'-6"
H-2	Sodium Hypochlorite (3-5% solution)	2	0	0		Wall	Bolts	5'-6"
H-3	Sodium Hypochlorite (12-15% solution)	3	0	0	COR	Wall	Bolts	5'-6"
H-4	Ferrous Sulfate (20-25% solution)	2	0	0	COR	Wall	Bolts	5'-6"

3.04 IDENTIFICATION LABELS

A. Pipe Labels:

1. Locate at connections to equipment, valves, or branching fittings at wall boundaries.
2. At intervals along piping not greater than 18 feet on center with at least one label applied to each exposed horizontal and vertical run of pipe.
3. At exposed piping not normally in view, such as above suspended ceilings and in closets and cabinets.
4. Supplementary Labels: Provide to Owner those listed on Piping Schedule that do not receive arrows.
5. Apply to pipe after painting in vicinity is complete, or as approved by Engineer.
6. Install in accordance with manufacturer’s instructions.

B. Equipment Labels:

1. Locate and install on equipment or concrete equipment base.

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2. Anchor to equipment or base for easy removal and replacement with ordinary hand tools.

3.05 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are part of this specification.

1. Sign Schedule.
2. Door Nameplate Schedule.

END OF SECTION

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Sign Schedule

Sign								Lettering				Other Requirements
			Size		Mounting							
Number[1]	Sign Type[2]	Detail Reference[3]	Width	Height	Location	Method	Height to Top	Height	Style	Color	Message	Faces	
S-1	A	1014-002	12"	6"	Equipment	Adhesive	5'-6"	1" min.	Helvetica	Black	EQUIPMENT STARTS AUTOMATICALLY	1	Provide a quantity of 10
S-2	A	1014-002	20"	14"	Door	Screws	5'-6"	1" min.	Helvetica	Black	EAR PROTECTION REQUIRED	1	Provide a quantity of 4
S-3	A	1014-001	20"	14"	Wall	Bolts	3'-6"	1" min.	Helvetica	Black	NONPOTABLE WATER NOT FOR DRINKING	1	Provide 4; at interior W3 hose valves
S-4	A	1014-008	20"	14"	Wall	Screws	5'-6"	1" min.	Helvetica	Black	AERATION SYSTEM EDUCTOR VALVE	1	Provide a quantity of 2
S-5	A	1014-008	20"	14"	Equipment	Adhesive	5'-6"	1" min.	Helvetica	Black	SLUICE WATER TO WASH-PRESS ADDED IN THIS CHUTE	1	Provide a quantity of 2
S-6	A	1014-008	20"	14"	Wall	Screws	5'-6"	1" min.	Helvetica	Black	SOLENOID VALVES OPEN AUTOMATICALLY TO DEPRESSURIZE ALP LINE	1	Provide a quantity of 2
S-7	A	1014-008	20"	14"	Equipment	Screws / Adhesive	5'-6"	1" min.	Helvetica	Black	EYE PROTECTION WHEN EQUIPMENT IS OPEN	1	Provide a quantity of 5
S-8	A	1014-008	20"	14"	Wall	Screws	5'-6"	1" min.	Helvetica	Black	CONFIRM DRAIN PUMP DISCHARGE POINT PRIOR TO STARTING PUMP	1	Provide a quantity of 1

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Sign Schedule

Sign									Lettering				Other Requirements
			Size		Mounting								
Number[1]	Sign Type[2]	Detail Reference[3]	Width	Height	Location	Method	Height to Top	Height	Style	Color	Message	Faces	
S-9	A	1014-008	20"	14"	Wall	Bolts	5'-6"	1" min.	Helvetica	Black	CPT OVERFLOW REACTOR BEHIND THIS WALL	1	Provide a quantity of 4
S-10	A	1014-008	20"	14"	Wall	Bolts	5'-6"	1" min.	Helvetica	Black	CPT REACTOR 1 BEHIND THIS WALL	1	Provide a quantity of 4
S-11	A	1014-008	20"	14"	Wall	Bolts	5'-6"	1" min.	Helvetica	Black	CPT REACTOR 2 BEHIND THIS WALL	1	Provide a quantity of 4
S-12	A	1014-008	20"	14"	Door	Screws	5'-6"	1" min.	Helvetica	Black	MAINTAIN DOORS CLOSED	1	Provide a quantity of 20
S-13	A	1014-008	20"	14"	Wall	Screws	5'-6"	1" min.	Helvetica	Black	REGULARLY CLEAN STRAINER AND CHECK FLOW	1	Provide a quantity of 7
S-14	A	1014-008	20"	14"	Wall	Screws	5'-6"	1" min.	Helvetica	Black	ACCESS TO CPT REACTOR 1 ROOF	1	Provide a quantity of 2
S-15	A	1014-008	20"	14"	Wall	Screws	5'-6"	1" min.	Helvetica	Black	ACCESS TO CPT REACTOR 2 ROOF	1	Provide a quantity of 2
S-16	A	1014-008	20"	14"	Wall	Screws	5'-6"	1" min.	Helvetica	Black	ACCESS TO ROOF	1	Provide a quantity of 1

[1]Numbers refer to a particular sign type with a particular message.
[2]Letters refer to Sign Types specified in this section.
[3]Numbers refer to Design Details that show sign layout.
[4]Verify requirements for this sign with Regulations in state where Project is located.

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Door Nameplate Schedule

Door Number	Lettering		Mounting	
	Door Nameplate 1	Door Nameplate 1	Location	Method
69-100A	DOOR 69-100A ACCESS TO CPT REACTOR 1 CONFINED ENTRY		Door/Wall	Adhesive
69-101A	DOOR 69-101A ACCESS TO CPT REACTOR 2 CONFINED ENTRY		Door/Wall	Adhesive
69-102A	DOOR 69-102A EXIT TO STAIRWELL 3	DOOR 69-102A HEAT EXCHANGER/PUMP ROOM	Door/Wall	Adhesive
69-102B	DOOR 69-102B EXIT TO STAIRWELL 3	DOOR 69-102B LOBBY	Door/Wall	Adhesive
69-102C	DOOR 69-102C STAIRWELL 3	DOOR 69-102C	Door/Wall	Adhesive
69-102D	DOOR 69-102D EXIT TO STAIRWELL 3	DOOR 69-102D BLOWER ROOM	Door/Wall	Adhesive
69-102E	DOOR 69-102E ACCESS TO CPT 2 ROOF	DOOR 69-102E STAIRWELL 3	Door/Wall	Adhesive
69-B02A	DOOR 69-B02A BLDG 69 ACCESS	DOOR 69-B02A GALLERY 1/10 ACCESS	Door/Wall	Adhesive
69- B03A	DOOR 69- B03A MECHANICAL ROOM	DOOR 69- B03A	Wall/Door	Adhesive
69- B04A	DOOR 69- B04A ELECTRICAL ROOM	DOOR 69- B04A	Door/Wall	Adhesive
69-110A	DOOR 69-110A ACCESS TO OVERFLOW TANK CONFINED ENTRY		Door/Wall	Adhesive
69-106B	DOOR 69-106B LOBBY	DOOR 69-106B	Door/Wall	Adhesive
69-107A	DOOR 69-107A OPERATOR STATION	DOOR 69-107A	Door/Wall	Adhesive
69-109A	DOOR 69-109A CHEMICAL FEED WASH-PRESS ROOM	DOOR 69-109A ACCESS TO LOBBY	Door/Wall	Adhesive
69-109A	DOOR 69-109B CHEMICAL FEED/ WASH-PRESS ROOM	DOOR 69-109B	Door/Wall	Adhesive
69-201A	DOOR 201A ACCESS TO CPT 1 ROOF	DOOR 201A ACCESS TO BLOWER ROOM MEZZANINE	Door/Wall	Adhesive

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SECTION 22 10 01
PLUMBING PIPING AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI).
2. American Society of Sanitary Engineering (ASSE):
   a. 1010, Performance Requirements for Water Hammer Arresters.
   b. 1050, Performance Requirements for Stack Air Admittance Valves for Sanitary Drainage Systems.
3. ASTM International (ASTM):
   a. A47/A47M, Standard Specification for Ferritic Malleable Iron Castings.
   b. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   c. A74, Standard Specification for Cast Iron Soil Pipe and Fittings.
   d. A105/A105M, Standard Specification for Carbon Steel Forgings for Piping Applications.
   e. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   f. A179/A179M, Standard Specification for Seamless Cold-Drawn Low-Carbon Steel Heat-Exchanger and Condenser Tubes.
   g. A181/A181M, Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.
   h. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   i. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   j. A197/A197M, Standard Specification for Cupola Malleable Iron.
   k. A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
   l. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
   m. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.

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n. A518/A518M, Standard Specification for Corrosion-Resistant High-Silicon Iron Castings.
o. A536, Standard Specification for Ductile Iron Castings.
p. A563, Standard Specification for Carbon and Alloy Steel Nuts.
q. A861, Standard Specification for High-Silicon Iron Pipe and Fittings.
r. A888, Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
s. B32, Standard Specification for Solder Metal.
t. B61, Standard Specification for Steam or Valve Bronze Castings.
u. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
v. B75/B75M, Standard Specification for Seamless Copper Tube.
w. B88, Standard Specification for Seamless Copper Water Tube.
x. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.
y. B127, Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip.
z. B139/B139M, Standard Specification for Phosphor Bronze Rod, Bar, and Shapes.
aa. B164, Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire.
bb. B194, Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar.
cc. B306, Standard Specification for Copper Drainage Tube (DWV).
dd. C564, Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
ee. C1277, Standard Specification for Shielded Couplings Joining Hubless Cast Iron Soil Pipe and Fittings.
ff. C1460, Standard Specification for Shielded Transition Couplings for use with Dissimilar DWV Pipe and Fittings Above Ground.
gg. C1540, Standard Specification for Heavy Duty Shielded Couplings Joining Hubless Cast Iron Soil Pipe and Fittings.
hh. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
ii. D1785, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
jj. D2000, Standard Classification System for Rubber Products in Automotive Applications.
kk. D2239, Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.

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ll. D2466, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
mm. D2564, Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
nn. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
oo. F656, Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings.
pp. F1412, Standard Specification for Polyolefin Pipe and Fittings for Corrosive Waste Drainage Systems.

4. Cast Iron Soil Pipe Institute (CISPI):
   a. 301, Standard Specification for Hubless Cast Iron Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
   b. 310, Specification for Couplings for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Strom Drain, Waste, and Vent Piping Applications.
5. CSA Group.
6. FM Global (FM).
7. International Association of Plumbing and Mechanical Officials (IAPMO).
8. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS):
   a. SP-58, Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.
   b. SP-69, Pipe Hangers And Supports - Selection And Application.
   c. SP-80, Bronze Gate, Globe, Angle, and Check Valves.
   d. SP-110, Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.

1.02 DESIGN REQUIREMENTS

A. Where pipe diameter, thickness, pressure class, pressure rating, or thrust restraint is not shown or specified, design piping system in accordance with the following:

   1. Sanitary Building Drainage and Vent Systems: ICC International Plumbing Code.

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1.03 SUBMITTALS

A. Action Submittals:

1. Product data sheets.
2. Shop Drawings:
   a. Show Contractor recommended changes in location of fixtures or equipment.
3. Isometric riser diagrams.

B. Informational Submittals:

1. Changes in location of equipment or piping that affect connecting or adjacent work, before proceeding with the Work.
2. Complete list of products proposed for installation.
3. Test records produced during testing.
4. For Polyethylene (PE) Pipe:
   a. Certificates of qualification for persons to be fusing PE pipe.
   b. Experience and training record of persons to be fusing PE pipe.
   c. Testing Plan:
      1) Submit at least 15 days prior to testing; include following as a minimum:
         a) Testing dates.
         b) Piping systems and section(s) to be tested.
         c) Method of isolation.
         d) Method of conveying water from source to system being tested.
   d. Certifications of Calibration: Approved testing laboratory certificate if pressure gauge for hydrostatic test has been previously used. If pressure gauge is new, no certificate is required.
   e. Test report documentation.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

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1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 PIPING

A. Piping Schedule: Refer to Section 40 27 00, Process Piping—General.

B. Piping Material: Refer to Piping Data Sheet(s), Article Supplements and Section 40 27 00, Process Piping—General.

2.03 PIPE HANGERS AND SUPPORTS

A. Refer to Section 40 05 15, Piping Support Systems.

PART 3 EXECUTION

3.01 GENERAL

A. Refer to the Area Classification and Materials Selection Table in the General Section on the Drawings for installation material requirements.

B. Install plumbing systems to meet applicable plumbing code.

C. Field Obstructions:

1. Drawings do not attempt to show exact details of piping. Provide offsets around obstructions.
2. Do not modify structural components, unless approved by Engineer.

D. Sleeves:

1. Pipe sizes shown are nominal sizes, unless shown or specified otherwise.
2. Provide piping passing through walls, floors, or ceilings with standard-weight pipe sleeves.
3. Provide pipes passing through finished walls with chrome-plated canopy flanges.
4. Dry pack sleeves in existing work in-place and provide finished appearance.
5. Pack holes left by removal of existing piping with grout and finish to match adjacent surface.

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3.02 SANITARY AND WASTE DRAINS AND VENTS PIPING

A. Installation:

1. Set piping above floor slab true and plumb.
2. Set exposed risers as close to walls as possible.
3. Slope drain lines at minimum 2 percent slope, unless otherwise noted. Vent lines shall be installed level or sloped, with no low spots.
4. Where vent stacks pass through roof slab, fit with flashing sleeve secured to roof.
5. Extend vents minimum 1-foot above roof.
6. Provide cleanouts where shown and where required by code.

3.03 PIPE HANGERS AND SUPPORTS

A. In accordance with Section 40 05 15, Piping Support Systems.

3.04 INTERIM CLEANING

A. As specified in Section 40 27 00, Process Piping—General.

3.05 PROTECTION OF INSTALLED WORK

A. Protective Covers:

1. Provide over floor and shower drains during construction, to prevent damage to drain strainers and keep foreign material from entering drainage system.
2. Cover roof drains and emergency overflow drains during roofing process so roofing material and gravel do not enter drain piping.
3. Remove at time of Substantial Completion.

3.06 FIELD FINISHING

A. In accordance with Section 40 27 00, Processing Piping—General.

3.07 PIPING IDENTIFICATION

A. Refer to Section 40 27 00, Process Piping—General, and Pipe Schedule.

END OF SECTION

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SECTION 22 40 00
PLUMBING FIXTURES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Americans with Disabilities Act (ADA).
2. American Gas Association (AGA).
3. American Society of Mechanical Engineers (ASME).
4. American Society of Sanitary Engineering (ASSE): 1010, Performance Requirements for Water Hammer Arresters.
5. ASTM International (ASTM): D4101, Standard Specification for Polypropylene Injection and Extrusion Materials.
6. Food and Drug Administration (FDA).
7. NSF International (NSF):
    a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
    b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
8. Plumbing and Drainage Institute (PDI):
    a. Code Guide 302 and Glossary of Industry Terms.
    b. WH-201, Water Hammer Arrester Standard.
9. Underwriters Laboratories Inc. (UL).

1.02 SUBMITTALS

A. Action Submittals: Catalog information and rough-in dimensions for plumbing fixtures, products, and specialties.

1.03 REGULATORY REQUIREMENTS

A. Comply with the Americans with Disabilities Act (ADA), and local and state requirements.

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PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Drainage Products:

1. General:
   a. Smith.
   b. Wade.
   c. Zurn.
2. Acid Resistant:
   a. Enfield.
   b. R&G Sloane.
   c. T&C Plastic Drain Co.

2.02 GENERAL

A. Fixture Trim: Provide plumbing fixture trim where applicable on fixtures.

B. Plumbing Fixtures: Indicated by fixture number as shown on Drawings.

C. Drainage Products: Indicated by fixture number as shown on Drawings.

D. Plumbing Specialties: Indicated by fixture number as shown on Drawings.

E. Exposed fixture connections and piping shall be polished chrome-plated.

2.03 MATERIALS

A. Drainage Products:

1. FD-2, Floor Drain (Unfinished Areas, General Drainage):
   a. Materials: Cast-iron body and grate.
   b. Options: Trap Guard, Jay R. Smith Mfg. Co.; Model 2692 vandal proof screws.
   c. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 2210T-U.

PART 3 EXECUTION

3.01 PREPARATION

A. Drawings do not attempt to show exact details of fixtures. Changes in locations of fixtures, advisable in opinion of Contractor, shall be submitted to Engineer for review before proceeding with the Work.

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3.02 INSTALLATION

A. Drainage Products:

1. Floor Drains: Set top flush with floor. Provide membrane clamps where required.
2. Cleanouts: Install where shown or required for purposes intended. Set cover flush with finished floor.

3.03 FIELD QUALITY CONTROL

A. Perform visual inspection for physical damage, blocked access, cleanliness, and missing items.

END OF SECTION

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SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Moving and Conditioning Association, Inc. (AMCA): 203, Field Performance Measurement of Fan Systems.
2. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE): HVAC Applications Handbook.
3. Associated Air Balance Council (AABC): National Standards for Field Management and Instrumentation Total System Balance.
4. National Environmental Balancing Bureau (NEBB):
   a. Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.
   b. Procedural Standards for Measuring Sound and Vibration.
5. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): HVAC Testing, Adjusting, and Balancing Manual.

1.02 SUBMITTALS

A. Informational Submittals:

1. Documentation of experience record of testing authority.
2. Documentation of current AABC or NEBB certifications for those technicians in responsible charge of the work under this Contract.
3. Submit detailed test and balance procedures, including test conditions for systems to be tested, prior to beginning the Work.
4. Written verification of calibration of testing and balancing equipment.
5. Balancing Log Report following completion of system adjustments including test results, adjustments, and rebalancing procedures.

1.03 QUALITY ASSURANCE

A. Air Balancing and Test Agency Qualifications:

1. Certification by AABC of NEBB for testing, adjusting and balancing of HVAC systems.
2. Corporately and financially independent organization functioning as an unbiased testing authority.

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3. Professionally independent of manufacturers, suppliers, and installers of HVAC equipment being tested.
4. Have a proven record of at least five similar projects.
5. Employer of engineers and technicians regularly engaged in testing, adjusting and balancing of HVAC equipment and systems.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide materials, tools, test equipment, computers and instrumentation required to complete the work included.

B. Test Hole Plugs: Plug test holes in ducts with plugs made for that purpose and replace any insulation removed to specified conditions.

C. Drives for Belt-Driven Fans:

1. Furnish cast iron or flanged steel sheaves.
2. Sheaves and belt combination shall be capable of providing 150 percent of motor horsepower.

PART 3 EXECUTION

3.01 GENERAL

A. Adjust and balance air and water systems in accordance with standard procedures and recognized practices of the AABC or SMACNA.

3.02 ADJUSTING AND BALANCING AIR SIDE

A. Preparation:

1. Prior to beginning the Work, perform the following activities:
   a. Review shop drawings and installed system for adequate and accessible balancing devices and test points.
   b. Recommend to Engineer dampers that need to be added or replaced in order to obtain proper air control.
   c. Verify proper startup procedures have been completed on the system.
   d. Verify controls installation is complete and system is in stable operation under automatic control.
   e. Verify test instruments have been calibrated to a recognized standard and are within manufacturer’s recommended calibration interval before beginning the Work.

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B. General:

1. When adjustments are made to a portion of a fan system, reread other portions of that same system to determine effects imposed by adjustments. Readjust as necessary.
2. Lock and mark final positions of balancing dampers with permanent felt pen.

C. Equipment Data:

1. Collect the following data and included in final report:
   a. Type of unit.
   b. Equipment identification number.
   c. Equipment nameplate data (including manufacturer, model, size, type, and serial number).
   d. Motor data (frame, hp, volts, FLA rpm, and service factor).
   e. Sheave manufacturer, size, and bore.
   f. Belt size and number.
   g. Sheave centerline distance and adjustment limits.
   h. Starter and motor overload protection data.
   i. Include changes made during course of system balancing.

D. Fan Systems:

1. Measure fan system performance in accordance with AMCA 203.
2. In each system at least one airpath from fan to final branch duct termination shall have dampers fully open. Achieve final air quantities by adjusting fan speed.
3. Adjust Fan Air Volumes:
   a. Adjust fan speeds and motor drives for required equipment air volumes, with allowable variation of plus 10 percent minus 0 percent.
   b. After final adjustments, do not operate motor above nameplate amperage on any phase.
   c. After final adjustments, do not operate fan above maximum rated speed.
   d. Perform airflow test readings under simulated or actual conditions of full cooling, full heating, minimum outside air, full outside air and exhaust, and full return air.
   e. Provide and make drive and belt changes on motors or fans as required to adjust equipment to specified conditions. Drives shall be able to deliver 150 percent of motor horsepower. Provide written notice to air handling unit manufacturer and Owner if drive or belt changes were made.

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4. Adjust outside air dampers, return air dampers, relief air dampers, exhaust air dampers, and motorized louvers for maximum and minimum air requirements.
5. Read and record static pressures at unit inlet and discharge, each filter set, coils, dampers, plenums, and mixing dual-duct or adjustable-volume boxes, on every supply, return, and exhaust fan for each test condition.
6. Read and record motor amperage on all phases for each test condition.

E. Air Outlets and Inlets:

1. In each system at least one air path from fan to final branch duct termination shall have dampers fully open.
2. Adjust air volumes on supply diffusers and grilles, and on return and exhaust grilles, to the quantity shown, with allowable variation of plus or minus 10 percent.
3. Adjust diffusers and grilles for proper deflection, throw, and coverage. Eliminate drafts and noise where possible.
4. After final adjustments are made secure dampers to prevent movement and mark final positions with permanent felt pen.

3.03 FIELD QUALITY CONTROL

A. General: Perform functional tests as required by Section 01 91 00, Equipment Systems Commissioning.

B. Performance Testing:

a. Test Procedures:
1) Identify maximum vibration velocity limits as specified for each piece of equipment to be tested.
2) Take measurements at each bearing housing using calibrated electronic analyzer.
3) Measure velocity in direction parallel to rotating shaft, and in two directions perpendicular to shaft and to each other. Align measurement directions where possible to the horizontal and vertical planes.
4) Record log shall include equipment symbol or tag, location, identification, specified vibration velocity limits, and maximum measured velocity in each direction.
5) Notify Engineer if amplitude exceeds upper limit specified.

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C. Balancing Log Report Requirements:

1. Include narrative description for each system explaining TAB methodology and assumptions used. Clearly identify test conditions for tests performed. Include control setpoint.
2. Log and record operational information from every test for each system, as necessary to accomplish services described.
3. Include equipment data for units tested.
4. Include reduced set of HVAC Drawings or system schematic diagrams with each element uniquely identified and indexed to balance log.
5. Indicate recorded site values, and velocity and mass correction factors used to provide equivalent standard air quantities.
6. Include separate section in log, if necessary, describing operating difficulties in air or water systems that could not be eliminated by specified procedures. Identify these problems by system and location within building; include outline or summary of condition and its effect on building, and describe corrective actions attempted and recommended.

D. Quality Control Verification:

1. After adjustments have been completed and balance logs submitted, balancing and testing agency shall be available to demonstrate the following:
   a. Air and water balancing procedures, vibration tests, and verification of test results.
   b. Perform spot tests on a maximum of 20 percent of total diffusers and grilles, on two air handling fan devices per building, and on 10 percent of total water balance fittings, with measuring equipment used in original tests, at random points selected by Engineer.
   c. Results of these spot tests shall agree with balance logs within plus or minus 10 percent. Where this accuracy cannot be verified, rebalance portions of system as requested by Engineer.
   d. At completion of rebalance procedures, perform another spot test if required to verify results.

END OF SECTION

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SECTION 23 31 13
METAL DUCTS AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Movement and Control Association (AMCA): 500, Test Methods for Louvers, Dampers and Shutters.
2. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Handbook.
3. American Society of Mechanical Engineers (ASME): A13.1, Scheme for the Identification of Piping Systems.
4. Association of the Nonwoven Fabrics Industry (INDA): IST 80.6, Water Resistance (Hydrostatic Pressure).
5. ASTM International (ASTM):
    a. A36/A36M, Standard Specification for Carbon Structural Steel.
    b. A90/A90M, Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
    c. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
    d. A176, Standard Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip.
    e. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
    f. A480/A480M, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip.
    g. A568/A568M, Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for.
    h. A653/A653M, Standard Specifications for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
    i. A700, Standard Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment.
    j. A924/A924M, Specification for General Requirements for Sheet Steel, Metallic-Coated by the Hot-Dip Process.

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k. A1008/A1008M, Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
l. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High- Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
m. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
n. C423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
o. C916, Standard Specification for Adhesives for Duct Thermal Insulation.
p. C1071, Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
q. C1139, Standard Specification for Fibrous Glass Thermal Insulation for Sound Absorbing Blanket and Board for Military Applications.
r. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
s. E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.

6. National Air Duct Cleaners Association (NADCA): General Specifications for the Cleaning of Commercial Heating, Ventilation and Air Conditioning Systems.
7. National Fire Protection Association (NFPA):
   a. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
   b. 90B Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
   c. 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
   d. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
   e. 259, Standard Test Method for Potential Heat of Building Materials.
   f. 701, Standard Methods of Fire Tests for Flame Propagation of Textiles and Films.
8. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
   a. Duct Construction Standards.
   b. Guidelines for Seismic Restraints of Mechanical Systems.
   c. Fibrous Glass Duct Construction Standards.

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d. Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems.
e. HVAC Air Duct Leakage Test Manual.

9. Underwriters Laboratories Inc. (UL):
   a. 181, Standard for Safety Factory-Made Air Ducts and Connectors.
   b. 214, Standard for Tests for Flame-Propagation of Fabrics and Films.
   c. 555, Standard for Safety Fire Dampers.
   d. 555S, Standard for Safety Smoke Dampers.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. CFM: cubic feet per minute.
2. FPM: feet per minute.
3. PCF: pounds per cubic foot.
4. WC: water column.

B. Sealing Requirements: For the purpose of duct systems sealing requirements specified in this section, the following definitions apply:

1. Seams: Joining of two longitudinally (in direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on perimeter are deemed to be joints.
2. Joints, duct surface connections including:
   a. Girth joints.
   b. Branch and subbranch intersections.
   c. Duct collar tap-ins.
   d. Fitting subsections.
   e. Louver and air terminal connections to ducts.
   f. Access door, and access panel frames and jambs.
   g. Duct, plenum, and casing abutments to building structures.

1.03 SUBMITTALS

A. Action Submittals:

1. Product Data:
   a. Rectangular, Rigid Round, and Oval Ductwork:
      1) Schedules of duct systems, materials, joints, sealing, gage and reinforcement.
      2) SMACNA Figure Numbers for each shop fabricated item.
      3) Reinforcing details and spacing.
      4) Seam and joint construction details.

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5) Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.

b. Ductwork Accessories:

1) Manufacturer's product data including catalog sheets, diagrams, standard schematic drawings, installation instructions and details, details of materials, construction, dimensions of individual components, and finishes, including the following items:

a) Fittings and volume control damper installation (both manual and automatic) details.
b) Duct liner.
c) Sealing materials.
d) Dampers; include leakage, pressure drop, and maximum back pressure data.
e) Duct-mounted access panels and doors.
f) Flexible ducts.
g) Sheet metal fasteners.

2. Duct Fabrication Drawings:

a. Drawn after actual job measurements are obtained.
b. Drawn to a scale not smaller than 1/4 inch equals 1 foot, on drawing sheets same size as Contract Drawings.
c. Include the following features:

1) Fabrication, assembly, and installation details including plans, elevations, sections, details of components, and attachments to other work.
2) Duct layout, indicating pressure classifications, and sizes in plan view.
3) For materials handling exhaust duct systems, indicate classification of materials handled.
4) Duct material and thickness.
5) Fittings and volume control damper installation (both manual and automatic) details.
6) Reinforcing details and spacing.
7) Seam and joint construction details.
8) Penetrations through fire-rated and other partitions.
9) Duct accessories and control devices such as automatic dampers, airflow monitors, terminal units, smoke detectors, regulators, air distribution devices, etc.
10) Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.
11) Fire and smoke damper installations, including sleeves and duct-mounted access door and panel installation.
12) Coordination with ceiling suspension members.
13) Spatial coordination with other systems installed in same space with duct systems.

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14) Coordination of ceiling- and wall-mounted access doors and panels required for access to dampers and other operating devices.
15) Coordination with ceiling-mounted lighting fixtures, air outlets, and inlets.
16) Coordination of ductwork with sprinkler piping and other mechanical and electrical services, and equipment.

B. Informational Submittals:

1. Record Drawings: Include duct systems routing, fittings details, and installed accessories and devices.

1.04 QUALITY ASSURANCE

A. Industry Standards:

1. Unless otherwise indicated or specified, sheet metal ductwork shall be constructed and installed in accordance with SMACNA Duct Construction Standards relevant to ductwork system being provided. These standards are herein referenced as the SMACNA Manual, unless otherwise indicated.
2. Comply with ASHRAE Fundamentals Handbook recommendations, except as otherwise indicated.
3. NFPA Compliance: NFPA 90A and NFPA 90B.

B. Manufacturers: Firms regularly engaged in manufacture of ductwork products of types, materials, and sizes required, whose products have been satisfactorily used in similar service for not less than 5 years.

C. Suppliers of duct and fitting components shall provide on request the following information:

1. Laboratory performance data for duct, including leakage rate, bursting strength, collapse strength, seam strength, and pressure loss.
2. Laboratory performance data for fittings, including zero-length dynamic losses.

D. Installer shall be a firm with at least 3 years' experience of successful installation on ductwork systems similar to that required for this Project.

E. Changes or alterations to layout or configuration of duct system shall be:

1. Specifically approved in writing by Engineer.

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2. Proposed layout shall provide original design results, without increasing system total pressure.

1.05 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts:

Item	Quantity
Fusible Links	10 percent of amount installed

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect ductwork from dirt, water, and debris. During storage on Job Site, keep ends of ductwork covered to prevent foreign objects and water from entering ductwork.

B. If fabricated sound-lined ductwork gets wet during installation, remove and dispose of ductwork from the Site.

C. Deliver sealant materials to Site in original unopened containers labeled with manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.

D. Store and handle sealant materials in compliance with manufacturers' recommendations to prevent deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

E. Deliver and store stainless steel sheets with mill-applied adhesive protective paper, maintained through fabrication and installation.

PART 2 PRODUCTS

2.01 SCHEDULES

A. Ductwork Schedule: Refer to Drawings.

2.02 GENERAL

A. Specified components of this ductwork system, including facings, mastics, and adhesives, shall have fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke developed, as per test conducted in accordance with ASTM E84 and NFPA 255 methods.

B. Internally Lined Ductwork is not acceptable.

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C. Ductwork thinner than 26-gauge will not be allowed.

D. Ductwork Interior Surfaces:

1. Smooth.
2. No sheet metal parts, tabs, angles, or other items may project into air ducts, unless otherwise specified.
3. Seams and joints shall be external.
4. For ductwork that is required to be reinforced, use only external reinforcing.

2.03 SHEET METAL MATERIALS

A. Construct metal duct systems from materials as indicated in Article, Ductwork Schedule.

B. Where no specific ductwork materials are indicated in Specifications or on Drawings, aluminum sheet metal shall be basis of Contract.

C. Aluminum Ductwork:

1. Comply with ASTM B209.
2. Aluminum Sheet: Alloy 3003-H14, unless indicated otherwise.
3. Aluminum Connectors and Bar Stock: Alloy 6061-T6 or equivalent.

D. Exposed Ductwork: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains, discoloration, and other imperfections, including those which would impair painting.

E. Reinforcement Shapes and Plates: Unless otherwise indicated, provide reinforcements of same material as ductwork.

2.04 DUCT SEALING MATERIALS

A. General: The term sealant used here is not limited to materials of adhesive or mastic nature, but also includes tapes and combinations of open weave fabric strips and mastics.

B. Adhesives, Cements, Sealant, and Installation Accessories: As recommended by duct manufacturer for application.

C. Solvent-Based Sealants:

1. Ultraviolet light resistant.
2. Mildew resistant.

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3. Flashpoint: Greater than 70 degrees F, SETA CC.
4. Manufacturers and Products:
    a. Hardcast, Inc.; Versagrip 102.
    b. Rectorseal; AT-33.
    c. Childers CP-140.

D. Water-Based Sealants:

1. Listed by manufacturer as nonflammable in wet and dry state.
2. Manufacturers and Products:
    a. Foster; Series 32.
    b. Childers; CP-145A, 146.
    c. Rectorseal; Airlok 181.

2.05 DUCTWORK FASTENERS

A. General:

1. Rivets, bolts, or sheet metal screws.
2. Ductwork fasteners shall be same metal as duct being supported, unless otherwise noted.

B. Self-Drilling Screws:

1. Aluminum Ductwork System:
    a. Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated Type 410 stainless steel, complete with bonded metal and fiber washer for dielectric separation.
    b. Manufacturers:
        1) DB Building Fasteners Inc., Santa Fe Springs, CA.
        2) Clark Craft Fasteners, Tonawanda, NY.
2. Stainless Steel Ductwork System:
    a. Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated Type 410 stainless steel.
    b. Manufacturers:
        1) DB Building Fasteners Inc., Santa Fe Springs, CA.
        2) Clark Craft Fasteners, Tonawanda, NY.

2.06 DUCTWORK PRESSURE CLASS

A. Construct duct systems to pressure classifications indicated in Ductwork Schedule.

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B. Where no specific duct pressure designations are indicated in Specifications or on Drawings, 2-inch WC pressure class shall be basis of Contract.

2.07 RECTANGULAR DUCTWORK

A. Fabricate rectangular ducts in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, unless specified otherwise.

B. Crossbreaking or Cross Beading: Crossbreak or bead duct sides that are 19 inches and larger and are 20-gauge or less, with more than 10 square feet of unbraced panel area, as indicated in SMACNA Manual, unless they are lined or are externally insulated.

2.08 RECTANGULAR DUCTWORK FITTINGS

A. Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible.

B. Elbows:

1. Fit square-turn elbows with vane side rails.
2. Shop fabricate double-blade turning vanes of same material as ductwork.
3. Fabricate with equal inlet and outlet.
4. Rectangular radius elbows with inside radius of 3/4 of duct width in direction of turn.

2.09 RECTANGULAR DUCTWORK BRANCH CONNECTIONS

A. Branch duct connections to rectangular duct mains shall be made using factory fabricated fittings with spot welded tap to main duct connections or with factory fabricated, field installed taps, with spin-in or mechanical fastened tap to main duct connections.

2.10 RIGID ROUND DUCTWORK

A. Construct rigid round ducts in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, unless specified otherwise.

B. Basic Round Diameter: As used in this Article, is inside diameter of size of round duct.

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C. Where space limitations prevent use of round duct or where shown on Drawings, provide ductwork of flat oval construction hydraulically equivalent to round ductwork.

D. Fabricate round ducts with spiral seam construction, except where diameters exceed 72 inches. Fabricate ducts having diameters greater than 72 inches with longitudinal butt-welded seams.

E. Ductwork seams of Snaplock type shall not be used.

2.11 RIGID ROUND DUCTWORK FITTINGS

A. Construct rigid round ductwork fittings in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, unless otherwise specified.

B. 90-Degree Tees, Laterals, and Conical Tees: Fabricate to conform to SMACNA manual with metal thicknesses specified for longitudinal seam straight duct.

C. Diverging Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from body onto branch tap entrance.

D. Elbows:

1. Fabricate in stamped (die-formed), pleated, or segmented (gored) construction 1.5 times elbow diameter. Two piece segment elbows are not allowed, except with turning vanes.
2. Segmented Elbows: Fabricate with welded construction.
3. Round Elbows 8 Inches and Smaller:
    a. Stamped elbows for 45- and 90-degree elbows and pleated elbows for 30-, 45-, 60-, and 90-degrees configuration.
    b. Fabricate nonstandard bend angle configurations or nonstandard sized (for example, 3-1/2 inches and 4-1/2 inches) elbows with segmented construction.
4. Round Elbows 9 Inches Through 14 Inches:
    a. Segmented or pleated elbows for 30, 45, 60, and 90 degrees.
    b. Fabricate nonstandard bend angle configurations or nonstandard sized (for example, 9-1/2 inches and 10-1/2 inches) elbows with segmented construction.

2.12 ROUND DUCTWORK BRANCH CONNECTIONS

A. Branch duct connections (taps) to round duct mains shall be made using factory fabricated fittings.

B. Field installed taps are not acceptable.

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2.13 DUCTWORK HANGERS AND SUPPORTS

A. General:

1. Attachments, hangers, and supports for ductwork shall be in accordance with SMACNA Manual referenced for type of duct system being installed.
2. Duct hanging system shall be composed of three elements; upper attachment to building, hanger itself, and lower attachment to duct.
3. Wire hangers are not acceptable.
4. Hanger Spacing:
    a. Ducts Up to 60 inches in Largest Dimension: 10 feet, maximum.
    b. Ducts Over 61 inches in Largest Dimension: 8 feet, maximum.

B. Construction Materials: Supporting devices including, but not limited to, angles used for support and bracing, baseplates, rods, hangers, straps, screws, bolts shall be as follows:

1. Aluminum Ductwork Indoors and Outdoors:
    a. Carbon steel, hot-dipped galvanized after fabrication.
    b. Non-metallic pad between lower attachment and ductwork, to achieve dielectric separation.
2. Stainless Steel Ductwork Indoor and Outdoor: Stainless steel, same ASTM Grade as ductwork.

C. Building Attachments:

1. Concrete inserts, powder-actuated fasteners, or structural steel fasteners appropriate for building materials.
2. Do not use powder-actuated concrete fasteners for lightweight aggregate concrete or for slabs less than 4 inches thick.
3. Upper Attachment (Concrete):
    a. Drive pin fastener and expansion nail anchor may be used for ducts up to 18-inch maximum dimension.
    b. Threaded stud fastener may be used for ducts up to 36-inch maximum dimension.
    c. Concrete attachments shall be made of steel.

D. Duct Fasteners: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials and conforming to requirements of Article Ductwork Fasteners.

E. Trapeze and Riser Supports: Steel shapes conforming to ASTM A36/A36M, hot-dipped galvanized after fabrication.

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2.14 DUCTWORK FLEXIBLE CONNECTIONS

A. General:

1. Factory fabricated metal-edged fabric flexible connectors for commercial or industrial applications.
2. Sheet metal permanently secured to fabric with double fabric fold, double metal crimp.
3. Comply with NFPA 90A and NFPA 90B requirements.
4. Airtight and waterproof.

B. Materials:

1. Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
2. Metal Edges: Construct from same material as ductwork, unless otherwise noted.
3. Fabric:
   a. Comply with NFPA 701 or UL 214 (except teflon coated).
   b. Woven polyester or nylon for most applications.
   c. Woven fiberglass for high temperature applications.
   d. Coating: Neoprene.

C. Construction:

1. Fold and crimp metal edge strips onto fabric as illustrated in SMACNA Manual.
2. Standard Metal Edged Connectors: Strip of fabric 3 inches wide attached to two strips of 3-inch-wide sheet metal.
3. Wide Metal Edged Connectors: Strip of fabric 4 inches wide attached to two strips of 4-inch-wide sheet metal.
4. Extra Wide Metal Edged Connectors: Strip of fabric 6 inches wide attached to two strips of 6-inch-wide sheet metal.

D. Manufacturers:

1. Ductmate; PROflex, Commercial.
2. Ventfabrics.
3. Duro-Dyne.

2.15 DUCT INSPECTION DOORS

A. General:

1. Insulated, gasketed, and at least 15 inches by 15 inches when duct dimensions are large enough.

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2. On ductwork where largest side dimension is less than 16 inches, furnish inspection doors at least 8 inches by 8 inches.
3. Complete with necessary hardware and either Amerlock 10 or Ventlock No. 100 latches, and Ventlock Series No. 100 hinges.
4. Fabricated of same material as ductwork.

B. Round Spin-in Type Access Doors:

1. Size: 18-inch and 24-inch diameter will be acceptable in lieu of comparable size square or rectangular access doors specified herein.
2. Complete with insulation, spin-in frame, inner door, attachment cable, gaskets, three latches, and pull ring.
3. Manufacturer and Product: Flexmaster; Inspector Series.

C. Manufacturers:

1. Ventlok.
2. Duro-Dyne.
3. Flexmaster.

2.16 MANUAL DAMPERS

A. Butterfly Manual Dampers:

1. Fabricate from two gauges heavier than duct in which installed, of same material as ductwork, or galvanized steel in fiberglass ductboard.
2. Align operating handle with damper blade.
3. Provide 2-inch standoff bracket for insulated duct systems.
4. Damper Manufacturers:
   a. Ruskin.
   b. American Warming and Ventilating.
5. Operator Manufacturers: Ventlok, “Or-equal”.

B. Manual Opposed-Blade Balancing Dampers:

1. Externally operated gang airfoil, damper blades.
2. Fabricate from same material as ductwork.
3. Stainless steel or nylon sleeve bearings.
4. Construction shall have interlocking edges and maximum 10-inch blade width.
5. Manufacturers and Products:
   a. Ruskin; CD102.
   b. American Warming and Ventilating; Model VC-31.

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2.17 BACK DRAFT DAMPERS

A. General: Damper pressure drop ratings shall be based on tests and procedures performed in accordance with AMCA 500.

B. Aluminum, Counterbalanced, Standard Duty:

1. Fabrication:
   a. Frame: 2 inches by minimum 0.06 inch (51 mm by minimum 1.5 mm), 6063-T5 extruded aluminum channel with mitered corners.
   b. Blades:
      1) Style: Single piece, overlap frame.
      2) Action: Parallel.
      3) Material: Minimum 0.025-inch (0.6 mm) 6063-T5 formed aluminum.
      4) Width: Maximum 6 inches (152 mm).
   c. Bearings: Corrosion-resistant, long-life, synthetic, formed as single piece with axles.
   d. Blade Seals: Extruded vinyl, mechanically attached to blade edge.
   e. Linkage: Concealed in frame.
   f. Axles: Corrosion-resistant, long-life, synthetic, locked to blade and formed as single piece with bearings.
   g. Counterbalances: Adjustable zinc plated steel weights mechanically attached to blade enabling damper to operate over wide range of pressures.
   h. Mounting:
      1) Suitable for mounting in vertical, horizontal airflow up, and horizontal airflow down positions.
      2) Configured for positions as shown on Drawings.
   i. Finish: Mill aluminum.
2. Performance Data:
   a. Temperature Rating: Withstand minus 40 degrees to 200 degrees F (minus 40 degrees to 93 degrees C).
   b. Maximum Back Pressure: 2-inch WC (500 Pa).
   c. Maximum Spot Air Velocity: 1,000 fpm (5 mps).
   d. Operation of Blades:
      1) Start to Open: 0.01-inch WC (0.002 kPa).
      2) Fully Open: 0.06-inch WC (0.01 kPa).
   e. Pressure Drop: Maximum 0.04-inch WC (0.01 kPa) at 1,000 fpm (305 mpm) through 24-inch by 24-inch (610 mm by 610 mm) damper.

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PART 3 EXECUTION

3.01 GENERAL INSTALLATION

A. Miscellaneous:

1. Install sheet metal ductwork and flexible ductwork in accordance with SMACNA Manual, NFPA 90A, and NFPA 90B.
2. Install ductwork using manufacturer's recommended adhesives, cement, sealant, and insulation accessories.
3. Align ductwork accurately at connections, within 1/8-inch misalignment tolerance and with internal surfaces smooth.
4. Interface Between Ductwork and Louvers: At locations where ductwork is connected to louver for either intake or exhaust purposes, ductwork shall be installed, sloped, and connected to louver so water entering ductwork system positively drains back to and out of louver.

B. Ductwork Location:

1. Locate ductwork runs vertically and horizontally, unless otherwise indicated.
2. Avoid diagonal runs wherever possible.
3. As indicated by diagrams, details, and notations or, if not otherwise indicated, run ductwork in shortest route that does not obstruct usable space or block access for servicing building and equipment.
4. In general, install as close to bottom of structure as possible.
5. For ductwork concealed above ceiling, maximize clearance between bottom of ductwork and top of ceiling construction.
6. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
7. Ductwork that must transition and drop below piping or other ductwork shall be transitioned back to bottom of structure immediately adjacent to obstruction.

C. Penetrations:

1. Provide duct sleeves or prepared openings for duct mains, duct branches, and ducts passing through roofs, walls and ceilings.
2. Clearances:
   a. For uninsulated ducts, allow 1-inch clearance between duct and sleeve, except at grilles, registers, and diffusers.
   b. For insulated ducts, allow 1-inch clearance between insulation and sleeve, except at grilles, registers, and diffusers.

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3. Closure Collars:
    a. Minimum 4 inches wide on each side of walls or floors where sleeves or prepared openings are installed.
    b. Fit collars snugly around ducts and insulation.
    c. Same gauge and material as duct.
    d. Grind edges of collar smooth to preclude tearing or puncturing insulation covering or vapor barrier.
    e. Use fasteners with maximum 6-inch centers on collars.
4. Packing: Mineral fiber in spaces between sleeve or opening and duct or duct insulation.

D. Coordination with Other Trades:

1. Coordinate duct installation with installation of accessories, dampers, coil frames, equipment, controls, and other associated work of ductwork system.
2. Ductwork shall be configured, positioned, and installed to permit installation of light fixtures as indicated on Drawings.
3. Coordinate ductwork layout with suspended ceiling, lighting and sprinkler head layouts and similar finished work.
4. Electrical Equipment Spaces: Do not run ductwork through transformer vaults and other electrical equipment spaces and enclosures.

3.02 RECTANGULAR DUCTWORK

A. General:

1. Where possible, install ductwork so seams and joints will not be cut for installation of grilles, registers, or ceiling outlets.
2. If cutting of seams or joints is unavoidable, reinforce cut portion to original strength.

B. Low Pressure Taps:

1. Use bell mouth or conical fittings with integral locking quadrant damper. Spin-in fitting shall be sealed at duct tap with a gasket or sealed with sealant as specified for medium pressure ductwork.
2. Determine location of spin-in after outlet location is determined.
3. Fitting shall be securely attached to shaft to prevent damper from rotating around shaft.

C. Fittings:

1. Use bell-mouth or conical tee fittings for round duct takeoffs from rectangular mains.

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2. Use 45-degree entry fittings conforming to SMACNA requirements for rectangular takeoffs from rectangular or round mains.
3. Make offsets with maximum angle of 45 degrees.
4. Use fabricated fittings for changes in directions, changes in size and shape, and connections.

D. Rectangular Ductwork Transverse Joints:

1. Install each run with a minimum of joints.
2. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.
3. Mechanical Joint Option:
   a. Construct transverse joints with Ductmate 25/35 duct connector systems, Ductmate W.D.C.I. Heavy/Lite duct connector systems, or Ductlok J/E duct connector system. Slip-on duct flange connectors shall have integral sealant pocket with permanently flexible sealant.
   b. When using Ductmate W.D.C.I. Heavy/Lite system, construct ductwork in accordance with the Ductmate W.D.C.I. Heavy J and Light H Assembly Manual and Duct Construction Standards.
   c. When using Ductlok J/E duct connector system, construct ductwork in accordance with Ductlok's Rectangular Duct Construction Manual for Low, Medium, and High Pressure.
   d. For longitudinal seams, use Pittsburgh lock seam sealed internally with permanently elastic sealer such as Ductmate 5511M mastic.
   e. Conform to SMACNA Class A sealing requirements.

3.03 DUCTWORK HANGERS AND SUPPORTS

A. Install ductwork with support systems in accordance with SMACNA Manual, unless otherwise noted.

B. Support ducts rigidly with suitable ties, braces, hangers, and anchors of type, which will hold ducts true-to-shape and to prevent buckling.

C. Install additional bracing on ductwork as required, to prevent ballooning or breathing.

D. Support horizontal ducts within 2 feet of each elbow and within 4 feet of each branch intersection.

E. Support vertical ducts at maximum interval of 16 feet and at each floor.

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F. Upper attachments to structures shall have allowable load not exceeding 1/4 of failure (proof test) load but are not limited to specific methods indicated.

G. In new construction, install concrete insert prior to placing concrete.

3.04 FLEXIBLE CONNECTIONS

A. Flexible Collars and Connections:

1. Use between fans and ducts.
2. For round ducts, securely fasten flexible connections by zinc-coated steel clinch-type draw bands.
3. For rectangular ducts, lock flexible connections to metal collars.

3.05 DAMPERS

A. General:

1. Inspection:
   a. Inspect areas to receive dampers.
   b. Notify Engineer of conditions that would adversely affect installation or subsequent utilization of dampers.
   c. Do not proceed with installation until unsatisfactory conditions are corrected.
2. Install dampers at locations indicated on Drawings and in accordance with manufacturer's installation instructions.
3. Install square and level.
4. Handle damper using sleeve or frame. Do not lift damper using blades or jack-shaft.
5. Damper blades and hardware shall operate freely without obstruction.
6. Damper blades and hardware that bind within frame or obstructed by adjacent construction will not be acceptable.
7. When installed, damper frames shall be gasketed or caulked to eliminate leakage between duct and damper frames.
8. Head and sill shall have stops.
9. Suitable for installation in mounting arrangement shown.
10. Do not compress or stretch damper frame into duct or opening.

B. Manual Dampers:

1. Provide balancing dampers for grilles and diffusers as indicated on Drawings in branch duct as near main as possible.
2. Add or remove balancing dampers as requested by air balancing firm for necessary control of air.

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C. Back Draft Dampers:

1. Install dampers square and free from racking with blades running horizontally.
2. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.

3.06 ACCESS DOORS

A. Ductwork: Install access doors in ductwork, in accordance with manufacturer's instructions, at each:

1. Duct mounted fire damper.
2. Duct mounted smoke or ionization detector.
3. Electric duct heater.
4. Booster coil.
5. Humidifier.
6. Motorized damper.
7. Sail switch.
8. Turning vane.
9. Volume damper.
10. Automatic damper.
11. Temperature controller.
12. Coil, on both upstream and downstream side.

3.07 DUCT SEALING

A. Seal duct seams and joints as follows: In accordance with SMACNA requirements.

B. If no specific duct sealing requirements are specified, requirements of SMACNA manual shall govern.

C. Seal externally insulated ducts prior to insulation installation.

D. Provide additional duct sealing as required to comply with Article Ductwork Leakage Testing.

E. Seal all audible leaks.

3.08 DUCTWORK LEAKAGE TESTING

A. General:

1. Tests shall be conducted on completed ductwork systems.

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2. Testing of partial installations or limited sections of ductwork will not be acceptable.
3. All ductwork leakage test procedures and results shall be submitted to Engineer for review.
4. Engineer shall retain the right to witness some or all ductwork leakage testing procedures.
5. Contractor shall notify Engineer in writing at least 5 working days prior to ductwork testing.

3.09 LEAKAGE CRITERIA

A. Assemble and install ductwork with maximum leakage limited as indicated in Ductwork Schedule. Leakage Testing Method:

1. Contractor shall be responsible for providing all necessary test fans and calibrated measuring devices to accomplish ductwork leakage test and to demonstrate that ductwork systems leakage rate is less than maximum rate specified.
2. Pressure testing shall be accomplished using a pressure blower with a calibrated orifice and manometer.
3. Blower shall maintain SMACNA construction pressure classification during test.
4. Perform testing in accordance with procedures given in SMACNA HVAC Air Duct Leakage Test Manual.

3.10 BALANCING OF AIR SYSTEMS

A. Perform air balancing in accordance with requirements of Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

3.11 PROTECTION OF INSTALLED WORK

A. Open ends of installed ductwork systems shall be covered to prevent dust, foreign objects and water from entering ductwork.

B. Ductwork systems shall not be used for air conveyance until adequate air filtration devices are installed in air handling equipment, to prevent ingress of construction dust.

3.12 CLEANING

A. Ductwork shall be cleaned of rust, dust, and debris, both internally and externally, before placing in operation.

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B. Before installing air outlets, use air handler to blow dry air through entire system at maximum attainable velocity. Provide temporary air filters for this operation.

C. If duct systems are found to contain construction debris at time of construction completion Contractor shall provide complete ductwork system cleaning in accordance with NADCA Standards.

END OF SECTION

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SECTION 23 34 00
HVAC FANS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Acoustical Society of America (ASA): S2.19, Mechanical Vibration—Balance Quality Requirements of Rigid Rotors—Part 1, Determination of Permissible Residual Unbalance.
2. Air Movement and Control Association International (AMCA):
   a. 99, Standards Handbook.
   b. 201, Fans and Systems.
   c. 203, Field Performance Measurement of Fan Systems.
   d. 204, Balance Quality and Vibration Levels for Fans.
   e. 210, Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.
   f. 300, Reverberant Room Method for Sound Testing of Fans.
   g. 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
3. American Bearing Manufacturers Association (ABMA): 9, Load Ratings and Fatigue Life for Ball Bearings.
4. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
5. ASTM International (ASTM):
   a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
   b. D2247, Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity.
   c. D2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
   d. D3363, Standard Test Method for Film Hardness by Pencil Test.
   e. D4167, Standard Specification for Fiber-Reinforced Plastic Fans and Blowers.
   f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
6. National Electrical Manufacturers Association (NEMA).
7. National Fire Protection Association (NFPA): 45, Standard on Fire Protection for Laboratories Using Chemicals.
8. Occupational Safety and Health Act (OSHA).

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9. Society for Protective Coatings (SSPC):
    a. SP 3, Power Tool Cleaning.
    b. SP 5, White Metal Blast Cleaning.
    c. SP 6, Commercial Blast Cleaning.
    d. SP 10, Near-White Blast Cleaning.
10. Underwriters Laboratories Inc. (UL): 507, Safety Standard for Electric Fans.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. AC: Alternating Current.
2. CISD: Chemical Industry, Severe-Duty.
3. dB: Decibel.
4. DWDI: Double Width, Double Inlet.
5. FRP: Fiberglass Reinforced Plastic.
6. hp: Horsepower.
7. ODP: Open Drip Proof.
8. SWSI: Single Width, Single Inlet.
9. TEFC: Totally Enclosed, Fan Cooled.
10. UV: Ultra Violet
11. XP: Explosion Proof.

1.03 SUBMITTALS

A. Action Submittals:

1. Provide the following for specified products:
    a. Identification as referenced in Contract Documents.
    b. Manufacturer’s name and model number.
    c. Descriptive specifications, literature, and drawings.
    d. Dimensions and weights.
    e. Fan sound power level data (reference 10 to power minus 12 watts) at design operating point.
    f. Fan Curves:
        1) Performance Curves Indicating:
            a) Relationship of flow rate to static pressure for various fan speeds.
            b) Brake horsepower curves.
            c) Acceptable selection range (surge curves, maximum revolutions per minute).

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d) Static pressure, capacity, horsepower demand and overall efficiency required at duty point, including drive losses.

2) For variable air volume applications, indicate operating points at 100, 80, 60 and 40 percent of design capacity on fan curves including data to indicate effect of capacity control devices such as inlet vanes on flow, pressure, and brake horsepower.

g. Capacities and ratings.
h. Construction materials.
i. Fan type, size, class, drive arrangement, discharge, rotation, and bearings.
j. Wheel type, diameter, maximum revolutions per minute for fan class, operating revolutions per minute, and tip speed.
k. Motor data, including service factor and operating horsepower, as specified in Section 26 05 01, Electrical.
l. Fan shaft first critical speed.
m. Belt service factor.
n. Drive assembly horsepower rating.
o. Sheave horsepower rating.
p. Power and control wiring diagrams, including terminals and numbers.
q. Vibration isolation.
r. Factory finish system.
s. Color selection charts where applicable.
t. Corrosion protection coating product data.

2. “Or-Equal” Equipment:
   a. Where submitted equipment results in change to fan inlet or outlet ductwork configuration shown on Drawings, submit system effect factor calculations indicating increased static pressure requirements as described in AMCA 201.
   b. Where submitted equipment results in change to ductwork and equipment configuration shown on Drawings, submit detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement to equipment furnished.

B. Informational Submittals:

1. Recommended procedures for protection and handling of products prior to installation.
2. Manufacturer’s installation instructions.

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3. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturer's Field Services, for the following:
   a. Motors specified to be premium efficient type.
4. Test reports.
5. Operation and maintenance data in conformance with Section 01 91 00, Equipment Systems Commissioning, Operation and Maintenance Data. Include as-built version of equipment schedules.

1.04 QUALITY ASSURANCE

A. Performance Ratings: Tested in accordance with AMCA 210.

B. Sound Ratings: Tested in accordance with AMCA 300.

C. Fabrication: In accordance with AMCA 99.

1.05 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage in accordance with Section 01 10 00, General Requirements.

B. Delivery: In accordance with Section 01 10 00, General Requirements.

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Some specific equipment requirements are listed in Equipment Schedule. Refer to Drawings.

2.02 GENERAL

A. Spark Resistant Construction: Fans required to be spark resistant shall comply with requirements of AMCA 99-0401.

B. Operating Limits: Fans designated to meet a specified fan class shall comply with requirements of AMCA 99-2408.

C. Acoustical Levels: Equipment selections shall produce sound power levels in each octave band no greater than shown in Equipment Schedule.

D. Fan Drives:

1. Drive assembly shall be sized for a minimum 140 percent of fan motor horsepower rating.
2. Furnish multiple drive belts where motor horsepower is 2 hp or larger.

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3. Sheaves:
   a. Capable of providing 150 percent of motor horsepower.
   b. Unless otherwise noted, furnish belt-driven fans with cast iron or flanged steel sheaves.
4. Drive Adjustment:
   a. When fixed-pitch sheaves are furnished, accomplish system air balancing by either trial of different fixed-pitch sheaves or use of temporary adjustable-pitch sheaves.
   b. Provide trial and final sheaves, as well as drive belts, as required.
5. Fan Shafts: First critical speed of at least 125 percent of fan maximum operating speed.
6. Provide speed test openings at shaft locations.
7. Belts: Oil and heat resistant, nonstatic type.
8. Motors:
   a. Motors 20 hp or Smaller:
      1) Variable pitch V-belt sheaves allowing at least 20 percent speed variation.
      2) Final operating point shall be at approximate sheave midpoint.
   b. Motors Larger than 20 hp: Fixed-pitch sheaves.
   c. Furnish motors for V-belt drives with adjustable rails or bases.
9. Weather Cover: For outdoor applications, factory fabricated drive assembly of same material as fan housing, unless specified otherwise.
10. Belt and Shaft Guards:
    a. Easily removable and to enclose entire drive assembly, meeting federal, OSHA requirements.
    b. Guard faces of expanded metal having minimum 60 percent free area for ventilation.
    c. Bright yellow finish.

E. Finishes:

1. Carbon Steel Parts: Factory finish as follows, unless indicated otherwise.
   a. Parts cleaned and chemically pretreated with phosphatizing process.
   b. Alkyd enamel primer.
   c. Air dry enamel topcoat.
2. Aluminum Parts: Finished smooth and left unpainted, unless stated otherwise.
3. Stainless Steel Parts: Finished smooth and left unpainted.
4. Fiberglass Parts: Finished in accordance with Paragraph Fiberglass Material.

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2.03 UTILITY BLOWER, CENTRIFUGAL SWSI, HEAVY DUTY

A. General:

1. Factory-assembled, centrifugal, inline fan, square housing configuration; including housing, fan wheel, drive assembly, motor and accessories.
2. Suitable to convey air at temperatures up to 250 degrees F.
3. Fan Performance: AMCA 99-2408 Class I
4. Bearing AMCA Certified Ratings Seal for sound and air performance.

B. Housing:

1. Material: Aluminum or steel, as scheduled.
2. Construction:
   a. Curved scroll configuration, with continuous seam welding and side angle reinforcement.
   b. Lifting lugs welded to housing.
   c. Flanged and drilled outlet to permit duct connection.
   d. Drain connection located at lowest point of fan housing. Inlet: Spun-formed aerodynamic bell mouth.
3. Base/Pedestal: All-welded heavy gauge steel.

C. Wheel:

1. Centrifugal, one-piece, nonoverloading, backward-inclined airfoil blade.
2. Fan wheel speed not to exceed 90 percent of manufacturer’s listed safe fan speed.
3. Material: Aluminum.
4. Attached to fan shaft with split taper lock bushing.

D. Shaft, Bearings, Drive:

1. Shafts:
   a. Turned, ground and polished steel.
   b. Ends drilled and countersunk for tachometer readings.
   c. Keyed for sheave installation.
2. Bearings:
   a. Grease lubricated, precision antifriction ball, self-aligning, pillow block style, relubricatable or sealed type.
   b. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
3. Drives:
   a. In accordance with Paragraph Fan Drives.
   b. Factory set to specified fan revolutions per minute.

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c. Type: Belt.
d. Arrangement: Arrangement 10.

E. Accessories: Provide as follows:

1. Housing Access Doors: Bolted and gasketed.
2. Disconnect: Factory-installed, nonfused, NEMA Type 4X.
3. Flanged Inlet: Heavy gauge construction, factory drilled and flanged.
4. Shaft Seal: Viton construction, located at shaft penetration of housing.
5. Belt Guard: OSHA type, sheet metal construction same material as fan housing, for complete coverage of belts and sheaves.
6. Motor and Drive Cover:
   a. Factory fabricated, OSHA type.
   b. Sheet metal construction, same material as fan housing.
   c. Vented, openings sufficient size for proper motor cooling.
   d. Fan speed controller.
7. Inlet Guard: Spiral wire type, OSHA-approved, removable, same material as fan housing.
8. Unitary Subbase:
   a. Structural metal subbase, same material as fan housing.
   b. Bolted to bottom of fan base/pedestal.
   c. Drilled for field installation of vibration isolators.
9. Spark-resistant Construction Classification: AMCA 99-0401 Type A.
10. Gravity Backdraft Damper: Aluminum steel frame, aluminum blades, brass pivot pins, neoprene seals on damper blade edges, gravity operation, and adjustable counterweight.
11. Disconnect: Factory installed, nonfused, NEMA Type 4X.

F. Manufacturers and Products:

1. Greenheck; Model USF; basis of design as scheduled on Drawings.

2.04 AEROVENT; MODEL BI. NEW YORK BLOWER; ACOUSTAFOIL/PLR.COOK: CP SERIES.CORROSION PROTECTION COATING

A. General:

1. Factory-applied corrosion protection coating for application to fan components and accessories, where required by this section.
2. Quality Control:
   a. Verify dry film thickness before final baking.
   b. Finished coating system shall be free from voids, checks, cracks, and blisters.

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3. Surface Cleaning: Clean parts to be coated as follows.
   a. Immerse parts in heated cleaning solution to remove lubricants, machining oils, and residual factory contamination.
   b. Follow with immersion in potable water bath to neutralize and remove cleaning solution.
   c. Chemical Pretreatment: Immerse parts in heated chemical solution, iron phosphate for steel, clear/yellow chromate for aluminum.

B. Baked Polyester:

1. Material: Polyester.
2. Surface Preparation: Sandblast surface to SSPC SP 5.
3. Application: Electrostatic spray.
4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
5. Finished Thickness: 1.5-mil to 2.5-mil dry film thickness.
6. Performance: Coating shall meet or exceed following criteria.
   a. Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
   b. Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
   c. Impact Resistance: 100-inch pounds, ASTM D2794 test method.
   d. Pencil Hardness: 2H, ASTM D3363 test method.
   e. Service Temperature: Maximum 230 degrees F, continuous.

2.05 ELECTRICAL

A. NEMA classification in accordance with Division 26.

B. Comply with Fans Schedule on Drawings.

2.06 MOTORS

A. General:

1. Provide IEEE 841 premium efficiency motors in strict conformance with Section 26 05 01, Electrical.
2. Motors shall not operate into service factor in any case.
3. Comply with Ventilation Fans Schedule on Drawings.

2.07 ACCESSORIES

A. Equipment Identification Plates: Provide 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch-high

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engraved block type black enamel-filled equipment tag number and plant identification number. Equipment tag number as shown in this Specification or Equipment Schedule and as shown on Drawings.

B. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

2.08 SOURCE QUALITY CONTROL

A. General

1. Fan shall operate at single stable point as indicated by fan curve. Fans having two potential operating points are not acceptable.
2. Fan and motor combination shall be capable of delivering 110 percent of scheduled air quantity and static pressure. Motor shall not operate into motor service factor in any listed case.
3. Consider drive efficiency in motor selection according to manufacturer's published recommendation or according to AMCA 203, Appendix L.

B. Testing Provisions:

1. Provide tachometer access holes large enough to accept standard tachometer drive shaft.
2. Center punch fan shaft to accommodate tachometer readings.

C. Acoustical Levels:

1. Perform noise tests in accordance with AMCA 300 and AMCA 301.
2. Fan sound power levels (dB, Reference 10-12 Watts) shall be no greater than scheduled values.

D. Balancing:

1. Unless noted otherwise, each fan wheel shall be statically and dynamically balanced to ASA S2.19 Grade G6.3.
2. Fans controlled by variable frequency drives shall be dynamically balanced at speeds 25 percent, 50 percent, 75 percent, and 100 percent of design revolutions per minute.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install fans level and plumb.

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B. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

C. Scroll Drains: Pipe drain connection through running trap to floor drain.

D. Labeling:

1. Label fans in accordance with Article Accessories.
2. Mark exhaust fans serving fume hoods with arrows to indicate proper direction of rotation, in accordance with NFPA 45.

E. Service Access: Locate units to provide access spaces required for motor, drive, bearing servicing, and fan shaft removal.

F. Equipment Support and Restraints:

1. Install floor-mounted units on concrete bases designed to withstand, without damage to equipment, the seismic force required by code.
2. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.
3. Seismic Restraint Snubbers: Install with sufficient clearance so unit isolators are not restricted for proper free isolation but do limit movement in all directions.

G. Connections:

1. Refer to Section 23 31 13, Metal Ducts and Accessories.
2. Isolate duct connections to fans.
3. Install ductwork adjacent to fans to allow proper service and maintenance.

3.02 FIELD QUALITY CONTROL

A. Functional Tests:

1. Verify blocking and bracing used during shipping are removed.
2. Verify fan is secure on mountings and supporting devices, and connections to ducts and electrical components are complete.
3. Verify proper thermal-overload protection is installed in motors, starters, and disconnect switches.
4. Verify cleaning and adjusting are complete.
5. Disconnect fan drive from motor; verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation.
6. Reconnect fan drive system; align and adjust belts and install belt guards.
7. Verify lubrication for bearings and other moving parts.

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8. Verify manual and automatic volume control and fire and smoke dampers in connected ductwork are in fully open position.

B. Performance Tests:

1. Starting Procedures:
   a. Energize motor and adjust fan to indicated revolutions per minute.
   b. Measure and record motor voltage and amperage.
2. Operational Test:
   a. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   b. Repair or replace malfunctioning units; retest as specified after repairs or replacement is made.
   c. Test and adjust control safeties.
   d. Replace damaged and malfunctioning controls and equipment.

3.03 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified component, subsystem, equipment, or system.

B. Manufacturer's Representative: Present at site or classroom designated by Owner, for minimum person-day listed below, travel time excluded:

1. 1 person-day for installation assistance and inspection.
2. 1 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.

3.04 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

D. Balancing:

1. Perform air system balancing as specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.
2. Replace fan and motor sheaves as required to achieve design airflow.

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E. Vibration Testing:

1. Perform field testing on rotating equipment, where specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC, to determine actual operating vibration.
2. If vibration limits described therein are exceeded, rebalance equipment in-place until design tolerances are met.

3.05 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

B. On completion of installation, internally clean fans according to manufacturers' written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

END OF SECTION

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SECTION 23 37 00
AIR OUTLETS AND INLETS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 880, Air Terminals.
2. ASTM International (ASTM): C636/C636M, Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels.
3. UL.

1.02 DEFINITIONS

A. NC: Noise Criteria; background sound rating method for indoor sound.

B. VAV: Variable air volume.

C. WC: Water column.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Manufacturer's data and descriptive literature for products specified.
   b. Furnish the following information for each type of diffuser, register, and grille furnished.
      1) NC sound data.
      2) Static pressure loss data.
      3) Throw data.

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Refer to Drawings.

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2.02 RETURN, EXHAUST AND TRANSFER GRILLES AND REGISTERS

A. Louvered Return, Exhaust and Transfer Grilles and Registers (RG1, RR1, EG1, ER1, TG1):

1. Construction: As follows:
   a. Material: Aluminum.
   b. Finish: Aluminum face finish.
   c. RR and ER Register Accessories:
      1) Gang-operated opposed-blade volume control damper.
      2) Material to match grille.
2. Fixed horizontal louvers set at 35 degrees to 45 degrees.
3. 1-inch minimum flat, rectangular frame.
4. Manufacturers and Products:
   a. Krueger; S80/S580H Series.
   b. Carnes; Type RAAAH.
   c. Titus; 350 Series.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install diffusers, grilles, and registers tight on their respective mounting surfaces, level, plumb, and true with room dimensions.

END OF SECTION

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SECTION 26 05 01
ELECTRICAL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway Transportation Officials (AASHTO).
2. ASTM International (ASTM):
   a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   b. A240/A240M, Standard Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.
   c. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
   d. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   e. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
3. Electronic Industries Association (EIA/TIA): 569, Commercial Building Standard for Telecommunications Pathways and Spaces.
4. Federal Specifications (FS):
   a. W-C-596, Connector, Electrical, Power, General Specification for.
   b. W-S-896, Switch, Toggle (Toggle and Lock), Flush Mounted (General Specification).
5. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
   b. PC62.41.1, Draft Guide on the Surge Environment in Low-Voltage (1000 V and less) AC Power Circuits.
   c. 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
   d. 114, IEEE Standard Test Procedure for Single-Phase Induction Motors.
6. International Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

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7. National Electrical Contractor's Association, Inc. (NECA): 1, Standard Practices for Good Workmanship in Electrical Contracting.
8. National Electrical Manufacturers Association (NEMA):
    a. C80.1, Rigid Steel Conduit-Zinc Coated.
    b. C80.3, Electrical Metallic Tubing-Zinc Coated.
    c. C80.6, Intermediate Metal Conduit-Zinc Coated (IMC).
    d. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
    e. CC1, Electrical Power Connectors for Substations.
    f. ICS 1, Industrial Control and Systems: General Requirements.
    g. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated Not More Than 2000 Volts AC or 750 Volts DC.
    h. ICS 2.3, Industrial Control and Systems: Instructions for the Handling, Installation, Operation and Maintenance of Motor Control Centers.
    i. MG 1, Motors and Generators.
    j. PB 1, Panelboards.
    k. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
    l. ST 20, Dry Type Transformers for General Applications.
    m. TC 2, Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.
    n. TC 3, PVC Fittings for Use with Rigid PVC Conduit and Tubing.
    o. WC 55, Instrumentation Cables and Thermocouple Wire.
    p. WC 70, Standard for Non-Shielded Power Cables Rated 2000 V or Less for the Distribution of Electrical Energy.
    q. WC 71, Standard for Non-Shielded Cables Rated 2001-5000 Volts for use in the Distribution of Electrical Energy.
    r. WC 74, 5-46 KV Shielded Power Cable for use in the Transmission and Distribution of Electric Energy.
    s. WD 1, General Color Requirements for Wiring Devices.
9. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
10. Underwriters Laboratories, Inc. (UL):
    a. 1, Flexible Metal Conduit.
    b. 6, Electrical Rigid Metal Conduit—Steel.
    c. 13, Power-Limited Circuit Cables.
    d. 44, Thermoset Insulated Wires and Cables.
    e. 62, Flexible Cord and Fixture Wire.
    f. 67, Panelboards.
    g. 98, Enclosed and Dead-Front Switches.
    h. 198C, High Interrupting Capacity Fuses, Current Limiting Types.
    i. 198E, Class R Fuses.
    j. 360, Liquid-Tight Flexible Steel Conduit.

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k. 486A, Wire Connectors and Soldering Lugs for Use with Copper Conductors.
l. 486C, Splicing Wire Connectors.
m. 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
n. 508, Industrial Control Equipment.
o. 510, Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape.
p. 514B, Fittings for Cable and Conduit.
q. 651, Schedule 40 and 80 PVC Conduit.
r. 674, Electric Motors And Generators for use in Division 1 Hazardous (Classified) Locations.
s. 797, Electrical Metallic Tubing.
t. 854, Service-Entrance Cables.
u. 870, Wireways, Auxiliary Gutters, and Associated Fittings.
v. 943, Ground-Fault Circuit Interrupters.
w. 1059, Terminal Blocks.
x. 1242, Intermediate Metal Conduit.
y. 1277, Electrical Power and Control Tray Cables with Optional Optical-Fibre Members.
z. 1449, Transient Voltage Surge Suppressors.
aa. 1561, Dry-Type General Purpose and Power Transformers.
bb. 2111, Overheating Protection for Motors.

1.02 DEFINITIONS

A. AHJ: Authority Having Jurisdiction.

B. MCOV: Maximum Allowable Continuous Operating Voltage.

C. MOV: Metal Oxide Varistor.

D. SASD: Silicon Avalanche Suppressor Diode.

E. SVR: Surge Voltage Rating.

F. TVSS: Transient Voltage Surge Suppressor.

1.03 SUBMITTALS

A. Action Submittals:

1. Boxes and device plates.
2. Junction and pull boxes.
3. Wiring devices.

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4. Circuit breakers and switches.
5. Control devices, terminal blocks, and relays.
6. Contactors.
7. Transformers.
8. Support and framing channels.
9. Nameplates and nameplate schedule.
10. Conduit, fittings, and accessories.
11. Conductors, cable, and accessories.
12. Motors: Nameplate data, detailed information on any special features.
13. Grounding materials.
14. Motor Controls: Arrangement drawings, ratings, schematic and wiring diagrams, bill of materials, nameplate schedule, manufacturer information on components.
15. Local Control Panels: Arrangement drawings, schematic and wiring diagrams, bill of materials, nameplate schedule, manufacturer information on components.
16. Luminaires.

B. Informational Submittals:

1. Factory test reports.
2. Field test reports.
3. Operation and Maintenance Data:
    a. As specified in Section 01 78 23, Operation and Maintenance Data.
    b. Provide for all equipment, as well as each device having features that can require adjustment, configuration, or maintenance.
    c. Minimum information shall include manufacturer's preprinted instruction manual, one copy of the approved submittal information for the item, tabulation of any settings, and copies of any test reports.

1.04 APPROVAL BY AUTHORITY HAVING JURISDICTION

A. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ, in order to provide a basis for approval under the NEC.

B. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc., shall conform to those standards and shall have an applied UL listing mark or label.

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1.05 QUALIFICATIONS

A. PVC-Coated, Rigid Steel Conduit Installer: Must be certified by conduit manufacturer as having received minimum 2 hours of training on installation procedures.

B. Testing Firm Qualifications: Professionally independent of manufacturers, suppliers, and installers, or electrical equipment and systems being tested.

PART 2 PRODUCTS

2.01 GENERAL

A. Products shall comply with all applicable provisions of NFPA 70.

B. Like Items of Equipment: End products of one manufacturer in order to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's service.

C. Equipment and Devices Installed Outdoors or in Unheated Enclosures: Capable of continuous operation within ambient temperature range of -10 degrees F to 115 degrees F.

D. Hazardous Areas: Products shall be acceptable to the regulatory authority having jurisdiction for the class, division, and group of hazardous area indicated.

E. Equipment Finish:

1. Manufacturer's standard finish color, except where specific color is indicated.
2. If manufacturer has no standard color, finish equipment in light gray color finish as approved by Owner.

2.02 OUTLET AND DEVICE BOXES

A. Cast Metal:

1. Box: Cast ferrous metal.
2. Cover: Gasketed, weatherproof, and cast ferrous metal with stainless steel screws.
3. Hubs: Threaded.
4. Lugs: Cast Mounting.

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5. Manufacturers and Products, Nonhazardous Locations:
   a. Crouse-Hinds; Type FS or FD.
   b. Appleton; Type FS or FD.
6. Manufacturers and Products, Hazardous Locations:
   a. Crouse-Hinds; Type GUA or EAJ.
   b. Appleton; Type GR.

B. PVC-Coated Cast Metal:

1. Type: One-piece.
2. Material: Malleable iron, cast ferrous metal, or cast aluminum.
3. Coating:
   a. All Exterior Surfaces; 40 mils PVC.
   b. All Interior Surfaces, 2 mils urethane.
4. Manufacturers:
   a. Robroy Industries.
   b. Ocal.

2.03 JUNCTION AND PULL BOXES

A. Outlet Boxes Used as Junction or Pull Box: As specified under Article Outlet and Device Boxes.

B. Conduit Bodies Used as Junction Boxes: As specified under Article Conduit and Fittings.

C. Large Sheet Steel Box:

1. NEMA 250, Type 1.
2. Box: Code-gauge, galvanized steel.
3. Cover: Full access, screw type.
4. Machine Screws: Corrosion-resistant.

D. Large Stainless Steel Box:

1. NEMA 250, Type 4X.
2. Box: 14-gauge, ASTM A240, Type 304 stainless steel with white enamel painted interior mounting panel.
3. Cover: Hinged with clamps.
4. Hardware and Machine Screws: ASTM A167, Type 304 stainless steel.
5. Manufacturers:
   a. Hoffman Engineering Co.
   b. Robroy Industries.

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2.04 WIRING DEVICES

A. Switches:

1. NEMA WD 1 and FS W-S-896.
2. Industrial grade, totally enclosed, ac type, with quiet tumbler switches and screw terminals.
3. Capable of controlling 100 percent tungsten filament and fluorescent lamp loads.
4. Rating: 20 amps, 120/277 volts.
5. Color: Ivory.
6. Automatic grounding clip and integral grounding terminal on mounting strap.
7. Manufacturers and Products:
    a. Leviton; 1221 Series.
    b. Bryant; 4901 Series.
    c. Hubbell; 1221 Series.

B. Receptacle, Single and Duplex:

1. NEMA WD 1 and FS W-C-596.
2. Specification grade, two-pole, three-wire grounding type with screw type wire terminals suitable for No. 10 AWG.
3. High strength, thermoplastic base color.
4. Color: Ivory.
5. Contact Arrangement: Contact to be made on two sides of each inserted blade without detent.
6. Rating: 125 volts, NEMA WD 1, Configuration 5-15R, 15 amps.
7. One-piece mounting strap with integral ground contact (rivetless construction).
8. Manufacturers and Products:
    a. Arrow Hart; 5262 Series.
    b. Leviton; 5262/5362 Series.
    c. Bryant; 5262/5362 Series.
    d. Hubbell; 5262/5362 Series.

C. Receptacle, Special-Purpose:

1. Rating and number of poles as shown or as required for anticipated purpose.
2. One matching plug with cord-grip features for each special-purpose receptacle.

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2.05 DEVICE PLATES

A. General: Sectional type plates not permitted.

B. Metal:

1. Material: Specification grade, one-piece, 0.040-inch nominal thickness stainless steel.
2. Finish: ASTM A167, Type 302/304, satin.
3. Mounting Screw: Oval-head, finish matched to plate.

C. Cast Metal:

1. Material: Malleable ferrous metal or Copper-free aluminum with gaskets.
2. Screw: Oval-head stainless steel.

D. Weatherproof:

1. For Receptacles, Damp Locations:
   a. Gasketed, cast-aluminum, with individual cap over each receptacle opening.
   b. Mounting Screw and Cap Spring: Stainless steel.
   c. Manufacturers and Products:
      1) Crouse-Hinds; Type WLRD-1.
      2) Appleton; Type FSK-WRD.
2. For Receptacles, Wet Locations:
   a. Impact-resistant, nonmetallic, single-gang, horizontal-mounting, providing, while in-use, NEMA 3R rating.
   b. Stainless steel mounting and hinge hardware.
   c. Lockable, paintable.
   d. Color: Gray.
   e. Manufacturers:
      1) Carlon.
      2) Leviton.
3. For Switches:
   a. Gasketed, cast-metal or cast-aluminum, incorporating external operator for internal switch.
   b. Mounting Screw: Stainless steel.
   c. Manufacturers and Products:
      1) Crouse-Hinds; DS-181 or DS-185.
      2) Appleton; FSK-1VTS or FSK-1VS.

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2.06 CIRCUIT BREAKER, INDIVIDUAL, 0 TO 600 VOLTS

A. UL 489 listed for use at location of installation.

B. Minimum Interrupt Rating: As indicated on drawings.

C. Thermal-magnetic, quick-make, quick-break, indicating type showing ON/OFF and TRIPPED indicating positions of operating handle.

D. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

E. Locking: Provisions for padlocking handle.

F. Enclosure: As specified under Execution.

G. Interlock: Enclosure and switch shall interlock to prevent opening cover with breaker in the ON position.

H. Manufacturers:

1. Eaton.
2. General Electric Co.
3. Square D Co.

2.07 NONFUSED SWITCH, INDIVIDUAL, 0 TO 600 VOLTS

A. NEMA KS 1.

B. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

C. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

D. Enclosure: As specified under Execution.

E. Interlock: Enclosure and switch to prevent opening cover with switch in the ON position.

F. Manufacturers:

1. Eaton.
2. General Electric Co.
3. Square D Co.

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2.08 PUSHBUTTONS, INDICATING LIGHTS, AND SELECTOR SWITCHES

A. Type: Heavy-duty, oiltight. Provide contact arrangements, colors, inscriptions, and functions as shown.

B. Contact Rating: NEMA ICS 2, Type A600.

C. Unless otherwise shown, provide the following features:

1. Selector Switch Operating Lever: Standard.
2. Indicating Lights: Push-to-test, transformer-type.
3. Pushbutton Color:
   a. ON or START: Black.
   b. OFF or STOP: Red.
4. Pushbuttons and selector switches lockable in OFF position where indicated.

D. Legend Plate:

1. Material: Aluminum.
2. Engraving: Indicating specific function, or as shown.
3. Letter Height: 7/64 inch.

E. Manufacturers and Products:

1. General Electric Co.; Type CR 104P.
2. Square D Co.; Type T.
3. Eaton; Type 10250T.

2.09 TERMINAL BLOCKS

A. Type: UL 1059. Compression screw clamp, with current bar providing direct contact with wire and yoke, with individual rail mounted terminals. Marking system shall permit use of preprinted or field-marked tags.

B. Yokes and Clamping Screws: Zinc-plated, hardened steel.

C. Rating: 600V ac.

D. Manufacturers:

1. Weidmuller, Inc.
2. Ideal.

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2.10 MAGNETIC CONTROL RELAYS

A. NEMA ICS 2, Class A600 (600 volts, 10 amperes continuous, 7,200VA make, 720VA break), machine tool type with field convertible contacts.

B. Manufacturer and Model:

1. Eaton; Type M-600.
2. General Electric; Type CR120B.

2.11 TIME DELAY RELAY

A. Industrial Relay Rated: 150 volts, 5 amps continuous, (3600 VA make, 360 VA break).

B. Solid-state electronic, field convertible ON/OFF delay.

C. Two Form-C contacts (minimum).

D. Repeat accuracy plus or minus 2 percent.

E. Timer Adjustment: Multiple adjustable ranges, including 1 second to 60 seconds, unless otherwise shown.

F. Manufacturers:

1. Omron.
2. Eaton.
3. General Electric Co.

2.12 SUPPORT AND FRAMING CHANNELS

A. Carbon Steel Framing Channel:

1. Material: Rolled, mild strip steel, 12 gauge, ASTM A1011/A1011M, Grade 33.
2. Finish: Hot-dip galvanized after fabrication.

B. Stainless Steel Framing Channel: Rolled, ASTM A167, Type 316 stainless steel, 12 gauge.

C. Manufacturers:

1. B-Line Systems, Inc.
2. Unistrut Corp.

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2.13 NAMEPLATES

A. Material: Laminated plastic.

B. Attachment: Adhesive.

C. Color: Black, engraved to a white core, or as shown.

D. Engraving:

1. Devices and Equipment: Name or tag shown, or as required.
2. Panelboards:
   a. Designation.
   b. Service voltage.
   c. Phases.
3. Minimum Requirement: Label metering and power distribution equipment, local control panels, junction boxes, motor controls, and transformers.

E. Letter Height:

1. Pushbuttons, Selector Switches, and Other Devices: 1/8 inch.
2. Equipment and Panelboards: 1/4 inch.

2.14 CONDUIT AND FITTINGS

A. Rigid Galvanized Steel Conduit (RGS):

1. Meet requirements of NEMA C80.1 and UL 6.
2. Material: Hot-dip galvanized, with chromated protective layer.

B. PVC-Coated Rigid Galvanized Steel Conduit:

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

C. Flexible Metal, Liquid-Tight Conduit:

1. UL 360 listed for 105 degrees C insulated conductors.
2. Material: Galvanized steel, with an extruded PVC jacket.

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D. Fittings:

1. Provide bushings, grounding bushings, conduit hubs, conduit bodies, couplings, unions, conduit sealing fittings, drain seals, drain/breather fittings, expansion fittings, and cable sealing fittings, as applicable.
2. Rigid Galvanized Steel and Intermediate Metal Conduit:
   a. Meet requirements of UL 514B.
   b. Type: Threaded, galvanized.
3. PVC-Coated Rigid Galvanized Steel Conduit:
   a. Meet requirements of UL 514B.
   b. Fittings: Rigid galvanized steel type, PVC-coated by conduit manufacturer.
   c. Conduit Bodies: Cast metal hot-dipped galvanized or urethane finish. Cover shall be of same material as conduit body. PVC-coated by conduit manufacturer.
   d. Finish: 40-mil PVC exterior, 2-mil urethane interior.
   e. Overlapping pressure sealing sleeves.
   f. Conduit Hangers, Attachments, and Accessories: PVC-coated.
   g. Manufacturers:
      1) Robroy Industries.
      2) Ocal.
   h. Expansion Fitting Manufacturer and Product: Ocal; Ocal-Blue XJG.
4. Flexible Metal, Liquid-Tight Conduit:
   a. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C.
   b. Insulated throat and sealing O-rings.

2.15 CONDUIT ACCESSORIES

A. Identification Devices:

1. Raceway Tags:
   a. Material: Permanent, nylon.
   b. Shape: Round.
   c. Raceway Designation: Pressure stamped, embossed, or engraved.
   d. Tags relying on adhesives or taped-on markers not permitted.
2. Warning Tape:
   a. Material: Polyethylene, 4-mil gauge with detectable strip.
   b. Color: Red.
   c. Width: Minimum 3 inches.
   d. Designation: Warning on tape that electric circuit is located below tape.

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e. Identifying Letters: Minimum 1-inch high permanent black lettering imprinted continuously over entire length.

B. Raceway Band:

1. Slip-on Type:
   a. Provide heat-shrinkable, black, medium-wall polyolefin tubing with factory-applied adhesive/sealant. Select product size based upon raceway outside diameter.
   b. Manufacturer and Product: 3M; Type IMCSN, medium wall cable sleeve.
2. Wrap-around Type:
   a. Provide 4-inch width, 20-mil thickness, nonprinted black PVC corrosion protection tape with primer.
   b. Manufacturer and Product: 3M; Type Scotchrap 51 with Scotch rap Pipe Primer.

2.16 CONDUCTORS AND CABLES

A. Conductors 600 Volts and Below:

1. Conform to applicable requirements of NEMA WC 71, WC 72, and WC 74.
2. Conductor Type:
   a. 120- and 277-Volt Lighting, No. 10 AWG and Smaller: Solid copper.
   b. 120-Volt Receptacle Circuits, No. 10 AWG and Smaller: Solid copper.
   c. All Other Circuits: Stranded copper.
3. Insulation: Type THHN/THWN, except for sizes No. 6 and larger, with XHHW-2 insulation.
4. Direct Burial and Aerial Conductors and Cables:
   a. Type USE/RHH/RHW insulation, UL 854 listed or Type RHW-2/USE-2.
   b. Conform to physical and minimum thickness requirements of NEMA WC 70.
5. Flexible Cords and Cables:
   a. Type SOW-A/50 with ethylene propylene rubber insulation in accordance with UL 62.
   b. Conform to physical and minimum thickness requirements of NEMA WC 70.

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B. 600-Volt Rated Cable:

1. General:
   a. Type TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 20,000 Btu per hour, and NFPA 70, Article 340, or UL 13 meeting requirements of NFPA 70, Article 725.
   b. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
   c. Suitable for installation in open air, in cable trays, or conduit.
   d. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
   e. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.
2. Type TSP, No. 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 55 requirements.
   a. Outer Jacket: 45 mils nominal thickness.
   b. Individual Pair Shield: 1.35 mils, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
   c. Dimension: 0.31-inch nominal outside diameter.
   d. Conductors:
      1) Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
      2) 20 AWG, seven-strand tinned copper drain wire.
      3) Insulation: 15 mils nominal PVC.
      4) Jacket: 4 mils nominal nylon.
      5) Color Code: Pair conductors black and red.
   e. Manufacturers: Okonite Co.

C. Accessories:

1. Tape:
   a. General Purpose, Flame Retardant: 7 mils, vinyl plastic, Scotch Brand 33, rated for 90 degrees C minimum, meeting requirements of UL 510.
   b. Flame Retardant, Cold and Weather Resistant: 8.5 mils, vinyl plastic, Scotch Brand 88.
   c. Arc and Fireproofing:
      1) 30 mils, elastomer.

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2) Manufacturers and Products:
   a) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.
   b) Plymount; Plyarc 53, with Plyglas 77 glass cloth tapebinder.

2. Identification Devices:
   a. Sleeve-type, permanent, PVC, yellow or white, with legible machine-printed black markings.
   b. Manufacturer and Products: Raychem; Type D-SCE or ZH-SCE.
3. Connectors and Terminations:
   a. Nylon, Self-Insulated Crimp Connectors:
      1) Manufacturers and Products:
         a) Thomas & Betts; Sta-Kon.
         b) Burndy; Insulug.
         c) ILSCO.
4. Self-Insulated, Freespring Wire Connector (Wire Nuts):
   a. Plated steel, square wire springs.
   b. UL Standard 486C.
   c. Manufacturers and Products:
      1) Thomas & Betts.
      2) Ideal; Twister.
5. Cable Lugs:
   a. In accordance with NEMA CC 1.
   b. Rated 600 volts of same material as conductor metal.
   c. Uninsulated Crimp Connectors and Terminators:
      1) Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
      2) Manufacturers and Products:
         a) Thomas & Betts; Color-Keyed.
         b) Burndy; Hydent.
         c) ILSCO.
   d. Uninsulated, Bolted, Two-Way Connectors and Terminators:
      1) Manufacturers and Products:
         a) Thomas & Betts; Locktite.
         b) Burndy; Quiklug.
         c) ILSCO.
6. Cable Ties:
   a. Nylon, adjustable, self-locking, and reusable.
   b. Manufacturer and Product: Thomas & Betts; TY-RAP.
7. Heat Shrinkable Insulation:
   a. Thermally stabilized, crosslinked polyolefin.
   b. Manufacturer and Product: Thomas & Betts; SHRINK-KON.

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2.17 MOTORS

A. Three-Phase:

1. For multiple units of the same type of equipment, furnish identical motors and accessories of a single manufacturer.
2. Meet requirements of NEMA MG 1.
3. Provide motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark.
4. Motors shall be specifically designed for use and conditions intended, with a NEMA design letter classification to fit application.
5. Lifting lugs on motors weighing 100 pounds or more.
6. Operating Conditions: Maximum ambient temperature not greater than 40 degrees C.
7. Horsepower Rating: As designated in motor-driven equipment specifications. Brake horsepower of the driven equipment at any operating condition shall not exceed motor nameplate horsepower rating, excluding any service factor.
8. Service Factor: 1.15 minimum at rated ambient temperature, unless otherwise shown.
9. Voltage and Frequency Rating: 460V ac, 60 Hz, unless otherwise indicated in motor-driven equipment specifications.
10. Suitable for full voltage starting. 100 hp and larger also suitable for reduced voltage starting with 65 percent or 80 percent voltage tap settings on reduced inrush motor starters.
11. Efficiency and Power Factor: Provide premium efficiency units, except for under 1 hp, multispeed, or short-time rated motors, or motors driving gates, valves, elevators, cranes, trolleys, and hoists. Provide standard power factor.
12. Insulation Systems: Unless otherwise indicated in motor-driven equipment specifications, Class B or Class F at nameplate horsepower and designated operating conditions, except EXP motors that shall be Class B with Class B rise.
13. Enclosures:
    a. Open drip-proof, unless specified otherwise in the motor-driven equipment specification. Provide screens over air openings. Enclosures shall conform to NEMA MG 1.
    b. TEFC and TENV: Furnish with a drain hole with porous drain/weather plug.
    c. Explosion-Proof (EXP):
        1) TEFC listed to meet UL 674 and NFPA 70 requirements for Class I, Division 1, Group D hazardous locations.
        2) Drain holes with drain and breather fittings.

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3) Integral thermostat opening on excessive motor temperature in accordance with UL 2111 and NFPA 70.
4) Terminate thermostat leads in terminal box separate from main terminal box.

d. Equipment Finish: Manufacturer's standard.

14. Winding Thermal Protection:
    a. Thermostats:
        1) Motors for constant speed application 10 hp. through 50 hp.
        2) Bi-metal disk or rod type thermostats embedded in stator windings.
        3) Automatic reset contacts rated 120V ac, 5 amps minimum, opening on excessive temperature.
    b. Thermistors:
        1) Motors for constant speed application 60 hp and larger. Motors for adjustable speed application 40 hp and larger.
        2) Thermistor embedded in each stator phase winding before winding dip and bake process.
        3) Epoxy-potted, solid state thermistor control module mounted in NEMA 250, Type 4X box on motor by motor manufacturer.
        4) Individual thermistor circuits factory-wired to control module.
        5) Control module suitable for 120V ac power supply.
        6) Control module automatically reset contact for external use rated 120V ac, 5 amps minimum, opening on abnormally high winding temperature. Manual reset shall be provided at motor controller.
15. Nameplates: In accordance with NEMA MG1.
16. Multispeed: Meet requirements for speeds, number of windings, and load torque classification indicated in the motor-driven equipment specifications.
17. Inverter Duty Motor:
    a. Motor supplied power by adjustable frequency drives shall be inverter duty-rated.
    b. Motor shall meet all applicable requirements of NEMA MG 1, Section IV, Part 30 and Part 31.
    c. Motor shall be suitable for operation over entire speed range indicated.
    d. Provide forced ventilation where speed ratio is greater than published range for motor being installed. Provide and coordinate fan power supply and motor control requirements with associated drive.

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e. Motor installed in Division 1 hazardous (classified) locations shall be identified as acceptable for variable speed when used in a Division 1 location.

B. Single-Phase:

1. Provide induction-type unit meeting NEMA MG 1 requirements and suitable for application and mounting with the driven load. Motor shall be 115/230V ac, 60 Hz. Provide integral thermal protection and manufacturer's standard insulation system.
2. Horsepower rating: As specified under motor-driven equipment specification.
3. Single-speed: Single-winding. Speed as specified under motor-driven equipment specification.
4. Two-speed: Two-winding; speeds as specified under motor-driven equipment specification.
5. Enclosure: Open drip-proof, unless otherwise noted.

C. Manufacturers:

1. General Electric.
2. Reliance Electric.
3. U.S. Electrical Motors.

D. Factory Testing:

1. Tests:
   a. In accordance with IEEE 112 for polyphase motors and IEEE 114 for single-phase motors.
   b. Provide routine (production) tests on all motors in accordance with NEMA MG 1. Test multispeed motors at all speeds.
   c. For premium efficiency motors, test efficiency and power factor at 50 percent, 75 percent, and 100 percent of rated horsepower:
      1) In accordance with IEEE 112, Test Method B, and NEMA MG 1, Paragraph 12.54 and Paragraph 12.57.
      2) Provide certified test reports for polyphase motors 100 hp and larger.
      3) For smaller motors, furnish a copy of a certified motor efficiency test report for identical motor.
2. Test Report Forms:
   a. Routine Tests: IEEE 112, Form A-1.
   b. Efficiency and power factor by Test Method B, IEEE 112, Form A-2, and NEMA MG 1, Paragraph (table) 12.57.

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2.18 GROUNDING

2.19 LOW VOLTAGE MOTOR CONTROL

A. General:

1. Make adjustments as necessary to wiring, conduit, disconnect devices, motor starters, branch circuit protection, and other affected material or equipment to accommodate motors and motor ratings actually provided.
2. Controllers: NEMA ICS 2, Class A.
3. Type: Electronic, providing integral overload, phase-loss, and phase-unbalance protection.
4. Electronic Overload Protection:
    a. Inverse-time-limit characteristic.
    b. Relay Trip: Integral, selectable trip class.
    c. Manual reset with indicator.
    d. Provide in each ungrounded phase.
    e. Provide N.O. auxiliary contact for remote status indication.
5. Control Transformer:
    a. Two winding, 120-volt secondary, primary voltage to suit.
    b. Two current-limiting fuses for primary circuit.
    c. One fuse in secondary circuit.
    d. Mount within starter unit.
6. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
7. Lifting lugs on all equipment and devices weighing over 100 pounds.
8. Operating Conditions:
    a. Ambient Temperature: Maximum 40 degrees C.
    b. Equipment to be fully rated without any derating for operating conditions listed above.
9. Equipment Finish:
    a. Electrocoating process applied over rust-inhibiting phosphated base coating.
    b. Exterior Color: Provide gray finish as approved by Engineer.
10. Phase Monitoring Relay: Where shown, provide three-phase monitoring relay to protect against low voltage, voltage unbalance, phase loss, and phase reversal.

B. Combination Full-Voltage, Magnetic Starter:

1. Rating: Horsepower rated at 600 volts; UL labeled for 22,000 amperes with overload protection.
2. Three-phase, non-reversing, full voltage.
3. Control: As shown.

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4. Disconnect Type: Motor circuit protector.
5. Enclosure: NEMA 250, Type 4X.
6. Pilot Lights: Red—ON and Green—OFF.
7. Padlockable operating handle.

C. Manufacturers:

1. Eaton.
2. General Electric.
3. Square D.
4. Allen Bradley.

2.20 LOCAL CONTROL PANELS

A. Enclosure:

1. NEMA 250, Type 12, or as shown.
2. Main power disconnect means. Doors shall be interlocked with main disconnect. Padlockable in “off” position.
3. Minimum Metal Thickness: 14 gauge.
4. Doors: Rubber gasketed with continuous hinge.
5. Finish: Gray.
6. Size panels to adequately dissipate heat generated by equipment mounted in or on panel.
7. Mount internal and door-mounted devices as shown.
8. Manufacturer:
   a. Hoffman.
   b. H. F. Cox.

B. Functions: As shown on schematic diagram(s).

C. Wiring:

1. Power and Control Wiring:
   a. 600-volt class, insulated, stranded copper.
   b. Size: Minimum 14 AWG enclosed in either sheet metal raceway or plastic wiring duct.
2. Signal Circuit Wiring: Twisted shielded pairs minimum No. 16 AWG, separated at least 6 inches from power wiring.
3. Device Identification: Provide engraved plastic nameplates, adhesive attachment, white letters on black background.

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2.21 LUMINAIRES AND ACCESSORIES

A. Specific requirements relating to fixture type, lamp type, and mounting hardware are provided in the Luminaire Schedule on Drawings.

PART 3 EXECUTION

3.01 GENERAL

A. Install materials and equipment in accordance with manufacturer's instructions and recommendations.

B. Work shall comply with all applicable provisions of NECA 1.

C. Install materials and equipment in hazardous areas in a manner acceptable to regulatory authority having jurisdiction for the class, division, and group of hazardous areas shown.

D. Electrical Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned.

3.02 DEMOLITION

A. General Demolition:

1. Where shown, de-energize and disconnect nonelectrical equipment for removal by others.
2. Where shown, de-energize, disconnect, and remove electrical equipment.
3. Remove affected circuits and raceways back to serving panelboard or control panel. Where affected circuits are consolidated with others, remove raceways back to first shared condulet or box. Where underground or embedded raceways are to be abandoned, remove raceway to 1 inch below surface of structure or 12 inches below grade and restore existing surface.

3.03 PROTECTION FOLLOWING INSTALLATION

A. Protect materials and equipment from corrosion, physical damage, and effects of moisture on insulation.

B. Cap conduit runs during construction with manufactured seals.

C. Close openings in boxes or equipment during construction.

D. Energize space heaters furnished with equipment.

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3.04 OUTLET AND DEVICE BOXES

A. Install suitable for conditions encountered at each outlet or device in wiring or raceway system, sized to meet NFPA 70 requirements.

B. Size:

1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted.
    a. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.
2. Ceiling Outlet: Minimum 4-inch octagonal sheet steel device box, unless otherwise required for installed fixture.
3. Switch and Receptacle: Minimum 2-inch by 4-inch sheet steel device box.

C. Locations:

1. Drawing locations are approximate.
2. To avoid interference with mechanical equipment or structural features, relocate outlets as directed by Engineer.
3. Light Switch: Install on lock side of doors.

D. Mounting Height:

1. General:
    a. Dimensions given to centerline of box.
    b. Where specified heights do not suit building construction or finish, mount as directed by Engineer.
2. Switches: 48 inches above floor.
3. Thermostat: 54 inches above floor.
4. Receptacles:
    a. General Indoor Areas: 18 inches above floor.
    b. General Indoor Areas (Counter Tops): Install device plate bottom or side 6 inches above counter tops.
    c. Industrial Areas, Workshops: 48 inches above floor.
    d. Outdoor, All Areas: 24 inches above finished grade.

E. Install plumb and level.

F. Flush Mounted:

1. Install with concealed conduit.
2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.

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G. Support boxes independently of conduit by attachment to building structure or structural member.

H. Box Type (Steel Raceway System):

1. Outdoor Locations: Cast metal.
2. Indoor Dry Locations:
   a. Exposed Rigid Conduit or IMC: Cast metal.
   b. Concealed Raceways: Sheet steel.
   c. Class I, II, or III Hazardous Areas: Cast metal.
3. Indoor Wet Locations:
   a. Exposed Raceways: Cast metal.
   b. Class I, II, or III Hazardous Areas: Cast metal.
4. Cast-in-Place Concrete Slabs: Sheet steel.

I. Box Type, Corrosive Locations (PVC-Coated rigid Galvanized Steel Raceway System): PVC-coated cast metal with matching cover.

3.05 JUNCTION AND PULL BOXES

A. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.

B. Install pull boxes where necessary in raceway system to facilitate conductor installation.

C. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.

D. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.

E. Use conduit bodies as junction and pull boxes where no splices are required, and their use is allowed by applicable codes.

F. Installed boxes shall be accessible.

G. Do not install on finished surfaces.

H. Install plumb and level.

I. Support boxes independently of conduit by attachment to building structure or structural member.

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J. Mounting Hardware:

1. Noncorrosive Indoor Dry Areas: Galvanized.
2. Outdoor or Noncorrosive Indoor Wet Areas: Stainless steel.
3. Corrosive Areas: Stainless steel.

K. Location/Type:

1. Indoor, Dry: NEMA 250, Type 1.
2. Indoor and Outdoor, Wet: NEMA 250, Type 4.
3. Indoor and Outdoor, Wet and Corrosive: NEMA 250, Type 4X, stainless steel.
4. Indoor and Outdoor, Wet, Dust, or Oil: NEMA 250, Type 13.
5. Corrosive: NEMA 250, Type 4X, stainless steel.
6. Outdoor, Where Indicated Weatherproof (WP): NEMA 250, Type 3R.
7. Industrial Use in Areas Not Otherwise Classified: NEMA 250, Type 12, unless otherwise shown.

3.06 WIRING DEVICES

A. Switches:

1. Mounting Height: See Article Outlet and Device Boxes.
2. Install with switch operation in vertical position.
3. Install single-pole, two-way switches such that toggle is in up position when switch is on.

B. Receptacles:

1. Install with grounding slot down, except where horizontal mounting is shown, in which case install with neutral slot up.
2. Ground receptacles to boxes with grounding wire only.
3. Weatherproof Receptacles:
   a. Install in cast metal box.
   b. Install such that hinge for protective cover is above receptacle opening.
4. Ground Fault Interrupter: Install feed-through model at locations where ground fault protection is specified for “downstream” conventional receptacles.
5. Special-Purpose Receptacles: Install in accordance with manufacturer’s instructions.

3.07 DEVICE PLATES

A. Securely fasten to wiring device; ensure a tight fit to box.

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B. Flush Mounted: Install with all four edges in continuous contact with finished wall surfaces without use of mats or similar materials. Plaster fillings will not be acceptable.

C. Surface Mounted: Plate shall not extend beyond sides of box, unless plates have no sharp corners or edges.

D. Install with alignment tolerance to box of 1/16 inch.

E. Types (Unless Otherwise Shown):

1. Outdoor: Weatherproof.
2. Indoor:
   a. Flush Mounted Boxes: Metal.
   b. Surface Mounted, Metal Boxes: Cast.

3.08 CIRCUIT BREAKERS AND SWITCHES

A. Location and Enclosure Type:

1. Hazardous Gas: NEMA 250, Type 7.
2. Hazardous Dust: NEMA 250, Type 9.
3. Wet or Outdoor: NEMA 250, Type 4.
4. Corrosive: NEMA 250, Type 4X.
5. Wet and Corrosive: NEMA 250, Type 4X.
6. Indoor Dry, Industrial Use: NEMA 250, Type 12.
7. Indoor Dry, General Purpose: NEMA 250, Type 1.
8. Where Denoted WP: NEMA 250, Type 3R.

3.09 TERMINAL BLOCKS

A. Install for termination of control circuits entering or leaving equipment and local control panels.

3.10 SUPPORT AND FRAMING CHANNELS

A. Install where required for mounting and supporting electrical equipment and raceway systems.

B. Channel Type:

1. Interior, Wet or Dry Noncorrosive Locations: Carbon steel.
2. Interior, Wet or Dry Corrosive Locations: Type 316 stainless steel.
3. Outdoor, Noncorrosive Locations: Carbon steel.
4. Outdoor, Corrosive Locations: Type 316 stainless steel.

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C. Paint carbon steel channel cut ends prior to installation with zinc-rich primer.

3.11 NAMEPLATES

A. Provide identifying nameplate on all equipment.

3.12 CONDUIT AND FITTINGS

A. General:

1. Crushed or deformed raceways not permitted.
2. Maintain raceway entirely free of obstructions and moisture.
3. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.
4. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.
5. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.
6. Group raceways installed in same area.
7. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.
8. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.
9. Block Walls: Do not install raceways in same horizontal course with reinforcing steel.
10. Install watertight fittings in outdoor, underground, or wet locations.
11. Paint threads and cut ends, before assembly of fittings, galvanized conduit, PVC-coated galvanized conduit, or IMC installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.
12. Metal conduit to be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.
13. Do not install raceways in concrete equipment pads, foundations, or beams.
14. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.
15. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.
16. Install conduits for fiber optic cables, telephone cables, and Category 5 data cables in strict conformance with the requirements of EIA/TIA 569.

B. Conduit Application:

1. Diameter:
   a. Interior Minimum: 3/4 inch.
   b. Exterior Minimum: 3/4 inch.

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2. Outdoor, Exposed:
   a. Rigid galvanized steel.
3. Indoor, Exposed:
   a. Rigid galvanized steel.
4. Indoor, Concealed (Not Embedded in Concrete):
   a. Intermediate metal.
   b. PVC Schedule 40.
5. Corrosive Areas:
   a. PVC-coated rigid galvanized steel.
6. Classified Areas:
   a. Rigid galvanized steel.
   b. PVC-coated rigid galvanized steel.

C. Connections:

1. For motors-, wall-, or ceiling-mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other equipment where flexible connection is required to minimize vibration:
   a. General: Flexible metal, liquid-tight conduit.
   b. Hazardous Areas: Flexible coupling suitable for Class I, Division 1 and 2 areas.
   c. Wet or Corrosive Areas: Flexible metal liquid-tight.
   d. Length: 18 inches minimum, 60 inches maximum, sufficient to allow movement or adjustment of equipment.
2. Lighting Fixtures in Dry Areas: Flexible metal, liquid-tight conduit.
3. Outdoor areas, process areas exposed to moisture, and areas required to be oiltight and dust-tight: Flexible metal, liquid-tight conduit.
4. Transition From Underground or Concrete Embedded to Exposed: Rigid galvanized steel PVC-coated rigid steel conduit.
5. Under Equipment Mounting Pads: Rigid galvanized steel conduit.

D. Penetrations:

1. Make at right angles, unless otherwise shown.
2. Notching or penetration of structural members, including footings and beams, not permitted.
3. Fire-Rated Walls, Floors, or Ceilings: Firestop openings around penetrations to maintain fire-resistance rating as shown on the drawings.
4. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack.

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5. Entering Structures:
    a. General: Seal raceway at the first box or outlet with oakum or expandable plastic compound to prevent the entrance of gases or liquids from one area to another.
    b. Concrete Roof or Membrane Waterproofed Wall or Floor: Provide watertight seal.
    c. Heating, Ventilating, and Air Conditioning Equipment:
        1) Penetrate equipment in area established by manufacturer.
        2) Terminate conduit with flexible metal conduit at junction box or condulet attached to exterior surface of equipment prior to penetrating equipment.
        3) Seal penetration with Type 5.
    d. Existing or Precast Wall (Underground): Core drill wall and install watertight entrance seal device.
    e. Nonwaterproofed Wall or Floor (Underground, without Concrete Encasement):
        1) Provide Schedule 40 galvanized pipe sleeve or watertight entrance seal device.
        2) Fill space between raceway and sleeve with expandable plastic compound or oakum and lead joint on each side.

E. Support:

1. Support from structural members only, at intervals not exceeding NFPA 70 requirements, and in any case not exceeding 10 feet. Do not support from piping, pipe supports, or other raceways.
2. Multiple Adjacent Raceways: Provide ceiling trapeze.
3. Application/Type of Conduit Strap:
    a. Steel Conduit: Zinc-coated steel, pre-galvanized steel, or malleable iron.
    b. PVC-Coated Rigid Steel Conduit: PVC-coated metal.
    c. Nonmetallic Conduit: Nonmetallic or PVC-coated metal.
4. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:
    a. Wood: Wood screws.
    b. Hollow Masonry Units: Toggle bolts.
    c. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.
    d. Steelwork: Machine screws.
    e. Location/Type of Hardware:
        1) Dry, Noncorrosive Areas: Galvanized.
        2) Wet, Noncorrosive Areas: Stainless steel.
        3) Corrosive Areas: Stainless steel.

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F. Bends:

1. Install concealed raceways with a minimum of bends in the shortest practical distance.
2. Make bends and offsets of longest practical radius. Bends in conduits and ducts being installed for fiber optic cables shall be not less than 20 times cable diameter, 15 inches minimum.
3. Install with symmetrical bends or cast metal fittings.
4. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.
5. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.
6. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run and raceways are same size.
7. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

G. Expansion and Deflection Fittings: Provide on all raceways at structural expansion joints and in long tangential runs.

H. Termination at Enclosures:

1. Cast Metal Enclosure: Provide manufacturer’s premolded insulating sleeve inside metallic conduit terminating in threaded hubs.
2. Nonmetallic, Cabinets, and Enclosures: Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.
3. Sheet Metal Boxes, Cabinets, and Enclosures:
   a. Rigid Galvanized Conduit:
      1) Provide one lock nut each on inside and outside of enclosure.
      2) Install grounding bushing.
      3) Provide bonding jumper from grounding bushing to equipment ground bus or ground pad; if neither ground bus nor pad exists, connect jumper to lag bolt attached to metal enclosure.
      4) Install insulated bushing on ends of conduit where grounding is not required.
      5) Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.
      6) Utilize sealing locknuts or threaded hubs on outside of NEMA 3R and NEMA 12 enclosures.

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7) Terminate conduits with threaded conduit hubs at NEMA 4 and 4X boxes and enclosures.

b. Electric Metallic Tubing: Provide gland compression, insulated connectors.

c. Flexible Metal Conduit: Provide two-screw type, insulated, malleable iron connectors.

d. PVC-Coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector.

e. PVC Schedule 40 Conduit: Provide PVC terminal adapter with locknut.

4. Free-Standing Enclosures:

a. Terminate metal conduit entering bottom with grounding bushing; provide a grounding jumper extending to equipment ground bus or grounding pad.

b. Terminate PVC conduit entering bottom with bell end fittings.

I. Empty Raceways:

1. Provide permanent, removable cap over each end.
2. Provide PVC plug with pull tab for underground raceways with end bells.
3. Provide nylon pull cord.
4. Identify, as specified in Article Identification Devices, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

J. Identification Devices:

1. Raceway Tags:

a. Identify origin and destination.

b. Install at each terminus, near midpoint, and at minimum intervals of every 50 feet of exposed raceway, whether in ceiling space or surface mounted.

c. Provide corrosion-resistant wire for attachment.

K. Raceway Band: Install wherever metallic conduit emerges from concrete slabs. Not required with PVC-coated RGS conduit. Center band at slab surface and install according to manufacturer's instructions.

1. Slip-on Type: Clean conduit surface at installation location. Cut tubing to 4-inch minimum lengths and slip onto raceway prior to slab placement and termination of conduit. Heat-shrink onto conduit.
2. Wrap-around Type: Use where slip-on access to conduit is not possible. Clean conduit surface at installation location. Apply primer. Apply

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wraps to provide two layers of tape. Neatly finish tape end to prevent unraveling.

3.13 CONDUCTORS AND CABLES

A. Conductor storage, handling, and installation shall be in accordance with manufacturer's recommendations.

B. Do not exceed manufacturer's recommendations for maximum pulling tensions and minimum bending radii.

C. Conduit system shall be complete prior to drawing conductors. Lubricate prior to pulling into conduit. Lubrication type shall be as approved by conductor manufacturer.

D. Terminate all conductors and cables, unless otherwise shown.

E. Do not splice conductors, unless specifically indicated or approved by Engineer.

F. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 12 inches.

G. Wiring within Equipment and Local Control Panels: Remove surplus wire, dress, bundle, and secure.

H. Power Conductor Color Coding:

1. No. 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. No. 8 AWG and Smaller: Provide colored conductors.
3. Colors:
    a. Neutral Wire: White.
    b. Live Wires, 120/240-Volt, Single-Phase System: Black, red.
    c. Live Wires, 120/208-Volt, Three-Phase System: Black, red, or blue.
    d. Live Wires, 277/480-Volt, Three-Phase System: Brown, orange, or yellow.
    e. Ground Wire: Green.

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I. Circuit Identification:

1. Circuits Appearing in Circuit Schedules: Identify power, instrumentation, and control conductor circuits, using circuit schedule designations, at each termination and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.
2. Circuits Not Appearing in Circuit Schedules: Assign circuit name based on device or equipment at load end of circuit. 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.
3. Method: Identify with sleeves. Taped-on markers or tags relying on adhesives not permitted.

J. Connections and Terminations:

1. Install wire nuts only on solid conductors.
2. Install nylon self-insulated crimp connectors and terminators for instrumentation and control circuit conductors.
3. Tape insulate all uninsulated connections.
4. Install crimp connectors and compression lugs with tools approved by connector manufacturer.

3.14 GROUNDING

A. Grounding shall be in compliance with NFPA 70 and as shown.

B. Ground electrical service neutral at service entrance equipment to supplementary grounding electrodes.

C. Ground each separately derived system neutral to nearest effectively grounded building structural steel member or separate grounding electrode.

D. Bond together system neutrals, service equipment enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.

E. Shielded Instrumentation Cables:

1. Ground shield to ground bus at power supply for analog signal.
2. Expose shield minimum 1 inch at termination to field instrument and apply heat shrink tube.
3. Do not ground instrumentation cable shield at more than one point.

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F. Equipment Grounding Conductors: Provide in all conduits containing power conductors and control circuits above 50 volts.

G. Ground Rods: Install full length with conductor connection at upper end. Install one ground rod in each handhole.

3.15 LOW VOLTAGE MOTOR CONTROL

A. Install equipment in accordance with NEMA ICS 2.3 and manufacturer's instructions and recommendations.

B. Field adjust trip settings of motor starter magnetic-trip-only circuit breakers. Adjust to approximately 11 times motor rated current.

C. Select and install overload relay heaters or adjust electronic overload protection after the actual nameplate full-load current rating of motor has been determined.

3.16 LUMINAIRES AND ACCESSORIES

A. Install in accordance with manufacturer's recommendations.

B. Install plumb and level at mounting heights shown.

C. Provide proper hangers, pendants, and canopies as necessary for complete installation

D. Unfinished Areas: Locate luminaires to avoid conflict with other building systems or blockage of luminaire light output.

3.17 FIELD QUALITY CONTROL

A. Tests shall be performed in accordance with the requirements of Section 01 91 00, Equipment Systems Commissioning.

B. General:

1. Test equipment shall have an operating accuracy equal to, or greater than, requirements established by NETA ATS.
2. Test instrument calibration shall be in accordance with NETA ATS.
3. Perform inspection and electrical tests after equipment has been installed.
4. Perform tests with apparatus de-energized whenever feasible.
5. Inspection and electrical tests on energized equipment are to be:
   a. Scheduled with Engineer prior to de-energization.

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b. Minimized to avoid extended period of interruption to the operating plant equipment.

C. Tests and inspection shall establish that:

1. Electrical equipment is operational within industry and manufacturer's tolerances.
2. Installation operates properly.
3. Equipment is suitable for energization.
4. Installation conforms to requirements of Contract Documents and NFPA 70.

D. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

E. Adjust mechanisms and moving parts for free mechanical movement.

F. Adjust adjustable relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

G. Verify nameplate data for conformance to Contract Documents.

H. Realign equipment not properly aligned and correct unlevelness.

I. Properly anchor electrical equipment found to be inadequately anchored.

J. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench to manufacturer's recommendations, or as otherwise specified.

K. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

L. Provide proper lubrication of applicable moving parts.

M. Investigate and repair or replace:

1. Electrical items that fail tests.
2. Active components not operating in accordance with manufacturer's instructions.
3. Damaged electrical equipment.

N. Electrical Enclosures:

1. Remove foreign material and moisture from enclosure interior.
2. Vacuum and wipe clean enclosure interior.

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3. Remove corrosion found on metal surfaces.
4. Repair or replace, as determined by Engineer, door and panel sections having damaged surfaces.
5. Replace missing or damaged hardware.

O. Provide certified test report(s) documenting the successful completion of specified testing. Include field test measurement data.

P. Test the following equipment and materials:

1. Conductors: Insulation resistance, No. 4 and larger only.
2. Panelboards, switches, and circuit breakers.
3. Motor controls.
4. Grounding electrodes.
5. Motors.

Q. Controls:

1. Test control and signal wiring for proper termination and function.
2. Test local control panels and other control devices for proper terminations, configuration and settings, and functions.
3. Demonstrate control, monitoring, and indication functions in presence of Owner and Engineer.

R. Balance electrical load between phases on panelboards and mini-power centers after installation.

S. Voltage Testing:

1. When installation is complete and facility is in operation, check voltage at point of termination of electric utility supply system to Project.
2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
3. Record supply voltage for 24 continuous hours.
4. If unbalance exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded conditions more than plus or minus 4 percent of nominal, make written request to electric utility to correct condition.
5. If corrections are not made, obtain written statement from a responsible electric utility official that voltage variations and/or unbalance are within their normal standards.

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T. Equipment Line Current:

1. Check line current in each phase for each piece of equipment.
2. If electric utility makes adjustments to supply voltage magnitude or balance, make line current check after adjustments are made.

END OF SECTION

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SECTION 26 29 23
LOW-VOLTAGE ADJUSTABLE FREQUENCY DRIVE SYSTEM

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Electronic Industries Alliance (EIA): 359-A-1, Special Colors.
2. Hydraulic Institute Standards (HIS).
3. Institute of Electrical and Electronics Engineers (IEEE):
   a. 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
   b. 519, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
   c. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
4. National Electrical Manufacturer's Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. CP 1, Shunt Capacitors.
   c. MG 1, Motors and Generators.
   d. WC 57, Standard for Control, Thermocouple Extensions, and Instrumentation Cables.
5. National Fire Protection Association (NFPA): 79, Electrical Standard for Industrial Machinery.

1.02 DEFINITIONS

A. Terms that may be used in this section:

1. AFD: Adjustable frequency drive.
2. CMOS: Complementary metal oxide semiconductor.
3. CSI: Current source inverter.
4. EMU: Energy monitoring unit.
5. GTO: Gate turn-off thyristor.
6. MPR: Motor protection relay.
7. MTBF: Mean time between failure.
8. PWM: Pulse width modulation.
9. ROM: Read only memory.
10. RTD: Resistance temperature detector.
11. RTU: Remote Telemetry Unit.
12. Rated Load: Load specified for equipment.

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13. Rated Speed: Nominal rated (100 percent) speed specified for equipment.
14. TDD: Total demand distortion.
15. THD: Total harmonic distortion.
16. TTL: Transistor transistor logic.

1.03 SYSTEM DESCRIPTION

A. Performance Requirements:

1. Composite drive/motor efficiency (CE) is defined as ratio of motor shaft kW to drive input kW. AFD system minimum requirements:
   a. At 60-Hz drive output and 100 percent load, CE equals 92 percent.
   b. At 50-Hz drive output and 60 percent load CE equals 89 percent.
   c. At 40-Hz drive output and 30 percent load CE equals 84 percent.
   d. At 30-Hz drive output and 12.5 percent load CE equals 77 percent.
2. Rated Continuous Operation Capacity: Not less than 1.15 times full load current rating of driven motor, as indicated on motor nameplate, and suitable for continuous operation at continuous overload which may be imposed on motor by driven pump operating over specified speed range.
3. Basis for Harmonic Computations: Using Simplified Plant One-Line Diagram for current and voltage distortion computations, furnish harmonic filters, line reactors, isolation transformers, or higher pulse converter arrangements required to meet current/voltage distortion limits.

B. Design Requirements:

1. Drive system consisting of adjustable frequency controller, drive motor, auxiliary items, and components necessary for complete operating system.
2. Other equipment is being powered from same bus as adjustable frequency drives. Ensure proper operation of drives and other loads under normal and emergency conditions.
3. Furnish AFDs rated on basis of actual motor full load nameplate current rating times the service factor.
4. Drive System: Convert incoming three-phase, 60-Hz ac power to variable voltage, adjustable frequency output for adjustable speed operation of a standard ac induction squirrel-cage motor, using pulse-width-modulation (PWM) technique to produce adjustable frequency output.

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5. System rated for continuous industrial duty and suitable for use with NEMA MG 1, Design B motors.
6. Incoming Line Circuit Breaker: Provide positive means of disconnecting incoming power, and overcurrent protection for drive system.
7. Incoming Line Reactor: Design to minimize harmonic distortion on incoming power feeder.

1.04 SUBMITTALS

A. Action Submittals:

1. Overall drive system operating data, including efficiencies, input currents, and power factors, at driven equipment actual load and rated system input voltage, at 0, 40, 60, 80, 100, and 110 percent of rated speed.
2. Individual and total harmonic content (voltage and current) reflected in system normal source supply at driven equipment actual load at 70 percent and 100 percent of rated speed at locations specified in Simplified Plant One-Line Diagram and load conditions specified. Normal source system short-circuit available at drive shall be calculated from data furnished in Supplements to this section. Use TDD and THD factors as defined in IEEE 519 to designate total harmonic content.
3. Individual and total current and voltage harmonic content reflected in standby power source, at locations specified in Supplements to this section, at driven equipment actual load at 70 percent and 100 percent of rated speed determined by using actual size and sub-transient reactance of standby system obtained from standby source manufacturer. Use TDD and THD factors as defined in IEEE 519 to designate total harmonic content.
4. AFD output pulse maximum peak voltage, pulse rise time, and pulse rate of rise including justification for proposed deviation from specified values. Include motor manufacturer’s certification motor insulation will withstand long-term over voltages caused at motor terminals due to specified output pulse data or proposed deviation from this data.
5. Data on shelf life of “dc link” capacitor.
6. Complete system rating, including nameplate data, continuous operation load capability throughout speed range of 0 percent to 120 percent of rated speed.
7. Complete adjustable frequency controller rating coordinated with motor full load nameplate current rating; list controller special features being supplied.

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8. Controller, reactor, harmonic filter, and isolating transformer (if applicable) dimensional drawings; information on size and location of space for incoming and outgoing conduit.
9. Maximum heat dissipation from enclosure.
10. Should separate enclosures and equipment be necessary for filter elements or power factor correction equipment, provide complete dimensional information including location of space for incoming and outgoing conduit, weight, maximum heat loss, and minimum current carrying capacity and recommended wire size for required interconnecting circuits.
11. Layout of controller face showing pushbuttons, switches, instruments, and indicating lights.
12. Complete system operating description.
13. Complete system schematic (elementary) wiring diagrams.
14. Complete system interconnection diagrams between controller, drive motor, and related components or controls external to system, including wire numbers and terminal board point identification.
15. One-line diagram of system, including component ratings.
16. Description of diagnostic features being provided.
17. Descriptive literature for control devices such as relays and timers.
18. Itemized bill-of-materials listing system components.
19. Specific description of provisions, such as filtering and harmonic suppression, being made to ensure proper system operation when power factor correction capacitors are included in system and system is supplied from standby engine generator.
20. Description of EMU and MPR being furnished or how these functions are accomplished within drive system.
21. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Statement of Supplier qualifications.
2. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
3. Special shipping, storage and protection, and handling instructions.
4. Manufacturer’s printed installation instructions.
5. Factory functional test reports.
6. Certified copy of test report for identical motor tested in accordance with NEMA MG 1-12.53a and IEEE 112, Test Method B, showing rated load, rated speed efficiency meeting or exceeding specified values; motors not as specified will be rejected.
7. Field test reports.

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8. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
9. Suggested spare parts list to maintain equipment in service for period of 1 year and 5 years. Include list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
10. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
11. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
12. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.05 QUALITY ASSURANCE

A. Supplier: Minimum 5 years' experience in furnishing similar size and type adjustable frequency, controlled speed, drive systems.

1.06 EXTRA MATERIALS

A. Furnish for each drive unit:

1. Complete set of components likely to fail in normal service.
2. Plug-in subassemblies.
3. Printed circuit boards.
4. SCRs.
5. Potentiometers.
6. Integrated circuits.
7. One complete power bridge and one spare printed circuit card for each modular, plug-in type card in controller.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Components and accessories specified in this section shall be products of:

1. Eaton Cutler Hammer.
2. Danfoss.
3. Siemens Robicon.
4. Allen-Bradley.
5. ABB.
6. Toshiba.
7. Square D.

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B. No “Or-equal” or substitute products will be considered.

2.02 SUPPLEMENTS

A. Some specific requirements are attached to this section as supplements.

2.03 SERVICE CONDITIONS

A. Ambient Operating Temperature: 32 degrees F to 104 degrees F.

B. Storage Temperature: Minus 40 degrees F to 158 degrees F.

C. Humidity: 0 percent to 95 percent relative (noncondensing).

D. Altitude: 0 foot to 3,300 feet.

E. Frequency Stability: Plus or minus 0.1 percent of maximum frequency.

2.04 COMPONENTS

A. Drive Units:

1. Incorporate switching power supply operating from dc bus, to produce PWM output waveform simulating sine wave and providing power loss ride through of 2 milliseconds at full load, full speed.
2. Current-limiting semiconductor fuses for protection of internal power semiconductors.
3. Employ diode bridge rectifier providing constant displacement power factor of 0.95 minimum at all operating speeds and loads.
4. Use transistors for output section, providing a minimum 97 percent drive efficiency at full speed, full load.
5. Employ dc power discharge circuit so that after removal of input power dc link capacitor voltage level will decay below 50 volts dc within 1 minute after de-energizing following NEMA CP 1 and NFPA 79. Design dc link capacitor for a MTBF of 5 years.
6. Operate with open circuited output.
7. Input Voltage: 480V ac plus or minus 10 percent.
8. Output Voltage: 0 to 480 volts, three-phase, 0 to 66 -Hz, minimum.
9. Maximum peak voltage of PWM AFD output pulse of 1,000 volts, with pulse rise time of not less than 2 microseconds, and maximum rate of rise of 500 volts per microsecond. Maximum frequency of PWM AFD output pulse (carrier) frequency of 3,000 -Hz. Should magnitudes of these characteristics be more stressful to motor insulation than specified values, furnish insulation systems on motors suitable for proposed values.

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10. Motor Audible Noise Level: When operating throughout speed range of PWM AFD, no more than 3 dBA above that designated in NEMA MG 1 for same motor operated at constant speed with a 60-Hz supply voltage.
11. Short-Time Overload Capacity: 125 percent of rated load in rms current for 1 minute following full load, full speed operation.
12. Equipment Short-Circuit Rating: Suitable for connection to system with maximum source three-phase, bolted fault, short-circuit available of 42,000 amps rms symmetrical at 480 volts.
13. Furnish drives with output current-limiting reactors mounted within equipment enclosure.
14. Diagnostics: Comprehensive for drive adjustment and troubleshooting:
    a. Memory battery backup; 100-hour minimum during power loss.
    b. Status messages will not stop drive from running but will prevent it from starting.
    c. Fault Condition Messages and History: First fault protection function to be activated, ability to store six successive fault occurrences in order. Minimum faults numerically:
        1) Overcurrent (time and instantaneous).
        2) Overvoltage.
        3) Undervoltage (dc and ac).
        4) Overtemperature (drive, motor windings, motor bearing, pump bearing).
        5) Serial communication fault.
        6) Short-circuit/ground fault (motor and drive).
        7) Motor stalled.
        8) Semiconductor fault.
        9) Microprocessor fault.
        10) Single-phase voltage condition.
15. Drive Protection:
    a. Fast-acting semiconductor fuses.
    b. Overcurrent, instantaneous overcurrent trip.
    c. Dc undervoltage protection, 70 percent dropout.
    d. Dc overvoltage protection, 130 percent pickup.
    e. Overtemperature, drive, inverter, converter, and dc link components.
    f. Overtemperature, motor, and pump.
    g. Single-phase protection.
    h. Reset overcurrent protection (manual or automatic reset).
    i. Active current limit/torque limit protection.
    j. Semiconductor fault protection.
    k. Short-circuit/ground fault protection.
    l. Serial communication fault protection.
    m. Microprocessor fault.

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n. Surge protection for transient overvoltage (6,000 volts, 80 joule surge, tested per IEEE C62.41).
o. Visual display of specific fault conditions.

16. Operational Features:
    a. Use manufacturer's standard unless otherwise indicated.
    b. Sustained power loss.
    c. Momentary power loss.
    d. Power interruption.
    e. Power loss ride through (0.1 second).
    f. Start on the fly.
    g. Electronic motor overload protection.
    h. Stall protection.
    i. Slip compensation.
    j. Automatic restart after power return (ability to enable/disable function).
    k. Critical frequency lockout (three selectable points minimum, by 1.5-Hz steps in 10-Hz bands, to prevent resonance of system).
    l. Drive maintenance system software for complete programming and diagnostics.
    m. Ground fault protection, drive, and motor.
    n. Operate with no motor connected to output terminals.

B. Rectifier: Three-phase, 6-pulse, 12-pulse full wave diode bridge rectifier to provide constant dc voltage to drive's dc bus.

C. Furnish series choke and capacitors on dc bus to reduce ripple in rectifier output and to reduce harmonic distortion reflected into incoming power feeders.

D. Controller: Microprocessor-controller PWM inverter to convert to dc voltage to variable voltage, adjustable frequency, three-phase ac output. Output voltage shall vary proportionally with frequency to maintain constant ratio of volts to hertz up to 60-Hz; above 60-Hz, voltage shall remain constant with drive operating in constant horsepower output mode.

E. Enclosure:

1. NEMA 250, Type 1, gasketed, freestanding, enclosure for mounting against wall, completely front accessible, and hinged doors. Properly sized to dissipate heat generated by controller within limits of specified operating conditions (including ambient temperature and ambient airflow). Enclosure not to exceed dimensions shown on Drawings.
2. Cable termination compartment door interlocked main circuit breaker, defeatable (lockable in the open position), emergency stop pushbutton,

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alphanumeric keypad and display, and operator's controls. Components and controls specified in Section 26 05 01, Electrical.

3. Wire drive from below and above for power and control wiring.
4. Size forced ventilation for periodic operation to cool each unit with maximum room ambient temperature of 95 degrees F. Furnish redundant fans such that if one fan fails remaining fans furnish adequate ventilation for drive when operating at maximum capacity. Furnish filters on ventilation intakes.
5. Wiring:
    a. Bundle stranded copper wiring neatly with nylon tie wraps or with continuous plastic spiral binding.
    b. Label each terminal for permanent identification of leads.
    c. Identify each wire at each end with imprinted mylar adhesive-back wire markers.
    d. Incorporate in as-installed wiring diagrams for wire and terminal numbers shown.
    e. Wiring across door hinge, use 19-strand, NEMA WC 57 Class C stranding looped for proper twist rather than bending at hinge.
    f. Wire connections internal to panels by crimp-on terminal types.
    g. For multiple enclosure systems, complete interconnection wiring with gasketed enclosure openings for wiring.
    h. Multipoint plug receptacles for control wiring crossing equipment shipping splits.
6. Selector switches, indicating lights, potentiometers, instruments, protective devices, and major system components identified by means of mechanically attached, engraved, laminated nameplates.

F. Operator Interface:

1. Controls: Mount drive local control on front door of enclosure and include control switch and membrane type keypad for the following operator functions:
    a. Start (when in local mode).
    b. Stop (when in local mode).
    c. Speed increase (when in local mode).
    d. Speed decrease (when in local mode).
    e. Parameter mode selection (recall programmed parameters).
    f. LOCAL/OFF/REMOTE control selection (in remote, furnish for remote RUN command digital input and speed increase/decrease via remote 4 mA to 20 mA analog signal).
    g. Fault reset, manual for faults, except loss of ac voltage which is automatic upon return.
    h. RUN/preset speed.

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i. Parameter lock, password or key switch lockout of changes to parameters.
j. Start disable, key switch or programmed code.

2. Control circuit disconnect shall de-energize circuits in units that are not de-energized by main power disconnect device as required by California Administrative Code.
3. 120 volts, single-phase, 60-Hz circuits for control power and operator controls from internal control power transformer. Furnish power for motor space heaters rated 120 volts.
4. Arrange component and circuit such that failure of a single component cannot cause cascading failure(s) of other component(s).
5. Alphanumeric Display: During normal operation and routine test, the following parameters shall be available:
   a. Motor current (percent of drive rated current).
   b. Output frequency (Hertz).
   c. Output voltage.
   d. Running time.
   e. Local/remote indicator.
   f. Status of digital inputs and outputs.
   g. Analog input and output values.
   h. Output motor current per leg.
   i. All test points.
6. Adjustable Parameters: Set drive operating parameters and indicate in numeric form. Potentiometers may not be used for parameter adjustment. Minimum setup parameters available:
   a. Frequency range, minimum, maximum.
   b. Adjustable acceleration/deceleration rate.
   c. Volts per Hertz (field weakening point).
   d. Active current limit/torque limit, 0 percent to 140 percent of drive rating.
   e. Adjustable voltage boost (IR compensation).
   f. Preset speed (adjustable, preset operating point).
   g. Provision for adjustment of minimum and maximum pump speed to be furnished as function of 4 mA to 20 mA remote speed signal.

G. Signal Interface:

1. Digital Input:
   a. Accept a remote RUN command contact closure input.
   b. High temperature contact closure input from field mounted motor temperature monitoring relay.
2. Digital Output: Furnish three discrete output dry contact closures rated 5 amps at 120YY volts ac. dc.

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a. DRIVE RUNNING.
b. DRIVE FAULT (with common contact closure for all fault conditions).
c. DRIVE IN REMOTE MODE.

3. Analog Input: When LOCAL/OFF/REMOTE switch is in REMOTE, control drive speed from remote 4 mA to 20 mA dc signal.
   a. Make provisions for adjustment of minimum and maximum motor speed which shall result from this signal.
   b. Factory set this adjustment to comply with operating speed range designated in driven equipment specifications.
   c. Frequency resolution shall be 0.1 percent of base speed.
   d. Accept second analog input from speed transmitter located on motor shaft.
4. Analog Output: Furnish two 4 mA to 20 mA dc signals for actual frequency, actual load.
5. Serial Communication Interface: RS232/RS 422, compatible with MODBUS as an RTU.

H. Accessories:

1. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in readily visible location.
2. Lifting Lugs: Equipment weighing over 100 pounds.
3. Anchor Bolts: Galvanized, Type 316 stainless steel, sized by equipment manufacturer, 1/2-inch minimum diameter, and as specified in Section 05 50 00, Metal Fabrications.
4. Motor Protection Relay (MPR): For each drive include a MPR as specified in Section 26 05 01, Electrical, or furnish functions within drive system. Communications protocol and signal compatibility shall be as required for MPRs.

I. Energy Monitoring System: For each drive include an EMU as specified in or furnish functions within drive system. Communications protocol and signal compatibility shall be as required for EMUs.

2.05 FACTORY FINISHING

A. Enclosure:

1. Primer: One coat of rust-inhibiting coating.
2. Finish:
   a. Interior: One coat white enamel.

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b. Exterior: One coat manufacturer's standard gray enamel or EIA 359-A-1, No. 61.

3. Manufacturer's standard baked enamel finish.

2.06 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.

B. Factory Tests and Adjustments: Test one control panels actually furnished.

C. Record test data for report.

D. Functional Test: Perform manufacturer's standard.

E. Motor Test: See Section 26 05 01, Electrical.

PART 3 EXECUTION

3.01 INSTALLATION

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

3.02 FIELD QUALITY CONTROL

A. Functional Test:

1. Conduct on each controller.
2. Inspect controller for electrical supply termination connections, interconnections, proper installation, and quiet operation.
3. Vibration Test:
   a. Complete assembly, consisting of motor, load, and flexible shafting, connected and in normal operation shall not develop amplitudes of vibration exceeding limits recommended by HIS.
   b. Where loads and drives are separated by intermediate flexible shafting, measure vibration both at top motor bearing and at two points on top pump bearing, 90 degrees apart.
4. Record test data for report.

B. Performance Test:

1. Conduct on each controller.
2. Perform under actual or approved simulated operating conditions.
3. Test for continuous 12-hour period without malfunction.

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4. Demonstrate performance by operating continuous period while varying application load, as input conditions allow, to verify system performance.
5. With plant load connected to normal utility source, measure the following to show parameters within specified limits:
    a. Total and individual current harmonic distortion, up to and including 35th harmonic, at location identified as PCC1 in Simplified Plant One-Line Diagram, under following load conditions:
        1) AFDs running at full load and half load.
        2) Half of specified AFDs running at full load and half load.
    b. Power factor at input side of each drive. Documented verification that power factor is maintained at 95 percent as speed of drive goes down from 100 percent to 33 percent.
    c. THD at location identified as PCC3 under following conditions:
        1) AFDs running at full load and half load.
        2) Half of specified AFDs running at full load and half load.
6. With plant load connected to standby power source, measure the following to show parameters within specified limits:
    a. Total and individual current harmonic distortion, up to and including 35th harmonic, at location identified as PCC2 in Simplified Plant One-Line Diagram, with drives running at:
        1) Full load.
        2) Half load.
    b. THD at location identified asPCC3 in Simplified Plant One-Line Diagram, with drives running at:
        1) Full load.
        2) Half load.
7. Record test data for report.

C. Test Equipment:

1. Use Dranetz, HDPQ series, harmonic distortion monitor and disturbance analyzer or equivalent instrument to document results.
2. Provide diagnostic plug-in test card complete with instructions, multi-position selector switch, and meters or built-in diagnostic control panel or ROM-based processor for monitoring ac, dc, and digital signals to assist in troubleshooting and startup of drive.

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3.03 MANUFACTURERS' SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:

1. 1 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
2. 2 person-days for facility startup.
3. 1 person-day for post-startup training of Owner's personnel.

B. See Section 01 43 33, Manufacturers' Field Services and Section 01 91 00, Equipment Systems Commissioning.

END OF SECTION

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SECTION 40 05 15
PIPING SUPPORT SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Mechanical Engineers (ASME): B31.1, Power Piping.
2. 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.
3. Manufacturers' Standardization Society (MSS):
   a. SP 58, Pipe Hangers and Supports—Materials, Design and Manufacture.
   b. SP 127, Bracing for Piping Systems Seismic-Wind-Dynamic Design, Selection, and Application.

1.02 DEFINITIONS

A. Ferrous Metal: Iron, steel, stainless steel, and alloys with iron as principal component.

B. 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 locations.

C. Atmospheric exposed: Fully or partially exposed to the atmosphere or air.

1.03 SUBMITTALS

A. Action Submittals:

1. Catalog information and drawings of piping support system, locating each support, sway brace, seismic brace, hanger, guide, component, and anchor for piping 6 inches and larger and 4 inches and smaller. Identify

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support, hanger, guide, and anchor type by catalog number and Shop Drawing detail number.
2. Calculations for each type of pipe support, attachment and anchor.
3. Revisions to support systems resulting from changes in related piping system layout or addition of flexible joints.
4. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.
5. Information on proposed field-applied coating system(s). See Section 09 90 00, Painting and Coating, for specific requirements. Include manufacturer descriptive catalog literature and specifications, hazardous communication data sheets, and written manufacturer's Certificate of Compliance that:
   a. The field-applied coating system(s) is identical to the requirements specified, or
   b. Where system proposed is different from that specified, or where, in the manufacturer's opinion, the coating system(s) proposed exceed(s) the requirements specified, submit the complete technical literature of the proposed system(s) for review.
6. Where applicable, Contractor shall provide drawings to show how existing supports shall be used to support new piping.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Contract Closeout Submittals: Maintenance information on piping support system.

1.04 QUALIFICATIONS

A. Piping support systems shall be designed, and Shop Drawings prepared and sealed by a Registered Professional Engineer in the state where the Work is to be installed.

1.05 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 supports may be required.
3. Piping 30 Inches and Larger: Support systems have been designed for piping shown.

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4. Meet requirements of MSS SP 58 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 insulation and weight of fluid in pipes.
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. Safety Factor: Minimum of 5.
5. Maximum Support Spacing and Minimum Rod Size:
    a. Steel, Stainless Steel, and Ductile Iron Piping:
    b. Plastic and FRP:
        1) Maximum Support/Hanger Spacing: As recommended by manufacturer for the higher of the exposed temperature, or temperature of fluid in the pipe.
        2) Minimum Hanger Rod Size As listed for steel pipe.

C. Channel Framing Support System:

1. Beams: Size as such that beams stress does not exceed 25,000 psi and maximum deflection does not exceed 1/240 of span.
2. Column Members: Size in accordance with manufacturer's recommended method.
3. Support loads: Calculate using the weight of pipes filled with water. For chemical systems, use the chemical weight if specific gravity is greater than 1.
4. Maximum Spans:
    a. Steel and Ductile Iron, 3-inch Diameter and Larger: 10-foot centers.
    b. Other Pipelines and Special Situations: May require supplemental hangers and supports.

D. 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 in accordance with Section 05 50 00, Metal Fabrications.

E. Vertical Sway Bracing: 10-foot maximum centers or as shown.

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F. Existing Support Systems: Use existing supports 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.

PART 2 PRODUCTS

2.01 GENERAL

A. Special support and hanger details may be required for cases where standard catalog supports are not applicable. When specified items are not available, fabricate pipe supports of correct material and to general configuration indicated.

B. Materials:

1. Wetted and Submerged: Stainless Steel.
2. Atmospheric exposed: Galvanized or painted steel. In accordance with Table 1 and Table 2, attached as Supplements at end of section.

2.02 HANGERS

A. Clevis: MSS SP 58, Type 1:

1. Anvil; Figure 260, sizes 1/2 inch through 30 inches.
2. Insulated Pipe: Anvil; Figure 260 with insulated saddle system (ISS), sizes 1/2 inch through 16 inches.
3. B-Line; Figure B3100, sizes 1/2 inch through 30 inches.

B. Adjustable Swivel Split-Ring Pipe Clamp: MSS SP 58, Type 6:

1. Anvil; Figure 104, sizes 3/4 inch through 8 inches.
2. B-Line; Figure B3171, sizes 3/4 inch through 8 inches.

C. Steel Yoke Pipe Rolls and Roller Supports: MSS SP 58, Type 41 or Type 43:

1. Anvil; Figure 181 for sizes 2-1/2 inches through 24 inches, and Figure 171 for sizes 1 inch through 2 inches.
2. B-Line; Figure B3110 for sizes 2 inches through 24 inches and Figure B3114 for 30 inches.

D. Pipe Rollers and Supports: MSS SP 58, Type 44:

1. Anvil; Figure 175, sizes 2 inches through 30 inches.
2. B-Line; Figure B3120, sizes 2 inches through 24 inches.

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E. Attachments:

1. I-Beam Clamp: Concentric loading type, MSS SP 58, Type 21, 28, 29, or 30, which engages both sides of flanges.
2. Concrete Insert: MSS SP 58, Type 18, continuous channel; insert with load rating not less than that of hanger rod it supports.

2.03 WALL BRACKETS, SUPPORTS, AND GUIDES

A. Welded Steel Wall Bracket: MSS SP 58, Type 33 (heavy-duty):

1. Anvil; Figure 199, 3,000-pound rating.
2. B-Line; Figure B3067, 3,000-pound rating.

B. Offset Pipe Clamp:

1. Anvil; Figure 103 (or Figure 100), sizes 3/4 inch through 8 inches.
2. B-Line; Figure B3148 (or Figure B3149), sizes 1/2 inch through 12 inches.

C. One-Hole Clamp: Anvil; Figure 126.

D. Channel Type:

1. Unistrut.
2. Anvil; Anvil-Strut.
3. B-Line; Strut System.
4. Aickinstrut (FRP).
5. Power Strut.

2.04 STEEL PIPE SADDLES

A. Provide 120-degree pipe saddle with baseplates drilled for anchors bolts; minimum four 7/8-inch holes for 3/4-inch bolts.

1. In accordance with Standard Detail 4005-515.
2. Sizes 20 inches though 60 inches.
3. Manufacturer and Product: Piping Technology & Products, Inc.; Fig. 2000.

B. Saddle Supports, Pedestal Type: Schedule 40 pipe stanchion, saddle, and anchoring flange.

1. Minimum standard weight pipe stanchion, saddle, and anchoring flange.
2. Nonadjustable Saddle: MSS SP 58, Type 37 with U-bolt.
   a. Anvil; Figure 259, sizes 6 inches with Figure 63C base.

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b. B-Line; Figure B3090, sizes 3/4 inch through 36 inches with B3088 base.

3. Adjustable Saddle: MSS SP 58, 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 Figure B3088T base.

2.05 CHANNEL TYPE SUPPORT SYSTEMS

A. Channel Size: 12-gauge, 1-5/8-inch wide minimum steel, or minimum FRP.

B. Members and Connections: Design for loads using a safety factor of 5.

C. Material: In accordance with the material outlines in Table 1 and Table 2 in Supplement sheets at the end of this specification.

1. Galvanized: Pre-galvanized in accordance with ASTM A525, Class G90, or hot-dipped galvanized after fabrication.
2. Stainless Steel: Type 304 stainless steel.

D. Manufacturers and Products:

1. B-Line; Strut System.
2. Unistrut.
3. Anvil; Power-Strut.
4. Aickinstrut (FRP System).

2.06 PIPE CLAMPS

A. Riser Clamp: MSS SP 58, 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.

2.07 INTERMEDIATE PIPE GUIDES

A. Type: Hold down pipe guide.

1. Manufacturer and Product: B-Line; Figure B3090, 1-1/2 inches through 36 inches.

B. Type: U-bolts with double nuts to provide nominal 1/8-inch to 1/4-inch clearance around pipe; MSS SP 58, Type 24.

1. Anvil; Figure 137 and Figure 137S.

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2. B-Line; Figure B3188 and Figure B3188NS.

2.08 PIPE ALIGNMENT GUIDES

A. Type: Spider.

B. Manufacturers and Products:

1. Anvil; Figure 255, sizes 1/2 inch through 24 inches.
2. B-Line; Figure B3281 through Figure B3287, sizes 1/2 inch through 24 inches.

2.09 PIPE ANCHORS

A. Type: Anchor chair with U-bolt strap.

B. Manufacturer and Product: B-Line; Figure B3147A or Figure B3147B.

2.10 ANCHORING SYSTEM

1. Size and Material: Sized by equipment manufacturer, ½ inch minimum diameter, and as specified in Section 05 50 00, Metal Fabrication.

2.11 ACCESSORIES

A. Insulation Shields:

1. Type: Galvanized steel or stainless steel, MSS SP 58, Type 40.
2. Manufacturers and Products:
   a. Anvil; Figure 167, 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, Type 39.
2. Manufacturers and Products:
   a. Anvil; Figure Series 160, sizes 1 inch through 36 inches.
   b. B-Line; Figure Series 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: B-Line; Figure Series B3106V, sizes 1/2 inch through 6 inches with Figure B3106 Vee bottom hanger.

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D. Hanger Rods, Clevises, Nuts, Sockets, and Turnbuckles: In accordance with MSS SP 58.

E. Attachments:

1. Welded Beam Attachment: MSS SP 58, Type 22.
   a. Anvil; Figure 66.
   b. B-Line; Figure B3083.
2. U-Channel Concrete Inserts: As specified in Section 05 50 00, Metal Fabrications.
3. Concrete Attachment Plates:
   a. Anvil; Figure 47, Figure 49, or Figure 52.
   b. B-Line; Figure B3084, Figure B3085, or Figure B3086.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install support systems in accordance with MSS SP 58, 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 completed.

B. Standard Pipe Supports:

1. Horizontal Suspended Piping:
   a. Single Pipes: Adjustable swivel ring, split-ring, or clevis hangers.

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b. Grouped Pipes: Trapeze hanger system.

2. Horizontal Piping Supported from Walls:
   a. Single Pipes: Wall brackets or wall chips attached to wall with anchors. Clips attached to wall mounted framing also acceptable.
   b. Stacked Piping: Wall mounted framing system and clips acceptable for pipe smaller than 3-inch minimal diameter.
   c. Pipe clamp that resists axial movement of pipe through support is not acceptable. Use cast iron hanging rolls supported from wall bracket.
3. 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 a18 inches or greater above floor and fir exterior installations.
      3) Provide minimum 1-1/2-inch grout beneath base plate.
   b. Floor Mounted Channel Supports:
      1) Use for pipe smaller than 3-inch nominal diameter running along floors and in trenches at pipe elevations lower than can be accommodated using pedestal pipe supports.
      2) Attach channel framing to floors with baseplate on minimum 1-1/2-inch nonshrink grout and with anchor bolts.
      3) Attach pipe to channel with clips or pipe clamps.
   c. Concrete Cradles: Use for pipe larger than 3 inches along floor and in trenches at pipe elevations lower than can be accommodated using stanchion type.
4. Insulated Pipe:
   a. Pipe hanger and support shall be on outside of insulation and shall not been closed within insulation.
   b. Provide precut 120-degree sections of rigid insulation (minimum length same as shield), galvanized steel shields and oversized hangers or insulated saddle system (ISS). Anvil; Figure 260 (ISS).
   c. Wall-mounted pipe clips not acceptable for insulated piping.
5. Vertical Pipe: Support with wall bracket and elbow support, or riser clamp on floor penetration.

C. Standard Attachments:

1. To Concrete Ceilings: U-channel concrete inserts, U-channel, or concrete attachment plates.
2. To Steel Beams: I-beam clamp or welded attachments.
3. To Wooden Beams: Lag screws and angle clips to members not less than 2-1/2 inches thick.

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4. To Concrete Walls: Concrete inserts or brackets or clip angles with concrete anchors.
5. 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.
6. Existing Walls and Ceilings: Install as specified for new construction, unless shown otherwise.

D. Intermediate and Pipe Alignment Guides:

1. Provide pipe alignment guides, or pipe supports that provide same function, at expansion joints and loops.
2. Guide pipe on each side of expansion joint or loop at 4 pipe and 14 pipe diameters from each joint or loop.
3. Install intermediate guides on metal framing support systems not carrying pipe anchor or alignment guide.

E. Accessories:

1. Insulation Shield: Install on insulated piping with oversize rollers and supports.
2. Welding Insulation Saddle: Install on insulated steel pipe with oversize rollers and supports.
3. Dielectric Barrier:
   a. Provide plastic coated hangers, or isolation tape such as B-Line Iso Pipe, or B-Line B1999 Vibra Cushion 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. Electrical Isolation: Install 1/4-inch by 3-inch neoprene rubber wrap between submerged metal pipe and oversized clamps.

3.02 FIELD FINISHING

A. Paint, prime and finish in accordance with Section 09 90 00, Painting and Coating.

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3.03 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are part of this specification:

1. Table 1: Nonchemical Areas.
2. Table 2: Chemical Areas.

END OF SECTION

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Table 1
Nonchemical Areas

Exposure Conditions	Support Material
Office Areas	Galvanized steel or precoated steel, plastic coated hangers for uninsulated copper or stainless steel piping
Shops and Warehouse Areas	Galvanized steel or precoated steel, plastic coated hangers for uninsulated copper or stainless steel piping
Pipe Galleries	Galvanized steel or precoated steel, plastic coated hangers for uninsulated copper or stainless steel piping
Headworks	Stainless steel or FRP
Process Areas: High Humidity or Hydrogen sulfide In rooms _____ or areas _____	Stainless steel or FRP
Process Areas: Wetted or Submerged	Stainless steel or FRP
Pipes conveying chemicals listed in Table 2	Provide with corresponding support per Table 2.

Notes:

1. Precoated steel to be fusion bonded epoxy or vinyl copolymer (Plastisol).
2. Stainless steel to be Type 304.
3. Galvanized steel to be per ASTM A653/A653M, Class G90, or hot-dip galvanized after fabrication to ASTM A123/A123M.
4. Do not use galvanized steel or aluminum where lime dust can accumulate on these surfaces.

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Table 2
Chemical Areas

Exposure Conditions	Support for Direct Exposure	Support for Remote Exposure
Alum	FRP	Precoated steel
Aqua Ammonia	Stainless steel	Precoated steel
Coagulants	FRP	Precoated steel or galvanized steel
Ferric Chloride	FRP	Precoated steel
Ferric Sulfate	FRP	Precoated steel
Hydrofluorosilic Acid	FRP	Precoated steel
Lime	Stainless steel, FRP, precoated steel	Stainless steel, FRP, precoated steel
Methanol	Galvanized steel	Galvanized steel
Polymers	FRP	Precoated steel
Potassium Permanganate	Precoated steel	Precoated steel
Powdered Activated Carbon	Precoated steel	Precoated steel
Sodium Carbonate	Stainless steel	Precoated steel
Sodium Hydroxide	Stainless steel	Precoated steel
Sodium Hypochlorite	FRP	Precoated steel
Sulfuric Acid	Stainless steel	Precoated steel

Notes:

1. Direct exposure includes entire area within containment area; area within 20 feet horizontal and 10 feet vertical of chemical pumps or chemical mixing stations; or as specified.
2. Remote exposure is area beyond area defined as direct exposure, but within designated building.
3. Precoated steel to be fusion bonded epoxy or vinyl copolymer (Plastisol).
4. Stainless steel to be Type 304.
5. Galvanized steel to be per ASTM A653/A653M, Class G90, or hot-dip galvanized after fabrication to ASTM A123/A123M.
6. Do not use galvanized steel or aluminum where lime dust can accumulate on these surfaces.

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SECTION 40 05 33
PIPE HEAT TRACING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Factory Mutual.
2. Institute of Electrical and Electronics engineers, Inc (IEEE): 515, Testing, Design, Installation and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications.
3. National Electrical Manufacturers' Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
4. Underwriters Laboratories, Inc. (UL).

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's descriptive literature.
2. Plastic Pipe Installations: Output adjustment factors for heating tape for the services indicated.
3. Pipe heat loss calculations for each pipe size to be heat traced.

PART 2 PRODUCTS

2.01 SYSTEM DESIGN REQUIREMENTS

A. Design Heating Load:

1. Heating load to be calculated based upon a 75-degree F delta, 20 mph wind if pipes are located outdoors, insulation as specified in Section 40 42 13, Process Piping Insulation, pipe as specified in Section 40 27 00, Process Piping—General, and shall include a 10 percent safety factor.
2. Heat loss calculations shall be based on IEEE 515, Equation 1, Page 19.

2.02 ELECTRICAL HEATING TAPE

A. Cable: Self-limiting, parallel circuit construction consisting of continuous inner core of variable resistance conductive heating material between two parallel copper bus wires. Provide tinned copper braid for PVC, FRP, and stainless steel pipe applications.

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B. UL Listing: Listed as self-limiting pipe tracing material for pipe freeze protection application in ordinary conditions.

C. Maximum Maintenance Temperature: 150 degrees F (65 degrees C).

D. Maximum Intermittent Temperature: 185 degrees F (85 degrees C).

E. Service Voltage: As indicated by branch circuits provided for heat tracing on the Drawings.

F. Manufacturers and Products:

1. Raychem; BTV-CR.
2. Thermon; BSX.
3. Nelson; CL1-J1 or L1-J1.

2.03 CONNECTION SYSTEM

A. Rating: NEMA 250, Type 4 and Factory Mutual approved.

B. Operating Monitor Light: Furnish with each circuit power connection kit to indicate when heat tracing is energized.

C. Manufacturers and Products:

1. Power Connection Kit:
   a. Raychem; JBS-100.
   b. Thermon; PCA-1-SR or DP-L.
   c. Nelson; PLT-BC.
2. Splice Kit:
   a. Raychem; S-150.
   b. Thermon; PCS-1-SR.
   c. Nelson; PLT-BS.
3. Tee Kit:
   a. Raychem; T-100.
   b. Thermon; DS-S.
   c. Nelson; PLT-BY.
4. End Seal Kit:
   a. Raychem; E-150.
   b. Thermon; DE-S.
   c. Nelson; LT-ME.
5. Lighted End Seal Kit:
   a. Raychem; E-100-L.
   b. Thermon; DLS.
   c. Nelson; LT-L.

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2.04 SECURING TAPE

A. Plastic Piping Systems:

1. Type: Aluminum foil coated adhesive tape.
2. Manufacturers and Products:
   a. Raychem; AT-180.
   b. Thermon; AL-20P.
   c. Nelson; AT-50.

B. Metallic Piping Systems:

1. Type: Glass or polyester cloth pressure sensitive tape.
2. Manufacturers and Products:
   a. Raychem; GS54 or GT66.
   b. Thermon; PF-1.
   c. Nelson; GT-6 or GT-60.

2.05 PIPE MOUNTED THERMOSTAT

A. Type: Fixed, nonadjustable, set at 40 degrees F.

B. Sensor: Fluid-filled with 3-foot capillary.

C. Enclosure: Glass-filled nylon, NEMA 250, Type 4X weatherproof with gasketed lid.

D. Switch: SP-ST, UL listed, rated 22 amps, 120 to 240V ac.

E. Manufacturers and Products:

1. Raychem; DigiTrace Model AMC-F5.
2. Thermon; E4X-1.
3. Raychem; DigiTrace Model E507S-LS for hazardous areas.
4. Thermon; E7-25325 for hazardous areas.

2.06 AMBIENT THERMOSTAT

A. Type: Adjustable setting (15 to 140 degrees F).

B. Sensor: Fluid-filled probe.

C. Enclosure: Epoxy-coated NEMA 250, Type 4X aluminum enclosure with exposed hardware of stainless steel.

D. Switch: SP-DT, UL or FM listed, rated 22 amps, 125 to 250V ac.

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E. Manufacturers and Products:

1. Raychem; DigiTrace Model AMC-1A.
2. Thermon; B4X-15140.
3. Raychem; DigiTrace Model AMC-1H for hazardous areas.
4. Thermon; B7-15140 for hazardous areas.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install in accordance with the manufacturer's instructions and recommended practices.
2. Provide insulation as specified in Section 40 42 13, Process Piping Insulation, over all pipe heat tracing.
3. Ground metallic structures or materials used for support of heating cable or on which it is installed in accordance with applicable codes.
4. Wiring between power connection points of heat tracing cable branch lines shall be provided by heat tracing system supplier.
5. Provide end of circuit pilot lights on heat tracing circuits for buried piping.

B. Electrical Heating Tape:

1. Determine required length of electrical heating tape by considering length of circuit, number and type of fittings and fixtures, design heating load, and heating tape output.
2. Where design heating load exceeds heating tape capacity, install by spiraling.
3. Derate heating tape capacity when installed on plastic piping.
4. Install on services as follows:

Service	Piping Material	Placement	Location
W3	CPVC	Exterior piping and fittings	Building 69, above reactors top deck

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5. Install additional heating tape at bolted flanges, valves, pipe supports, and other fittings and fixtures as recommended by supplier, but not less than the following:

Item	Heating Tape Length (min. feet)
Bolted flanges (per pair)	Two times pipe diameter
Valves	Four times valve length
Pipe hanger or support penetrating insulation	Three times pipe diameter

C. Heat Tracing Circuits: Limit individual lengths of heat tracing circuits such that maximum single circuit capacity is 20 amps when starting the circuit at 40 degrees F. Provide multiple 20-amp circuits as required at individual heat tracing locations.

D. Thermostats:

1. Install in accordance with manufacturer's instructions and as approved by Engineer.
2. For each group of heat traced circuit, install one ambient thermostat.

3.02 FIELD QUALITY CONTROL

A. Test each circuit with 500-volt insulation tester between circuit and ground with neutrals isolated from ground.

1. Insulation Resistance: Minimum 1,000 megohms per 1,000 feet.

END OF SECTION

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SECTION 40 27 00
PROCESS PIPING—GENERAL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section and any supplemental Data Sheets:

1. American Society of Mechanical Engineers (ASME):
   a. B1.20.1, Pipe Threads, General Purpose (Inch).
   b. B16.5, Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Metric/Inch Standard.
   c. B16.9, Factory-Made Wrought Buttwelding Fittings.
   d. B16.11, Forged Fittings, Socket-Welding and Threaded.
   e. B16.21, Nonmetallic Flat Gaskets for Pipe Flanges.
   f. B16.25, Buttwelding Ends.
   g. B16.42, Ductile Iron Pipe Flanges and Flanged Fittings Classes 150 and 300.
   h. B31.1, Power Piping.
   i. B31.3, Process Piping.
   j. B31.9, Building Services Piping.
   k. B36.10M, Welded and Seamless Wrought Steel Pipe.
2. American Society for Nondestructive Testing (ASNT): SNT-TC-1A, Recommended Practice for Personal Qualification and Certification in Nondestructive Testing.
3. American Water Works Association (AWWA):
   a. C104/A21.4, Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
   b. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
   c. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   d. C115/A21.15, Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
   e. C151/A21.51, Ductile-Iron Pipe, Centrifugally Cast.
   f. C153/A21.53, Ductile-Iron Compact Fittings.
   g. C606, Grooved and Shouldered Joints.
4. American Welding Society (AWS):
   a. Brazing Handbook.
   b. A5.8M/A5.8, Specification for Filler Metals for Brazing and Braze Welding.
   c. D1.1/D1.1M, Structural Welding Code - Steel.

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d. QC1, Standard for AWS Certification of Welding Inspectors.

5. ASTM International (ASTM):
   a. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   b. A135/A135M, Standard Specification for Electric-Resistance-Welder Steel Pipe.
   c. A139/A139M, Standard Specification for Electro-Fusion (Arc)–Welded Steel Pipe (NPS 4 Inches and Over).
   d. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   e. A182/A182M, Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
   f. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   g. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   h. A216/A216M, Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
   i. A276, Standard Specification for Stainless Steel Bars and Shapes.
   j. A269, Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
   k. A312/A312M, Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
   l. A320/A320M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
   m. A403/A403M, Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings..
   n. A536, Standard Specification for Ductile Iron Castings.
   o. A774/A774M, Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures.
   p. A778, Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
   q. B464, Standard Specification for Welded UNS N08020 Alloy Pipe.
   r. D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension.
   s. D413, Standard Test Methods for Rubber Property-Adhesion to Flexible Substrate.
   t. D543, Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents.

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u. D1248, Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.
v. D1330, Standard Specification for Rubber Sheet Gaskets.
w. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
x. D1785, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
y. D2310, Standard Classification for Machine-Made "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
z. D2464, Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
aa. D2467, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
bb. D2564, Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
cc. D2996, Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
dd. D3222, Standard Specification for Unmodified Poly(Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating Materials.
ee. D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
ff. Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges.
gg. F436, Standard Specification for Hardened Steel Washers.
hh. F439, Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
ii. F441/F441M, Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
jj. F493, Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
kk. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
ll. F656, Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings.

6. FM Global (FM).
7. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS): SP-43, Wrought and Fabricated Butt-Welding Fittings for Low-Pressure, Corrosion Resistant Applications.
8. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

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1.02 DEFINITIONS

A. Submerged or Wetted: Zone below elevation of top of CPT Reactor roof deck.

1.03 DESIGN REQUIREMENTS

A. Where pipe diameter, thickness, pressure class, pressure rating, or thrust restraint is not shown or specified, design piping system in accordance with the following:

1. Process Piping: ASME B31.3, normal fluid service unless otherwise specified.
2. Building Service Piping: ASME B31.9, as applicable.
3. Thrust Restraints: Design for test pressure shown in Piping Schedule.

1.04 SUBMITTALS

A. Action Submittals: Information on proposed factory and field applied coating system. See Section 09 90 00, Painting and Coating for specific requirements.

B. Informational Submittals:

1. Manufacturer's Certification of Compliance, in accordance with Section 01 61 00, Common Product Requirements for:
   a. Pipe and fittings.
   b. Factory applied resins and coatings.
2. Qualifications:
   a. Nondestructive Testing Personnel: SNT-TC-1A Level II certification and qualifications.
   b. AWS QC1 Certified Welding Inspector: Submit evidence of current certification prior to commencement of welding activities.
   c. Welders:
      1) Continuity log for welders and welding operators.
      2) Welder qualification test records conducted by Contractor or manufacturer.
3. Welding Procedures: Qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX for weld type(s) and base metal(s).
4. Nondestructive inspection and testing procedures.
5. Test logs.
6. Pipe coating applicator certification.

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1.05 QUALITY ASSURANCE

A. Qualifications:

1. Independent Inspection and Testing Agency:
   a. Ten years' experience in field of welding and welded pipe and fittings' testing required for this Project.
   b. Calibrated instruments and equipment and documented standard procedures for performing specified testing.
   c. Certified in accordance with ASNT SNT-TC-1A for testing procedures required for this Project.
   d. Testing Agency: Personnel performing tests shall be NDT Level II certified in accordance with ASNT SNT-TC-1A.
   e. Verification Welding Inspector: AWS QC1 Certified.
2. Welding Procedures: In accordance with ASME BPVC SEC IX (Forms QW-482 and QW-483) or AWS D1.1/D1.1M (Annex N Forms).
3. Welder Qualifications: In accordance ASME BPVC SEC IX (Form QW-484) or AWS D1.1/D1.1M (Annex N Forms).
4. Contractor's CWI: Certified in accordance with AWS QC1 and having prior experience with specified welding codes. Alternate welding inspector qualifications require approval by Engineer.

B. Quality Assurance: Provide services of independent inspection and testing agency for welding operations.

1. The presence of Owner's Special Inspector or Verification CWI does not relieve Contractor from performing own quality control, including 100 percent visual inspection of welds.

1.06 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01 61 00, Common Product Requirements, and:

1. Flanges: Securely attach metal, hardboard, or wood protectors over entire gasket surface.
2. Threaded or Socket Welding Ends: Fit with metal, wood, or plastic plugs or caps.
3. Linings and Coatings: Prevent excessive drying.
4. Cold Weather Storage: Locate products to prevent coating from freezing to ground.
5. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.

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PART 2 PRODUCTS

2.01 PIPING

A. As specified on Piping Data Sheet(s) and Piping Schedule located at the end of this section as Supplement.

B. Diameters Shown:

1. Standardized Products: Nominal size.
2. Fabricated Steel Piping (Except Cement-Lined): Outside diameter, ASME B36.10M.
3. Cement-Lined Steel Pipe: Lining inside diameter.

2.02 JOINTS

A. Flanged Joints:

1. Flat-faced, carbon steel, or alloy flanges when mating with flat-faced cast or ductile iron flanges.
2. Higher pressure rated flanges as required to mate with equipment when equipment flange is of higher-pressure rating than required for piping.

B. Threaded Joints: NPT taper pipe threads in accordance with ASME B1.20.1.

2.03 GASKET LUBRICANT

A. Lubricant shall be supplied by pipe manufacturer and no substitute “Or-equal” will be allowed.

2.04 PIPE CORROSION PROTECTION

A. Coatings: See Section 09 90 00, Painting and Coating, for details of coating requirements.

B. Insulating Flanges, Couplings, and Unions:

1. Materials:
   a. In accordance with applicable piping material specified in Pipe Data Sheet. Complete assembly shall have ASME B31.3 working pressure rating equal to or higher than that of joint and pipeline.
   b. Galvanically compatible with piping.
   c. Resistant for intended exposure, operating temperatures, and products in pipeline.

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2. Union Type, 2 Inches and Smaller:
   a. Screwed or solder-joint.
   b. O-ring sealed with molded and bonded insulation to body.
3. Flange Type, 2-1/2 Inches and Larger:
   a. Flanged, complete with bolt insulators, dielectric gasket, bolts, and nuts.
   b. Bolt insulating sleeves shall be provided full length between insulating washers.
   c. Ensure fit-up of components of insulated flange assembly to provide a complete functioning installation.
   d. AWWA C207 steel flanges may be drilled oversize up to 1/8-inch to accommodate insulating sleeves.
   e. No less than minimum thread engagement in accordance with specified bolting standards will be permitted to accommodate thicknesses of required washers, flanges, and gasket.
4. Flange Insulating Kits:
   a. Gaskets: Full-face, Type E with elastomeric sealing element. Sealing element shall be retained in a groove within retainer portion of gasket.
   b. Insulating Sleeves: Full-length mylar.
   c. Insulating Washers: High strength phenolic or Fiberglass-reinforced epoxy (NEMA LI-1, G-10 grade).
   d. Steel Washers: Plated, hot-rolled steel, 1/8 inch thick.
      1) Flange Diameters 36 Inches or Less: Provide two washers per bolt.
      2) Flange Diameters Larger Than 36 Inches: Provide four washers per bolt.
5. Manufacturers and Products:
   a. Dielectric Flanges and Unions:
      1) PSI, Houston, TX.
      2) Advance Products and Systems, Lafayette, LA.
   b. Insulating Couplings:
      1) Dresser; STAB-39.
      2) Baker Coupling Company, Inc.; Series 216.

2.05 VENT AND DRAIN VALVES

A. Pipeline 2-Inch Diameter and Smaller: 1/2-inch vent, 1-inch drain, unless shown otherwise.

B. Pipelines 2-1/2-Inch Diameter and Larger: 3/4-inch vent unless shown otherwise.

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2.06 FABRICATION

A. Mark each pipe length on outside with the following:

1. Size or diameter and class.
2. Manufacturer's identification and pipe serial number.
3. Location number on laying drawing.
4. Date of manufacture.

B. Code markings according to approved Shop Drawings.

C. Shop fabricate flanged pipe in shop, not in field, and delivered to Site with flanges in place and properly faced. Threaded flanges shall be individually fitted and machine tightened on matching threaded pipe by manufacturer.

2.07 FINISHES

A. Factory prepare, prime, and finish coat in accordance with Pipe Data Sheet(s) and Piping Schedule.

B. Galvanizing:

1. Hot-dip applied, meeting requirements of ASTM A153/A153M.
2. Electroplated zinc or cadmium plating is unacceptable.
3. Stainless steel components may be substituted where galvanizing is specified.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify size, material, joint types, elevation, horizontal location, and pipe service of existing pipelines to be connected to new pipelines or new equipment.

B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

3.02 PREPARATION

A. See Piping Schedule and Section 09 90 00, Painting and Coating, for additional requirements.

B. Notify Engineer at least 2 weeks prior to field fabrication of pipe or fittings.

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C. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.

D. Damaged Coatings and Linings: Repair using original coating and lining materials in accordance with manufacturer's instructions.

3.03 WELDING

A. Perform in accordance with Section IX, ASME Boiler and Pressure Vessel Code and ASME B31.3 for Pressure Piping, as may be specified on Piping Data Sheets, and if recommended by piping or fitting manufacturer.

B. Weld Identification: Keep paper record of which welder welded each joint.

C. Pipe End Preparation:

1. Machine Shaping: Preferred.
2. Oxygen or Arc Cutting: Smooth to touch, true, and slag removal by chipping or grinding.
3. Beveled Ends for Butt Welding: ASME B16.25.

D. Surfaces:

1. Clean and free of paint, oil, rust, scale, slag, or other material detrimental to welding.
2. Clean stainless steel joints with stainless steel wire brushes or stainless steel wool prior to welding.
3. Thoroughly clean each layer of deposited weld metal, including final pass, prior to deposition of each additional layer of weld metal with a power-driven wire brush.

E. Alignment and Spacing:

1. Align ends to be joined within existing commercial tolerances on diameters, wall thicknesses, and out-of-roundness.
2. Root Opening of Joint: As stated in qualified welding procedure.
3. Minimum Spacing of Circumferential Butt Welds: Minimum four times pipe wall thickness or 1 inch, whichever is greater.

F. Climatic Conditions:

1. Do not perform welding if there is impingement of any rain, snow, sleet, or wind exceeding 5 mph on the weld area, or if ambient temperature is below 32 degrees F.

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2. Stainless Steel and Alloy Piping: If ambient is less than 32 degrees F, local preheating to a temperature warm to the hand is required.

G. Tack Welds: Performed by qualified welder using same procedure as for completed weld, made with electrode similar or equivalent to electrode to be used for first weld pass, and not defective. Remove those not meeting requirements prior to commencing welding procedures.

H. Surface Defects: Chip or grind out those affecting soundness of weld.

I. Weld Quality: Meet requirements of governing welding codes.

3.04 INSTALLATION—GENERAL

A. Join pipe and fittings in accordance with manufacturer's instructions, unless otherwise shown or specified.

B. Remove foreign objects prior to assembly and installation.

C. Flanged Joints:

1. Install perpendicular to pipe centerline.
2. Bolt Holes: Straddle vertical centerlines, aligned with connecting equipment flanges or as shown.
3. Use torque-limiting wrenches to ensure uniform bearing and proper bolt tightness.
4. Plastic Flanges: Install annular ring filler gasket at joints of raised-face flange.
5. Grooved Joint Flange Adapters: Include stainless steel washer plates as required for mating to serrated faces and lined valves and equipment.
6. Raised-Face Flanges: Use flat-face flange when joining with flat-faced ductile or cast-iron flange.
7. Verify compatibility of mating flange to adapter flange gasket prior to selecting grooved adapter flanging.
8. Flange fillers are to be avoided, but, if necessary, may be used to make up for small angles up to 6 degrees and for filling gaps up to 2 inches between flanges. Stacked flange fillers shall not be used.
9. Threaded flanged joints shall be shop fabricated and delivered to Site with flanges in-place and properly faced.
10. Manufacturer: Same as pipe manufacturer.

D. Threaded and Coupled Joints:

1. Conform to ASME B1.20.1.

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2. Produce sufficient thread length to ensure full engagement when screwed home in fittings.
3. Countersink pipe ends, ream and clean chips and burrs after threading.
4. Make connections with not more than three threads exposed.
5. Lubricate male threads only with thread lubricant or tape as specified on Piping Data Sheets.

E. Pipe Connections at Concrete Structures: As specified in Article Piping Flexibility Provisions in Section 40 27 01, Process Piping Specialties.

F. PVC and CPVC Piping:

1. Provide Schedule 80 threaded nipple where necessary to connect to threaded valve or fitting.
2. Use strap wrench for tightening threaded plastic joints. Do not overtighten fittings.
3. Do not thread Schedule 40 pipe.

G. Ductile Iron Piping:

1. Cutting Pipe: Cut pipe with milling type cutter, rolling pipe cutter, or abrasive blade cutter. Do not flame cut.
2. Dressing Cut Ends:
   a. General: As required for the type of joint to be made.
   b. Rubber Gasketed Joints: Remove sharp edges or projections.
   c. Push-On Joints: Bevel, as recommended by pipe manufacturer.
   d. Flexible Couplings, Flanged Coupling Adapters, and Grooved End Pipe Couplings: As recommended by the coupling or adapter manufacturer.

H. High-Density Polyethylene Piping:

1. Join pipes, fittings, and flange connections by means of thermal butt-fusion.
2. Perform butt-fusion in accordance with pipe manufacturer’s recommendations as to equipment and technique.
3. Special Precautions at Flanges: Polyethylene pipe connected to heavy fittings, manholes, and rigid structures shall be supported in such a manner that no subsequent relative movement between polyethylene pipe at flanged joint and rigid structures is possible.

I. Fiberglass Reinforced Piping:

1. Cut, fabricate, and install in accordance with manufacturer’s written instructions.

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2. Provide manufacturer's representative for instructing workers on proper installation and jointing methods.
3. Installation shall be made by workers experienced in FRP pipe lay-up techniques.

3.05 INSTALLATION—EXPOSED PIPING

A. Piping Runs:

1. Parallel to building or column lines and perpendicular to floor, unless shown otherwise.
2. Piping upstream and downstream of flow measuring devices shall provide straight lengths as required for accurate flow measurement.

B. Supports: As specified in Section 40 05 15, Piping Support Systems.

C. Group piping wherever practical at common elevations; install to conserve building space and not interfere with use of space and other work.

D. Unions or Flanges: Provide at each piping connection to equipment or instrumentation on equipment side of each block valve to facilitate installation and removal.

E. Install piping so that no load or movement in excess of that stipulated by equipment manufacturer will be imposed upon equipment connection; install to allow for contraction and expansion without stressing pipe, joints, or connected equipment.

F. Piping clearance, unless otherwise shown:

1. Over Walkway and Stairs: Minimum of 7 feet 6 inches measured from walking surface or stair tread to lowest extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
2. Between Equipment or Equipment Piping and Adjacent Piping: Minimum 3 feet, measured from equipment extremity and extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
3. From Adjacent Work: Minimum 1 inch from nearest extremity of completed piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
4. Do not route piping in front of or to interfere with access ways, ladders, stairs, platforms, walkways, openings, doors, or windows.
5. Headroom in front of openings, doors, and windows shall not be less than the top of the opening.

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6. Do not install piping containing liquids or liquid vapors in transformer vaults or electrical equipment rooms.
7. Do not route piping over, around, in front of, in back of, or below electrical equipment including controls, panels, switches, terminals, boxes, or other similar electrical work.

G. Provide stainless steel bird screen on open pipe ends connected to process piping (such as, vent piping), unless otherwise indicated on the Drawings. Attach bird screen with ring flange, threaded connection or other applicable pipe fitting.

3.06 PIPE CORROSION PROTECTION

A. Ductile Iron Pipe:

1. Exposed: As specified in Section 09 90 00, Painting and Coating, and as shown in Piping Schedule.
2. Submerged or Embedded: Coat with coal-tar epoxy as specified in Section 09 90 00, Painting and Coating.

B. PVC and CPVC Pipe, Exposed: As specified in Section 09 90 00, Painting and Coating.

C. Piping Accessories:

1. Exposed:
   a. Field paint black and galvanized steel, brass, copper, and bronze piping components as specified in Section 09 90 00, Painting and Coating, as applicable to base metal material.
   b. Accessories include, but are not limited to, pipe hangers, supports, expansion joints, pipe guides, flexible couplings, vent and drain valves, and fasteners.

D. Insulating Flanges, Couplings, and Unions:

1. Applications:
   a. Dissimilar metal piping connections.
   b. Submerged to unsubmerged metallic piping connections.
   c. Connections to existing metallic pipe.
   d. Where required for electrically insulated connection.
2. Pipe Installation:
   a. Insulating joints connecting immersed piping to non-immersed piping shall be installed above maximum water surface elevation.
   b. Carbon steel, ductile iron, or galvanized piping in reinforced concrete shall be isolated from the concrete reinforcement steel.

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c. Align and install insulating joints as shown on the Drawings and according to manufacturer's recommendations. Bolt lubricants that contain graphite or other metallic or electrically conductive components that can interfere with the insulating capabilities of the completed flange shall not be used.

3.07 THRUST RESTRAINT

A. Location:

1. Exposed Piping: At all joints in piping.
2. Submerged Piping: At all joints in piping.

B. Thrust Ties:

1. Steel Pipe: Attach with lugs fabricated in accordance with details shown on Drawings.
2. Ductile Iron Pipe: Attach tie rods and lugs plates or flange.
3. Flanged Coupling Adapters: For exposed installations, install tie rods through lug plates or use dismantling joints.

C. Mechanical Joint Valve Restraint in Proprietary Restrained Joint Piping: Install pipe joint manufacturer's adapter gland follower and pipe end retainer, or mechanical joint anchor gland follower.

3.08 SLAB, FLOOR, WALL, AND ROOF PENETRATIONS

A. Application and Installation: As specified in Section 40 27 01, Process Piping Specialties.

3.09 BRANCH CONNECTIONS

A. Do not install branch connections smaller than 1/2-inch nominal pipe size, including instrument connections, unless shown otherwise.

B. When line of lower pressure connects to a line of higher pressure, requirements of Piping Data Sheet for higher pressure rating prevails up to and including first block valve in the line carrying the lower pressure, unless otherwise shown.

C. Threaded Pipe Tap Connections:

1. Ductile Iron Piping: Connect only with service saddle or at tapping boss of a fitting, valve body, or equipment casting.

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2. Welded Steel or Alloy Piping: Connect only with welded threadolet or half-coupling as specified on Piping Data Sheet.

3.10 VENTS AND DRAINS

A. Vents and drains at high and low points in piping required for completed system may or may not be shown. Install vents on high points and drains on low points of pipelines at all low and high point locations.

3.11 INSULATION

A. See Section 40 42 13, Process Piping Insulation.

3.12 HEAT TRACING

A. See Section 40 05 33, Pipe Heat Tracing.

3.13 FIELD FINISHING

A. Notify Engineer at least 3 days prior to start of surface preparation or coating application work.

B. As specified in Section 09 90 00, Painting and Coating.

3.14 PIPE IDENTIFICATION

A. As specified in Section 10 14 00, Signage and 09 90 00, Painting and Coating.

3.15 FIELD QUALITY CONTROL

A. Pressure Leakage Testing: As specified in Section 40 80 01, Process Piping Leakage Testing.

B. Minimum Duties of Welding Inspector:

1. Job material verification and storage.
2. Qualification of welders.
3. Certify conformance with approved welding procedures.
4. Maintenance of records and preparation of reports in a timely manner.
5. Notification to Engineer of unsatisfactory weld performance within 24 hours of weld test failure.

C. Required Weld Examinations:

1. Perform examinations in accordance with Piping Code ASME B31.3.

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2. Perform examinations for every pipe thickness and for each welding procedure, progressively, for piping covered by this section.
3. Examine at least one of each type and position of weld made by each welder or welding operator.
4. For each weld found to be defective under the acceptance standards or limitations on imperfections contained in the applicable Piping Code, examine two additional welds made by the same welder that produced the defective weld. Such additional examinations are in addition to the minimum required above. Examine, progressively, two additional welds for each tracer examination found to be unsatisfactory.

3.16 CLEANING

A. Following assembly and testing, and prior to final acceptance, flush pipelines, except as stated below, with water at 2.5 fps minimum flushing velocity until foreign matter is removed.

B. Blow clean of loose debris plant process air and instrument air lines with compressed air at 4,000 fpm; do not flush with water.

C. If impractical to flush large diameter pipe at 2.5 fps or blow at 4,000 fpm velocity, clean in-place from inside by brushing and sweeping, then flush or blow line at lower velocity.

D. Insert cone strainers in flushing connections to attached equipment and leave in-place until cleaning is complete.

E. Remove accumulated debris through drains 2 inches and larger or by removing spools and valves from piping.

3.17 SUPPLEMENTS

A. The supplement listed below, following “End of Section,” is part of this Specification:

1. Piping Schedule.
2. Data Sheets.

Number	Title
40 27 00.01	Cement-Mortar -Lined Ductile Iron Pipe and Fittings
40 27 00.08	Stainless Steel Pipe and Fittings—General Service
40 27 00.10	Polyvinyl Chloride (PVC) Pipe and Fittings

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Number	Title
40 27 00.11	Chlorinated Polyvinyl Chloride (CPVC) Pipe and Fittings
40 27 00.16	Reinforced Chemical Tubing (RCT)

END OF SECTION

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PIPING SCHEDULE LEGEND

SERVICE

ALP	Air-Low Pressure
RD	Roof Drain
V	Vents
W3	Plant Effluent Water

EXPOSURE

ALL	All
BUR	Buried
EXP	Exposed
SUB	Submerged
ENC	Concrete Encased

MATERIAL

CLDI	Cement-Lined Ductile Iron
CPVC	Chlorinated PVC
DI	Ductile Iron
FRP	Fiberglass Reinforced Plastic Pipe Type
PVC	Polyvinyl Chloride
RCT	Reinforced Chemical Tubing
SST	Stainless Steel
TFD	Thermoplastic Flexible Duct

JOINT TYPE

FL	Flanged
PRJ	Proprietary Restrained

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RM	Restrained Mechanical
S	Screwed
W	Welded (including solvent and fusion)

PRESSURE TEST

G	Gravity Service: Test pressure is not shown on gravity services. Test to highest liquid level that pipe can be subject to.
H	Hydrostatic
I	In Service
P	Pneumatic
PC	Test per Uniform Plumbing Code
NA	Not Applicable

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Piping Schedule

Service	Legend	Size(s) (In.)[1]	Exposure	Piping Material	Specification Section	Maximum Operating Pressure (psig)	Lining/ Coating[2]	Test Pressure and Type (psig-x), x = Type indicated in Legend	Pipe Color and Label	Remarks
Air Low Pressure	ALP	>=6 <6	EXP SUB	SST SST CPVC	40 27 00.08 40 27 00.11	15	See Remarks	30 P 30 P 50 H	SST Gray	Insulate in accordance with Section 40 42 13, Process Piping Insulation ALP Pipe will transition to CPVC within reactors where indicated on drawings. 1" ALP to depressurization valves will be SST.
Drain	D	ALL	EXP	CPVC	40 27 00.11	40	System No. 25	15H	Light Gray/Light Blue Gray 5019R/Black	
Recycle	RCY	<=4.0	EXP/SUB	CPVC	40 27 00.11	40	System No. 25	150 H	Light Brown/Light Brown 5050V/Black	
Centrate Pre-Treatment Effluent	CPTE	ALL	EXP/BUR/ENC	CLDI	40 27 00.01	40	System No. 6	60	Light Gray/Light Blue Gray 5019R/Black	Gravity Line
Dewatering Centrate	DC CPTI	ALL	EXP in Galleries	CPVC	40 27 00.11	40	System No. 25	150 H	Light Gray/Light Blue Gray 5019R/Black	Within Galleries
		ALL	EXP/SUB	CLDI	40 27 00 01	40	System No. 6	150 H	Light Gray/Light Blue Gray 5019R/Black	Outside Galleries
Micronutrients	MNU	3/4" <3/4"	EXP EXP	CPVC RCT	40 27 00.10 40 27 00.16	50	System No. 25	50 H	Kentucky Blue 5205R/White	RCT shall be installed inside a 2" CPVC pipe serving as carrier pipe. RCT may be exposed at bends, where the carrier pipe is discontinued.

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Piping Schedule

Service	Legend	Size(s) (In.)[1]	Exposure	Piping Material	Specification Section	Maximum Operating Pressure (psig)	Lining/ Coating[2]	Test Pressure and Type (psig-x), x = Type indicated in Legend	Pipe Color and Label	Remarks
Odorous Air	OA	ALL	EXP	CPVC TFD	40 27 00.10 See Remarks	>-1	System No. 25	NA	SST/Tan Light Brown/Tan	Provide FRP flanged nozzles per Section 23 31 13 to connect to existing OA line. Provide thermoplastic flexible duct where indicated on drawings per Section 40 27 01 Process Piping Specialties 2.11F
Overflow	OF	ALL	EXP	CPVC	40 27 00.10	-	System No. 25	NA	Light Gray/Light Blue Gray 5019R/Black	
Plant Effluent Water	W3	< 4.0	EXP/SUB	CPVC	40 27 00 10	80	System No. 25	150 H	Green/Bright Terrace 5155/Black	Heat Trace W3 piping outdoors to Anammox Retention screens in accordance with section 40 42 13, Process Piping Insulation.
	NaOCL/W3 (Foam Control and Washdown)	ALL	EXP/SUB	CPVC	40 27 00.11	80	System No. 25	150 H	Green/Bright Terrace 5155V/Black	
Process Drain	PD	ALL	EXP	CLDI	40 27 00 01	80	System No. 6	150H	Light Gray/Light Blue Gray 5019R/Black	Pipe < 4 inches shall be stainless steel.
Sample	SA	ALL	EXP/BUR	SST	40 27 00.08	See remarks		See remarks	Alamo 5042P/Black	Same as pipe
Screenings	SCR	ALL	EXP	SST TFD	40 27 00.08 See Remarks			NA	None	Provide thermoplastic flexible duct where indicated on drawings per Section 40 27 01 Process Piping Specialties 2.11F

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Piping Schedule										
Service	**Legend**	**Size(s) (In.)[1]**	**Exposure**	**Piping Material**	**Specification Section**	**Maximum Operating Pressure (psig)**	**Lining/ Coating[2]**	**Test Pressure and Type (psig-x), x = Type indicated in Legend**	**Pipe Color and Label**	**Remarks**
Sodium Hydroxide	NaOH	ALL	EXP	CPVC	40 27 00.10	50	System No. 25	75 H	Light Lime/Sharp Green (5110T)/Black	
Vent	VENT	ALL	EXP	CPVC	40 27 00 10	-	System No. 25	NA	Light Gray/Light Blue Gray 5019R/Black	

[1]">" Greater Than<" Less Than
"<=" Less Than or Equal To
">=" Greater Than or Equal To
"All" All Sizes
[2]Coating system number as specified in Section 09 90 00, Painting and Coating and as specified in Article Pipe Corrosion Protection.

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SECTION 40 27 00.01 CEMENT-MORTAR LINED DUCTILE IRON PIPE AND FITTINGS	
Item	**Description**
General	Materials in contact with potable water shall conform to NSF 61 acceptance. Pipe manufacturer shall submit certification that source manufacturing facility has been producing ductile iron pipe of specified diameters, dimensions, and standards for a period of not less than 10 years. Testing of pipe required by AWWA C151/A21.51 shall be conducted in testing and laboratory facilities located in the USA and operating under USA laws and regulations. Pipe shall be handled during manufacture and shipped without nesting (without insertion of one pipe inside another).
Pipe	Exposed Pipe Using Grooved End and Flange Joints: AWWA C115/A21.15, thickness Class 53 minimum, 250 psi minimum working pressure.
Lining	Cement-mortar: AWWA C104/A21.4 with asphaltic seal coat. Use only for liquid service.
Fittings	Lined and coated same as pipe. Proprietary Restrained: AWWA C110/A21.10, AWWA C111/A21.11, and AWWA C153/A21.53, ductile iron, 250 psi minimum working pressure. Restraint shall be achieved with removable metal elements fitted between a welded bar on the pipe barrel and the inside of the joint bell or fitting sizes smaller than 16 inches may be mechanical joint, restrained by anchor gland followers, ductile iron anchor type, wedge action, with break-off tightening bolts. Assembled joints shall be rated for deflection in operation at rated pressure. Rated deflection shall be not less than 1-1/2 degrees for 36-inch and smaller pipe. Rated deflection shall be not less than 1/2 degree for 42-inch and larger pipe. Clow Corp., American Cast Iron Pipe Co., U.S. Pipe. Restrained joints relying on metal teeth molded into the gasket to prevent joint separation under pressure will not be accepted. Grooved End: AWWA C606 and AWWA C110/A21.10, ductile iron, 250 psi minimum working pressure; Victaulic. Flange: AWWA C110/A21.10 ductile iron, faced and drilled, Class 125 flat face. Gray cast iron will not be allowed.

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SECTION 40 27 00.01 CEMENT-MORTAR LINED DUCTILE IRON PIPE AND FITTINGS	
Item	**Description**
Joints	Proprietary Restrained: 250 psi minimum working pressure. American Cast Iron Pipe Co., Flex-Ring or Lok-Ring; U.S. Pipe, TR Flex or HP Lok. Grooved End: Rigid type radius cut conforming to AWWA C606, 250 psi minimum working pressure; Victaulic. Flange: Dimensions per AWWA C110/A21.10 flat face, ductile iron, threaded conforming to AWWA C115/A21.15. Gray cast iron will not be allowed. Branch connections 3 inches and smaller, shall be made with service saddles as specified in Section 40 27 01, Process Piping Specialties.
Couplings	Grooved End: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536; Victaulic. Grooved End Adapter Flanges: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536; Victaulic.
Bolting	Mechanical, Proprietary Restrained, and Grooved End Joints: Manufacturer's standard. Flanged: ASTM A307, Grade B carbon steel heavy hex head or stud bolts, ASTM A563, Grade A carbon steel heavy hex head nuts and ASTM F436 hardened steel washers at nuts and bolt heads. Stud bolts are not allowed when bolting to tapped flanges. Torque bolts per gasket manufacturer recommendations. Flanged Joints in Sumps, Wet Wells, and Submerged and Wetted Installations: Type 316 stainless steel, ASTM A320/A320M, Grade B8M heavy hex head or stud bolts; ASTM A194/A194M, Grade 8M heavy hex nuts and ASTM F436 Type 3 alloy washers at nuts and bolt heads. Stud bolts are not allowed when bolting to tapped flanges. Torque bolts per gasket manufacturer recommendations.
Gaskets	General: Gaskets in contact with potable water shall be NSF ANSI 61 certified. Proprietary Restrained Joints; Water and Sewage Service: Halogenated butyl or EPDM, Shore A hardness durometer 60, conforming to AWWA C111/A21.11.

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SECTION 40 27 00.01 CEMENT-MORTAR LINED DUCTILE IRON PIPE AND FITTINGS	
Item	**Description**
	Proprietary Restrained Joints; Hot Air Service: EPDM or Viton, Shore A hardness durometer 60, conforming to AWWA C111/A21.11. Grooved End Joints: Halogenated butyl conforming to ASTM D2000 and AWWA C606. Flanged, Water, Sewage and Hot Air Services: Full face, 1/8-inch-thick, homogeneous black rubber (EPDM), hardness 60-80 (Shore A), rated to 275 degrees F, conforming to ASME B16.21 and ASTM D1330. Blind flanges shall be epoxy-lined in accordance with the system specified above. Gasket pressure rating to equal or exceed the system hydrostatic test pressure.
Joint Lubricant	Manufacturer's standard.

END OF SECTION

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SECTION 40 27 00.08 STAINLESS STEEL PIPE AND FITTINGS—GENERAL SERVICE		
Item	**Size**	**Description**
Pipe	2-1/2" & smaller	Buttwelded Pipe, Schedule 40S: ASTM A312/A312M, Grade TP316/316L dual marked, seamless, pickled and passivated. Threaded Pipe, Schedule 80S: ASTM A312/A312M, Grade TP316/316L dual marked, seamless, pickled and passivated.
	3" thru 24"	Schedule 10S: ASTM A312/A312M, Grade TP304/304L, dual marked, seamless or welded pickled and passivated.
	30" & larger	AWWA C220, ASTM A240/A240M TP304/304L dual marked, wall thickness as shown on Drawings.
Tubing	All	ASTM A269, Type 316 stainless steel, seamless, fully annealed hydraulic tubing, 0.065-inch wall thickness minimum.
Joints	1-1/2" & smaller	Threaded or flanged at equipment as required or shown.
	2" & larger	Butt-welded or flanged at valves and equipment.
Tubing Joints	All	Flareless compression fitting.
Fittings	1-1/2" & smaller	Threaded: Forged ASTM A182/A182M, Grade F304, conforming to MSS SP-114 Class 1000.
	2" & 2-1/2"	Butt Welded: ASTM A403/A403M, Grade WP304/304L-S dual marked, conforming to ASME B16.9, annealed, pickled, and passivated; fitting wall thickness to match adjoining pipe; long radius elbows, unless shown otherwise.

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SECTION 40 27 00.08 STAINLESS STEEL PIPE AND FITTINGS—GENERAL SERVICE		
Item	**Size**	**Description**
	3" thru 24"	Butt-Welded: ASTM A403/A403M, Grade WP304/304L dual marked, conforming to ASME 16.9, pickled and passivated; fitting wall thickness to match adjoining pipe; long radius elbows, unless shown otherwise.
	30" & larger	AWWA C208, ASTM A240/A240M TP304/304L dual marked, wall thickness as shown on Drawings, wall thickness to match adjoining pipe, long radius elbows, unless shown otherwise.
Tubing Fittings	All	Flareless Compression Type Forged: ASTM A182/A182M, Grade F316, Parker-Hannifin Ferulok, Flodar BA Series.
Branch Connections	1-1/2" & smaller	Tee or reducing tee in conformance with fittings above.
	2" & larger	Butt-welding tee or reducing tee in accordance with fittings above.
Tubing Branch Connections	All	Compression type tees or reducing tees in accordance with Tubing Fittings above.
Flanges	All	Stainless Steel: AWWA C228, Class SD, 304/304L or ASTM A182/A182M, Grade F304/304L ASME B16.5 Class 150 or Class 300, flat face, weld neck, threaded, blind, or slip-on. Weld slip-on flanges inside and outside. Weld neck bore to match internal pipe diameter.
Unions	2" & smaller	Threaded Forged: ASTM A182/A182M, Grade F304, CL 3000, integral ground seats, AAR design meeting the requirements of MSS SP-83.

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SECTION 40 27 00.08
STAINLESS STEEL PIPE AND FITTINGS—GENERAL SERVICE

Item	Size	Description
Bolting	All	Flanges: AWWA C228, Type 316 stainless steel, ASTM A193/A193M Grade B8M, Class 2 heavy hex head or stud bolts, ASTM A194/A194M Grade 8M heavy hex head nuts. Torque bolts per gasket manufacturer recommendations. Anywhere mating flange on equipment is cast iron or plastic: Carbon steel ASTM A307 Grade B hex head or stud bolts, ASTM A563 Grade A hex head nuts and ASTM F436 hardened steel washers at nuts and bolt heads. Torque bolts per gasket manufacturer recommendation.
Gaskets	All Flanges	Flanged, Water, Hot Air, Fuel Gas and Sewage Services: Full face, 1/8-inch-thick, homogeneous black rubber (EPDM), hardness 60-80 (Shore A), rated to 250 degrees F. continuous and conforming to ASME B16.21 and ASTM D1330, Steam Grade.
Thread Lubricant (fittings)	1 1/2" & smaller	General Service: 100 percent virgin PTFE Teflon tape. Fuel Gas Service: Yellow Teflon tape designed for fuel gas service, Air Force A-A-58092, AA Thread Seal Tape, Inc.

END OF SECTION

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SECTION 40 27 00.10 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS		
Item	**Size**	**Description**
General	All	Materials in contact with potable water shall conform to NSF 61 acceptance.
Pipe	All	Schedule 80 PVC: Type I, Grade I or Class 12454 conforming to ASTM D1784 and ASTM D1785. Pipe shall be manufactured with titanium dioxide for ultraviolet protection. Threaded Nipples: Schedule 80 PVC.
Fittings	All	Schedule to Match Pipe Above: ASTM D2466 and ASTM D2467 for socket weld type and Schedule 80 ASTM D2464 for threaded type. Fittings shall be manufactured with titanium dioxide for ultraviolet protection.
Joints	All	Solvent socket weld except where connection to threaded valves and equipment may require future disassembly.
Flanges	All	One-piece, molded hub type PVC flat face flange in accordance with Fittings above, ASME B16.1, Class 125 drilling.
Bolting	All	Flat Face Mating Flange and In Corrosive Areas: ASTM A193/A193M, Type 316 stainless steel Grade B8M heavy hex head or stud bolts, ASTM A194/A194M Grade 8M heavy hex head nuts and ASTM F436 Type 3 alloy washers at nuts and bolt heads. Torque bolts per gasket manufacturer recommendations. With Raised Face Mating Flange: Carbon steel ASTM A307 Grade B heavy hex head or stud bolts, ASTM A563 Grade A heavy hex head nuts and ASTM F436 hardened steel washers at nuts and bolt heads. Torque bolts per gasket manufacturer recommendations.

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SECTION 40 27 00.10
POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS

Item	Size	Description
Gaskets	All	Gaskets for sodium hydroxide (NaOH) piping shall be Buna-N only. Gaskets for nonchemical services shall be EPDM only. Flat Face Mating Flange: Full faced 1/8-inch thick. Raised Face Mating Flange: Flat ring 1/8-inch, with filler gasket between OD of raised face and flange OD to protect the flange from bolting moment.
Solvent Cement	All	Socket type joints shall be made employing solvent cement that meets or exceeds requirements of ASTM D2564 and primer that meets or exceeds requirements of ASTM F656, chemically resistant to the fluid service, and as recommended by pipe and fitting manufacturer. Solvent weld cement for PVC pipe joints in chemical service shall be free of silica filler and shall be certified by the manufacturer to be suitable for the intended service, IPS Weld-On 724 “or-equal”. Certification shall be submitted. Solvent cement and primer shall be listed by NSF 61 for contact with potable water.
Thread Lubricant	All	Teflon Tape.

END OF SECTION

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SECTION 40 27 00.11
CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPE AND FITTINGS

Item	Size	Description
Pipe	All	Schedule 80 CPVC: Type IV, Grade I or Class 23447 conforming to ASTM D1784 and ASTM F441/F441M. Pipe shall be manufactured with titanium dioxide for ultraviolet protection. Threaded nipples shall be Schedule 80.
Fittings	All	Schedule to Match Pipe Above: Conforming to the requirements of ASTM F439 for socket weld type and Schedule 80 ASTM F437 for threaded type. Fittings shall be manufactured with titanium dioxide for ultraviolet protection.
Joints	All	Solvent socket weld except where connection to threaded valves and equipment may require future disassembly.
Flanges	All	One-piece, molded hub Type CPVC flat face flange in accordance with Fittings above; ASME B16.1, Class 125 drilling.
Bolting	All	Flat Face Mating Flange and In Corrosive Areas: ASTM A193/A193M, Type 316 stainless steel Grade B8M heavy hex head or stud bolts, ASTM A194/A194M Grade 8M heavy hex head nuts and ASTM F436 Type 3 alloy washers at nuts and bolt heads. Torque bolts per gasket manufacturer recommendations. Raised Face Mating Flange, Non-Corrosive Area: Carbon steel ASTM A307 Grade B heavy hex head or stud bolts, ASTM A563 Grade A heavy hex head nuts and ASTM F436 hardened steel washers at nuts and bolt heads. Torque bolts per gasket manufacturer recommendations.

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SECTION 40 27 00.11
CHLORINATED POLYVINYL CHLORIDE (CPVC) PIPE AND FITTINGS

Item	Size	Description
Gaskets	All	Flat Face Mating Flange: Full faced 1/8-inch thick. Gaskets for sodium hypochlorite (NaOCL) piping shall be Viton only. Gaskets for non-chemical services shall be EPDM only. Gaskets for potable water applications shall be NSF certified. Raised Face Mating Flange: Flat ring 1/8-inch with filler gasket between OD of raised face and flange OD to protect the flange from bolting moment.
Solvent Cement	All	All socket type joints shall be made employing primer and solvent cements that meet or exceed the requirements of ASTM F493 and primers that meet or exceed the requirements of ASTM F656, resistant to the fluid service, and as recommended by the pipe and fitting manufacturer. Solvent weld cement for CPVC pipe joints in chemical service shall be free of silica filler and shall be certified by the manufacturer to be suitable for the intended service, IPS Weld-On 724 “or-equal”. Certification shall be submitted. Solvent cement and primer shall be listed by NSF 61 for contact with potable water.
Thread Lubricant	All	Teflon tape.

END OF SECTION

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SECTION 40 27 00.16
REINFORCED CHEMICAL TUBING

Item	Size	Description
Tubing	All	Polyvinyl chloride suitable for sodium hypochlorite, sodium hydroxide, and aluminum sulphate. Reinforced tubing with a maximum working pressure of 140 psi at 73 degrees°F for 1/2-inch ID and 100 psi at 73 degrees°F for 1-inch ID. Minimum length per coil of 100 feet. Custom lengths may be required for yard piping.
Reinforcement	All	Polyester braid embedded in wall of tubing.
Fittings	All	Tubing joined to pipe with male adapter fitting. Tubing externally secured with stainless steel hose clamp. Fittings between tubing ends as recommended by the tubing manufacturer and approved by Engineer.
Carrier	All	Use PVC pipe as carrier where specified and/or shown on the Drawings. Provide 2-foot gap between end of carrier pipe at each change of direction.
Manufacturers	All	Saint-Gobion, Tygon B44-4X1B “Or-equal”.

END OF SECTION

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SECTION 40 27 01
PROCESS PIPING SPECIALTIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250).
   b. B16.5, Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard.
2. American Water Works Association (AWWA):
   a. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
   b. C153/A21.53, Ductile-Iron Compact Fittings for Water Service.
   c. C210, Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
   d. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
   e. C219, Bolted, Sleeve-Type Couplings for Plain-End Pipe.
   f. 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.
4. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.
5. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer’s data on materials, construction, end connections, ratings, overall lengths, and live lengths (as applicable).
2. Chemical Injectors:
   a. Type, size, quantity, materials, and model number of each.
   b. Sketch of each showing major parts, main pipe, and dimensions.

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c. Details and model number of each support system and component.
d. Details and model of connects (for example, service saddle, weld-o-let).

PART 2 PRODUCTS

2.01 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.

2.02 CONNECTORS

A. 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. U.S. Hose Corp.; Series 300.
   b. Anamet Industrial, Inc.
   c. Unisource Manufacturing, Inc.
   d. Proco Products, Inc.

B. Quick Connect Couplings for chemical service and line drains:

1. Type: Twin cam arm actuated, male and female, locking, for chemical loading and transfer.
2. Materials: Glass-filled polypropylene or PVDF with EPDM, Viton-A or Teflon gaskets as recommended for the service by manufacturer.
3. End Connections: NPT threaded or flanged to match piping connections. Hose shank for chemical installations.
4. Plugs and Caps: Female dust cap for each male end; male dust plug for each female end.
5. Pressure Rating: 125 psi, minimum, at 70 degrees F.
6. Manufacturers and Products:
   a. OPW; Kamlock.
   b. Ryan Herco; 1300 Series.

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C. Quick Connect Couplings for Thermoplastic Flexible Tubing for Screenings:

1. Type: Twin cam arm actuated, male and female, locking, for chemical loading and transfer.
2. Materials: 316 Stainless steel with EPDM, Viton-A or Teflon gaskets.
3. End Connections: flanged to match piping connections. Hose shank for connection to flexible hose.
4. Plugs and Caps: Female dust cap for each male end; male dust plug for each female end.
5. Pressure Rating: 125 psi, minimum, at 70 degrees F.
6. Manufacturers and Products:
   a. PT Couplings,- Cam and Groove, “Or-equal”.

2.03 COUPLINGS

A. General:

1. Couplings shall be rated for working pressure not less than indicated in Piping Schedule for the service and not less than 150 psi.
2. Couplings shall be lined and coated with fusion-bonded epoxy in accordance with AWWA C213 or lined and coated with liquid epoxy in accordance with AWWA C210.
3. Unless thrust restraint is provided by other means, couplings shall be harnessed in accordance with requirements of AWWA Manual M11 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. Transition Coupling for Steel Pipe:

1. Manufacturers and Products:
   a. Dresser Piping Specialties; Style 162.
   b. Smith-Blair, Inc.; Style 413.

C. Flanged Coupling Adapter:

1. Manufacturers and Products:
   a. Steel Pipe:
      1) Dresser Piping Specialties; Style 128.
      2) Smith-Blair, Inc.; Style 913.
   b. Ductile Iron Pipe:
      1) Dresser Piping Specialties; Style 128.
      2) Smith-Blair, Inc.; Style 912.

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D. 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.

E. Restrained Dismantling Joints:

1. Pressure Rating:
   a. Minimum working pressure rating shall not be less than rating of the connecting flange.
   b. Proof testing shall conform to requirements of AWWA C219 for bolted couplings.
2. Manufacturers and Products:
   a. Dresser Piping Specialties; Style 131.
   b. Smith Blair, Inc.; Model 975.

2.04 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: 50 psig at 300 degrees F.
5. Length: Minimum of eight convolutions and minimum axial compression of 3/4 inches.
6. Manufacturers and Products:
   a. U.S. Bellows, Inc.; Universal Tied expansion joint.
   b. Metraflex, Model MN.
   c. Senior Flexonics Pathway, Inc.; Expansion Joints.

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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. U.S. Hose Corp.; Series 401M.
   b. Anamet Industrial, Inc.; BWC21-1.

2.05 SEAL WATER HOSE

A. Product as specified for water hose, except 3/8 inch with male NPT ends, in 2-foot lengths.

2.06 SERVICE SADDLES

A. Double-Strap Iron:

1. Pressure Rating: Capable of withstanding 150 psi internal pressure without leakage or over stressing.
2. Run Diameter: Compatible with outside diameter of pipe on which saddle is installed.
3. Taps: Iron pipe threads.
4. Materials:
   a. Body: Malleable or ductile iron.
   b. Straps: Galvanized steel.
   c. Hex Nuts and Washers: Steel.
   d. Seal: Rubber.
5. Manufacturers and Products:
   a. Smith-Blair; Series 313 or 366.
   b. Dresser; Style 91.

2.07 OUTLET/TAPPING SADDLES

A. Materials:

1. Straps: Alloy steel with 3/4-inch threaded ends.
2. Seal: O-Ring SBR rubber gasket.
3. Compatible with ductile iron pipe.

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B. Connection: AWWA C110/A21.10 flange.

C. Pressure Rating: Capable of withstanding 250 psi internal pressure without leakage over stressing.

D. Manufacturer and Product: American Ductile Iron; Outlet/Tapping Saddle.

2.08 PIPE SLEEVES

A. Insulated and Encased Pipe Sleeve:

1. Manufacturer and Product: Pipe Shields, Inc.; Models WFB, WFB CS and CW Series, as applicable.

B. Modular Mechanical Seal:

1. Type: Interconnected synthetic rubber links shaped and sized to continuously fill annular space between pipe and wall sleeve opening.
2. Fabrication:
   a. Assemble interconnected rubber links with ASTM A276, Type 316 stainless steel bolts and nuts.
   b. Pressure plates shall be reinforced nylon polymer.
3. Size: According to manufacturer's instructions for size of pipes shown to provide a watertight seal between pipe and wall sleeve opening, and to withstand a hydrostatic head of 40 feet of water.
4. Manufacturer: Thunderline Corp., Link-Seal Division.

2.09 SLAB, FLOOR, WALL AND ROOF PENETRATIONS

A. Ductile Iron Wall Pipe:

1. Diameter, Lining, and Ends: Same as connecting ductile iron pipe.
2. Thickness: Equal to or greater than remainder of pipe in line.
3. Fittings: In accordance with applicable Pipe Data Sheet.
4. Thrust Collars:
   a. Rated for thrust load developed at 250 psi.
   b. Safety Factor: 2, minimum.
   c. Material and Construction: Ductile iron or cast iron, cast integral with wall pipe wherever possible, or thrust rated, welded attachment to wall pipe.
5. Manufacturers:
   a. American Cast Iron Pipe Co.
   b. U.S. Pipe and Foundry Co.

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B. Steel or Stainless Steel Wall Pipe:

1. Same material and thickness as connecting pipe, except 1/4-inch minimum thickness.
2. Lining: Same as connecting pipe.
3. Thrust Collar:
   a. Outside Diameter: Unless otherwise shown, 3 inches greater than outside diameter of wall pipe.
   b. Continuously fillet welded on each side all around.

2.10 CHEMICAL INJECTOR SYSTEM

A. Chemical Injectors:

1. Type, size, quantity, and materials as shown on Drawings and Standard Details.
2. Manufacturer: SAF-T-FLO.

B. Support System: Stainless steel Unistrut or FRP Aickenstrut.

2.11 MISCELLANEOUS SPECIALTIES

A. Strainers, Plastic Piping Systems, 4 Inches and Smaller:

1. Type: Y-pattern PVC body, 150 psi nonshock rated, with screwed PVC cap and Viton seals.
2. End Connections: Screwed or solvent weld, 2 inches and smaller. Class 150 ANSI flanged, 2-1/2 inches and larger.
3. Screen: Heavy-gauge PVC, 1/32-inch mesh, minimum 2 to 1 screen area to pipe size ratio.
4. Manufacturer: Hayward.

B. Water Hose:

1. Furnish 50-foot lengths of 1-inch rubber hose. EPDM black cover and EPDM tube, reinforced with two textile braids. Provide each length with brass male and female NST hose thread couplings to fit hose nozzle and hose valve.
2. Rated minimum working pressure of 200 psi.
3. Manufacturers:
   a. Goodyear.
   b. Boston.

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C. Hose Nozzles:

1. Furnish 1-inch and cast brass, satin finish, nozzles with adjustable fog, straight-stream, and shut-off feature and rubber bumper. Provide nozzles with female NST hose thread.
2. Manufacturers:
   a. Croker.
   b. Elkhart.

D. Pump Seal Water Sight Flow Indicators:

1. Bronze body, 3/8-inch, horizontal, ball action with tempered glass.
2. Rated 125 psi with NPT screwed ends.
3. Operate with a minimum flow of 0.25 gpm.
4. Manufacturers and Products:
   a. Eugene Ernst Co.; Series E-57-4.
   b. Jacoby Tarbox Co.

E. Spray Water Flow Indicators:

1. In-line, pressure differential flowmeter, direct reading with a temperature rating of -30 to 212 degrees F., and a pressure rating of 180 psig.
2. Materials: 316 Stainless steel, threaded FNPT connection, Teflon seals.
3. Accuracy +/- 3 percent Full Scale.
4. Flow range for screens: 1 – 20 gpm.
5. Flow range for wash press: 10 – 45 gpm.
6. Manufacturers and Products: Kobold, RCM, Model Series 7000.

F. Thermoplastic Flexible Tubing for Screenings:

1. Reinforced high density thermoplastic hose; smooth PVC.
2. Temperature Range: Minus 0 degrees F to158 degrees F.
3. Size: Match piping or equipment flange size shown on Drawings.
4. Length: Provide length as indicated on Drawings for each duct connection.
5. End Connections: Size to match quick-connect couplings.
6. Accessories: transition connectors, crimp for matching inside diameter of flexible ducting to outside diameter of barbed connectors.
7. Manufacturer and Product:
   a. Contitech USA; Velocity™ Water Transfer.

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G. Thermoplastic Flexible Tubing for Odorous Air Service:

1. Provide double-ply neoprene coated black polyester fabric hose reinforced with spring steel helix and external PVC coated polyester.
2. Listed UL 94 V-O flame retardant.
3. Temperature Range: Minus 40 degrees F to 250 degrees F.
4. Size: Match piping or equipment flange size shown on drawings.
5. Length: Provide length as indicated on drawing for each duct connection.
6. End Connections: Size to match quick-connect couplings. Provide all necessary transition connectors for matching inside diameter of flexible ducting to outside diameter of connectors.
7. Manufacturer and Product:
   a. Rubber-Cal Company; Thermoplastic Flex Medium Duty WS Flexible Duct
   b. "Or-equal."

H. Unloading Secondary Containment:

1. Construction: High Density Polyethylene (HDPE).
2. Designed for forklift use and two 50-inches square IBC Tanks stacked vertically.
3. Minimum 350 gallons capacity, with integral drain, pail holder, and nonskid removable grates.
4. Meeting EPA 40 CFR 264.5.
5. Manufacturers:
   a. UltraTech.
   b. Uline.

PART 3 EXECUTION

3.01 GENERAL

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

3.02 PIPING FLEXIBILITY PROVISIONS

A. General:

1. Thrust restraint shall be provided as specified in Section 40 27 00, Process Piping—General.
2. Install flexible couplings to facilitate piping installation, in accordance with approved shop drawings.

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3.03 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.

3.04 PIPING EXPANSION

A. Piping Installation: Allow for thermal expansion due to differences between installation and operating temperatures.

B. Expansion Joints:

1. Nonmetallic Pipe: Teflon bellows expansion joint.
2. Air and Water Service above 120 degrees F: Metal bellows expansion joint.
3. Pipe Run Offset: Flexible metal hose.

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C. Anchors Install as specified in Section 40 05 15, Piping Support Systems, to withstand expansion joint thrust loads and to direct and control thermal expansion.

3.05 SERVICE SADDLES

A. Ferrous Metal Piping (except stainless steel): Double-strap iron.

B. Plastic Piping: Nylon-coated iron.

3.06 OUTLET/TAPPING SADDLE

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

3.07 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. Application:
   a. Metallic Piping Systems: Flexible couplings, transition couplings, and flanged coupling adapters.
   b. Concrete Encased Couplings: Flexible coupling.

3.08 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.

3.09 PIPE SLEEVES

A. Application:

1. As specified in Section 40 27 00, Process Piping—General.

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2. Above Grade in Nonsubmerged Areas: Hot-dip galvanized after fabrication.
3. Below Grade or in Submerged or Damp Environments: CPVC.

B. Installation:

1. Caulk joint with specified sealant in nonsubmerged applications and seal below grade and submerged applications with modular mechanical seal.

3.10 SLAB, FLOOR, WALL AND ROOF PENETRATIONS

A. Applications:

1. Nonwatertight Penetrations: Pipe sleeves with seep ring.
2. Existing Walls: Rotary drilled holes.
3. Fire-Rated or Smoke-Rated Walls, Floors or Ceilings: Insulated and encased pipe sleeves.

B. Wall Pipe Installation:

1. Isolate embedded metallic piping from concrete reinforcement using coated pipe penetrations as specified in Section 09 90 00, Painting and Coating.
2. Support wall pipes securely by formwork to prevent contact with reinforcing steel and tie-wires.

3.11 CHEMICAL INJECTOR SYSTEM

A. Install in accordance with manufacturer’s instructions.

END OF SECTION

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SECTION 40 27 02
PROCESS VALVES AND OPERATORS

PART 1 GENERAL

A. The Work of this section includes providing valves, actuators, and all appurtenant Work.

B. General Requirements: See Division 1, General Requirements, which contains information and requirements that apply to the work specified herein and are mandatory for this project including but not limited to Codes and Standards.

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Gas Association (AGA): 3, Orifice Metering of Natural Gas.
2. American National Standards Institute (ANSI): Z21.15, Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves.
3. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250).
   b. B16.44, Manually Operated Metallic Gas Valves for Use in Above Ground Piping Systems up to 5 psi.
4. American Society of Sanitary Engineers (ASSE): 1011, Performance Requirements for Hose Connection Vacuum Breakers.
5. American Water Works Association (AWWA):
   a. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   b. C500, Metal-Seated Gate Valves for Water Supply Service.
   c. C504, Rubber-Seated Butterfly Valves.
   d. C508, Swing-Check Valves for Waterworks Service, 2-In. Through 24-In. (50-mm Through 600-mm) NPS.
   e. C509, Resilient-Seated Gate Valves for Water Supply Service.
   f. C511, Reduced-Pressure Principle Backflow Prevention Assembly.
   g. C542, Electric Motor Actuators for Valves and Slide Gates.
   h. C550, Protective Interior Coatings for Valves and Hydrants.
   i. C606, Grooved and Shouldered Joints.
   j. C800, Underground Service Line Valves and Fittings.

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6. ASTM International (ASTM):
   a. A276, Standard Specification for Stainless Steel Bars and Shapes.
   b. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
   c. A564/A564M, Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.
   d. B61, Standard Specification for Steam or Valve Bronze Castings.
   e. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
   f. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.
   g. B127, Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip.
   h. B139, Standard Specification for Phosphor Bronze Rod, Bar and Shapes.
   i. B164, Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire.
   j. B194, Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar.
   k. B584, Standard Specification for Copper Alloy Sand Castings for General Applications.
   l. D429, Standard Test Methods for Rubber Property-Adhesion to Rigid Substrates.
   m. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
7. Canadian Standards Association, Inc. (CSA): 9.1, Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves.
8. FM Global (FM).
9. Food and Drug Administration (FDA).
10. International Association of Plumbing and Mechanical Officials (IAPMO).
11. Manufacturers Standardization Society (MSS):
   a. SP-80, Bronze Gate, Globe, Angle, and Check Valves.
   b. SP-81, Stainless Steel, Bonnetless, Flanged Knife Gate Valves.
   c. SP-85, Gray Iron Globe and Angle Valves, Flanged and Threaded Ends.
   d. SP-88, Diaphragm Valves.
   e. SP-110, Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.
12. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.

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13. Underwriters Laboratories (UL).
14. USC Foundation for Cross-Connection Control and Hydraulic Research.

1.02 SUBMITTALS

A. Action Submittals:

1. Product data sheets for each make and model. Indicate valve Type Number, applicable Tag Number, and facility name/number or service where used.
2. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
3. Power and control wiring diagrams, including terminals and numbers.
4. For each power actuator provided, manufacturer's standard data sheet, with application specific features and options clearly identified.
5. Actuator sizing calculations for open-close/throttle and modulating valves.
6. Information on proposed factory-applied coating system(s). See Section 09 90 00, Painting and Coating, for specific requirements. Include manufacturer's descriptive technical catalog literature and specifications, hazardous communication data sheets, and written manufacturer's Certificate of Compliance that the factory-applied coating is identical to the requirements specified.
    a. Where system proposed is different from that specified, or where in the manufacturer's opinion, the costing system(s) proposed exceed(s) the requirements specified, submit the complete technical literature of the proposed system(s) for review.
    b. Submit valves by individual type or group similar valves (e.g., metal ball valves) to facilitate the review process.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance and Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services for:
    a. Electric actuators; full compliance with AWWA C542.
    b. Butterfly valves; full compliance with AWWA C504.
2. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.03 DEFINITIONS

A. Exposed Valve: A valve that is in contact with the atmosphere or air.

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PART 2 PRODUCTS

2.01 GENERAL

A. Valves to include operator, actuator, handwheel, chain wheel, extension stem, floor stand, operating nut, chain, wrench, and accessories to allow a complete operation from the intended operating level.

B. Valve to be suitable for intended service. Renewable parts not to be of a lower quality than specified.

C. Valve same size as adjoining pipe, unless otherwise called out on Drawings or in Supplements.

D. Valve ends to suit adjacent piping.

E. Size operators and actuators to operate valve for full range of pressures and velocities.

F. Valve to open by turning counterclockwise, unless otherwise specified.

G. Factory mount operator, actuator, and accessories.

2.02 SCHEDULE

A. Additional requirements relative to this section are shown on Electric Actuated Valve Schedule located at the end of this section.

2.03 MATERIALS

A. Bronze and brass valve components and accessories that have surfaces in contact with water to be alloys containing less than 16 percent zinc and 2 percent aluminum.

1. Approved alloys are of the following ASTM designations: B61, B62, B98/B98M (Alloy UNS No. C65100, C65500, or C66100), B139/B139M (Alloy UNS No. C51000), B584 (Alloy UNS No. C90300 or C94700), B164, B194, and B127.
2. Stainless steel Alloy 18-8 may be substituted for bronze.

2.04 FACTORY FINISHING

A. General:

1. Interior coatings for valves and hydrants shall be in accordance with AWWA C550, unless otherwise specified.

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2. Exterior coating for valves and hydrants shall be in accordance with Section 09 90 00, Painting and Coating.
3. Material in contact with potable water shall conform to NSF/ANSI 61.
4. Exposed safety isolation valves and lockouts valves with handles, handwheels, or chain wheels shall be “safety yellow”.

B. General:

1. Interior coatings for valves and hydrants shall be in accordance with AWWA C550, unless otherwise specified.
2. Exterior coating for valves and hydrants shall be in accordance with Section 09 90 00, Painting and Coating.
3. Material in contact with potable water shall conform to NSF/ANSI 61.
4. Exposed safety isolation valves and lockout valves with handles, handwheels, or chain wheels shall be “safety yellow.”

C. Where epoxy lining and coating are specified, factory finishing shall be as follows:

1. In accordance with AWWA C550.
2. Either two-part liquid material or heat-activated (fusion) material except only heat-activated material if specified as “fusion” or “fusion bonded” epoxy.
3. Minimum 7-mil dry film thickness except where limited by valve operating tolerances.

2.05 VALVES

A. Globe Valves:

1. Type V200 Globe Valve 3 Inches and Smaller:
   a. All-bronze, union bonnet, packed gland, inside screw, rising stem, TFE disc, Class 150 rated 150 psi SWP/300 psi CWP, complies with MSS SP-80 Type 2.
   b. Manufacturers and Products:
      1) Stockham; Figure B-22T, NPT threaded end.
      2) Crane Co.; Figure 7TF, NPT threaded end.
      3) Milwaukee; Model 1590T, soldered ends.
      4) NIBCO; Figure S-235-Y, soldered ends.
2. Type V235 Angle Type Hose Valve 3/4 Inch:
   a. 3/4-inch NPT female inlet, 3/4-inch male hose thread outlet, heavy rough brass body rated 125 psi, lock shield bonnet, removable handle, atmospheric vacuum breaker conforming to ASSE 1011 and IAPMO code.

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b. Manufacturers and Products:
   1) Acorn; 8126, surface pipe mount valve, bent nose without flange.
   2) Acorn; 8121, surface mount through wall valve, bent nose with flange.
   3) Acorn; 8131, pipe and pedestal mounted valve located above 6 inches, straight nose.
   4) Acorn; 8136, pedestal mounted valve located lower than 6 inches, inverted nose.

B. Ball Valves:

1. Type V300 Ball Valve 3 Inches and Smaller for General Water and Air Service:
   a. Two-piece, standard port, NPT threaded ends, bronze body and end piece, hard chrome-plated solid bronze or brass ball, RTFE seats and packing, blowout-proof stem, adjustable packing gland, zinc-coated steel hand lever operator with vinyl grip, rated 600-pound WOG, 150-pound SWP, complies with MSS SP-110. For steam service, provide stainless steel ball and stem.
   b. Manufacturers and Products:
      1) Threaded:
         a) Conbraco Apollo; 70-100.
         b) Nibco; T-580-70.
      2) Soldered:
         a) Conbraco Apollo; 70-200.
         b) Nibco; S-580-70.
2. Type V304 Ball Valve 2 Inches and Smaller for General Water and Air Service:
   a. Three-piece, full port, NPT threaded ends, bronze body and end pieces, hard chrome plated solid bronze or brass ball, RTFE seats and packing, blowout-proof stem, zinc-plated steel hand lever operator with vinyl grip, rated 600-pound WOG, 150 psi SWP, complies with MSS SP-110. For steam service, provide stainless steel ball and stem.
   b. Manufacturers and Products:
      1) Threaded Ends:
         a) Conbraco Apollo; 82-100.
         b) Nibco; T-595-Y.
         c) Stockham; T-395 Series.
      2) Solder Ends:
         a) Conbraco Apollo; 82-200.
         b) Nibco; S-595-Y.
         c) Stockham; S-395 Series.

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3. Type V307 Stainless Steel Ball Valve 2 Inches and Smaller:
   a. Two-piece, full port, ASTM A276 GR 316 or ASTM A351/A351M GR CF8M stainless steel body and end pieces, stainless steel ball, ANSI Class 150 Flanged ends, reinforced PTFE seats, seals, and packing, adjustable packing gland, blowout-proof stainless steel stem, stainless steel lever operator, rated 275 psig CWP, complies with MSS SP-72.
   b. Manufacturers and Products:
      1) Conbraco Apollo; 87A-200 Series.
      2) Nibco; F-515-S6-F-66-FS.
4. Type V330 PVC Ball Valve 2 Inches and Smaller:
   a. Rated 150 psi at 73 degrees F, with ASTM D1784, Type I, Grade 1 polyvinyl chloride body, ball, and stem, end entry, double union design, solvent-weld socket ends, PTFE seat, PTFE O-ring stem seals, for use with sodium hypochlorite, provide pressure relief hole drilled on low pressure side of ball.
   b. Manufacturers and Products:
      1) Chemtrol Tru-Bloc.
      2) ASAHI/America; Type 21.
      3) Spears; True Union.
5. Type V335 CPVC Ball Valve 2 Inches and Smaller:
   a. Rated 150 psi at 100 degrees F, 80 psi at 140 degrees, with ASTM D1784, Type IV, Grade 1 chlorinated polyvinyl chloride (CPVC) body, ball, and stem, end entry, double union design, with solvent-weld socket ends or single union ball with flanged ends drilled to ASME B16.1, replaceable Teflon seat, Teflon O-ring stem seals, to block flow in both directions. When using flanges, confirm that the gasket material is compatible with the liquid pumped. For use with sodium hypochlorite, provide pressure relief hole drilled on low pressure side of ball.
   b. Manufacturers and Products:
      1) Nibco; Chemtrol Tru-Bloc.
      2) ASAHI/America; Type 21.
      3) Spears; True Union.

C. Plug Valves:

1. Type V400 Eccentric Plug Valve 2 Inches and Smaller:
   a. Nonlubricated type rated 175 psig CWP, drip-tight shutoff with pressure from either direction, cast-iron body, threaded ends, lever operator, cast-iron plug with round or rectangular port, plug coated with Buna-N, stem bearing lubricated stainless steel or bronze, stem seal multiple V-rings, or U-cups with O-rings of nitrile rubber.

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b. Manufacturers and Products:
   1) Pratt; Ballcentric.
   2) DeZurik; Style PEC.
   3) Milliken; Millcentric Series 603.

2. Type V405 Eccentric Plug Valve 3 Inches to 12 Inches:
   a. Nonlubricated type rated 175 psig CWP, drip-tight shutoff with pressure from either direction, cast-iron body, exposed service flanged ends per ASME B16.1.
   b. Plug cast iron with round or rectangular port of no less than 80 percent of connecting pipe area and coated with Buna-N, seats welded nickel, stem bearings lubricated stainless steel or bronze, stem seal multiple V-rings, or U-cups with O-rings of nitrile rubber, grit seals on both upper and lower bearings.
   c. Operators:
      1) Refer to Article, Installation, Paragraph Chain Wheel and Guide; and to Electric Actuator Schedule supplement to this section.
      2) 3-Inch to 4-Inch Valves: Wrench lever manual.
      3) 6-Inch to 12-Inch Valves: Totally enclosed, geared, manual operator with handwheel, 2-inch nut or chain wheel. Size operator for 1.5 times maximum operating shutoff pressure differential for direct and reverse pressure, whichever is higher.
   d. Manufacturers and Products:
      1) Pratt; Ballcentric.
      2) DeZurik; Style PEC.

D. Butterfly Valves:

1. General:
   a. In full compliance with AWWA C504 and following requirements:
      1) Suitable for throttling operations and infrequent operation after periods of inactivity.
      2) Elastomer seats which are bonded or vulcanized to the body shall have adhesive integrity of bond between seat and body assured by testing, with minimum 75-pound pull in accordance with ASTM D429, Method B.
      3) Bubble-tight with rated pressure applied from either side. Test valves with pressure applied in both directions.
      4) No travel stops for disc on interior of body.
      5) Self-adjusting V-type or O-ring shaft seals.
      6) Isolate metal-to-metal thrust bearing surfaces from flow stream.

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7) Provide traveling nut or worm gear actuator with handwheel. Valve actuators to meet the requirements of AWWA C504.
8) Provide linings and coatings per AWWA, unless otherwise indicated on Drawings or specified herein.
9) Valves to be in full compliance with NSF/ANSI 61.

b. Non-AWWA butterfly valves to meet the following actuator requirements:
1) For above ground installations, provide handle and notch plate for valves 6 inches and smaller and heavy-duty, totally enclosed gearbox type operators with handwheel, position indicator and travel stops for valves 8 inches and larger, unless otherwise indicated on Drawings or specified herein.

2. Type V500 Butterfly Valve Water Works Service 3 Inches to 72 Inches:
a. AWWA C504, Class 150B.
b. Short body type, flanged ends.
c. Cast-iron body, cast or ductile iron disc, Type 304 stainless steel shafts, Buna-N rubber seat bonded or molded in body only, and stainless steel seating surface.
d. Provide epoxy lining and coating in compliance with AWWA C550.
e. Manufacturers and Products:
1) Pratt; Model 2FII or Triton XR-70.
2) DeZurik; AWWA Valve.

3. Type V502 Butterfly Valve General Service 3 Inches to 20 Inches:
a. AWWA C504, Class 150B.
b. Wafer style type.
c. Buna-N rubber seat.

4. Type V510 Lug Style Butterfly Valve, Resilient Seated, 2 Inches to 20 Inches for Low Pressure Process Air Service:
a. Lug style cast-iron body, aluminum bronze discs, Type 316 stainless steel one-piece stem, self-lubricating sleeve type bushings, Viton replaceable resilient seat suitable for operating temperatures up to 260 degrees F, 150 psi working pressure rating, bubble-tight at 50 psi differential pressure, valve body to fit between ANSI Class 125/150 flanges.
b. Manufacturers and Products:
1) Bray Controls; Series 31.
2) Tyco/Keystone; Model AR2.

5. Type V514 High Performance Butterfly Valve 2 Inches to 36 Inches:
a. ASME B16.1 Class 150 lug style, high performance type, Type 316 stainless steel body, Type 316 stainless steel single or double offset disc, Type 316 stainless steel shaft and taper pins,

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PTFE seat, PTFE stem packing, stainless steel with RTFE thrust washer.

b. Manufacturers and Products:
   1) DeZurik; BHP Series.
   2) Tyco/Keystone; K-Lok Series.

6. Type V520 CPVC Butterfly Valve 3 Inches to 6 Inches:
   a. Lug style CPVC body, Type 316 stainless disc, Viton or EPDM seat, rated 150 psi at 73 degrees F, valve body to fit between ANSI Class 125/150 flanges.
   b. Provide 2-inch operating nut with T-wrench.
   c. Manufacturers and Products:
      1) Spears ®: Butterfly valve.
      2) Chemtrol; Model B.

E. Check and Flap Valves:

1. Type V602 Check Valve 2 Inches and Smaller:
   a. All bronze, threaded cap, threaded ends, swing type replaceable Teflon disc and bronze disc holder, rated 150-pound SWP, 300-pound WOG.
   b. Manufacturers and Products:
      1) Walworth; Figure 3412.
      2) Milwaukee; Figure 510.
2. Type V630 PVC Ball Check Valve 4 Inches and Smaller:
   a. ASTM D1784, Type I, Grade 1 polyvinyl chloride body, dual union socket weld ends, rated 150 psi at 73 degrees F, and Viton seat and seal.
   b. Manufacturers and Products:
      1) Nibco; Chemtrol Tru Union.
      2) ASAHI/America.
      3) Spears; True Union.
3. Type V631 CPVC Ball Check Valve 4 Inches and Smaller:
   a. ASTM D1784 Cell Class 23477B CPVC body, single or dual union socket weld ends, rated 150 psi at 73 degrees F, 110 psi at 140 degrees F, EPDM seat and seal.
   b. Manufacturers and Products:
      1) Nibco; Chemtrol Tru Union.
      2) ASAHI/America.
      3) Spears; True Union.

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4. Type V632 Ball Check Valve 3 Inches and Larger:
   a. Flanged end, iron body valve with cleanout and floating type hollow steel ball, vulcanized nitrile rubber exterior, flanges ASME B16.1, Class 125, rated 150-pound working pressure, suitable for vertical up or horizontal flow.
   b. Manufacturers and Products:
      1) Flomatic Corp.; Series 408.
      2) Golden Anderson; Series 240.

F. Self-Regulated Automatic Valves

1. Type V745 Air Release Valve 1/2 Inch to 4 Inches:
   a. Suitable for 15 percent sulfuric acid, and 25 percent ferrous sulfate, automatically exhaust air that accumulates in the system. At 20 psi and above, the valve piston shall seat against a resilient seat to prevent leakage.
   b. Rated 150 psig working pressure at 68 degrees C. Valve body constructed of CPVC with FKM seals. NPT threaded connection.
   c. Manufacturer:
      1) PlastOmatic: ARV
      2) Primary Fluid Systems Inc.; Accu-vent.

G. Miscellaneous Valves:

1. Type V940 Solenoid Valve 1/4 Inch to 2 Inches:
   a. Two-way internal pilot operated diaphragm type, brass body, resilient seat suitable for air or water, solenoid coil molded epoxy, NEMA insulation Class F, 120 volts ac, 60Hz, unless otherwise indicated. Solenoid enclosure NEMA 250, Type 4 unless otherwise indicated. Size and normal position (when de-energized) as indicated on drawings.
   b. Minimum operating pressure differential no greater than 5 psig, maximum operating pressure differential not less than 125 psig.
   c. Manufacturers and Products:
      1) ASCO; Model 8210G054.
      2) Skinner, Model 8210G054.
2. V942 Solenoid Valve:
   a. Two-way internal pilot operated diaphragm type, Type 304 stainless steel body, resilient seat suitable for air, water, liquid propane and natural gas solenoid coil molded epoxy, NEMA insulation Class F, 120V ac, 60-Hz, unless otherwise indicated. Solenoid enclosure NEMA 250, Type 4. Normally Closed.

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b. Size, operating differential, and normal position (when de-energized) as indicated on schedule included as a supplement at the end of this Specification.
c. Maximum operating temperature: 180 degrees F.
d. Manufacturers and Products: ASCO, Model 8210G089.

2.06 OPERATORS AND ACTUATORS

A. Manual Operators:

1. General:
   a. For AWWA valves, operator force not to exceed requirements of applicable valve standard. Provide gear reduction operator when force exceeds requirements.
   b. For non-AWWA valves, operator force not to exceed applicable industry standard or 40 pounds, whichever is less, under operating condition, including initial breakaway. Provide gear reduction operator when force exceeds requirements.
   c. Operator self-locking type or equipped with self-locking device.
   d. Position indicator on quarter-turn valves.
   e. Worm and gear operators one-piece design, worm-gears of gear bronze material. Worm of hardened alloy steel with thread ground and polished. Traveling nut type operator's threaded steel reach rod with internally threaded bronze or ductile iron nut.
2. Exposed Operator:
   a. Galvanized and painted handwheel.
   b. Lever operators allowed on quarter-turn valves 8-inches and smaller, except valves for ALP service which shall have geared actuators.
   c. Cranks on gear type operator.
   d. Chain wheel operator with tieback, extension stem, floor stand, and other accessories to permit operation from normal operation level.
   e. Valve handles to take a padlock and wheels a chain and padlock.

B. Electric Motor Actuators, 480 Volts:

1. General:
   a. Comply with latest version of AWWA C542.
   b. Size to 1-1/2 times required operating torque. Motor stall torque not to exceed torque capacity of valve.
   c. Controls integral or Remote, as shown in the Electric Operator Valve Schedule supplement to this section and fully equipped as specified in AWWA C542.

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d. Stem protection for rising stem valves.

2. Actuator Operation—General:
   a. Suitable for full 90-degree rotation of quarter-turn valves or for use on multiturn valves, as applicable.
   b. Manual override handwheel.
   c. Valve position indication.
   d. Operate from FULL CLOSED to FULL OPEN positions or the reverse in the number of seconds given in Electric Actuated Valve Schedule.
3. Open-Close(O/C)/Throttling(T) Service:
   a. Size motors for one complete OPEN-CLOSE-OPEN cycle no less than once every 10 minutes.
   b. Actuator suitable for throttling operation of valve at intermediate positions.
   c. LOCAL-OFF-REMOTE Selector Switch, padlockable in each position:
      1) Integral OPEN-STOP-CLOSE momentary pushbuttons with seal-in circuits to control valve in LOCAL position.
      2) Remote OPEN-STOP-CLOSE momentary control dry contact inputs in REMOTE position. Integral seal-in circuits for remote OPEN and CLOSE commands; valve travel stops when remote STOP contact opens.
      3) Auxiliary contact that closes in REMOTE position.
   d. OPEN and CLOSED indicating lights.
   e. Integral reversing motor starter with built-in overload protection.
4. Modulating (M) Service:
   a. Size motors for continuous duty.
   b. Feedback potentiometer, or equivalent, and integral electronic positioner/comparator circuit to maintain valve position.
   c. HAND-OFF-AUTO (Local-Off-Remote) Selector Switch, padlockable in each position:
      1) Integral OPEN-STOP-CLOSE momentary pushbuttons with seal-in circuits to control valve in HAND (Local) position.
      2) 4 mA to 20 mA dc input signal to control valve in AUTO (Remote) position.
      3) Auxiliary contact that closes in AUTO (Remote) position.
   d. OPEN and CLOSED indicating lights.
   e. AC motor with solid state reversing starter or dc motor with solid state reversing controller, and built-in overload protection. Controller capable of 1,200 starts per hour.
   f. Duty cycle limit timer and adjustable band width, or equivalent, to prevent actuator hunting.

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g. Valve position output converter that generates isolated 4 mA to 20 mA dc signal in proportion to valve position and is capable of driving into loads of up to 500 ohms at 24 volts dc.

5. Limit Switch:
   a. Single-pole, double-throw (SPDT) type, field adjustable, with contacts rated for 5 amps at 120 volts ac.
   b. Each valve actuator to have a minimum of two auxiliary transfer contacts at end position, one for valve FULL OPEN and one for valve FULL CLOSED.
   c. Housed in actuator control enclosure.
6. Control Features: Electric motor actuators with features as noted above, and as modified/supplemented in Electric Actuated Valve Schedule.
7. Manufacturers and Products:
   a. Rotork Controls.
   b. Flowserve Limitorque.

2.07 ACCESSORIES

A. Tagging: 1-1/2-inch diameter heavy brass or stainless steel tag attached with No. 16 solid brass or stainless steel jack chain for each, bearing valve tag number shown on Valve Schedule and Drawings.

B. Limit Switch:

1. Factory installed NEMA 4X limit switch by actuator manufacturer.
2. SPST, rated at 5 amps, 120 volts ac.

C. Chain Wheel and Guide:

1. Handwheel direct-mount type.
2. Complete with chain.
3. Galvanized or cadmium-plated.
4. Manufacturers and Products:
   a. Clow Corp.; Figure F-5680.
   b. Walworth Co.; Figure 804.
   c. DeZurik Corp.; Series W or LWG.

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PART 3 EXECUTION

3.01 INSTALLATION

A. Flange Ends:

1. Flanged valve bolt holes shall straddle vertical centerline of pipe.
2. Clean flanged faces, insert gasket and bolts, and tighten nuts progressively and uniformly.

B. Screwed Ends:

1. Clean threads by wire brushing or swabbing.
2. Apply joint compound.

C. PVC and CPVC Valves: Install using solvents approved for valve service conditions.

D. Valve Installation and Orientation:

1. General:
   a. Install valves so handles operate from fully open to fully closed without encountering obstructions.
   b. Install valves in location for easy access for routine operation and maintenance.
   c. Install valves per manufacturer's recommendations.
2. Gate, Globe, and Ball Valves:
   a. Install operating stem vertical when valve is installed in horizontal runs of pipe having centerline elevations 4 feet 6 inches or less above finished floor, unless otherwise shown.
   b. Install operating stem horizontal in horizontal runs of pipe having centerline elevations greater than 4 feet 6 inches above finish floor, unless otherwise shown.
3. Eccentric Plug Valves:
   a. Unless otherwise restricted or shown on Drawings, install valve as follows:
      1) Liquids with suspended solids service with horizontal flow: Install valve with stem in horizontal position with plug up when valve is open. Install valve with seat end upstream (flow to produce unseating pressure).
      2) Liquids with suspended solids service with vertical flow: Install valve with seat in highest portion of valve (seat up).
      3) Clean Liquids and Gas Service: Install valve with seat end downstream of higher pressure when valve is closed (higher pressure forces plug into seat).

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4. Butterfly Valves:
    a. Unless otherwise restricted or shown on Drawings, install valve a minimum of 8 diameters downstream of a horizontal elbow or branch tee with shaft in horizontal position.
    b. For vertical elbow or branch tee immediately upstream of valve, install valve with shaft in vertical position.
    c. For horizontal elbow or branch tee immediately upstream of valve, install valve with shaft in horizontal position.
    d. When installed immediately downstream of swing check, install valve with shaft perpendicular to swing check shaft.
    e. For free inlet or discharge into basins and tanks, install valve with shaft in vertical position.
5. Check Valves:
    a. Install valve in accordance with manufacturer's instructions and provide required distance from immediate upstream fitting.
    b. Install valve in vertical flow (up) piping only for gas services.
    c. Install swing check valve with shaft in horizontal position.
6. Solenoid Valves: Install in accordance with manufacturer's instructions.

E. Install line size ball valve and union upstream of each solenoid valve, in-line flow switch, or other in-line electrical device, excluding magnetic flowmeters, for isolation during maintenance.

F. Locate valve to provide accessibility for control and maintenance. Install access doors in finished walls and plaster ceilings for valve access.

G. Extension Stem for Operator: Where depth of valve operating nut is 3 feet or greater below finish grade, furnish operating extension stem with 2-inch operating nut to bring operating nut to a point within 6 inches of finish grade.

H. Chain Wheel and Guide: Install chain wheel and guide assemblies or chain lever assemblies on manually operated valves over 6 feet 9 inches above finish floor. Install chain to within 3 feet of finish floor. Where chains hang in normally traveled areas, use appropriate "L" type tie-back anchors. Install chains to within operator horizontal reach of 2 feet 6 inches maximum, measured from normal operator standing location or station.

3.02 TESTS AND INSPECTION

A. Valve may be either tested while testing pipelines, or as a separate step.

B. Test that valves open and close smoothly under operating pressure conditions. Test that two-way valves open and close smoothly under operating pressure conditions from both directions.

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C. Inspect air and vacuum valves as pipe is being filled to verify venting and seating is fully functional.

D. Count and record number of turns to open and close valve; account for discrepancies with manufacturer's data.

E. Set, verify, and record set pressures for relief and regulating valves.

F. Automatic valves to be tested in conjunction with control system testing. Set opening and closing speeds, limit switches, as required or recommended by Engineer.

G. Test hydrostatic relief valve seating; record leakage. Adjust and retest to maximum leakage of 0.1 gpm per foot of seat periphery.

3.03 MANUFACTURER'S SERVICES

A. Present at Site for each valve type minimum person-days listed below, travel time excluded:

1. 1/2 person day and one trip for Contractor assistance for installation assistance and, startup assistance, functional and/or performance testing and completion of Manufacturer's Certificate of Proper Installation.

B. Refer to Section 01 43 33, Manufacturers' Field Services, and Section 01 91 00, Equipment Systems Commissioning., for specific requirements. Manufacturer's representation shall provide supervision of equipment installations, field inspection of equipment before startup and the executed copies of Manufacturers Services and Certificate of Proper Installation.

3.04 SUPPLEMENTS

A. The supplement listed below, following "End of Section," is part of this Specification.

1. 480 V Electric Actuated Valve Schedule.

END OF SECTION

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	480 V Electric Actuated Valve Schedule								
Tag Number	**Valve Type**	**Actuator Power Supply**	**Valve Size (inches)**	**Process Fluid**	**Operating Flow**	**Maximum ΔP (psi)**	**Service**	**Travel Time (Seconds)**	**Control Feature Modifications/Supplements**
FV 69-2201	V514	480-volt, 3-phase	6	ALP	239-710 scfm	11 psig	O/C	< 20	C, G, L, R
FV 69-2202	V514	480-volt, 3-phase	6	ALP	239-710 scfm	11 psig	O/C	< 20	C, G, L, R
FV69-1011	V405	480-volt, 3-phase	4	DC	115 – 333 gpm	60 psig	O/C	< 20	C, G, L, I
FV69-1012	V405	480-volt, 3-phase	4	DC	115 – 333 gpm	60 psig	O/C	< 20	C, G, L, I
FCV 69-1101	V514	480-volt, 3-phase	4	CPTE	290 gpm	1.3 psig	M	< 20	C, G, L, I
FCV 69-1102	V514	480-volt, 3-phase	4	CPTE	290 gpm	1.3 psig	M	< 20	C, G, L, I

Service: O/C = Open-Close, T = Throttling, M = Modulating.
ALP = Air Low Pressure.
DC = Dewatering Centrate.
CPTI = Centrate Pretreatment Influent.
Control Feature Modifications/Supplements:
A = Actuator shall open valve upon loss of signal.
B = Actuator shall close valve upon loss of signal.
C = Actuator shall remain in last position upon loss of signal.
G = TEFC Motor and control enclosure(s) NEMA 250, Type 4.
I = Valve controls mounted on the valve actuator.
L = Externally operable power disconnect switch per Section 26 05 01, Electrical
R = Valve controls mounted remotely on a control panel provided by the valve supplier, accessible from the floor level, and where indicated on the Drawings.

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SECTION 40 42 13
PROCESS PIPING INSULATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Heating, Refrigerating and Air Conditioning Engineers Inc. (ASHRAE): 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
2. ASTM International (ASTM):
   a. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   b. C165, Standard Test Method for Measuring Compressive Properties of Thermal Insulations.
   c. C177, Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
   d. C518, Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
   e. C534, Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
   f. C547, Standard Specification for Mineral Fiber Pipe Insulation.
   g. C552, Standard Specification for Cellular Glass Thermal Insulation.
   h. C585, Standard Practice for Inner and Outer Diameters of Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
   i. C1136, Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
   j. C1729, Standard Specification for Aluminum Jacketing for Insulation.
   k. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
   l. E96, Standard Test Methods for Water Vapor Transmission of Materials.
3. International Code Council (ICC): International Energy Conservation Code (IECC).
4. Manufacturers Standardization Society (MSS): SP-69, Pipe Hangers and Supports.

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5. Underwriters Laboratories Inc. (UL).

1.02 SUBMITTALS

A. Action Submittals: Manufacturer's descriptive literature.

B. Informational Submittals: Maintenance information.

PART 2 PRODUCTS

2.01 PIPE INSULATION

A. Type 1—Elastomeric:

1. Material: Flexible elastomeric pipe insulation, closed-cell structure in accordance with ASTM C534.
2. Temperature Rating: Minus 40 degrees F to 180 degrees F.
3. Nominal Density: 3 pcf to 6 pcf.
4. Conductivity in accordance with ASHRAE 90.1 and maximum numerical value of 0.25 Btu-in./hr-square foot degrees F at 75 degrees F per ASTM C177 or ASTM C518.
5. Minimum water vapor transmission of 0.08 perm-inch per ASTM E96, Procedure A.
6. Joints: Manufacturer's adhesive.
7. Flame Spread Rating: Less than 25 per ASTM E84.
8. Smoke Developed Index: Less than 50 per ASTM E84.
9. Manufacturers and Products:
   a. Nomaco: K-Flex
   b. Rubatex; Insul-Tube 180 or Insul-Sheet 1800.
   c. Armacell; AP Armaflex.

B. Type 3—Foamglass:

1. Material: Cellular glass per ASTM C552.
2. Nominal Density: 7.5 pcf.
3. Compressive Strength: 90 psi per ASTM C165.
4. Temperature Rating: Minus 290 degrees F to 900 degrees F.
5. Conductivity in accordance with ASHRAE 90.1 and maximum numerical value of 0.29 Btu-in./hr-square foot degrees F.
6. Minimum water vapor transmission for insulation of 0.00 perm-inch per ASTM E96.
7. Joints: Matching pressure-sensitive butt strips for sealing circumferential joints.
8. Flame Spread Rating: 0 per ASTM E84.
9. Smoke Developed Index: 0 per ASTM E84.

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10. Follow manufacturer's recommendation, based upon temperature of piping to be insulated.
11. Manufacturer and Product: Pittsburgh Corning; Foamglas One.

2.02 FITTING INSULATION

A. Type 1: Same as pipe.

B. Type 3: Same as pipe

2.03 INSULATION AT PIPE HANGERS AND SUPPORTS

A. Refer to Section 40 05 15, Piping Support Systems.

B. Copper, Ductile Iron, and Nonmetallic Pipe: High-density insert, thickness equal to adjoining insulation of Type 3 or other rigid insulation or manufactured pre-insulated pipe hanger and insulation shield per MSS SP-69, Table 5 at support locations. Extend insert beyond shield.

C. Steel Pipe: Insulation saddle or high-density insert, thickness equal to adjoining insulation of Type 3 or other rigid insulation or manufactured pre-insulated pipe hanger and insulation shield at support location per MSS SP-69, Table 5 at support locations. Extend insert beyond shield.

2.04 INSULATION FINISH SYSTEMS

A. Type F1—PVC:

1. Polyvinyl chloride (PVC) jacketing, minimum 20 mils indoors and 30 mils outdoors, for straight run piping and fitting locations, temperatures to 140 degrees F.
2. Flame Spread Rating: 25 per ASTM E84.
3. Smoke Developed Index: 50 per ASTM E84.
4. Manufacturers and Products:
   a. Knauf Insulation; Proto 1000.
   b. Johns Manville; Zeston 2000 or 300.

B. Type F3—Aluminum:

1. Aluminum Roll Jacketing: For straight run piping, wrought aluminum Alloy 3003, 5005, 1100, or 3105 to ASTM B209 with H-14 temper minimum 0.016-inch thickness, with smooth mill finish.
2. Vapor Barrier: Provide factory applied vapor barrier, consisting of 40-pound kraft paper with 1-mil thick low density polyethylene film, heat and pressure bonded to inner surface of aluminum jacketing.

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3. Fitting Covers: Material as for aluminum roll jacketing, premolded, one or two piece covers, which includes elbows, tee/valves, end caps, mechanical line couplings, and specialty fittings.
4. Manufacturers:
   a. RPR Products; Insul-Mate.
   b. Childers.
   c. Pabco.

PART 3 EXECUTION

3.01 APPLICATION

A. General:

1. Insulate flanges, and pipe couplings.
2. Insulate and vapor seal hangers, supports, anchors, and other piping appurtenances that are secured directly to cold surfaces.
3. Do not insulate valves, flexible pipe couplings, and expansion joints in the aeration system ALP.
   a. Cover these elements with the retained/salvaged prefabricated reusable covers.
4. Service and Insulation Thickness: Refer to Supplement Service and Insulation Thickness table following “End of Section” and to Piping Schedule in Section 40 27 00, Process Piping—General.

3.02 INSTALLATION

A. General:

1. Install in accordance with manufacturer’s instructions and as specified herein.
2. Install after piping system has been pressure tested and leaks corrected.
3. Apply insulation over clean dry surfaces.
4. Do not allow insulation to cover nameplates or code inspection stamps.
5. Run insulation or insulation inserts continuously through pipe hangers and supports, wall openings, ceiling openings, and pipe sleeves, unless otherwise shown.
6. Install removable insulation sections on devices that require access for maintenance of equipment or removal, such as unions and strainer end plates.
7. Use insulating cements, lagging adhesives, and weatherproof mastics recommended by insulation manufacturer.
8. Personnel Protection: Install on pipes from floor to 8 feet high. Install on pipes within 4 feet of platforms and to 8 feet high above platforms.

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B. Connection to Existing Piping: Cut back existing insulation to remove portion damaged by piping revisions. Install new insulation.

C. Cold Surfaces: Provide continuous vapor seal on insulation on cold surfaces where vapor barrier jackets are used.

D. Placement:

1. Slip insulation on pipe or tubing before assembly when practical to avoid longitudinal seams.
2. Insulate valves and fittings with sleeved or cut pieces of same material.
3. Seal and tape joints.

E. Insulation at Hangers and Supports: Insulation or insulation inserts to be continuous through hanger or support.

F. Heat Traced Piping: Apply insulation after heat-tracing work is completed and inspected.

G. Vapor Barrier:

1. Provide continuous vapor barrier at joints between rigid insulation and pipe insulation.
2. Install vapor barrier jackets with pipe hangers and supports outside jacket.
3. Do not use staples and screws to secure vapor sealed system components.

H. Aluminum Jacket:

1. Use continuous friction type joint to hold jacket in place, providing positive weatherproof seal over entire length of jacket.
2. Secure circumferential joints with preformed snap straps containing weatherproof sealant.
3. On exterior piping, apply coating over insulation and vapor barrier to prevent damage when aluminum fitting covers are installed.
4. Do not use screws or rivets to fasten fitting covers.
5. Install removable prefabricated aluminum covers on exterior flanges and unions.
6. Caulk and seal exterior joints to make watertight.

3.03 FIELD FINISHING

A. Apply coating of insulating cement where needed to obtain smooth and continuous appearance.

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B. Where pipe labels or banding are specified for a piping system, they shall be applied to the finished insulation, not to the pipe.

C. Painting Piping Insulation (Exposed to View):

1. Metal or PVC jacketing does not require painting.
2. If insulated piping system is indicated to be painted in Section 40 27 00, Process Piping—General, piping shall receive the following:
   a. Prime coat in accordance with Section 09 90 00, Painting and Coating.
   b. Finished insulation (and not pipe) shall be painted in accordance with Section 09 90 00, Painting and Coating.

3.04 SUPPLEMENTS

A. The supplement listed below, following "End of Section," is part of this specification:

1. Service and Insulation Thickness Table.

END OF SECTION

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Service and Insulation Thickness Table

Service Type	Pipe Legend	Thickness	Fluid Temperature (degrees F)*	Insulation	Finish Systems			
					Concealed from View	Indoors Exposed	Outdoors	Buried
Air Low Pressure	ALP	All: 2.0	260	Type 3**	F3**	F3**	F3	N/A
Plant effluent water	W3, NaOCl/ W3	All: 1	55 to 80	Type 1	F1	F1	N/A	N/A

*Use these fluid temperatures unless otherwise noted in the Piping Schedule.
Inches*: Based upon insulation with glass fiber per ASTM C547, outdoors with 20 mph wind with 10 percent safety and no value assigned to cladding or air space at cladding. Matches the watts per foot in Section 40 05 33, Pipe Heat Tracing. 2012 IECC requires 1-inch minimum thickness.

** Install prefabricated reusable insulation covers on valves and expansion joints; these covers were retained from the existing ALP piping demolition.

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SECTION 40 80 01
PROCESS PIPING LEAKAGE TESTING

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Testing Plan:
   a. Submit prior to testing and include at least the information that follows.
      1) Testing dates.
      2) Piping systems and section(s) to be tested.
      3) Test type.
      4) Method of isolation.
      5) Calculation of maximum allowable leakage for piping section(s) to be tested.
2. Certifications of Calibration: dated within 12-months of testing equipment.
3. Certified Test Report.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PREPARATION

A. Notify Engineer in writing 5 days in advance of testing. Perform testing in presence of Engineer.

B. Pressure Piping:

1. Install temporary thrust blocking or other restraint as necessary to protect adjacent piping or equipment and make taps in piping prior to testing.
2. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by pressure testing.
3. New Piping Connected to Existing Piping:
   a. Isolate new piping with grooved-end pipe caps, spectacle blinds, blind flanges, or as acceptable to Engineer.
   b. Test joint between new piping and existing piping by methods that do not place entire existing system under test load, as approved by Engineer and Owner.

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4. Items that do not require testing include tank overflows to atmospheric vented drains, tank atmospheric vents, and as indicated on Piping Schedule supplement to Section 40 27 00, Process Piping—General.
5. Test Pressure: As indicated on Piping Schedule.

C. Test section may be filled with water and allowed to stand under low pressure prior to testing.

D. Gravity Piping:

1. Perform testing after service connections, manholes, and backfilling have been completed between stations to be tested.
2. Determine groundwater level at time of testing by exploratory holes or other method acceptable to Engineer.

3.02 HYDROSTATIC TEST FOR PRESSURE PIPING

A. Fluid: Clean water of such quality to prevent corrosion of materials in piping system.

B. Exposed Piping:

1. Maximum Filling Velocity: 0.25 foot per second, applied over full area of pipe.
2. Vent piping during filling. Open vents at high points of piping system or loosen flanges, using at least four bolts, or use equipment vents to purge air pockets.
3. Maintain hydrostatic test pressure continuously for 30 minutes, minimum, and for such additional time as necessary to conduct examinations for leakage.
4. Examine joints and connections for leakage.
5. Correct visible leakage and retest as specified.
6. Leave pipe full of water after repair of leaks. Empty pipe of water prior to final cleaning or disinfection.

C. Buried Piping:

1. Test after backfilling has been completed.
2. Expel air from piping system during filling.
3. Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.
4. Maintain hydrostatic test pressure continuously for 2 hours minimum, reopening isolation valve only as necessary to restore test pressure.
5. Determine actual leakage by measuring quantity of water necessary to maintain specified test pressure for duration of test.

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6. Maximum Allowable Leakage:

$$L = \frac{S\,D(P)^{1/2}}{133{,}200}$$

where:

L = Allowable leakage, in gallons per hour.
S = Length of pipe tested, in feet.
D = Nominal diameter of pipe, in inches.
P = Test pressure during leakage test, in pounds per square inch.

7. Correct leakage greater than allowable, and retest as specified.

3.03 PNEUMATIC TEST FOR PRESSURE PIPING

A. Do not perform on:

1. PVC or CPVC pipe.
2. Piping larger than 18 inches.

B. Fluid: Oil-free, dry air.

C. Procedure:

1. Apply preliminary pneumatic test pressure of 25 psig maximum to piping system prior to final leak testing, to locate visible leaks. Apply soap bubble mixture to joints and connections; examine for leakage.
2. Correct visible leaks and repeat preliminary test until visible leaks are corrected.
3. Gradually increase pressure in system to half of specified test pressure. Thereafter, increase pressure in steps of approximately one-tenth of specified test pressure until required test pressure is reached.
4. Maintain pneumatic test pressure continuously for minimum of 10 minutes and for such additional time as necessary to conduct soap bubble examination for leakage.
5. Correct visible leakage and retest as specified.

D. Allowable Leakage: Piping system, exclusive of possible localized instances at pump or valve packing, shall show no visual evidence of leakage.

E. After testing and final cleaning, purge with nitrogen those lines that will carry flammable gases to assure no explosive mixtures will be present in system during filling process.

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3.04 HYDROSTATIC TEST FOR GRAVITY PIPING

A. Testing Equipment Accuracy: Plus or minus 1/2-gallon water leakage under specified conditions.

B. Maximum Allowable Leakage: 0.16gallon(s) per hour per inch diameter per 100 feet. Include service connection footage in test section, subjected to minimum head specified.

C. Gravity Sanitary and Roof Drain Piping: Test with 15 feet of water to include highest horizontal vent in filled piping. Where vertical drain and vent systems exceed 15 feet in height, test systems in 15-foot vertical sections as piping is installed.

D. Exfiltration Test:

1. Hydrostatic Head:
    a. At least 6 feet above maximum estimated groundwater level in section being tested.
    b. No less than 6 feet above inside top of highest section of pipe in test section, including service connections.
2. Length of Pipe Tested: Limit length such that pressure on invert of lower end of section does not exceed 30 feet of water column.

E. Infiltration Test:

1. Groundwater Level: At least 6 feet above inside top of highest section of pipe in test section, including service connections.

F. Piping with groundwater infiltration rate greater than allowable leakage rate for exfiltration will be considered defective even if pipe previously passed a pressure test.

G. Defective Piping Sections: Replace or test and seal individual joints, and retest as specified.

3.05 FIELD QUALITY CONTROL

A. Test Report Documentation:

1. Test date.
2. Description and identification of piping tested.
3. Test fluid.
4. Test pressure.

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5. Remarks, including:
   a. Leaks (type, location).
   b. Repair/replacement performed to remedy excessive leakage.
6. Signed by Contractor and Engineer to represent that test has been satisfactorily completed.

END OF SECTION

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SECTION 40 90 00
INSTRUMENTATION AND CONTROL FOR PROCESS SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. This section outlines general requirements for Process Instrumentation and Control System (PICS), including the integration of new and replaced equipment and instruments to existing plant-wide process SCADA monitoring and control system.

B. Major Work Items: Includes but is not limited to engineering, furnishing, installing, calibrating, adjusting, testing, documenting, starting up, and training for complete PICS.

1. Process instrumentation including primary elements, transmitters, control devices, and control panels.
2. Programmable controllers.
3. Computers and networks for Human Machine Interface (HMI).
4. Existing Plant PLC and HMI Applications Software to be used to integrate newly added and replaced equipment and instruments to plant wide existing SCADA system. Integrating the vendor supplied Package Systems to existing plant SCADA system.
5. Demonstration testing of newly added and replaced instruments and equipment at staging site.
    a. For additional related requirements refer to:
        1) Article Sequencing and Scheduling in this section.

1.02 RELATED SECTIONS

A. The following PICS specifications expand on the requirements of this section.

1. 40 91 00, Instrumentation and Control Components.
2. 40 99 90, Package Control Systems.

1.03 REFERENCE STANDARDS

A. The following is a list of standards which may be referenced in this section and other PIC subsections:

1. American National Standards Institute (ANSI).

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2. ASTM International (ASTM):
   a. A182/A182M, Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
   b. A276, Standard Specification for Stainless Steel Bars and Shapes.
   c. A312/A312M, Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
   d. B32, Standard Specification for Solder Metal.
   e. B88, Standard Specification for Seamless Copper Water Tube.
3. Deutsche Industrie-Norm (DIN): VDE 0611, Specification for modular terminal blocks for connection of copper conductors up to 1,000V ac and up to 1,200V dc.
4. Institute of Electrical and Electronics Engineers, Inc. (IEEE): C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
5. International Society of Automation (ISA):
   a. RP12.06.01, Recommended Practice for Wiring Methods for Hazardous (Classified) Locations Instrumentation Part 1: Intrinsic Safety.
   b. S5.1, Instrumentation Symbols and Identification.
   c. S5.4, Instrument Loop Diagrams.
   d. S50.1, Compatibility of Analog Signals for Electronic Industrial Process Instruments.
   e. TR20.00.01, Specification Forms for Process Measurement and Control Instruments, Part 1: General.
6. International Conference on Energy Conversion and Application (ICECA).
7. National Electrical Code (NEC).
8. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. ICS 1, Industrial Control and Systems General Requirements.
9. National Fire Protection Association (NFPA): 820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities.
10. Underwriters Laboratory, Inc. (UL): 508A, Standard for Safety, Industrial Control Panels.

1.04 ABBREVIATIONS AND DEFINITIONS

A. Abbreviations:

1. CP: Control Panel.
2. DCU: Distributed Control Unit.
3. FDT: Factory Demonstration Test.

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4. HMI: Human-Machine Interface.
5. HVAC: Heating, Ventilating, and Air Conditioning.
6. I&C: Instrumentation and Control.
7. I/O: Input and Output.
8. MCC: Motor Control Center.
9. O&M: Operation and Maintenance.
10. PAT: Performance Acceptance Test.
11. P&ID: Process and Instrument Diagram.
12. PC: Personal Computer.
13. PIC: Process Instrumentation and Control.
14. PLC: Programmable Logic Controller.
15. RTU: Remote Terminal Unit.
16. SCADA: Supervisory Control and Data Acquisition.
17. SLDC: Single Loop Digital Controller.
18. SSDT: Staging Site Demonstration Test.

B. Enclosure: Control panel, console, cabinet, or instrument housing.

C. Engineer: The Engineer of Record (EOR) or their designated professionally licensed representative.

D. Instructor Day: Eight hours of actual instruction time.

E. Standard Software: Software packages that are independent of Project on which they are used. Standard software includes system software, supervisory control, and data acquisition (SCADA) software.

1. System Software: Application independent (non-project specific) software developed by digital equipment manufacturers and software companies. Includes, but is not limited to, operating systems; network support, programming languages (C, C++, Visual C++, BASIC, Visual Basic, etc); Office Suites (word processor, spreadsheet, database, etc.); e-mail; security (firewall, antivirus; spam, spyware, etc.) debugging aids; and diagnostics.
2. SCADA Software: Software packages independent of specific process control project on which they are used. Includes, but is not limited to, providing configuring and run-time capability for, data acquisition (I/O driver, OPC servers, etc.), monitoring, alarming, human-machine interface, supervisory control, data collection, data retrieval, trending, report generation, control, and diagnostics.
3. Controller Programming Software: Software packages for the configuring of PLCs, RTUs, DCUs, SLDC, and fieldbus devices.

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F. Application Software: Software to provide functions unique to this Project and that are not provided by standard software alone, including but not limited to:

1. Configuring databases, tables, displays, historians, reports, parameter lists, ladder logic, function block, and control strategies required to implement functions unique to this Project.
2. Programming in any programming or scripting language.

G. Rising/Falling: Define action of discrete devices about their setpoint.

1. Rising: Contacts close when an increasing process variable rises through setpoint.
2. Falling: Contacts close when a decreasing process variable falls through setpoint.

H. Signal Types:

1. Analog Signal, Current Type:
   a. 4 to 20 mA dc signals conforming to ISA S50.1.
   b. Unless otherwise indicated for specific PIC subsection components, use the following ISA S50.1 options.
      1) Transmitter Type: Number 2, two-wire.
      2) Transmitter Load Resistance Capacity: Class L.
      3) Fully isolated transmitters and receivers.
2. Analog Signal, Voltage Type: 1 to 5 volts dc within panel where common high precision dropping resistor is used.
3. Discrete signals, two-state logic signals using dc or 120V ac sources as indicated.
4. Pulse Frequency Signals:
   a. Direct-current pulses whose repetition rate is linearly proportional to process variable.
   b. Pulses generated by contact closures or solid state switches.
   c. Power source less than 30V dc.
5. Special Signals: Other types of signals used to transmit analog and digital information between field elements, transmitters, receivers, controllers, and digital devices.

1.05 QUALITY ASSURANCE

A. All Work to be in accordance with the Design-Builder’s Quality Assurance and Quality Control (QA/QC) Plan.

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B. Qualifications:

1. PIC System Integrator: Minimum of 5 years' experience providing, integrating, installing, and starting up similar systems as required for this Project.
2. PIC System Integrator's Site Representative: Minimum of 5 years' experience installing systems similar to PIC required for this Project.
3. Systems Integrator Personnel Qualifications:
    a. Systems integrator shall provide qualified personnel, possessing necessary equipment and experience in performing similar installations.
    b. Provide qualified personnel resumes showing experience for the proposed roles on this project.
    c. Project manager: Control System Engineer (CSE) registration, Professional Engineer (PE) registration, or Project Management Professional (PMP) certification.
    d. Systems engineer: Control System Engineer (CSE) registration, Professional Engineer (PE) registration, or completion of the relevant core courses in the Engineering Skills Training program as certified by ISA.
    e. Programmer: Certified by the software/hardware manufacturer for the software and hardware being used on the project, or Control System Engineer (CSE), or Professional Engineer (PE) registration.
    f. Field instrument technician: Certified Control Systems Technician (CCST) registration or completion of the relevant core courses in the Technical Skills Training program as certified by ISA.
    g. Network programmer: Cisco Certified Network Associate CCNA.
    h. Network technician: Network Preferred Installer (NPI) registration by CISCO.
    i. Technician: Installation, calibration and testing of equipment furnished under this section shall be performed by qualified, skilled, NICET certified technicians who are regularly engaged in such activities involving systems of similar complexity, and who possess all licenses and certificates required to perform such work.

C. PIC Coordination Meetings:

1. General: Refer to the Contract Documents, Part II, Section 3.
2. Project Meetings, for PIC coordination meetings.
3. PIC Schedule Coordination Meeting:
    a. Timing: Following EOR review of PIC Schedule.
    b. Purpose: Discuss EOR's comments and resolve scheduling issues.

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4. Training Coordination Meeting:
    a. Timing: Following EOR review of preliminary training plan.
    b. Purpose:
        1) Resolve required changes to proposed training plan.
        2) Identify specific Owner personnel to attend training.

1.06 SUBMITTALS

A. Action Submittals:

1. Submittals shall be provided under a project-wide submittal register.
2. Submit proposed Submittal breakdown consisting of sequencing and packaging of information in accordance with Project Schedule.
3. Partial Submittals not in accordance with Project Schedule will not be accepted.
4. Submittal Format:
    a. Electronic Copies: Required, unless otherwise noted for specific items.
        1) Manufacturers' Standard Documents: Adobe Acrobat PDF.
        2) Documents created specifically for Project:
            a) Text and Graphics: Microsoft Word.
            b) Lists: Microsoft Excel, unless otherwise noted for specific items.
            c) Drawings: AutoCAD.
5. Identify proposed items, options, installed spares, and other provisions for future work (for example, reserved panel space; unused components, wiring, and terminals).
6. Legends and Abbreviation Lists:
    a. Definition of symbols and abbreviations used; for example, engineering units, flowstreams, instruments, structures, and other process items used in nameplates, legends, data sheets, point descriptions, HMI displays, alarm/status logs, and reports.
    b. Use identical abbreviations in PIC subsections.
    c. Submit updated versions as they occur.
7. Activity Completion:
    a. Action Submittals: Completed when reviewed and approved.
    b. Informational Submittals: Completed when reviewed and found to meet conditions of the Contract.
8. Bill of Materials: List of required equipment.
    a. Group equipment items by enclosure and field, and within an enclosure, as follows:
        1) PIC Components: By component identification code.
        2) Other Equipment: By equipment type.

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b. Data Included:
   1) Equipment tag number.
   2) Description.
   3) Manufacturer, complete model number and all options not defined by model number.
   4) Quantity supplied.
   5) Component identification code where applicable.
   6) For panels, include panel reference number and name plate inscription.
c. Formats: Microsoft Excel.

9. Catalog Cuts: I&C components, electrical devices, and mechanical devices:
   a. Catalog information, marked to identify proposed items and options.
   b. Descriptive literature.
   c. External power and signal connections.
   d. Scaled drawings showing exterior dimensions and locations of electrical and mechanical interfaces.
10. Instrument List:
   a. EOR will provide an initial Instrument List in Microsoft Excel. Data from this may be used as starting point for creating final Instrument List and Component Data Sheets.
   b. Applicable fields to be completed include, but are not limited to:

Instrument List Characteristics	
Item	**Initially Completed By**
Tag Number	Engineer
Loop Number	Engineer
Description	Engineer
Manufacturer and complete model number	Contractor
Size and scale range	Engineer
Setpoints	Engineer
Reference P&IDs, Electrical, Mechanical, Interconnection Drawings and Installation Details Drawings	Engineer
Instrument detail number	Engineer

   c. Submit updated version of Instrument List.
   d. Electronic Copies: Microsoft Excel.

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11. Component Data Sheets: Data sheets for I&C components.
    a. Format:
        1) Similar to ISA TR20.00.01.
        2) Microsoft Excel, one component per data sheet.
        3) Submit proposed format for Component Data Sheets before completing data sheets for individual components.
    b. Content: Specific features and configuration data for each component, including but not limited to:
        1) Tag Number.
        2) Component type identification code and description.
        3) Location or service.
        4) Service conditions.
        5) Manufacturer and complete model number.
        6) Size and scale range.
        7) Setpoints.
        8) Materials of construction.
        9) Options included.
        10) Power requirements.
        11) Signal interfaces.
        12) Name, address, and telephone number of manufacturer's local office, representative, distributor, or service facility.
    c. Electronic Copies: Microsoft Excel.
12. Sizing and Selection Calculations:
    a. Primary Elements:
        1) Complete calculations plus process data used. Example for Flow Elements:
            a) Minimum and maximum values, permanent head loss, and assumptions made.
    b. Controller, Computing, and Function Generating Modules: Actual scaling factors with units and how they were computed.
    c. Electronic Copies: Microsoft Excel, one file for each group of components with identical sizing calculations.
13. Preliminary Panel Elevation Drawings: Provide prior to submitting Panel Construction Drawings:
    a. Scale Drawings: Show dimensions and location of front of panel devices.
    b. Panel Legend (Bill of Material): List front of panel devices by tag number. Include nameplate inscriptions, service legends, and annunciator inscriptions.
    c. Submit electronic copies of Drawings.
14. Panel Construction Drawings:
    a. Scale Drawings: Show dimensions and locations of panel-mounted devices, doors, louvers, subpanels, internal and external. Panel dimensions shall include both enclosure and backplane

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sizes, clearly indicating width, height, and depth in consistent engineering units.

b. Panel Legend (Bill of Material): List front of panel devices by tag numbers, nameplate inscriptions, service legends, and annunciator inscriptions.

c. Bill of Materials: List devices mounted within panel that are not listed in panel legend. Include tag number, description, manufacturer, and model number.

d. Construction Details: NEMA rating, materials, material thickness, structural stiffeners and brackets, lifting lugs, mounting brackets and tabs, door hinges and latches, and welding and other connection callouts and details.

e. Construction Notes: Finishes, wire color schemes, wire ratings, wire, terminal block numbering, and labeling scheme.

f. Submit electronic copies of Drawings.

15. Detailed Wiring Diagrams:

a. Refer to Drawings for Detailed Wiring Diagrams including:

1) Panel Wiring Diagrams for discrete control and power circuits.

2) Loop Wiring Diagrams showing individual wiring diagram for each analog or pulse frequency loop.

3) Interconnecting Wiring Diagrams showing electrical connections between equipment, consoles, panels, terminal junction boxes, and field-mounted components.

b. Prepare as-built redline markup of detailed wiring diagrams. Show terminal numbers on switch blocks, relays, and internal components.

c. Submit electronic copies of Drawings.

16. Panel Wiring Diagrams:

a. Cover wiring within a panel including, but not limited to, instrumentation, control, power, and communications, and digital networks.

b. Objectives: For use in wiring panels, making panel connections, and future panel trouble shooting.

c. Diagram Type:

1) Ladder diagrams where applicable**.** Include devices that are mounted in or on the panel that require electrical connections. Show unique rung numbers on left side of each rung.

2) Schematic drawings for wiring of circuits that cannot be well represented by ladder diagrams.

d. Item Identification: Identify each item with attributes listed.

1) Wires: Wire number and color. Cable number if part of multiconductor cable.

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2) Terminals: Location (enclosure number, terminal junction box number, or MCC number), terminal strip number, and terminal block number.
3) Components:
   a) Tag number, terminal numbers, and location ("FIELD", enclosure number, or MCC number).
   b) Switching action (open or close on rising or falling process variable), setpoint value and units, and process variable description (for example, Sump Level High).
4) I/O Points: PLC unit number, I/O tag number, I/O address, terminal numbers, and terminal strip numbers.
5) Relay Coils:
   a) Tag number and its function.
   b) On right side of run where coil is located, list contact location by ladder number and sheet number. Underline normally closed contacts.
6) Relay Contacts: Coil tag number, function, and coil location (ladder rung number and sheet number).
7) Communications and Networks: Network type, address or node identification, port or channel number, and type of connector.

e. Show each circuit individually. No "typical" diagrams or "typical" wire lists will be allowed.
f. Show all ground wires, surge protectors, and connections.
g. Wire and Cable Names: Show names and wire color for circuits entering and leaving a panel. Refer to Division 26, Electrical.

17. Loop Wiring Diagrams: Individual, end-to-end wiring diagram for each analog and discrete or equipment loop.
    a. Conform to the minimum requirements of ISA S5.4.
    b. Under Paragraph 5.3 of ISA S5.4, include the information listed under Subparagraphs 2 and 6.
    c. Show loop components within a panel and identify each component, component terminals, and panel terminals.
    d. If a loop connects to panels or devices not provided under this section and its subsections, such as control valves, motor control centers, package system panels, variable speed drives, include the following information:
       1) Show the first component connected to within the panel or device that is not provided under this section and its subsections.
       2) Identify the component by tag and description.
       3) Identify panel and component terminal numbers.

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e. Drawing Size: Individual 11-inch by 17-inch sheet for each loop.
f. Divide each loop diagram into areas for panel face, back-of-panel, field and PLC.
g. One Drawing Per Loop: Show each loop individually. No "typical" loop diagrams will be allowed.
h. Show:
    1) Terminal numbers, location of dc power supply, and location of common dropping resistors.
    2) Switching contacts in analog loops and output contacts of analog devices. Reference specific control diagrams where functions of these contacts are shown.
    3) Tabular summary on each analog loop diagram:
        a) Transmitting Instruments: Output capability.
        b) Receiving Instruments: Input impedance.
        c) Loop Wiring Impedance: Estimate based on wire sizes and lengths shown.
        d) Total loop impedance.
        e) Reserve output capacity.
    4) Circuit and raceway schedule names.

18. Communications and Digital Networks Diagrams:
    a. Scope: Includes connections to telephone system, Ethernet network, remote I/O, and fieldbus (for example, Modbus, Profibus, Foundation Fieldbus, Device Net, etc.).
    b. Format: Network schematic diagrams for each different type of network.
    c. Show:
        1) Interconnected devices, both passive and active.
        2) Device names and numbers.
        3) Terminal numbers.
        4) Communication Media: Type of cable.
        5) Connection Type: Type of connector.
        6) Node and device address numbers.
        7) Wire and cable numbers and colors.
19. Panel Power Requirements and Heat Dissipation: For control panels tabulate and summarize:
    a. Required voltages, currents, and phases(s).
    b. Maximum heat dissipations Btu per hour.
    c. Calculations.
    d. Steady State Temperature Calculations: For nonventilated panels, provide heat load calculations showing the panel estimated internal steady state temperature for ambient air temperatures.
20. Panel Plumbing Diagrams: For each panel containing piping and tubing. Show type and size for:
    a. Pipes and Tubes: Thickness, pressure rating, and materials.

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b. Components: Valves, regulators, and filters.
c. Connections to panel-mounted devices.
d. Panel interface connections.
e. Submit electronic copies of Drawings.

21. Installation Details: Include modifications or further details required and define installation of I&C components.
22. Spares, expendables, and test equipment.
23. Electronic Copies: Microsoft Excel.
24. PLC I/O List: Submit I/O assignment and Rack/Slot/Point.
25. Shop Drawings for Changes Impacting PLC and SLDC Programming:
    a. Submit details of changes required to PLC and SLDC monitoring and control resulting from installation of alternative or upgraded process equipment and instrumentation, and other causes.
    b. Submit changes at 30-day intervals.
26. Color schedule for control panels.
27. Applications Software Documentation: For equipment for which Engineer does not provide applications software provide:
    a. Complete configuration documentation for microprocessor based programmable devices.
    b. For each device, include program listings and function block diagrams, as appropriate, showing:
        1) Functional blocks or modules used.
        2) Configuration, calibration, and tuning parameters.
        3) Descriptive annotations.
    c. Refer to PIC subsections for additional requirements.

B. Informational Submittals:

1. Statements of Qualification:
    a. PIC System Integrator.
    b. PIC System Integrator's site representative.
    c. Resume for each PIC System Integrator's onsite startup and testing team member (engineers, technicians, and software/configuring personnel).
2. Operation and Maintenance Data: In accordance with Section 01 78 23, Operation and Maintenance Data, and in addition, the following:
    a. General:
        1) Provide sufficient detail to allow operation, removal, installation, adjustment, calibration, maintenance and purchasing replacements for PIC components.
        2) Submittal Format: Both hard copy and electronic copies for all submittals. Refer to Article Submittals, heading Submittal Format.
    b. Final versions of Legend and Abbreviation Lists.

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c. Process and Instrumentation Diagrams: Marked up copy of revised P&ID to reflect as-built PIC design.
d. Provide the following items as defined under heading Action Submittals:
    1) Bill of materials.
    2) Catalog cuts.
    3) Instrument list.
    4) Component data sheets.
    5) Detailed Wiring Diagrams: As-built drawings.
        a) Panel wiring diagrams.
        b) Loop diagrams.
        c) Interconnecting wiring diagrams.
    6) Panel plumbing diagrams.
    7) Applications software documentation.
e. Manufacturer's O&M manuals for components, electrical devices, and mechanical devices:
    1) Content for Each O&M Manual:
        a) Table of Contents.
        b) Operations procedures.
        c) Installation requirements and procedures.
        d) Maintenance requirements and procedures.
        e) Troubleshooting procedures.
        f) Calibration procedures.
        g) Internal schematic and wiring diagrams.
        h) Component and I/O Module Calibration Sheets from field quality control calibrations.
    2) Provide PDF file with linked index to all manuals.
f. List of spares, expendables, test equipment and tools provided.
g. List of additional recommended spares, expendables, test equipment, and tools. Include quantities, unit prices, and total costs.

3. Provide Manufacturer's Certificate of Proper Installation where specified.
4. Testing Related Submittals:
    a. Factory Demonstration Test:
        1) Preliminary Test Procedures: Outline of proposed tests, forms, and checklists.
        2) Final Test Procedures:
            a) Proposed test procedures, forms, and checklists.
            b) Capacity, Timing, and Simulation: Describe simulation and monitoring methods used to demonstrate compliance with capacity and timing requirements.
        3) Test Documentation: Copy of signed off test results.

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b. Staging Site Demonstration Test:
   1) Preliminary Test Procedures: Outline of proposed tests, forms, and checklists.
   2) Final Test Procedures: Proposed test procedures, forms, and checklists.
   3) Test Documentation: Copy of signed-off test results when tests are completed.

c. Functional Test:
   1) Preliminary Test Procedures: Outline of proposed tests, forms, and checklists.
   2) Final Test Procedures: Proposed test procedures, forms, and checklists.
   3) Test Documentation:
      a) Copy of signed-off test results.
      b) Completed component calibration sheets.

d. Performance Test:
   1) Preliminary Test Procedures: Outline of proposed tests, forms, and checklists.
   2) Final Test Procedures: Proposed test procedures, forms, and checklists.
   3) Test Documentation: Copy of signed-off test results.

5. Maintenance Service Agreement: Prior to Substantial Completion, submit service agreements signed by Owner and maintenance provider for work required under Article Maintenance Service.

1.07 TOLERANCES

A. Refer to Design Criteria Standards.

1.08 DESIGN CRITERIA

A. Detailed Wiring Design: Panel wiring diagrams, interconnecting wiring diagrams, and loop wiring diagrams are included in Contract Drawings and designed to completely show control panel wiring, terminations, wire numbers, interfaces with other systems, hardwired functions, interlocks, and wiring of components to be provided.

B. Design Requirements:

1. Complete detailed design of PIC components and PIC drawings.
2. Provide consistent hardware and software functions for PIC. For example, provide functions in control logic, sequence controls, and display layouts in same or similar manner.

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3. PIC design as shown and specified includes:
   a. Functional requirements, performance requirements, and component specifications.
   b. P&IDs, block diagrams, and network diagrams.
4. Typical drawings for installation details, control panel layouts, control panel schedules, PLC I/O module wiring, panel power, and control diagrams.

C. Use a qualified PIC System Integrator for at least the following work:

1. For PIC Equipment and Ancillaries:
   a. Completing detail design.
   b. Submittals.
   c. Equipment, enclosures, and ancillaries.
   d. Instructions, details, and recommendations to, and coordination with Contractor for Certificate of Proper Installation.
   e. Verify readiness for operation.
   f. Verify correctness of final power and signal connections (lugging and connecting).
   g. Adjusting and calibrating.
   h. Starting up.
   i. Testing and coordination of testing.
   j. Training.
   k. Assist EOR with Functional Test Part 2 as defined in Article Field Quality Control.
2. Verify following Work not by PIC System Integrator is provided:
   a. Correct type, size, and number of signal wires with their raceways.
   b. Correct electrical power circuits and raceways.
   c. Correct size, type, and number of PIC-related pipes, valves, fittings, and tubes.
   d. Correct size, type, materials, and connections of process mechanical piping for in-line primary elements.
3. Non-PIC Equipment Directly Connected to PIC Equipment:
   a. Obtain from Contractor, manufacturers' information on installation, interface, function, and adjustment for reference purposes.
   b. Coordinate with Contractor to allow required interface and operation with PIC.
   c. For operation and control, verify installations, interfacing signal terminations, and adjustments have been completed in accordance with manufacturer's recommendations.
   d. Test to demonstrate required interface and operation with PIC.

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e. Examples of items in this category, but not limited to the following:
   1) Valve operators, position switches, and controls.
   2) Chemical feed pump and feeder speed/stroke controls.
   3) Automatic samplers.
   4) Motor control centers.
   5) Adjustable speed and adjustable frequency drive systems.

f. Examples of items not in this category:
   1) Internal portions of equipment provided under Division 26, Electrical, that are not directly connected to PIC equipment.
   2) Internal portions of package system instrumentation and controls that are not directly connected to PIC equipment.

1.09 PROJECT AND SITE CONDITIONS

A. Product selection shall ensure compatibility with environment where products are installed.

1.10 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01 61 00, Common Product Requirements.

B. Prior to shipment, include corrosive inhibitive vapor capsules in shipping containers, and related equipment as recommended by capsule manufacturer.

C. Prior to installation, store items in dry indoor locations. Provide heating in storage areas for items subject to corrosion under damp conditions.

D. Cover panels and other elements that are exposed to dusty construction environments.

1.11 SEQUENCING AND SCHEDULING

A. Refer to Section 01 31 13, Project Coordination, for Contractor's scheduling requirements for applications software testing.

B. Prerequisite Activities and Lead Times: Do not start following key Project activities until prerequisite activities and lead times listed below have been completed and satisfied:

1. Shop Drawing Reviews by Engineer:
   a. Prerequisite: Engineer acceptance of Schedule of Values and Progress Schedule.

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b. Schedule: In accordance with completed schedule of Shop Drawing and Sample submittals specified in Section 01 33 00, Submittal Procedures.

2. Test Prerequisite: Associated test procedures Submittals completed.
3. Training Prerequisite: Associated training plan Submittal completed.

1.12 EXTRA MATERIALS

A. As specified in PIC subsections.

B. In computing spare parts quantities based on specified percentages, round up to nearest whole number.

C. Spare Parts:

Description	Percent of Each Type and Size Used	No Less Than
DC Power Supplies	-	1 of each type
Fuses	-	5 of each type provided for each panel or device
Terminal Blocks	10	10 of each type provided
Hand Switches and Lights	10	5 of each type provided
120V ac Isolation Transformers	10	2 of each type provided
Surge Suppressors	-	1 of each type provided

D. Expendables: For following items provide manufacturer's recommended 2-year supply, unless otherwise noted.

1. Chemical for analyzers.
2. Calibration/test gas for combustible gas detection.
3. Corrosion-inhibiting vapor capsules.
4. pH, NO3, NH3 and DO sensor overhaul kits: Two.

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PART 2 PRODUCTS

2.01 GENERAL

A. Provide PIC functions shown on Drawings and required in PIC subsections for each system and loop. Furnish equipment items required in PIC subsections. Furnish materials, equipment, and software, whether indicated or not, necessary to effect required system and loop performance.

B. First Named Manufacturer: PIC design is based on first named manufacturers of equipment, materials, and software.

1. If an item is proposed from other than first named manufacturer, obtain approval from Engineer for such changes in accordance with the General Conditions, Article 6.05 Substitutes and "Or-equal".
2. If proposed item requires, but not limited to, different installation, wiring, raceway, enclosures, intrinsically safe barriers, and accessories, provide such equipment and work.

C. Like Equipment Items:

1. Use products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's services.
2. Implement same or similar functions in same or similar manner. For example, control logic, sequence controls, and display layouts.

2.02 I&C COMPONENTS

A. Specifications: Refer to Section 40 91 00, Instrumentation and Control Components, for specifications for I&C components.

B. Components for Each Loop: Major components for each loop are listed in Instrument List referenced in Article Supplements. Furnish equipment that is necessary to achieve required loop performance.

C. Control Panels: Reference Control Panel Schedule in Article Supplements.

2.03 PROGRAMMABLE LOGIC CONTROLLERS

A. Reference PLC Equipment List in Article, Supplements, and PLC components in Section 40 91 00, Instrumentation and Control Components.

2.04 FIELD BUS, NETWORK, AND HMI COMPONENTS

A. Reference PIC subsections.

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2.05 SERVICE CONDITIONS

A. Standard Service Conditions: The following defines certain types of environments. PIC subsections refer to these definitions by name to specify the service conditions for individual equipment units. Design equipment for continuous operation in these environments:

1. Computer Room, Air Conditioned:
   a. Temperature: 60 degrees F to 80 degrees F.
   b. Relative Humidity: 40 percent to 60 percent.
   c. NEC Classification: Nonhazardous.
2. Inside, Air Conditioned:
   a. Temperature:
      1) Normal: 60 degrees F to 80 degrees F.
      2) With Up to 4-Hour HVAC System Interruptions: 40 degrees F to 105 degrees F.
   b. Relative Humidity:
      1) Normal: 10 percent (winter) to 70 percent (summer).
      2) With Up to 4-Hour HVAC System Interruption: 10 percent to 100 percent.
   c. NEC Classification: Nonhazardous.
3. Inside:
   a. Temperature: 20 degrees F to 104 degrees F.
   b. Relative Humidity: 10 percent to 95 percent noncondensing.
   c. NEC Classification: Nonhazardous.
4. Outside:
   a. Temperature: Minus 20 degrees F to 104 degrees F.
   b. Relative Humidity:10 percent to 95 percent noncondensing rain, snow, freezing rain.
   c. NEC Classification: Nonhazardous.
5. Outside, Hazardous:
   a. Temperature Minus 20 degrees F to 104 degrees F.
   b. Relative Humidity: 10 to 95 percent noncondensing rain, snow, freezing rain.
   c. NEC Classification: As shown on Electrical Drawings.

B. Standard Service Conditions for Panels and Consoles: Unless otherwise noted, in Control Panel Schedule located in Article Supplements at End of Section, design equipment for continuous operation in these environments:

1. Freestanding Panel and Consoles:
   a. Inside, Air Conditioned: NEMA 1.
   b. Inside: NEMA 12.

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2. Smaller Panels and Assemblies (that are not freestanding):
   a. Inside, Air Conditioned: NEMA 12.
   b. All Other Locations: NEMA 4X.
3. Field Elements: Outside.

C. Special Environmental Requirements: Design following panels for continuous operation in environments listed.

2.06 NAMEPLATES AND TAGS

A. Panel Nameplates: Enclosure identification located on enclosure face.

1. Location and Inscription: As shown on Drawings.
2. Materials: Laminated plastic attached to panel with stainless steel screws.
3. Letters: 1/2-inch-high, white on black background, unless otherwise noted.

B. Component Nameplates, Panel Face: Component identification located on panel face under or near component.

1. Location and Inscription: As shown on panel drawing.
2. Materials: Adhesive-backed, laminated plastic.
3. Letters: 3/16-inch-high, white on black background, unless otherwise noted.

C. Component Nameplates, Back of Panel: Component identification located on or near component inside of enclosure.

1. Inscription: Component tag number.
2. Materials: Adhesive-backed, laminated plastic.
3. Letters: 3/16-inch-high, white on black background, unless otherwise noted.

D. Legend Plates for Panel Mounted Pushbuttons, Lights, and Switches.

1. Inscription:
   a. Refer to table under Paragraph Standard Pushbutton Colors and Inscriptions.
   b. Refer to table under Paragraph Standard Light Colors and Inscriptions.
   c. Refer to P&IDs on Drawings.
2. Materials: Stainless steel, keyed legend plates. Secured to panel by mounting nut for pushbutton, light, or switch.
3. Letters: Black on gray or white background.

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E. Service Legends: Component identification nameplate located on face of component.

1. Inscription: As shown on panel drawing.
2. Materials: Adhesive-backed, laminated plastic.
3. Letters: 3/16-inch-high, white on black background, unless otherwise noted.

F. Nametags: Component identification for field devices.

1. Inscription: Component tag number.
2. Materials: 16-gauge, Type 304 stainless steel.
3. Letters: 3/16-inch-high, imposed.
4. Mounting: Affix to component with 16-guage or 18-gauge stainless steel wire or stainless steel screws.

2.07 MECHANICAL SYSTEM COMPONENTS

A. Reference Section 40 91 00, Instrumentation and Control Components.

2.08 FUNCTIONAL REQUIREMENTS FOR CONTROL LOOPS

A. Shown on Drawings, in panel control diagrams, and Process and Instrumentation Diagrams (P&ID). P&ID format and symbols are in accordance with ISA S5.1, except as specified or shown on Drawings.

B. Supplemented by Loop Specifications that describe requirements not obvious on P&IDs or panel control diagrams.

C. Supplemented by standard functional requirements in PIC subsections.

2.09 LOOP SPECIFICATIONS

A. To be developed by Owner.

B. Organization: By unit process and loop number.

C. Loop Subheadings:

1. Hardwired Special Functions: Clarifies functional performance of loop, including abstract of interlocks for hard wired logic, for example in MCCs and control panels.
2. PLC Special Functions: Specifies nonstandard PLC functions. When required for clarification, additional definition is shown by logic diagrams or sequence diagrams on Drawings.
3. HMI Special Functions: Specifies nonstandard HMI functions.

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2.10 ELECTRICAL REQUIREMENTS

A. Electrical Raceways: As specified in Section 26 05 01, Electrical.

B. Wiring External to PIC Equipment:

1. Special Control and Communications Cable: Provided by PIC System Integrator as noted in Component Specifications and PIC subsections.
2. Other Wiring and Cable: As specified in Section 26 05 01, Electrical.

C. I&C and electrical components, terminals, wires, and enclosures UL recognized or UL listed.

D. Wires within Enclosures:

1. ac Circuits:
   a. Type: 600-volt, Type MTW stranded copper.
   b. Size: For current to be carried, but not less than No. 18 AWG.
2. Analog Signal Circuits:
   a. Type: 600-volt stranded copper, twisted shielded pairs or triad with a 100 percent, aluminum-polyester shield, rated 60 degrees C.
   b. Panels with Circuits Less Than 600 volts: Rated at 600 volts. Belden No. 18 AWG Type 9341, Triad Beldon No. 1121A.
   c. Size: No. 18 AWG, minimum.
3. Other dc Circuits.
   a. Type: 600-volt, Type MTW stranded copper.
   b. Size: For current carried, but not less than No. 18 AWG.
4. Special Signal Circuits: Use manufacturer’s standard cables.
5. Wire Identification: Numbered and tagged at each termination.
   a. Wire Tags: Machine printed, heat shrink.
   b. Manufacturers:
      1) Brady Perma Sleev.
      2) Tyco Electronics.

E. Terminate and identify wires entering or leaving enclosures as follows:

1. Analog and discrete signal, terminate at numbered terminal blocks.
2. Special signals terminated using manufacturer’s standard connectors.
3. For each signal wire terminated at a PLC I/O module, apply heat-shrink plastic label inside enclosure with the following printed information displayed, at minimum:
   a. PLC Designation.
   b. PLC Address by Rack, Slot, Point designation.
   c. Field Equipment Designation.

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F. Terminal Blocks for Enclosures:

1. Quantity:
   a. Accommodate present and spare indicated needs.
   b. Wire spare PLC I/O points to terminal blocks.
   c. One wire per terminal for field wires entering enclosures.
   d. Maximum of two wires per terminal for No. 18 AWG wire for internal enclosure wiring.
   e. Spare Terminals: 20 percent of connected terminals, but not less than 10 per terminal block, unless otherwise shown on Drawings.
2. Terminal Block Types: Reference Section 40 91 00, Instrumentation and Control Components, Part 2, Article Electrical Components.

G. Grounding of Enclosures:

1. Furnish isolated copper grounding bus for signal and shield ground connections.
2. Ground this ground bus at a common signal ground point in accordance with National Electrical Code requirements.
3. Single Point Ground for Each Analog Loop:
   a. Locate signal ground at dc power supply for loop.
   b. Use to ground wire shields for loop.
4. Ground terminal block rails to ground bus.

H. Analog Signal Isolators:

1. Furnish signal isolation for analog signals that are sent from one enclosure to another.
2. Do not wire in series instruments on different panels, cabinets, or enclosures.

I. Intrinsic Safety System Installation:

1. Comply with NEC Article 504, Intrinsically Safe Systems.
2. Install intrinsically safe circuits in a separate wire way that:
   a. Is separated from nonintrinsically safe circuits as specified by NEC.
   b. Is colored light blue and has message “Intrinsically Safe Circuits Only” on raceway cover every 6 inches.

J. Wiring Interface: Terminate and identify wiring entering or leaving enclosures.

1. Analog and Discrete Signal Wires: Terminate at numbered terminal blocks as shown on the wiring diagrams.

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2. Wiring for Special Signals: Terminate communications, digital data, and multiplexed signals using manufacturer's standard connectors for the device to which the signals terminate.

K. Electrical Transient Protection:

1. General:
   a. Function: Protect elements of PIC against damage due to electrical transients induced in interconnecting lines by lightning and nearby electrical systems.
   b. Surge suppressors are not shown for external analog transmitters. Determine quantity and location and show in Shop Drawings. Refer to example wiring in installation details in Drawings.
   c. Provide, install, coordinate, and inspect grounding of surge suppressors at:
      1) Connection of ac power to PIC equipment including panels, consoles assemble, and field-mounted analog transmitters and receivers.
      2) At the field and panel, console, or assembly connection of signal circuits that have portions of the circuit extending outside of a protective building.
2. Surge Suppressor Types: Reference Section 40 91 00, Instrumentation and Control Components, Part 2, Surge Suppressors.
3. Installation and Grounding of Suppressors:
   a. As shown. See Surge Suppressor Installation Details.
   b. Grounding equipment, installation of grounding equipment, and terminations for field mounted devices are provided under Division 26, Electrical.

2.11 TEST EQUIPMENT AND TOOLS

Below test equipment and tools to be supplied by the manufacturer.

A. Digital Multimeter:

1. Type: Industrial True RMS Digital Multimeter, CAT IV 600V protection with test leads, removable test probes, long reach alligator clips, magnetic hanger, temperature probe, and carrying case.
2. Quantity: Two.
3. Manufacturers and Products:
   a. Fluke; Model 87V/E Industrial Electrician Combo Kit.
   b. Greenlee; Model DM-860.
   c. Extech; Model EX530.

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B. Clamp-on Ammeter:

1. Type: True RMS Digital Clamp-on meter with 3-1/2-digit display and protective case.
2. Quantity: One.
3. Manufacturers and Products:
   a. TES; Model 3040.
   b. Fluke; Model 337E.
   c. Greenlee; Model CMI-100.
   d. Extech; Model EX830.

C. DC Digital Process Signal Calibrator:

1. Type: Portable, two-channel, with test leads, rechargeable batteries, charger, and carrying case.
2. Quantity: Two.
3. Manufacturers and Products:
   a. Transmation; Model 1045-01.
   b. Fluke; Model 789.
   c. Extech; Model CMM17.

D. Datalogger:

1. Type: Portable Handheld Multichannel Datalogger, USB communications, Graphical Display, with Analysis Software.
2. Quantity: One.
3. Manufacturers and Products:
   a. Graphtec; Model GL200A.
   b. Omega; Model OM-DAQPRO-5300.

E. Pressure and Electrical Calibrator:

1. Type: Test leads, rechargeable batteries, ac charger, pressure transducer modules, and protective case.
2. Pressure Ranges: Specify pressure ranges. Appropriate for pressure devices provided.
3. Quantity: One.
4. Manufacturers and Products:
   a. Transmation; Model 1091PLUS-LP.
   b. Fluke; Model 717/718.
   c. Heise; Model PTE-1.

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F. Pressure Pump Kit:

1. Type: Hand pump (0 to 600 psig), calibration labels, tubing, fittings, and carrying case.
2. Quantity: One.
3. Manufacturers and Products;
   a. Transmation; Pump Kit 22980P-300.
   b. Fluke; Model 700PTP-1.
   c. Heise; Model TP1-40.

G. Small Tool Kit:

1. Type: Kit of instrument maintenance tools in soft, zipper case.
2. Quantity: One.
3. Manufacturer and Product: Jensen Tools; Model JTK-47GC Field Engineer's Kit.

H. Large Tool Kit:

1. Type: Kit of instrument maintenance tools in high-density polyethylene case.
2. Quantity: One.
3. Manufacturer and Product: Jensen Tools; Model JTK-17LST.

I. Screw Starters:

1. Type: Kits of slotted screw starters with magnetic retrievers.
2. Quantity: One.
3. Manufacturer and Products: Jensen Tools; Models 23B021 and 23B023.

J. Terminal Kit:

1. Type: Kit of solderless terminals and cable ties.
2. Quantity: 1.
3. Manufacturer and Product: Jensen Tools; Model 23B210.

2.12 SOURCE QUALITY CONTROL

A. General:

1. Engineer may actively participate in many of the tests.
2. Engineer reserves right to test or retest specified functions.
3. Engineer's decision will be final regarding acceptability and completeness of testing.

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4. Procedures, Forms, and Checklists:
    a. Except for Unwitnessed Factory Test, conduct tests in accordance with, and documented on, Engineer accepted procedures, forms, and checklists.
    b. Describe each test item to be performed.
    c. Have space after each test item description for sign off by appropriate party after satisfactory completion.
5. Required Test Documentation: Test procedures, forms, and checklists signed by Engineer and Contractor.
6. Conducting Tests:
    a. Provide special testing materials and equipment.
    b. Wherever possible, perform tests using actual process variables, equipment, and data.
    c. If not practical to test with real process variables, equipment, and data provide suitable means of simulation.
    d. Define simulation techniques in test procedures.
    e. Test Format: Cause and effect.
        1) Person conducting test initiates an input (cause).
        2) Specific test requirement is satisfied if correct result (effect), occurs.
    f. For PIC systems for which Engineer provides applications software, provide sufficient temporary software configuring to allow FDT and SSDT testing of these subsystems.

B. Unwitnessed Factory Test:

1. Scope: Inspect and test PIC to ensure it is operational, ready for FDT.
2. Location: PIC System Integrator’s facility.
3. Integrated Test:
    a. Interconnect and test PIC, except for primary elements and smaller panels.
    b. Exercise and test functions.
    c. Provide stand-alone testing of smaller panels.
    d. Simulate inputs and outputs for primary elements, final control elements, and panels excluded from test.

C. Factory Demonstration Tests (FDT):

1. Notify Engineer of test schedule 4 weeks prior to start of test.
2. Scope:
    a. Test entire PIC, with exception of primary elements, final control elements, and certain smaller panels, to demonstrate it is operational.

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b. Refer to Control Panel Schedule in Article Supplements for list of panels for which FDT is required.

3. Location: PIC System Integrator's facility.
4. Correctness of wiring from panel field terminals to PLC system input/output points and to panel components.
   a. Simulate each discrete signal at terminal strip.
   b. Simulate correctness of each analog signal using current source.
5. Operation of communications between PLCs and remote I/O and between PLCs and computers.
6. Operation of communications between the PLC system, single loop controllers (SLC).
7. Loop-Specific Functions: Demonstrate functions shown on P&IDs, control diagrams, and loop specifications:
   a. One of each type function; for example, if there are filter backwash sequence control for several identical filters, demonstrate controls for one filter.
   b. One of each type of function in each panel; for example, but not limited to annunciator operation, controller operation, and recorder operation.
   c. All required and shown functions for 100 percent of loops.
8. Nonloop-Specific Functions:
   a. Capacity: Demonstrate that PIC systems have required spare capacity for expansion. Include tests for both storage capacity and processing capacity.
   b. Timing: Include tests for timing requirements.
   c. Diagnostics: Demonstrate online and offline diagnostic tests and procedures.
9. Correct deficiencies found and complete prior to shipment to Site.
10. Failed Tests:
    a. Repeat and witnessed by Engineer.
    b. With approval of Engineer, certain tests may be conducted by PIC System Integrator and witnessed by Engineer as part of Functional Test.
11. Make following documentation available to Engineer at test site both before and during FDT:
    a. Drawings, Specifications, Addenda, and Change Orders.
    b. Master copy of FDT procedures.
    c. List of equipment to be tested including make, model, and serial number.
    d. Approved hardware Shop Drawings for equipment being tested.
    e. Approved preliminary software documentation Submittal.

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12. Daily Schedule for FDT:
    a. Begin each day with meeting to review day's test schedule.
    b. End each day with each meeting to review day's test results and to review or revise next day's test schedule.

2.13 MAINTENANCE OF PROGRAMMING EQUIPMENT

A. Provide for maintenance of programming equipment while at Engineer's office. Repair or replace failed equipment within 2 days of notice by Engineer.

PART 3 EXECUTION

3.01 EXAMINATION

A. For equipment not provided by PIC System Integrator, but that directly interfaces with PIC, verify the following conditions:

1. Proper installation.
2. Calibration and adjustment of positioners and I/P transducers.
3. Correct control action.
4. Switch settings and dead bands.
5. Opening and closing speeds and travel stops.
6. Input and output signals.

3.02 INSTALLATION

A. Material and Equipment Installation: Follow manufacturers' installation instructions, unless otherwise indicated or directed by Engineer.

B. Mechanical Systems:

1. Copper and Stainless Steel Tubing Support: Continuously supported by aluminum tubing raceway system.
2. Plastic Tubing Support: Except as shown on Drawings, provide continuous support in conduit or by aluminum tubing raceway system.
3. Install conduit for plastic tubing and tubing raceways parallel with, or at right angles to, structural members of buildings. Make vertical runs straight and plumb.
4. Tubing and Conduit Bends:
    a. Tool-formed without flattening, and of same radius.
    b. Bend Radius: Equal to or larger than conduit and tubing manufacturer's recommended minimum bend radius.
    c. Slope instrument connection tubing in accordance with installation details.

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d. Do not run liquid filled instrument tubing immediately over or within a 3-foot plan view clearance of electrical panels, motor starters, or mechanical mounting panel without additional protection. Where tubing must be located in these zones, shield electrical device to prevent water access to electrical equipment.
e. Straighten coiled tubing by unrolling on flat surface. Do not pull to straighten.
f. Cut tubing square with sharp tubing cutter. Deburr cuts and remove chips. Do not gouge or scratch surface of tubing.
g. Blow debris from inside of tubing.
h. Make up and install fittings in accordance with manufacturer's recommendations. Verify make up of tube fittings with manufacturer's inspection gauge.
i. Use lubricating compound or TFE tape on stainless steel threads to prevent seizing or galling.
j. Run tubing to allow but not limited to, clear access to doors, controls and control panels; and to allow for easy removal of equipment.
k. Provide separate support for components in tubing runs.
l. Supply expansion loops and use adapters at pipe, valve, or component connections for proper orientation of fitting.
m. Keep tubing and conduit runs at least 12 inches from hot pipes.
n. Locate and install tubing raceways in accordance with manufacturer's recommendations. Locate tubing to prevent spillage, overflow, or dirt from above.
o. Securely attach tubing raceways to building structural members.

5. Enclosure Lifting Rings: Remove rings following installation and plug holes.

C. Field Finishing: Refer to Section 09 90 00, Painting and Coating.

3.03 FIELD QUALITY CONTROL

A. General:

1. Coordinate PIC testing with Owner and affected Subcontractors.
2. Notify Engineer of Performance Test schedule 4 weeks prior to start of test.
3. Engineer may actively participate in tests.
4. Engineer reserves right to test or retest specified functions.
5. Engineer's decision will be final regarding acceptability and completeness of testing.

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B. Onsite Supervision:

1. Require PIC System Integrator to observe PIC equipment installation to extent required in order to provide Certificates of Proper Installation.
2. Require PIC site representative to supervise and coordinate onsite PIC activities.
3. Require PIC site representative to be onsite while onsite work covered by this section and PIC subsystems is in progress.

C. Testing Sequence:

1. Provide Functional Tests and Performance Tests for facilities as required to support staged construction and startup of plant.
2. Refer to article Sequence of Work under Section 01 31 13, Project Coordination, for a definition of project milestones.
3. Refer to Section 01 91 00, Equipment Systems Commissioning, for overall testing requirements.
4. Completion: When tests (except Functional Test) have been completed and required test documentation has been accepted.

D. Testing:

1. Prior to Facility Startup and Performance Evaluation period for each facility, inspect, test, and document that associated PIC equipment is ready for operation. Divide Functional Test for each facility into two parts.
2. Preparation for Testing: Performed by PIC System Integrator to test and document PIC is ready for operation.
    a. Loop/Component Inspections and Tests:
        1) These inspections and tests will be spot checked by Engineer.
        2) Check PIC for proper installation, calibration, and adjustment on loop-by-loop and component-by-component basis.
        3) Provide space on forms for signoff by PIC System Integrator.
        4) Use loop status report to organize and track inspection, adjustment, and calibration of each loop and include the following:
            a) Project name.
            b) Loop number.
            c) Tag number for each component.

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d) Checkoffs/Signoffs for Each Component:
   (1) Tag/identification.
   (2) Installation.
   (3) Termination wiring.
   (4) Termination tubing.
   (5) Calibration/adjustment.
e) Checkoffs/Signoffs for the Loop:
   (1) Panel interface terminations.
   (2) I/O interface terminations withPLCs.
f) I/O Signals for PLCs are Operational: Received/sent, processed, adjusted.
g) Total loop operational.
h) Space for comments.

5) Component calibration sheet for each active I&C component (except simple hand switches, lights, gauges, and similar items) and each PLCs I/O module and include the following:
   a) Project name.
   b) Loop number.
   c) Component tag number or I/O module number.
   d) Component code number for I&C elements.
   e) Manufacturer for I&C elements.
   f) Model number/serial number for I&C elements.
   g) Summary of Functional Requirements; For Example:
      (1) Indicators and recorders, scale and chart ranges.
      (2) Transmitters/converters, input and output ranges.
      (3) Computing elements' function.
      (4) Controllers, action (direct/reverse) and control modes (P, I, D).
      (5) Switching elements, unit range, differential (fixed/adjustable), reset (auto/manual).
      (6) I/O Modules: Input or output.
   h) Calibrations, for example, but not limited to:
      (1) Analog Devices: Actual inputs and outputs at 0, 10, 50, and 100 percent of span, rising and falling.
      (2) Discrete Devices: Actual trip points and reset points.
      (3) Controllers: Mode settings (P&ID).
      (4) I/O Modules: Actual inputs or outputs of 0, 10, 50, and 100 percent of span, rising and falling.
      (5) Space for comments.

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b. Maintain loop status reports, valve adjustment sheets, and component calibration sheets at Site, and make them available to Engineer at all times.
c. Engineer reviews loop status sheets and component calibration sheets and spot-check their entries periodically, and upon completion of Preparation for Testing. Correct deficiencies found.
d. FDT-Repeat:
1) Repeat FDT onsite with installed PIC equipment and software.
2) As listed in PIC subsections, certain portions of FDT may not require retesting.
3) Use FDT test procedures as basis for this test.
4) In general, this test shall not require witnessing. However, portions of this test, as identified by Engineer during original FDT shall be witnessed.
e. Forms: See Loop Status Report, Instrument Calibration Sheet, and I&C Valve Adjustment Sheet referenced in Article Supplements.

3. Functional Test:
a. Scope: Confirm PIC, including applications software, is ready for operation.
b. Refer to PIC subsections for additional requirements.
c. Completed when Functional Test has been conducted and Engineer has spot-checked associated test forms and checklists in field.
4. Required Test Documentation: Test procedures, forms, and checklists. Signed by Engineer and Contractor except for Functional Test items signed only by Contractor.

E. Performance Test During and After Facility Startup:

1. Once a facility's Functional Test has been completed and that facility has been started up, perform a witnessed. Performance Test on associated PIC equipment to demonstrate that it is operating as required by Contract Documents. Demonstrate each required function on a paragraph-by-paragraph, loop-by-loop, and site-by-site basis.
2. Loop-specific and nonloop-specific tests same as required for FDT except that entire installed PIC tested using actual process variables and functions demonstrated.
3. Perform local and manual tests for each loop before proceeding to remote and automatic modes.
4. Where possible, verify test results using visual confirmation of process equipment and actual process variable. Unless otherwise directed, exercise and observe devices supplied by others, as needed to verify correct signals to and from such devices and to confirm overall system

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functionality. Test verification by means of disconnecting wires or measuring signal levels is acceptable only where direct operation of plant equipment is not possible.

5. Make updated versions of documentation required for Performance Test available to Engineer at Site, both before and during tests.
6. Make O&M data available to Engineer at Site both before and during testing.
7. Follow daily schedule required for FDT.
8. Determination of Ready for Operation: When Functional Test has been completed.
9. Refer to examples of Performance Test procedures and forms in Article Supplements.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: As required by each PIC subsection.

B. Specialty Equipment: For certain components or systems provided under this section, but not manufactured by PIC System Integrator, provide services of qualified manufacturer's representative during installation, startup, demonstration testing, and training. Provide original equipment manufacturer's services for: None.

3.05 TRAINING

A. General:

1. Provide an integrated training program for Owner's personnel.
2. Perform training to meet specific needs of Owner's personnel.
3. Include training sessions, classroom and field, for managers, engineers, operators, and maintenance personnel.
4. Provide instruction on twoworking shift(s) as needed to accommodate the Owner's personnel schedule.
5. Owner reserves the right to reuse videotapes of training sessions.

B. Operations and Maintenance Training:

1. General:
   a. Refer to specific requirements specified in PIC Subsections.
   b. Include review of O&M data and survey of spares, expendables, and test equipment.
   c. Use equipment similar to that provided.
   d. Unless otherwise specified in PIC subsections, provide training suitable for instrument technicians with at least a 2-year associate

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engineering or technical degree, or equivalent education and experience in electronics, instrumentation, or digital systems.

2. Maintenance Training:
   a. Training Session Duration: 1 instructor day.
   b. Number of Training Sessions: One.
   c. Location: Project Site.
   d. Course Objective: Develop skills needed for routine maintenance of PIC.
   e. Content: Provide training for each type of component and function provided.
      1) Loop Functions: Understanding details of each loop and how they function.
      2) Component calibration.
      3) Adjustments: For example, controller tuning constants, current switch trip points, and similar items.
      4) Troubleshooting and diagnosis for equipment and software.
      5) Replacing lamps, chart paper, and fuses.
      6) I&C components removal and replacement.
      7) Periodic preventive maintenance.

3.06 CLEANING

A. Upon completion of Work, remove materials, scraps, and debris from interior and exterior of equipment.

3.07 PROTECTION

A. Use corrosion-inhibiting vapor capsules in enclosures to protect electrical, instrumentation, and control devices, including spare parts, from corrosion.

B. Periodically replace capsules based on capsule manufacturer's recommendations.

3.08 SUPPLEMENTS

A. Supplements listed below, follows "End of Section," are part of this Specification.

1. Preparation for Testing and Functional Test Forms:
   a. System Problem Report
   b. Loop Status Report: Each sheet shows status of instruments on a loop. Also, gives functional description for loop.
   c. Instrument Calibration Sheet: Shows details on each instrument (except simple hand switches, lights, and similar items).

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d. I&C Valve Adjustment Sheet: Shows details for installation, adjustment, and calibration of a given valve.
e. Performance Test Sheet: Describe Performance Test for a given loop.
    1) List requirements of the loop.
    2) Briefly describe test.
    3) Cite expected results.
    4) Provide space for checkoff by witness.

2. Supplement A - Instrument List.
3. Supplement B - PLC Input/Output List.
4. Supplement C - Control Panel Schedule.

END OF SECTION

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JACOBS **SYSTEM PROBLEM REPORT**			
Project Name:		Project No.:	
Test Name:		**SPR Number:**	
Test Number:		Problem Status:	
Problem Type: Hardware, Software, Documentation, Unknown, Other			
SYMPTOMS:	Time:	Date:	By:
Description:			
Can problem be reproduced at will? Y / N			
DIAGNOSIS:	Time:	Date:	By:
Description:			
CORRECTION:	Time:	Date:	By:
Description:			
FINAL SIGN OFF	Time:	Date:	By:

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JACOBS
LOOP STATUS REPORT

Project Name:	Project No.

FUNCTIONAL REQUIREMENTS:

COMPONENT STATUS (Check and initial each item when complete)

Tag Number	Delivered	Tag ID Checked	Installation	Termination Wiring	Termination Tubing	Calibration	

REMARKS:

Loop Ready for Operation	By:	Date:	Loop No.:

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JACOBS
INSTRUMENT CALIBRATION SHEET

COMPONENT	**MANUFACTURER**	**PROJECT**
Code:	Name:	Number:
Name:	Model:	Name:
	Serial #:	

FUNCTIONS

	RANGE	VALUE	UNITS	COMPUTING FUNCTIONS? Y / N	CONTROL? Y / N Action? direct / reverse Modes? P / I / D
Indicate? Y / N	Chart:			Describe:	
Record? Y / N	Scale:				SWITCH? Y / N Unit Range: Differential: fixed/adjustable Reset? automatic / manual
Transmit/	Input:				
Convert? Y / N	Output:				

ANALOG CALIBRATIONS

REQUIRED			AS CALIBRATED			
			Increasing Input		Decreasing Input	
Input	Indicated	Output	Indicated	Output	Indicated	Output
CONTROL MODE SETTINGS:			P:	I:	D:	

DISCRETE CALIBRATIONS

	REQUIRED		AS CALIBRATED		Note.
Number	Trip Point	Reset Pt.	Trip Point	Reset Pt.	No
	(note rising or falling)		(note rising or falling)		
1.					
2.					
3.					
4.					
5.					
6.					

#	**NOTES:**	**Component Calibrated and Ready for Start-up**
		Date:
		Tag No.:

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JACOBS I&C VALVE ADJUSTMENT SHEET		
PARTS	Project Name:	Project Number:
Body	Type:	Mfr:
	Size:	Model:
	Line Connection:	Serial #:
Operator	Type:	Mfr:
	Action:	Model:
	Travel:	Serial #:
Positioner	Input Signal:	Mfr:
	Action:	Model:
	Cam:	Serial #:
Pilot Solenoid	Action:	Mfr:
	Rating:	Model:
		Serial #:
I/P Converter	Input:	Mfr:
	Output:	Model:
	Action:	Serial #:
Position Switch	Settings:	Mfr:
	Contacts:	Model:
		Serial #:
Power Supply	Type:	Air Set Mfr:
	Potential:	Model:
		Serial #:

ADJUSTMENTS	Initial	Date	**VERIFICATION**	Initial	Date
Air Set			Valve Action		
Positioner			Installation		
Position Switches			Wire Connection		
I/P Converter			Tube Connection		
Actual Speed					

REMARKS:	**Valve Ready for Start-up**
	By:
	Date:
	Tag No.:

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JACOBS **PERFORMANCE TEST SHEET**	
Project Name:	Project No.:
Demonstration test(s): For each functional Requirement of the loop: (a) List and number the requirement. (b) Briefly describe the demonstration test. (c) Cite the results that will verify the required performance. (d) Provide space for signoff.	

Forms/Sheets Verified	By	Date	**Loop Accepted By Owner**
Loop Status Report			By:
Instrument Calibration Sheet			Date:
I&C Valve Calibration Sheet			
Performance Test	By	Date	
Performed			
Witnessed			Loop No.:

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INSTRUMENT LIST											
No	**DEVICE TAG**	**P&ID**	**DESCRIPTION**	**PANEL**	**Component Code (Refer to 40 91 00)**	**Scale Range**	**PLC I/O Type**	**Signal Type**	**POWER SUPPLY**	**Mounting Detail**	**NOTES**
1	LSH 69-1011A	69-I-1	CPT Influent Screen 1 - Level Switch	PLC-69	L31	See Notes	DI	NO CONTACT	120V AC	4092-011	Part of vendor supplied package system
2	LS 69-1011B	69-I-1	CPT Influent Screen 1 - Overflow Level Switch	PLC-69	L31	See Notes	DI	NO CONTACT	120V AC	4091-026	Part of vendor supplied package system
3	LSH 69-1012A	69-I-1	CPT Influent Screen 2 - Level Switch	PLC-69	L31	See Notes	DI	NO CONTACT	120V AC	4092-011	Part of vendor supplied package system
4	LS 69-1012B	69-I-1	CPT Influent Screen 2 - Overflow Level Switch	PLC-69	L31	See Notes	DI	NO CONTACT	120V AC	4091-026	Part of vendor supplied package system
5	FV 69-4901	69-I-2	Anammox Screen 1 W3 Spray - Solenoid	PLC-69	See Notes	See Notes	DI	NO CONTACT	120V AC	4092-011	Part of vendor supplied package system
6	LSH 69-4901	69-I-2	Anammox Screen 1 W3 Spray - Level Switch	PLC-69	See Notes	See Notes	DI	NO CONTACT	120V AC	4091-026	Part of vendor supplied package system
7	FV 69-4902	69-I-2	Anammox Screen 2 W3 Spray - Solenoid	PLC-69	See Notes	See Notes	DI	NO CONTACT	120V AC	4092-011	Part of vendor supplied package system
8	LSH 69-4902	69-I-2	Anammox Screen 2 W3 Spray - Level Switch	PLC-69	See Notes	See Notes	DI	NO CONTACT	120V AC	4091-026	Part of vendor supplied package system
9	FE 69-1101	69-I-2	Flow Split to Reactor 1 - Flow Meter	PLC-69	F4	115 - 400 gpm	AI	4-20mA	120V AC	4091-220G	Section 02 64 02- Existing Products
10	FE 69-1102	69-I-2	Flow Split to Reactor 2 - Flow Meter	PLC-69	F4	115 - 400 gpm	AI	4-20mA	120V AC	4091-220G	Section 02 64 02- Existing Products
11	AE/AIT 69-6100	69-I-2	Reactor 1 Conductivity Probe	PLC-69	See Notes	10 µS/cm -20 mS/cm	AI	4-20mA	120V AC	See Drawings Wall mount terminal/controller per 4091-388	Section 02 64 02- Existing Products
12	AE 69-6601	69-I-2	Reactor 1 DO sensor	PLC-69	See Notes	0 - 5 mg/L @ 25°C	AI	4-20mA	120V AC	Existing Installation	Section 02 64 02- Existing Products
13	AE 69-6701	69-I-2	Reactor 1 PH sensor	PLC-69	See Notes	5 - 10 pH	AI	4-20mA	120V AC	Existing Installation	Section 02 64 02- Existing Products
14	AE/AY 69-6801	69-I-2	Reactor 1 NH3 Sensor	PLC-69	See Notes	NH4-N: 1 - 1000 mg/l; NH4 +: 1 - 1290 mg/l; K+: 1 - 1000 mg/l; pH 4 - 8.5	AI	4-20mA	120V AC	Existing Installation	Section 02 64 02- Existing Products
15	AE 69-6901	69-I-2	Reactor 1 NO3 Sensor	PLC-69	See Notes	NO3-N: 1-1000 mg/l; NO3 -: 5 - 4500 mg/l; Cl-: 1 - 1000 mg/l; pH 4 - 11	AI	4-20mA	120V AC	Existing Installation	Section 02 64 02- Existing Products
16	AE/AIT 69-6200	69-I-2	Reactor 2 Conductivity Probe	PLC-69	See Notes	10 µS/cm -20 mS/cm	AI	4-20mA	120V AC	See Drawings Wall mount terminal/controller per 4091-388	Section 02 64 02- Existing Products
17	AE 69-6602	69-I-2	Reactor 2 DO sensor	PLC-69	See Notes	0 - 5 mg/L @ 25°C	AI	4-20mA	120V AC	Existing Installation	Section 02 64 02- Existing Products
18	AE 69-6702	69-I-2	Reactor 2 pH sensor	PLC-69	See Notes	5 - 10 pH	AI	4-20mA	120V AC	Existing Installation	Section 02 64 02- Existing Products
19	AE/AY 69-6802	69-I-2	Reactor 2 NH3 Sensor	PLC-69	See Notes	NH4-N: 1 - 1000 mg/l; NH4 +: 1 - 1290 mg/l; K+: 1 - 1000 mg/l; pH 4 - 8.5	AI	4-20mA	120V AC	Existing Installation	Section 02 64 02- Existing Products
20	AE 69-6902	69-I-2	Reactor 2 NO3 Sensor	PLC-69	See Notes	NO3-N: 1-1000 mg/l; NO3 -: 5 - 4500 mg/l; Cl-: 1 - 1000 mg/l; pH 4 - 11	AI	4-20mA	120V AC	Existing Installation	Section 02 64 02- Existing Products
21	TIT 69-1201	69-I-2	Reactor 1 CPTE Temperature Indicator	PLC-69	T3	50 - 120 F	AI	4-20mA	120V AC	4091-362	Relocate from existing RCY Lines
22	TIT 69-1202	69-I-2	Reactor 2 CPTE Temperature Indicator	PLC-69	T3	50 - 120 F	AI	4-20mA	120V AC	4091-362	Relocate from existing RCY Lines
23	FE/FIT 69-2201	69-I-3	Reactor 1 Thermal Mass Air Flow Meter	PLC-69	F51	Flow: 239-710 scfm Pressure: 11 psig Temp.: Up to 240 deg. F	AI	4-20mA	120V AC	4091-217	
24	FE/FIT 69-2202	69-I-3	Reactor 2 Thermal Mass Air Flow Meter	PLC-69	F51	Flow: 239-710 scfm Pressure: 11 psig Temp.: Up to 240 deg. F	AI	4-20mA	120V AC	4091-217	

INPUT / OUTPUT LIST

NO.	AREA	DEVICE TYPE	LOOP NO.	MODIFIER	DEVICE TAG	SIGNAL SUFFIX	P&ID	DESCRIPTION	PANEL	I/O Type	Signal Type	POWER SUPPLY	NOTES
1	69	FV	1011		69-FV-1011	OPEN	69-I-1	Influent Flow Valve - Open	PLC-69	DO	NO CONTACT	N/A	
2	69	FV	1011		69-FV-1011	CLOSE	69-I-1	Influent Flow Valve - Close	PLC-69	DO	NO CONTACT	N/A	
3	69	FV	1011		69-FV-1011	OPENED	69-I-1	Influent Flow Valve - Opened	PLC-69	DI	NO CONTACT	N/A	
4	69	FV	1011		69-FV-1011	CLOSED	69-I-1	Influent Flow Valve - Closed	PLC-69	DI	NO CONTACT	N/A	
5	69	FV	1011		69-FV-1011	PLC	69-I-1	Influent Flow Valve - PLC	PLC-69	DI	NO CONTACT	N/A	
6	69	FV	1012		69-FV-1012	OPEN	69-I-1	Influent Flow Valve - Open	PLC-69	DO	NO CONTACT	N/A	
7	69	FV	1012		69-FV-1012	CLOSE	69-I-1	Influent Flow Valve - Close	PLC-69	DO	NO CONTACT	N/A	
8	69	FV	1012		69-FV-1012	OPENED	69-I-1	Influent Flow Valve - Opened	PLC-69	DI	NO CONTACT	N/A	
9	69	FV	1012		69-FV-1012	CLOSED	69-I-1	Influent Flow Valve - Closed	PLC-69	DI	NO CONTACT	N/A	
10	69	FV	1012		69-FV-1012	PLC	69-I-1	Influent Flow Valve - PLC	PLC-69	DI	NO CONTACT	N/A	
11	69	HS	1011		69-HS-1011	E-STOP	69-I-1	CPT Influent Screen 1 - E-stop	PLC-69	DI	NC CONTACT	N/A	Provided with CPT Influent Screens
12	69	HS	1011		69-HS-1011	PLC	69-I-1	CPT Influent Screen 1 - PLC	PLC-69	DI	NO CONTACT	N/A	Provided with CPT Influent Screens
13	69	XA	1011		69-XA-1011	FAULT	69-I-1	CPT Influent Screen 1 -Fault	PLC-69	DI	NC CONTACT	N/A	Provided with CPT Influent Screens
14	69	YL	1011		69-YL-1011	ENABLE	69-I-1	CPT Influent Screen 1 - ENABLE Run Command	PLC-69	DO	NO CONTACT	N/A	Provided with CPT Influent Screens
15	69	XA	1011		69-XA-1011	ON	69-I-1	CPT Influent Screen 1 - On Status	PLC-69	DI	NO CONTACT	N/A	Provided with CPT Influent Screens
16					CP69-1011	ENABLE SLUICE WATER	69-I-1	CPT Influent Screen 1 - ENABLE Sluice Water	PLC-69	DO	NO CONTACT	N/A	Provided with CPT Influent Screens
17	69	CP	1011		69-CP-1011	SLUICE WATER ON	69-I-1	CPT Influent Screen 1 - Sluice Water On	PLC-69	DI	NO CONTACT	N/A	Provided with CPT Influent Screens
18	69	LSH	1011	A	69-LSH-1011A	OVERFLOW	69-I-1	CPT Influent Screen 1 - Overflow	PLC-69	DI	NO CONTACT	N/A	Provided with CPT Influent Screens
19	69	LSH	1011	B	69-LSH-1011B	LEVEL SWITCH	69-I-1	CPT Influent Screen 1 - Level switch	PLC-69	DI	NO CONTACT	N/A	Provided with CPT Influent Screens
20	69	HS	1012		69-HS-1012	E-STOP	69-I-1	CPT Influent Screen 2 - E-stop	PLC-69	DI	NC CONTACT	N/A	Provided with CPT Influent Screens
21	69	HS	1012		69-HS-1012	PLC	69-I-1	CPT Influent Screen 2 - PLC	PLC-69	DI	NO CONTACT	N/A	Provided with CPT Influent Screens
22	69	XA	1012		69-XA-1012	FAULT	69-I-1	CPT Influent Screen 2 -Fault	PLC-69	DI	NC CONTACT	N/A	Provided with CPT Influent Screens
23	69	YL	1012		69-YL-1012	ENABLE	69-I-1	CPT Influent Screen 2 - ENABLE Run Command	PLC-69	DO	NO CONTACT	N/A	Provided with CPT Influent Screens
24	69	XA	1012		69-XA-1012	ON	69-I-1	CPT Influent Screen 2 - On Status	PLC-69	DI	NO CONTACT	N/A	Provided with CPT Influent Screens
25					CP69-1012	ENABLE SLUICE WATER	69-I-1	CPT Influent Screen 2 - ENABLE Sluice Water	PLC-69	DO	NO CONTACT	N/A	Provided with CPT Influent Screens
26	69	CP	1012		69-CP-1012	SLUICE WATER ON	69-I-1	CPT Influent Screen 2 - Sluice Water On	PLC-69	DI	NO CONTACT	N/A	Provided with CPT Influent Screens
27	69	LSH	1012	A	69-LSH-1012A	OVERFLOW	69-I-1	CPT Influent Screen 2 - Overflow	PLC-69	DI	NO CONTACT	N/A	Provided with CPT Influent Screens
28	69	LSH	1012	B	69-LSH-1012B	LEVEL SWITCH	69-I-1	CPT Influent Screen 2 - Level switch	PLC-69	DI	NO CONTACT	N/A	Provided with CPT Influent Screens
29	69	HS	1021		69-HS-1021	E-STOP	69-I-1	CPT Wash Press - E-stop	PLC-69	DI	NC CONTACT	N/A	Provided with CPT Wash Press
30	69	HS	1021		69-HS-1021	PLC	69-I-1	CPT Wash Press - PLC	PLC-69	DI	NO CONTACT	N/A	Provided with CPT Wash Press
31	69	XA	1021		69-XA-1021	FAULT	69-I-1	CPT Wash Press -Fault	PLC-69	DI	NC CONTACT	N/A	Provided with CPT Wash Press
32	69	YL	1021		69-YL-1021	ENABLE	69-I-1	CPT Wash Press - ENABLE Run Command	PLC-69	DO	NO CONTACT	N/A	Provided with CPT Wash Press
33	69	XA	1021		69-XA-1021	ON	69-I-1	CPT Wash Press - On Status	PLC-69	DI	NO CONTACT	N/A	Provided with CPT Wash Press
34	69	FE	1101		69-FE-1101	FI	69-I-2	Flow split to reactor 1 - Flow Indicator	PLC-69	AI	4-20mA	120 V	
35	69	FCV	1101		69-FCV-1101	POSITION CMD	69-I-2	Flow split to reactor 1 - Position Command	PLC-69	AO	NO CONTACT	N/A	
36	69	FIT	1101		69-FIT-1101	POSITION	69-I-2	Flow split to reactor 1 - Position	PLC-69	AI	4-20mA	120 V	
37	69	HS	1101		69-HS-1101	PLC	69-I-2	Flow split to reactor 1 - PLC	PLC-69	DI	NO CONTACT	N/A	
38	69	XA	1101		69-XA-1101	FAULT	69-I-2	Flow split to reactor 1 - Fault	PLC-69	DI	NC CONTACT	N/A	
39	69	FE	1102		69-FE-1102	FI	69-I-2	Flow split to reactor 2 - Flow Indicator	PLC-69	AI	4-20mA	120 V	
40	69	FCV	1102		69-FCV-1102	POSITION CMD	69-I-2	Flow split to reactor 2 - Position Command	PLC-69	AO	NO CONTACT	N/A	
41	69	FIT	1102		69-FIT-1102	POSITION	69-I-2	Flow split to reactor 2 - Position	PLC-69	AI	4-20mA	120 V	
42	69	HS	1102		69-HS-1102	PLC	69-I-2	Flow split to reactor 2 - PLC	PLC-69	DI	NO CONTACT	N/A	
43	69	XA	1102		69-XA-1102	FAULT	69-I-2	Flow split to reactor 2 - Fault	PLC-69	DI	NC CONTACT	N/A	
44	69	AE/AIT	6501		69-AE/AIT-6501	DATA LINK	69-I-2	Reactor 1 - Conductivity	PLC-69				Each Datalink from Multiparameter Composition Sensor to PLC 69 will be supporting the conductivity meter, NO2, NO3, pH, DO, NH3.
45	69	AE/AIT	6901		69-AE/AIT-6901	DATA LINK	69-I-2	Reactor 1 - NO2	PLC-69				
46	69	AE/AIT	6901		69-AE/AIT-6901	DATA LINK	69-I-2	Reactor 1 - NO3	PLC-69				
47	69	AE/AIT	6601		69-AE/AIT-6601	DATA LINK	69-I-2	Reactor 1 - DO	PLC-69				
48	69	AE/AIT	6701		69-AE/AIT-6701	DATA LINK	69-I-2	Reactor 1 - pH	PLC-69				
49	69	AE/AIT	6801		69-AE/AIT-6801	DATA LINK	69-I-2	Reactor 1 - NH3	PLC-69				
50	69	AE/AIT	6502		69-AE/AIT-6502	DATA LINK	69-I-2	Reactor 2 - Conductivity	PLC-69				Each Datalink from Multiparameter Composition Sensor to PLC 69 will be supporting the conductivity meter, NO2, NO3, pH, DO, NH3.
51	69	AE/AIT	6902		69-AE/AIT-6902	DATA LINK	69-I-2	Reactor 2 - NO2	PLC-69				
52	69	AE/AIT	6902		69-AE/AIT-6902	DATA LINK	69-I-2	Reactor 2 - NO3	PLC-69				
53	69	AE/AIT	6602		69-AE/AIT-6602	DATA LINK	69-I-2	Reactor 2 - DO	PLC-69				
54	69	AE/AIT	6702		69-AE/AIT-6702	DATA LINK	69-I-2	Reactor 2 - pH	PLC-69				
55	69	AE/AIT	6802		69-AE/AIT-6802	DATA LINK	69-I-2	Reactor 2 - NH3	PLC-69				
56	69	XA	1401		69-XA-1401	ON	69-I-2	CPT Reactor Mixer -1	PLC-69	DI	NC CONTACT	N/A	
57	69	HS	1401		69-HS-1401	PLC	69-I-2	CPT Reactor Mixer -1	PLC-69	DI	NC CONTACT	N/A	
58	69	M	1401		69-M-1401	RUN	69-I-2	CPT Reactor Mixer -1	PLC-69	DO	NO CONTACT	N/A	
59	69	XA	1402		69-XA-1402	ON	69-I-2	CPT Reactor Mixer -2	PLC-69	DI	NC CONTACT	N/A	
60	69	HS	1402		69-HS-1402	PLC	69-I-2	CPT Reactor Mixer -2	PLC-69	DI	NC CONTACT	N/A	
61	69	M	1402		69-M-1402	RUN	69-I-2	CPT Reactor Mixer -2	PLC-69	DO	NO CONTACT	N/A	
62	69	FV	4901		69-FV-4901	SPRAY ON	69-I-2	Anammox Screen 1 - Spray On	PLC-69	DO	NO CONTACT	120 V	Provided with WWW Package System
63	69	LSH	4901		69-LSH-4901	HIGH LEVEL	69-I-2	Anammox Screen 1 - Level High	PLC-69	DI	NC CONTACT	120 V	Provided with WWW Package System
64	69	FV	4901		69-FV-4902	SPRAY ON	69-I-2	Anammox Screen 2 - Spray On	PLC-69	DO	NO CONTACT	120 V	Provided with WWW Package System
65	69	LSH	4901		69-LSH-4902	HIGH LEVEL	69-I-2	Anammox Screen 2 - Level High	PLC-69	DI	NC CONTACT	120 V	Provided with WWW Package System
66	69	P	4601		69-P-4601	ON	69-I-2	Reactor 1 Submersible Pump - On	PLC-69	DI	NO CONTACT	N/A	Through MCC-69-1A
67	69	P	4601		69-P-4601	FAULT	69-I-2	Reactor 1 Submersible Pump - Fault	PLC-69	DI	NC CONTACT	N/A	Through MCC-69-1A
68	69	HS	4601		69-HS-4601	PLC	69-I-2	Reactor 1 Submersible Pump - PLC	PLC-69	DI	NO CONTACT	N/A	Through MCC-69-1A

INPUT / OUTPUT LIST

NO.	AREA	DEVICE TYPE	LOOP NO.	MODIFIER	DEVICE TAG	SIGNAL SUFFIX	P&ID	DESCRIPTION	PANEL	I/O Type	Signal Type	POWER SUPPLY	NOTES
69	69	P	4601		69-P-4601	RUN	69-I-2	Reactor 1 Submersible Pump - Run	PLC-69	DO	NO CONTACT	N/A	Through MCC-69-1A
70	69	P	4602		69-P-4602	ON	69-I-2	Reactor 2 Submersible Pump - On	PLC-69	DI	NO CONTACT	N/A	Through MCC-69-1A
71	69	P	4602		69-P-4602	FAULT	69-I-2	Reactor 2 Submersible Pump - Fault	PLC-69	DI	NC CONTACT	N/A	Through MCC-69-1A
72	69	HS	4602		69-HS-4602	PLC	69-I-2	Reactor 2 Submersible Pump - PLC	PLC-69	DI	NO CONTACT	N/A	Through MCC-69-1A
73	69	P	4602		69-P-4602	RUN	69-I-2	Reactor 2 Submersible Pump - Run	PLC-69	DO	NO CONTACT	N/A	Through MCC-69-1A
74	69	TIT	1201		69-TIT-1201	TI	69-I-2	Reactor 1 CPTE Temperature Indicator	PLC-69	AI	4-20mA	120 V	
75	69	TIT	1202		69-TIT-1202	TI	69-I-2	Reactor 2 CPTE Temperature Indicator	PLC-69	AI	4-20mA	120 V	
76	69	B	2001		69-B-2001	FAULT	69-I-3	PD Blower 1 - Fault	PLC-69	DI	NC CONTACT	N/A	
77	69	B	2001		69-B-2001	DATA LINK	69-I-3	PD Blower 1	PLC-69				Datalink from Blower Control Panel to Plant PLC
78	69	B	2002		69-B-2002	FAULT	69-I-3	PD Blower 2 - Fault	PLC-69	DI	NC CONTACT	N/A	
79	69	B	2002		69-B-2002	DATA LINK	69-I-3	PD Blower 2	PLC-69				Datalink from Blower Control Panel to Plant PLC
80	69	B	2003		69-B-2003	FAULT	69-I-3	PD Blower 3 - Fault	PLC-69	DI	NC CONTACT	N/A	
81	69	B	2003		69-B-2003	DATA LINK	69-I-3	PD Blower 3	PLC-69				Datalink from Blower Control Panel to Plant PLC
82	69	FV	2201		69-FV-2201	OPEN	69-I-3	Blower Header Isolation Valve 1 - Open	PLC-69	DO	NO CONTACT	N/A	
83	69	FV	2201		69-FV-2201	CLOSE	69-I-3	Blower Header Isolation Valve 1 - Close	PLC-69	DO	NO CONTACT	N/A	
84	69	FV	2201		69-FV-2201	OPENED	69-I-3	Blower Header Isolation Valve 1 - Opened	PLC-69	DI	NO CONTACT	N/A	
85	69	FV	2201		69-FV-2201	CLOSED	69-I-3	Blower Header Isolation Valve 1 - Closed	PLC-69	DI	NO CONTACT	N/A	
86	69	FV	2201		69-FV-2201	PLC	69-I-3	Blower Header Isolation Valve 1 - PLC	PLC-69	DI	NO CONTACT	N/A	
87	69	FV	2201		69-FV-2201	FAULT	69-I-3	Blower Header Isolation Valve 1 - Fault	PLC-69	DI	NC CONTACT	N/A	
88	69	FV	2202		69-FV-2202	OPEN	69-I-3	Blower Header Isolation Valve 2 - Open	PLC-69	DO	NO CONTACT	N/A	
89	69	FV	2202		69-FV-2202	CLOSE	69-I-3	Blower Header Isolation Valve 2 - Close	PLC-69	DO	NO CONTACT	N/A	
90	69	FV	2202		69-FV-2202	OPENED	69-I-3	Blower Header Isolation Valve 2 - Opened	PLC-69	DI	NO CONTACT	N/A	
91	69	FV	2202		69-FV-2202	CLOSED	69-I-3	Blower Header Isolation Valve 2 - Closed	PLC-69	DI	NO CONTACT	N/A	
92	69	FV	2202		69-FV-2202	PLC	69-I-3	Blower Header Isolation Valve 2 - PLC	PLC-69	DI	NO CONTACT	N/A	
93	69	FV	2202		69-FV-2202	FAULT	69-I-3	Blower Header Isolation Valve 2 - Fault	PLC-69	DI	NC CONTACT	N/A	
94	69	FIT	2201		69-FIT-2201	Airflow	69-I-3	Reactor 1 Thermal Mass Meter	PLC-69	AI	4-20mA	120 V	
95	69	FIT	2202		69-FIT-2202	Airflow	69-I-3	Reactor 2 Thermal Mass Meter	PLC-69	AI	4-20mA	120 V	
96	69	SV	2311		69-SV-2311	OPEN	69-I-3	Reactor 1 Dropleg 1 Purge Solenoid Valve	PLC-69	DO	NO CONTACT	N/A	
97	69	SV	2321		69-SV-2321	OPEN	69-I-3	Reactor 1 Dropleg 2 Purge Solenoid Valve	PLC-69	DO	NO CONTACT	N/A	
98	69	SV	2312		69-SV-2312	OPEN	69-I-3	Reactor 2 Dropleg 1 Purge Solenoid Valve	PLC-69	DO	NO CONTACT	N/A	
99	69	SV	2322		69-SV-2322	OPEN	69-I-3	Reactor 2 Dropleg 2 Purge Solenoid Valve	PLC-69	DO	NO CONTACT	N/A	
98	69				P69-6601	DATA LINK	69-I-6	Micronutrient Pump	PLC-69				Datalink from Pump Control Panel to Plant PLC

CONTROL PANEL SCHEDULE

Panel Name	Building	Service/Location	New Enclosure	New PLC/RIO	P&ID	Mounting	NEMA	Dimensions H W D	Notes
SCADA AND LOCAL CONTROL PANELS									
CP 69-1011	69	CPT Influent Screen 1	Yes	No	69-I-1	Freestanding	NEMA 4X	24"H x 24"W x 8"D	Part of Vendor Supplied Package System
CP 69-1012	69	CPT Influent Screen 2	Yes	No	69-I-1	Freestanding	NEMA 4X	24"H x 24"W x 8"D	Part of Vendor Supplied Package System
CP 69-1021	69	Wash Press	Yes	No	69-I-1	Wall	NEMA 4X	30"H x 24"W x 10"D	Part of Vendor Supplied Package System
FP 69-2001	69	Blower Control Panel	N/A	No	69-I-3	Integrated in Unit	NEMA 12	48"H x 36"W x 16"D	Part of Vendor Supplied Package System
FP 69-2002	69	Blower Control Panel	N/A	No	69-I-3	Integrated in Unit	NEMA 12	48"H x 36"W x 16"D	Part of Vendor Supplied Package System
FP 69-2003	69	Blower Control Panel	N/A	No	69-I-3	Integrated in Unit	NEMA 12	48"H x 36"W x 16"D	Part of Vendor Supplied Package System
CP 69-2201	69	Blower Header Isolation Valve 1	Yes	No	69-I-3	Wall	NEMA 12	20" x 16" x 8"	
CP 69-2202	69	Blower Header Isolation Valve 2	Yes	No	69-I-3	Wall	NEMA 12	20" x 16" x 8"	
Totals			**5**	**0**	**0**				

SECTION 40 91 00
INSTRUMENTATION AND CONTROL COMPONENTS

PART 1 GENERAL

1.01 SUMMARY

A. This section gives general requirements for instrumentation and control components.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

PART 2 PRODUCTS

2.01 GENERAL

A. Article Mechanical Systems Components covers requirements of mechanical PIC components that are not specifically referenced by Section 40 90 00, Instrumentation and Control for Process Systems, Instrument Lists or Data Sheets.

B. Article Electrical Components covers requirements for electrical PIC components that are not specifically referenced by Section 40 90 00, Instrumentation and Control for Process Systems, Instrument Lists or Data Sheets.

C. All other Part 2 articles cover components that are referenced by Instrument Lists or Data Sheets in Section 40 90 00, Instrumentation and Control for Process Systems, or by specific component numbers in other PIC subsections.

D. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the

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maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 MECHANICAL SYSTEMS COMPONENTS

A. Flow Element, Rotameter, Purge:

1. For air or water service, unless otherwise noted.
2. Materials: Glass tube, fiberglass body, stainless steel float, nylon ball check valve.
3. Direct-Reading Scale Length: 2-1/2 inches, minimum.
4. Scale Ranges: 0 scfh to 2.5 scfh for air service or 0 gph to 10 gph for water service.
5. Integral inlet needle valves.
6. Integral differential pressure regulators:
   a. For water service.
   b. For air service for level ranges greater than 10 feet of water.
7. Rotameters for water service.
8. Manufacturers and Products:
   a. Fischer & Porter; Series 10A3130.
   b. Brooks; Series DS-1350.

B. Manifold, Three-Valve Equalizing:

1. Type: For isolation and equalization of differential pressure transducers.
2. Materials: Stainless steel.
3. Manufacturers and Products:
   a. Anderson, Greenwood and Co.; Type M1.
   b. Evans.

C. Pressure Gauge: For other than process variable measurement.

1. Dial Size: Nominal 2-inch dial size.
2. Accuracy: 2 percent of span.
3. Scale Range: Such that normal operating pressure lies between 50 percent and 80 percent of scale range.
4. Connection: 1/4-inch NPT through bottom, unless otherwise noted.
5. Manufacturers and Products:
   a. Ashcroft Utility; Gauge Series 1000.
   b. Marsh; Standard Gauge Series.
   c. Ametek U.S.; Gauge Series P500.
   d. Acculite; Series 2000.

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D. Valve, Needle:

1. Materials: Brass, stainless steel, PVC, or CPCV, as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
2. Size: 0.020-inch orifice.
3. Manufacturers and Products:
    a. Whitey; Model 21RF2.
    b. Hoke; 3700 Series.

E. ON/OFF Valves:

1. Type: Ball valve.
2. Materials: Brass, stainless steel, PVC, or CPCV, as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
3. Manufacturers and Products:
    a. Whitey; Series 41 through Series 43.
    b. Hoke; Flomite 7100 Series.

F. Regulating Valves:

1. Type: Needle valves, with regulating stems and screwed bonnets.
2. Materials: Brass, stainless steel, PVC, or CPCV, as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
3. Manufacturers and Products:
    a. Whitey; Catalog No. RF or No. RS.
    b. Hoke; 3100 through 3300 Series.

G. Valve, Three-Way:

1. Type: Ball valve.
2. Materials: Brass or stainless steel with nylon handle as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
3. Manufacturers and Products:
    a. Whitey; Series 41 through Series 43.
    b. Hoke; Selecto-Mite Series.

H. Valve, Four-Way:

1. Type: Four-way, two-position ball valve.

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2. Materials:
    a. Body and Stem: Type 316 stainless steel.
    b. Handle: Black nylon.
    c. Packing Gland: Teflon.
3. Ball and stem bed, one-piece assembly.
4. Machined handle stops and directional nameplates.
5. Manufacturers and Products:
    a. Whitey; Series 457.
    b. Hoke; Multi-Mite Series.

I. Spool Valve:

1. Type: Five-port arrangement as shown, two-position, push-to-operate knob attached to the spool stem, and spring return.
2. Materials: Aluminum construction with Teflon impregnated aluminum spool, stainless steel spring, and Buna-N O-rings.
3. Port Connection: 1/4-inch outside diameter tube fittings.
4. Manufacturer and Product: Norgren; T71DAOO-TSO-TKO.

J. Pressure Regulator, Air:

1. Provide air at reduced pressures, as shown, constant to within plus or minus 10 percent for flows from 0 scfh to 300 scfh with 100 psi supply pressure.
2. Setscrew for outlet pressure adjustment.
3. Integral filter and relief valve.
4. Manufacturers and Products:
    a. Masoneilan; Series 77-4.
    b. Fisher; Series 67FR.

K. Pressure Regulator, Water:

1. Materials:
    a. Body: Bronze.
    b. Spring Case: Cast iron.
    c. Seat Rings: Brass.
    d. Valve Disk and Holder: Buna-N and bronze.
    e. Diaphragm: Buna-N diaphragm.
2. Sizing: For maximum of 7 psi offset pressure.
3. Manufacturers and Products:
    a. Fisher; Controls Type 95H or 95L.
    b. Masoneilan; Series 17.

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L. Test Tap:

1. Manufacturers and Products:
   a. Imperial-Eastman; quick-disconnect couplings No. 292-P and caps No. 259-P.
   b. Crawford Fitting Co.; Swagelok quick-connects Series QC4 and caps QC4-DC.
   c. Parker; CPI Series precision quick couplings.

M. Copper Tubing and Fittings:

1. Type K hard copper, ASTM B88, with commercially pure wrought copper solder joint fittings. Make joints with 95-5 wire solder, ASTM B32, Grade 95 TA. Do not use cored solder.
2. Alternatively, Type K, soft temper copper tubing, ASTM B88, with brass compression type fittings may be used where shown on Drawings.
3. Manufacturers:
   a. Parker-Hannifin.
   b. Swagelok tube fittings.

N. Plastic Tubing and Fittings:

1. Tubing:
   a. Polyethylene capable of withstanding 190 psig at 175 degrees F.
   b. Manufacturers and Products:
      1) Dekoron; Type P.
      2) Imperial Eastman; Poly-Flo black instrument tubing.
2. Fittings:
   a. Type: Brass compression.
   b. Manufacturers and Products:
      1) Imperial Eastman; Poly-Flo tube fittings.
      2) Dekoron; E-Z fittings.

O. Stainless Steel Tubing: ASTM A312/A312M, Type 316, 0.065-inch wall, seamless, soft annealed, as shown on Drawings.

P. Stainless Steel Fittings:

1. Compression Type:
   a. Materials: Type 316 stainless steel, ASTM A182/A182M forged bodies or ASTM A276 barstock bodies, flareless.
   b. Manufacturers and Products:
      1) Parker Flodar; BA Series.
      2) Swagelok tube fittings.

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3) Parker CPI tube fittings; Parker A-LOK dual ferrule tube fittings.

2. Socket Weld Type:
   a. Materials: Type 316 stainless steel, ASTM A182/A182M forged bodies or ASTM A276 barstock bodies, 3,000 psi maximum working pressure, safety factor 4:1.
   b. Manufacturers:
      1) Cajon.
      2) Swagelok.
      3) Parker WELDLOK.

Q. Air Set: Consists of a shutoff valve, pressure regulator, discharge pressure gauge, and interconnecting tubing.

R. Purge Set:

1. Parts: Purge rotameter flow element, pressure regulator, pressure gauge, test tap, shutoff valve, spool valve, and interconnecting tubing as shown on Drawings and as required in this section.
2. Pressure Gauge Scale Range: 150 percent of the process variable.
3. Mounting:
   a. Within consoles, panels, or a separate enclosure as shown.
   b. For separate enclosure mounted purge sets, refer to paragraphs Nonfreestanding Panel Construction and Factory Finishing for enclosure requirements.

S. Tubing Raceways:

1. Cable tray systems complete with tees, elbows, reducers, and covers.
2. Size in accordance with manufacturer’s recommendations for intended service.
3. Materials: Galvanized steel or aluminum brass as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
4. Manufacturers:
   a. Globetray.
   b. Cope.

T. Air Supply Sets:

1. Parts: Integrally Mounted:
   a. Pressure Controls: Automatic START/STOP, factory set at 30 psig to 50 psig.
   b. Valves: Manual drain, manual shutoff, pressure relief, and check valve.

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c. Pressure gauge.
d. Inlet filter muffler.
e. Power: 120V ac.
f. Compressor: Oilless, single cylinder, rated for at least 1 scfm at 50 psig.
g. Manufacturers and Products:
1) ITT Pneumotive; GH Series.
2) Gast.

2. Simplex Air Supply Sets:
a. Air Receiver: 2 gallons.
b. Compressors: One.

3. Duplex Air Supply Sets:
a. Air Receiver: 20 gallons.
b. Compressors: Two.
c. Automatic Failover Control: Factory set at 20 psig.

2.03 ELECTRICAL COMPONENTS

A. Terminal Blocks for Enclosures:

1. General:
a. Connection Type: Screw compression clamp.
b. Compression Clamp:
1) Complies with DIN-VDE 0611.
2) Hardened steel clamp with transversal grooves that penetrate wire strands providing a vibration-proof connection.
3) Guides strands of wire into terminal.
c. Screws: Hardened steel, captive, and self-locking.
d. Current Bar: Copper or treated brass.
e. Insulation:
1) Thermoplastic rated for minus 55 degrees C to plus 110 degrees C.
2) Two funneled shaped inputs to facilitate wire entry.
f. Mounting:
1) Standard DIN rail.
2) Terminal block can be extracted from an assembly without displacing adjacent blocks.
3) End Stops: Minimum of one at each end of rail.
g. Wire Preparation: Stripping only permitted.
h. Jumpers: Allow jumper installation without loss of space on terminal or rail.

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i. Marking System:
   1) Terminal number shown on both sides of terminal block.
   2) Allow use of preprinted and field marked tags.
   3) Terminal strip numbers shown on end stops.
   4) Mark terminal block and terminal strip numbers as shown on panel control diagrams and loop diagrams.
   5) Fuse Marking for Fused Terminal Blocks: Fuse voltage and amperage rating shown on top of terminal block.

j. Test Plugs: Soldered connections for 18 AWG wire.
   1) Pin Diameter: 0.079 inch.
   2) Quantity: (10, 20, 40 (need two plugs per test meter).
   3) Manufacturer and Product: Entrelec; Type FC2.

2. Terminal Block, General Purpose:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 30 amp.
   c. Wire Size: 24 AWG to 10 AWG.
   d. Rated Wire Size: 10 AWG.
   e. Color: Gray body.
   f. Spacing: 0.25 inch, maximum.
   g. Test Sockets: One screw test socket 0.079-inch diameter.
   h. Manufacturer and Product: Entrelec; Type M4/6.T.
3. Terminal Block, Ground:
   a. Wire Size: 24 AWG to 10 AWG.
   b. Rated Wire Size: 10 AWG.
   c. Color: Green and yellow body.
   d. Spacing: 0.25 inch, maximum.
   e. Grounding: Electrically grounded to mounting rail.
   f. Manufacturer and Product: Entrelec; Type M4/6.P.
4. Terminal Block, Blade Disconnect Switch:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 10 amp.
   c. Wire Size: 22 AWG to 10 AWG.
   d. Rated Wire Size: 10 AWG.
   e. Color: Gray body, orange switch.
   f. Spacing: 0.25 inch, maximum.
   g. Manufacturer and Product: Entrelec; Type M4/6.SNT.
5. Terminal Block Diode:
   a. Rated Voltage: 24V dc.
   b. Rated Current: 30 ma.
   c. Wire Size: 16 AWG.
   d. Manufacturer and Product: Phoenix Contact ST-IN.
6. Terminal Block, Fused, 24V dc:
   a. Rated Voltage: 600V dc.
   b. Rated Current: 25 amp.

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c. Wire Size: 22 AWG to 10 AWG.
d. Rated Wire Size: 10 AWG.
e. Color: Gray body.
f. Fuse: 0.25 inch by 1.25 inches.
g. Indication: LED diode 24V dc.
h. Spacing: 0.512 inch, maximum.
i. Manufacturer and Product: Entrelec; Type ML10/13.SFD.

7. Terminal Block, Fused, 120V ac:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 25 amp.
   c. Wire Size: 22 AWG to 10 AWG.
   d. Rated Wire Size: 10 AWG.
   e. Color: Gray body.
   f. Fuse: 0.25 inch by 1.25 inches.
   g. Indication: Neon lamp, 110V ac.
   h. Leakage Current: 1.8 mA, maximum.
   i. Spacing: 0.512 inch, maximum.
   j. Manufacturer and Product: Entrelec; Type ML10/13.SFL.
8. Terminal Block, Fused, 120V ac, High Current:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 35 amps.
   c. Wire Size: 18 AWG to 8 AWG.
   d. Rated Wire Size: 8 AWG.
   e. Color: Gray.
   f. Fuse: 13/32 inch by 1.5 inches.
   g. Spacing: 0.95 inch, maximum.
9. Manufacturer and Product: Entrelec; Type MB10/24.SF.

B. Relays:

1. General:
   a. Relay Mounting: Plug-in type socket.
   b. Relay Enclosure: Furnish dust cover.
   c. Socket Type: Screw terminal interface with wiring.
   d. Socket Mounting: Rail.
   e. Provide holddown clips.
2. Signal Switching Relay:
   a. Type: Dry circuit.
   b. Contact Arrangement: 2 Form C contacts.
   c. Contact Rating: 5 amps at 28V dc or 120V ac.
   d. Contact Material: Gold or silver.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 0.9 watt (dc), 1.2VA (ac).
   g. Expected Mechanical Life: 10,000,000 operations.

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h. Expected Electrical Life at Rated Load: 100,000 operations.
i. Indication Type: Neon or LED indicator lamp.
j. Seal Type: Hermetically sealed case.
k. Manufacturer and Product: Potter and Brumfield; Series KH/KHA.

3. Control Circuit Switching Relay, Nonlatching:
   a. Type: Compact general purpose plug-in.
   b. Contact Arrangement: 3 Form C contacts.
   c. Contact Rating: 10A at 28V dc or 120V ac, and 6.6A at 240V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 1.8 watts (dc), 2.7VA (ac).
   g. Expected Mechanical Life: 10,000,000 operations.
   h. Expected Electrical Life at Rated Load: 100,000 operations.
   i. Indication Type: Neon or LED indicator lamp.
   j. Push-to-test button.
   k. Manufacturer and Product: Potter and Brumfield; Series KUP.
4. Control Circuit Switching Relay, Latching:
   a. Type: Dual coil mechanical latching relay.
   b. Contact Arrangement: 2 Form C contacts.
   c. Contact Rating: 10A at 28V dc or 120V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 2.7 watts (dc), 5.3VA (ac).
   g. Expected Mechanical Life: 500,000 operations.
   h. Expected Electrical Life at Rated Load: 50,000 operations.
   i. Manufacturer and Product: Potter and Brumfield; Series KB/KBP.
5. Control Circuit Switching Relay, Time Delay:
   a. Type: Adjustable time delay relay.
   b. Contact Arrangement: 2 Form C contacts.
   c. Contact Rating: 10A at 30V dc or 277V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Operating Temperature: Minus 10 degrees C to 55 degrees C.
   g. Repeatability: Plus or minus 2 percent.
   h. Delay Time Range: Select range such that time delay setpoint fall between 20 percent to 80 percent of range.
   i. Time Delay Setpoint: As noted or shown.
   j. Mode of Operation: As noted or shown.
   k. Adjustment Type: Integral potentiometer with knob external to dust cover.
   l. Manufacturer and Products: Potter and Brumfield; Series CB for 0.1-second to 100-minute delay time ranges, Series CK for 0.1-second to 120-second delay time ranges.

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C. Surge Suppressors:

1. General:
   a. Construction: First-stage, high-energy metal oxide varistor and second-stage, bipolar silicon avalanche device separated by series impedance; includes grounding wire, stud, or terminal.
   b. Response: 5 nanoseconds maximum.
   c. Recovery: Automatic.
   d. Temperature Range: Minus 20 degrees C to plus 85 degrees C.
   e. Enclosure Mounted: Encapsulated inflame retardant epoxy.
2. Suppressors on 120V ac Power Supply Connections:
   a. Occurrences: Tested and rated for a minimum of 50 occurrences of IEEE C62.41 Category B test waveform.
   b. First-Stage Clamping Voltage: 350 volts or less.
   c. Second-Stage Clamping Voltage: 210 volts or less.
   d. Power Supplies for Continuous Operation:
      1) Four-Wire Transmitter or Receiver: Minimum5 amps at 130V ac.
      2) All Other Applications: Minimum 30 amps at 130V ac.
3. Suppressors on Analog Signal Lines:
   a. Test Waveform: Linear 8-microsecond rise in current from 0 amps to a peak current value followed by an exponential decay of current reaching one-half the peak value in 20 microseconds.
   b. Surge Rating: Tested and rated for 50 occurrences of 2,000-amp peak test waveform.
      1) dc Clamping Voltage: 20 percent to 40 percent above operating voltage for circuit.
      2) dc Clamping Voltage Tolerance: Plus or minus 10 percent.
      3) Maximum Loop Resistance: 18 ohms per conductor.
4. Manufacturers and Products:
   a. Analog Signals Lines: Emerson Edco PC-642 or SRA-64 series.
   b. 120V ac Lines: Emerson Edco HSP-121.
   c. Field Mounted at Two-Wire Instruments:
      1) Encapsulated in stainless steel pipe nipples.
      2) Emerson Edco SS64 series.
   d. Field Mounted at Four-Wire Instruments: With 120V ac outlet, ac circuit breaker, and 10-ohm resistors on signal lines, all in enclosure.
      1) Enclosure:
         a) NEMA 4X Type 316 stainless steel with door.
         b) Maximum Size: 12 inches by 12 inches by 8 inches deep.
      2) Emerson Edco; SLAC series.

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D. Power Supplies:

1. Furnish as required to power instruments requiring external dc power, including two-wire transmitters and dc relays. Provide dual power supplies with diode auctioneered outputs.
2. Convert 120V ac, 60-Hz power to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.
3. Provide output over voltage and over current protective devices to:
   a. Protect instruments from damage due to power supply failure.
   b. Protect power supply from damage due to external failure.
4. Enclosures: NEMA 1.
5. Mount such that dissipated heat does not adversely affect other components.
6. Fuses: For each dc supply line to each individual two-wire transmitter.
   a. Type: Indicating.
   b. Mount so fuses can be easily seen and replaced.

E. Intrinsic Safety Barriers:

1. Intrinsically Safe Relays: Monitor discrete signals that originate in hazardous area and are used in a safe area.
   a. Manufacturer and Product: MTL, Inc.; Series MTL 5000.
2. Intrinsically Safe Barriers: Interface analog signals as they pass from hazardous area to safe area.
   a. Manufacturer and Product: MTL, Inc.; Series MTL 5000.

2.04 I&C COMPONENTS

A. F4 – Flow Element and Transmitter, Electromagnetic:

1. General:
   a. Function: Measure, indicate, and transmit the flow of a conductive process liquid in a full pipe.
   b. Type:
      1) Electromagnetic flowmeter, with operation based on Faraday’s Law, utilizing the pulsed dc type coil excitation principle with high impedance electrodes.
      2) Full bore meter with magnetic field traversing entire flow-tube cross section.
      3) Unacceptable are insert magmeters or multiple single point probes inserted into a spool piece.
   c. Parts: Flow element, transmitter, interconnecting cables, and mounting hardware. Other parts as noted.

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2. Service:
   a. Stream Fluid:
      1) As shown on RFC Drawings.
      2) Suitable for liquids with a minimum conductivity of 5 microS/cm and for demineralized water with a minimum conductivity of 20 microS/cm.
3. Operating Temperature:
   a. Element:
      1) Ambient: Minus 5 to 140 degrees F, typical, unless otherwise noted.
      2) Process: Minus 5 to 140 degrees F, typical, unless otherwise noted.
   b. Transmitter:
      1) Ambient: Minus 5 to 140 degrees F, typical, unless otherwise noted.
      2) Storage: 15 to 120 degrees F, typical, unless otherwise noted.
4. Performance:
   a. Flow Range: 0-300 gpm.
   b. Accuracy: Plus or minus 0.5 percent of rate for all flows resulting from pipe velocities of 2 to 30 feet per second.
   c. Turndown Ratio: Minimum of 10 to 1 when flow velocity at minimum flow is at least 1 foot per second.
5. Features:
   a. Zero stability feature to eliminate the need to stop flow to check zero alignment.
   b. No obstructions to flow.
   c. Very low-pressure loss.
   d. Measures bi-directional flow.
6. Process Connection:
   a. Meter Size (diameter inches): 4 inches.
   b. Connection Type: 150-pound ANSI raised-face flanges; AWWA C207, Table 2 Class D; or wafer style depending on meter size, unless otherwise noted.
   c. Flange Material: Type 316 stainless steel, unless otherwise noted.
7. Power (Transmitter): 120V ac, 60-Hz, unless otherwise noted.
8. Element:
   a. Meter Tube Material: Type 316 stainless steel, unless otherwise noted.
   b. Liner Material:
      1) Teflon, unless otherwise noted.
      2) For potable water service, must have appropriate approvals.

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c. Liner Protectors: Covers (or grounding rings) on each end to protect liner during shipment.
d. Electrode Type: Flush or bullet nose as recommended by the manufacturer for the noted stream fluid.
e. Electrode Material: Type 316 stainless steel or Hastelloy C, unless otherwise noted.
f. Grounding Ring:
    1) Required, unless otherwise noted.
    2) Quantity: Two, unless otherwise noted.
    3) Material: Type 316 stainless steel, unless otherwise noted.
g. Enclosure: NEMA 4X, minimum, unless otherwise noted.

9. Transmitter:
    a. Mounting:
        1) Surface (wall), unless otherwise noted.
        2) Remote to element, unless otherwise noted.
    b. Display: Required, unless otherwise noted.
        1) Digital LCD display, indicating flow rate and total.
    c. Parameter Adjustments: By keypad or non-intrusive means.
    d. Enclosure: NEMA 4X, minimum, unless otherwise noted.
    e. Minimum threshold velocity: 0.3 m/s, unless otherwise noted.
    f. Empty Pipe Detection:
        1) If noted.
        2) Drives display and outputs to zero when empty pipe detected.
10. Signal Interface (at Transmitter):
    a. Communications:
        1) Ethernet/IP protocol ethernet signal.
        2) 4 to 20mA analog signal.
11. Cables:
    a. Types: As recommended by manufacturer.
    b. Lengths: As required to accommodate device locations.
12. Built-in Diagnostic System:
    a. Features:
        1) Field programmable electronics.
        2) Self-diagnostics with troubleshooting codes.
        3) Ability to program electronics with full scale flow, engineering units, meter size, zero flow cutoff, desired signal damping, totalizer unit digit value, etc.
        4) Initial flow tube calibration and subsequent calibration checks.

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13. Factory Calibration:
    a. Calibrated in an ISO 9001 and NIST certified factory.
    b. Factory flow calibration system must be certified by volume or weight certified calibration devices.
    c. Factory flow calibration system shall be able to maintain calibration flow rate for at least 5 minutes for repeatability point checks.
14. Factory Ready for Future In situ Verifications: If noted.
    a. Original meter parameter values available from vendor by request.
    b. In situ Verification System: If noted.
        1) Quantity: One complete system provided for the Project.
        2) Verifies quantitatively that the meter and signal converter's present condition is the same as originally manufactured.
        3) Physical access to the flow-tube not required.
        4) Meet standards established by the National Testing Laboratory.
        5) Tests and stores over 50-meter parameters related to primary coils, electrodes, interconnecting cable and signal converter.
        6) Verification standard shall be plus or minus 1 percent of wet calibration for meters produced using the calibration verification service, or plus or minus 2 percent for standard meters.
        7) Windows-based software.
    c. Primary Simulation System: If noted.
        1) Quantity: One complete system provided for the Project.
        2) Verifies proper operation of the signal converter by simulating the flow meter's output signal.
            a) Generates pulsed dc excitation signal with a reference voltage of 70 mV.
            b) Generated signal ranges from 0 to 99 percent (0 to 32.8 feet per second) with a resolution of 0.1 percent.
            c) Switch selectable for forward, reverse and zero flow rate.
        3) Verifies various input and output signals.

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15. Manufacturers:
    a. Endress & Hauser; Promag L400.
    b. ABB; Watermaster.
    c. Krohne; Optiflux 4000.
    d. “Or-equal.”

B. F51 Flow Element and Transmitter, Thermal Mass Flow:

1. General:
    a. Function: Directly measure, indicate, and transmit mass flow of gas in pipe.
    b. Type: Insertion type, thermal dispersion detection probe using platinum resistance temperature detectors (RTD).
    c. Parts: Elements, transmitter, and interconnecting cable.
2. Performance:
    a. Process Gas: As noted or shown.
    b. Range for Air at 70 Degrees F and 14.7 psia:
        1) As noted, within the following: 0.25 to 600 standard fps.
    c. Calibrated Span: As noted.
    d. Accuracy:
        1) Flow: Plus or minus 0.75 percent of reading plus 0.5 percent full scale.
        2) Temperature: Plus or minus 2 degrees F.
    e. Repeatability:
        1) Flow: Plus or minus 0.5 percent of reading.
        2) Temperature: Plus or minus 1 degree F.
    f. Temperature, Operating:
        1) Flow Element: Minus 50 degrees F to plus 350 degrees F, unless otherwise noted.
        2) Transmitter Housing: 0 degree F to plus 150 degrees F.
    g. Pressure, Operating, Flow Element: Up to 50 psig, unless otherwise noted.
3. Flow Element:
    a. Features:
        1) Insertion Length: As noted or manufacturer’s recommendation.
        2) Wetted Surfaces Materials: Type all welded Type 316 stainless steel, unless otherwise noted.
    b. Process Connection:
        1) Line Size: As noted or shown.
        2) Connection Type: As shown.
        3) Connection Material: Type 316 stainless steel, unless otherwise noted.

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c. Sensor Enclosure:
1) Type: Aluminum, NEMA 4X, rated for Classes 1 and 2, Divisions 1 and 2, Groups B, C, D, E, F, G, and Eexd IIC; unless otherwise noted.

4. Transmitter:
a. Features: 2-inch by 2-inch backlit LCD, touch keys, bargraph, and numeric display.
b. Nonvolatile memory.
c. Signal Interface:
1) Outputs:
a) Analog: Two isolated 4 mA to 20 mA dc for maximum 600 ohm load, unless otherwise noted.
2) Communication: USB port with configuration software.
d. Power:
1) Selectable: 85 to 265 VAC 50/60 Hz, or 19 to 29V dc.
e. Electrical Connection: 1-inch FNPT.
f. Transmitter Enclosure:
1) Type: Aluminum, NEMA 4X, rated for Classes 1 and 2, Divisions 1 and 2, Groups B, C, D, E, F, G, and Eexd IIC; unless otherwise noted.
2) Mounting: Remote from sensor.
g. Single factory calibration, unless otherwise noted.
h. Data Logging: Micro SD card.

5. Cables:
a. Length: As required.
b. Cable Jacket: PVC rated for 220 degrees F, unless otherwise noted.

6. Manufacturer and Product:
a. Kurz.
b. Sage Prime.
c. “Or-equal.”

C. L31 Level Switch, Integral Conductive Probe:
1. General:
a. Function: Actuate contact at preset liquid level.
b. Type: Probe with integral conductance type switch.
c. Parts: Probe; interconnecting cable; relay or indicating controller, as noted; accessories as noted.
d. Coordinate installing applicable parts within panel furnished by PIC Supplier.
2. Service: Wastewater, unless otherwise noted.

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3. Performance:
    a. Setpoint: As noted.
    b. Relay Operating Temperature Range: 14 degrees F to 140 degrees F.
    c. Indicating Controller Operating Temperature Range: 14 degrees F to 140 degrees F.
    d. Intrinsically Safe Barrier Operating Temperature Range: 14 degrees F to 140 degrees F.
4. Parts and Features:
    a. Probe:
        1) Quantity: As noted.
        2) Materials: 316L Stainless Steel with PPS probe body
        3) Length: As noted.
        4) Switch Separation Distance: As noted.
    b. Cable Length: As noted.
5. Signal Interface:
    a. Relay: One set of contacts per relay.
    b. Indicating Controller: 10 sets of contacts.
    c. Common Characteristics:
        1) Contact Set: One NO and one NC.
        2) Contact Rating: 5 amps resistive at 250V ac.
        3) Adjustable output time delay ranging from 2.5 to 160 seconds.
    d. Analog Output (Indicator Controller Only): 4 mA to 20 mA dc with rated load of 940 ohms.
6. Manufacturer and Products:
    a. Siemens Pointek CLS200 Standard
    b. “Or-equa.l”

D. M51 – Alarm Beacon:
1. General:
    a. Function: Visual alarm or status indication.
    b. Type:
        1) Light Emitting Diode (LED) type.
        2) Steady-on or flashing bulb.
    c. Parts: Light and spare bulbs.
2. Performance:
    a. Temperature, Operating: Minus 31 degrees F to 150 degrees F.
    b. Flash Rate: Nominally 90 per minute.
3. Features:
    a. Materials of Construction:
        1) Lens: Polycarbonate, shatter-resistant.
        2) Base: Glass-filled nylon.
    b. Lamp Life: 50,000 hours or greater.

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c. Lens colors: Amber, unless otherwise noted.

4. Enclosure:
   a. Type: IP65 (NEMA 4X).
   b. Mounting: Surface or wall mount.
   c. Listing: UL listed, CSA certified.
      1) Approved for use in NEC Class 1, Division 2 hazardous classified areas.
5. Power: 120V ac, 50/60-Hz.
6. Spare Bulbs: Provide one for each light.
7. Manufactures and Models:
   a. Federal Signal Corp; 225XL Series.
   b. "Or-equal."

E. Y375 Programmable Logic Controller System, Chassis Unit:

1. Provide power supplies, I/O modules, processor, cables, etc., for a complete functional system installed in Blower integrated control panel.
   a. Provide a minimum of 25 percent spare I/O points for each type of I/O used.
2. For signals originating in hazardous areas, provide intrinsic safety barriers and relays in the PLC panel. Refer to Electrical drawings and Division 1 specifications for area classifications.
3. Provide individual indicating fuse block for each analog signal (input and output).
4. The discrete inputs to the Process SCADA system shall be 24V dc. Provide interposing relays for discrete output modules in the PLC panel, as required.
5. Provide individual fuse block for each digital input card.
6. The package system PLC shall communicate with the process SCADA system via Ethernet network and support the common industrial protocol (CIP) used by ODVA Ethernet/IP. Provide fully managed Ethernet switch so that Blower can be a working node on the plant network.
7. Engineer of Record (EOR) will provide IP addresses for the package system PLC.
8. Vendor to provide the PLC Program of the Blower for record.
9. Manufacturers:
   a. Allen-Bradley CompactLogix PLC with 5380 PLC controller with no substitutions allowed.

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F. Y40 Uninterruptible Power Supply System:

1. General:
   a. Function: Provides isolated, regulated uninterrupted AC output power during a complete or partial interruption of incoming line power.
   b. Provide UPS system for all panels that are not connected with central plant UPS backup circuit.
2. Performance:
   a. Input Power:
      1) 120V ac.
      2) Buffer period: 1 hour.
      3) Connections: Manufacturer's standard, unless otherwise noted.
   b. Output Power:
      1) 120V ac.
      2) Nominal Output Current: 4.3A.
      3) Provide panel load calculations and size UPS to provide min. 15 minutes of backup power at full load.
      4) Connections: Manufacturer's standard, unless otherwise noted.
   c. On-line Efficiency: 95 percent minimum, unless otherwise noted.
   d. Continuous no-break power with no measurable transfer time.
   e. Operating Temperature: 0 degrees to 40 degrees C (32 degrees to 104 degrees F).
   f. Operating Relative Humidity: 5 percent to 95 percent without condensation.
   g. Lightning and Surge Protection:
      1) Pass lightning standard IEEE C62.41 Categories A and B tests.
      2) 2,000 to 1 attenuation of input spike.
3. Features:
   a. LED status indicators:
      1) Power OK.
      2) UPS Active.
      3) UPS Charging.
      4) Fail/Alarm.
   b. Signal outputs to PLC:
      1) Hardwired:
         a) UPS Active.
         b) UPS Low Battery.
         c) UPS Fail.

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c. Physical:
   1) Tower style.
   2) Polycarbonate housing.

4. Manufacturers and Products:
   a. APC Smart-UPS.
   b. Eaton.
   c. “Or-equal.”

PART 3 EXECUTION (NOT USED)

END OF SECTION

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SECTION 40 99 90
PACKAGE CONTROL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. This Section includes general requirements for the Instrumentation and Control (I&C) Systems being furnished with the equipment packages. The package I&C System shall monitor and control all process and ancillary equipment within the limits of the associated equipment package.

B. Major components that can be procured as vendor supplied Package Systems includes CPT Wash Press System. Refer to the P&ID drawings for additional information.

C. The Work of this Section shall be performed by a Package Systems Integrator (SI) provided by the Equipment Supplier. If the Equipment Supplier chooses to self-perform the work, all requirements included herein shall be applicable to the Equipment Supplier.

D. This Section shall be used in conjunction with the associated equipment specification Sections and RFC Drawings.

E. All services and products included in this Section may not be applicable to all package I&C System. Refer to associated equipment specification Sections for applicable items.

F. Engineering, furnishing, installing, storing, protecting, unpacking, integrating, calibrating, adjusting, testing, documenting, application programming, commissioning, and providing training for a complete Instrumentation and Control (I&C) System for the package.

G. Major Items Include (refer to associated equipment specifications for applicability):

1. Primary elements, transmitters, control devices, and control panels.
2. Programmable Logic Controllers (PLC) panels and Operator Interface Terminals (OIT), if and as required in the associate equipment specification Sections.
3. Control system software licenses, and application programming of the complete package I&CS, if the package I&C System includes PLCs, OITs, or other programmable devices.
4. Commissioning of the complete package I&C System.

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5. Interfaces with plant-wide process Supervisory Control and Data Acquisition (SCADA) System being programmed by the Engineer.
6. Startup assistance, performance testing, and training as described herein.

1.02 RELATED SECTIONS

A. Section 40 90 00, Instrumentation and Control for Process Systems.

B. Section 26 05 01, Electrical.

1.03 REFERENCE AND STANDARDS

A. The following is a list of standards which may be referenced in this section:

1. The Institute of Electrical and Electronics Engineers, Inc. (IEEE): C62.41, IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
2. International Society of Automation (ISA): S50.1, Compatibility of Analog Signals for Electronic Process Instruments.
3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. AB 1, Molded Case Circuit Breakers and Molded Case Switches.
   c. ICS 2, Industrial Control Devices, Controllers and Assemblies.
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. Underwriters Laboratories Inc. (UL): 508A, Standards for Safety, Industrial Control Panels.

1.04 SYSTEM DESCRIPTION

A. Assemble panels and install instruments, plumbing, and wiring in equipment manufacturer’s factories.

B. Test panels and panel assemblies for proper operation prior to shipment from equipment manufacturer’s factory.

1.05 SUBMITTALS

A. Refer to Section 01 33 00, Submittal Procedures.

B. Action Submittals for review:

1. Bill of material, catalog information, descriptive literature, wiring diagrams, and Shop Drawings for components of package I&CS.
2. Catalog information on electrical devices furnished with package I&Cs.

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3. Shop Drawings, catalog material, and dimensional layout drawings for package control panels and enclosures.
4. Panel construction drawings, panel elevation drawings showing placement of operator interface devices, panel wiring diagrams, and panel elementary diagrams for all panels. Include in diagrams control devices and auxiliary devices, for example, relays, alarms, fuses, lights, fans, and heaters. The package panel drawings shall be in conformance with the requirements of Section 40 90 00, Instrumentation and Control for Process Systems.
5. Power and control wiring diagrams that include numbered terminal designations showing internal and external interfaces.
6. Plumbing diagrams of pre-plumbed panels and interconnecting plumbing diagrams.
7. Control Panel interconnection diagrams showing wiring interconnections between all system components and remote components.
8. Panel Power Requirements and Heat Dissipation: As defined in Section 40 90 00, Instrumentation and Control for Process Systems. Package control panel heat dissipation calculations to demonstrate that the maximum internal temperature does not exceed the rated operating range of any internal components.
9. For systems with PLCs exchanging data, submit the data exchange table, defined in this section, for approval within the 60 days after Contract Award.
10. Where indicated in equipment specification, provide updated process and instrumentation diagrams (P&IDs) for the package system, showing all components as furnished. The PIDs included in the Contract Documents for the package systems can be used as the starting point.
11. Testing Procedures. Refer to Package Control Systems subsections for additional requirements for testing related submittals.

C. Informational Submittals:

1. Functional description of internal and external instrumentation and controls, including parameters monitored, controlled, and alarmed.
2. Sequential description of operation under various modes of control, describing the complete control circuit and equipment operation and logic, including interlocks and permissives.
3. Description of all automatic shutdown features and interfaces with the process SCADA systems, in both word and schematic form.
4. If the package I&CS uses a programmable logic controller (PLC) system with or without OIT, submit the following:
    a. Process Control Narrative.
    b. Input/Output (I/O) List.

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c. Alarm List.
d. Interlock List.
e. Cause & Effect Matrix.
f. Complete set of user manuals.
g. Fully documented ladder logic listings.
h. Function listing for function blocks not fully documented by ladder logic listings.
i. Cross-reference listing.
j. Color copies of the OIT graphic screens.
k. The native (source) files for the as-installed PLC and OIT application software shall be provided to the Owner.
l. Programmable Controller Submittals:
    1) Complete set of user manuals.
    2) Fully documented ladder logic listings.
    3) Function listing for function blocks not fully documented by ladder logic listings.
    4) Cross-reference listing.
m. Data Exchange with process SCADA System:
    1) The package PLC shall be configured to allow remote monitoring and control of the package equipment from the process SCADA system.
    2) The data exchange requirements between the package PLC and the process SCADA system will be further developed during the submittal review and commissioning process. As a minimum, data exchange shall include status, alarms, analog values and control permissive signals. Reserve two independent read and write files in the package system PLC for exclusive use as data exchange portals.
    3) Develop and submit a data exchange table/map. Data table shall include:
        a) For each data point, its name, register location, and tag number:
            (1) Discrete data points shall include states (On/Off, Enable/Disable, etc.).
            (2) Analog data points shall include units (gpm, psi, etc.) and range (minimum value and maximum value).
        b) Group data by type; e.g., discrete inputs, discrete outputs, analog inputs, analog outputs.

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5. Operation and Maintenance Data: In accordance with Division 1 requirements, and in addition the following.
    a. General:
        1) Provide sufficient detail to allow operation, removal, installation, adjustment, calibration, maintenance and purchasing replacements for package I&CS components.
        2) Provide both electronic (AutoCAD for drawings, Microsoft Word for text, and Microsoft Excel for forms) and hard copies for all items listed below.
    b. Final versions of Legend and Abbreviation Lists.
    c. Updated process and instrumentation diagrams (P&IDs), if indicated in the associated equipment specification.
    d. Provide the following items as defined under heading Action Submittals:
        1) Bill of materials.
        2) Catalog cuts.
        3) Instrument list.
        4) Component data sheets.
    e. Detailed Wiring Diagrams: As-built drawings.
        1) Panel elevation, construction, and wiring diagrams.
        2) Interconnecting wiring diagrams.
    f. Communications and digital networks diagrams.
    g. Panel plumbing diagrams.
6. Manufacturer's O&M manuals for components, electrical devices, and mechanical devices:
    a. Content for Each O&M Manual:
        1) Table of Contents.
        2) Operations procedures.
        3) Installation requirements and procedures.
        4) Maintenance requirements and procedures.
        5) Troubleshooting procedures.
        6) Calibration procedures.
        7) Internal schematic and wiring diagrams.
        8) Component and I/O Module Calibration Sheets from field quality control calibrations.
    b. Provide PDF file with linked index to all manuals.
7. List of spares, expendables, test equipment and tools provided.
8. List of additional recommended spares, expendables, test equipment, and tools. Include quantities, unit prices, and total costs.

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D. Manufacturer's list of proposed spares, expendables, test equipment and tools provided.

E. List of additional recommended spares, expendables, test equipment, and tools. Include quantities, unit prices, and total costs.

F. Manufacturer's list of proposed spares, expendables, and test equipment.

G. Manufacturer's Certificate of Proper testing, installation and commissioning, in accordance with Section 01 91 00, Equipment Systems Commissioning.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Prior to shipment, include corrosive-inhibitive vapor capsules in shipping containers and related equipment as recommended by capsule manufacturer.

1.07 EXTRA MATERIALS

A. Spares, Expendables, and Test Equipment:

1. Selector Switch, Pushbutton, and Indicating Light: 20 percent, one minimum, of each type used.
2. Light Bulb: 100 percent, 2 minimum, of each type used.
3. Fuse: 100 percent, 5 minimum, of each type used.
4. Surge Suppressors: 20 percent, one minimum, of each type used.

PART 2 PRODUCTS

2.01 SIGNAL CHARACTERISTICS

A. As defined in Section 40 90 00, Instrumentation and Control for Process Systems.

2.02 CORROSION PROTECTION

A. Corrosion-Inhibiting Vapor Capsule Manufacturers:

1. Northern Instruments; Model Zerust VC.
2. Hoffmann Engineering; Model A-HCI.

2.03 CONTROL PANEL

A. Panel Construction and Interior Wiring: In accordance with the National Electrical Code (NEC), UL 508, state and local codes, and applicable sections of NEMA, ANSI, and ICECA.

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B. Conform to NEMA ratings as specified in individual equipment sections.

C. Minimum Metal Thickness: 14 gauge.

D. NEMA 250, Type 4X Panels: Type 316 stainless steel construction unless otherwise specified.

E. Doors:

1. Three-point latching mechanisms in accordance with NEMA 250 Type 1 and 12 panels with doors higher than 18 inches.
2. For other doors, stainless steel quick release clamps.
3. Rubber-gasketed with continuous hinge.

F. Cutouts shall be cut, punched, or drilled and finished smoothly with rounded edges.

G. Access: Front, suitable for installation with back and sides adjacent to or in contact with other surfaces, unless otherwise specified.

H. Temperature Control:

1. Size panels to adequately dissipate heat generated by equipment mounted on or in the panel.
2. Furnish cooling fans with air filters if required to dissipate heat.
3. For panels outdoors or in unheated areas, furnish thermostatically controlled heaters to maintain temperature above 40 degrees F.

I. Push-to-Test Circuitry: For each push-to-test indicating light, provide a fused push-to-test circuit.

J. Lighting: Minimum of one hand switch controlled internal 100-watt incandescent light for panels 12 cubic feet and larger.

K. Minimum of one 120-volt GFCI duplex receptacle for panels 12 cubic feet and larger.

L. Finish:

1. Metallic External Surfaces (Excluding Aluminum and Stainless Steel): Manufacturer’s standard gray unless otherwise specified.
2. Internal Surfaces: White enamel.

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M. Panel Manufacturers:

1. Hoffman.
2. H.F. Cox.

N. Breather and Drains: Furnish with NEMA 250, Type 4 and 4X panels.

1. Manufacturer and Product: Cooper Crouse-Hinds; ECD Type 4X Drain and Breather; Drain Model ECD1-N4D, Breather Model ECD1-N4B.

O. Uninterruptible Power Supply (UPS) System:

1. Quantity: One for each package control panel containing PLC/OIT hardware.
2. UPS shall power the PLC, Network Switch and POE Camera.
3. General:
    a. Function: Provides isolated, regulated uninterrupted ac output power during a complete or partial interruption of incoming line power.
    b. Major Parts: Inverter, battery charger, sealed battery. Control panels powered by a local UPS shall be provided with the following functionality:
        1) In control panels, all components shall be powered by a UPS except for receptacles, lights and heaters to ensure that the control panel can continue to perform communications, data manipulation, calculations, monitoring, and process data archiving during a complete or partial interruption of incoming line power.
        2) The incoming power to the control panel shall be connected to and monitored by a PLC input to detect a loss of incoming power at which time a “Loss of Power Alarm” will be generated.
        3) The UPS power to the control panel shall be connected in series with the normally-closed UPS common alarm output contact to and monitored by a PLC input to detect a loss of UPS power or UPS common alarm at which time a “UPS Common Alarm” will be generated.
        4) The UPS power to the control panel shall power a failover relay installed in the control panel. The purpose of the relay is to monitor the UPS for output power and if power is not present switch the UPS powered components in the control panel from UPS output power to incoming control panel power.

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c. UPS may be installed inside the panel on a dedicated shelf above the bottom of the panel, provided that adequate ventilation is provided. If adequate ventilation cannot be provided the UPS shall be installed in a separate ventilated enclosure rated for the environment. Provide interconnecting power wiring and control wiring (for status monitoring) in separate conduits between the UPS enclosure and the control panel in accordance with Division 16, Electrical.

d. Type: true-online, double conversion type. Line-interactive or stand-by type is not acceptable.

e. Performance:
   1) Capacity: 150 percent of connected load.
   2) Input Power:
      a) 120V ac single-phase, 60-Hz, unless otherwise noted.
      b) Connections: Manufacturer's standard, unless otherwise noted.
   3) Output Power:
      a) 120V ac single-phase, 60-Hz, unless otherwise noted.
      b) Connections: Manufacturer's standard, unless otherwise noted.
   4) On-line Efficiency: 90 percent minimum.
   5) Backup Runtime: 30 minutes runtime at 150 percent of connected load.
   6) Continuous no-break power with no measurable transfer time.
   7) Sine-Wave Output Voltage Total Harmonic Distortion (THD): Plus or minus 5 percent or less.
   8) Input Voltage Range: Plus 15 percent, minus 20 percent.
   9) Output Voltage Regulation: Plus or minus 3 percent nominal.
   10) Operating Temperature: 0 to 40 degrees C (32 to 104 degrees F).
   11) Operating Relative Humidity: 5 to 95 percent without condensation.
   12) Lightning and Surge Protection:
      a) Pass lightning standard IEEE C62.41 Categories A and B tests.
      b) 2,000 to 1 attenuation of input spike.
   13) Bypass: Built-in.
   14) User replaceable hot swappable batteries.

f. Accessories:
   1) Discrete Output: One SPDT contact, rated at 5 amps continuous, at 120V ac for Common Alarm.

g. Enclosure: Tower, unless otherwise noted.

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h. Manufacturers and Products:
   1) APC; Smart UPS RT series.
   2) For panels mounted in unconditioned space where the internal panel temperature can go above 104 degrees F, provide APC Industrial UPS suitable for the environment.
   3) "Or approved equal".

2.04 CONTROL PANEL ELECTRICAL

A. UL Listing Mark for Enclosures: Mark stating "Listed Enclosed Industrial Control Panel" per UL 508A.

B. I&C and electrical components, terminals, wires, and enclosures UL recognized or UL listed.

C. Control Panels without Motor Starters:

1. Furnish main circuit breaker and a circuit breaker on each individual branch circuit distributed from power panel.
2. Locate to provide clear view of and access to breakers when door is open. Group on single subpanel. Provide typed directory.
3. Circuit Breakers:
   a. Coordinate for fault in branch circuit trips, branch breaker, and not main breaker.
   b. Branch Circuit Breakers: 15 amps at 250V ac.
   c. Breaker Manufacturers and Products:
      1) Heineman Electric Co.; Series AM.
      2) Airpax/North American Philips Controls Corp.; Series 205.

D. Control Panels with Three-Phase Power Supplies and Motor Starters:

1. Interlock main circuit breaker with panel door.
   a. Mount logic controls, branch circuit breakers, overload reset switches, and other control circuit devices.
   b. Mount operator controls and indications on front access door.
2. Circuit Breakers:
   a. In accordance with NEMA AB 1.
   b. 18,000-ampere RMS symmetrical rating, minimum at 480 volts, unless otherwise specified.
   c. Breakers, except Motor Branch Breakers: Molded case thermal magnetic.
   d. 42,000 ampere RMS symmetrical rating, minimum at 480 volts, unless otherwise specified in package system equipment specification sections.
   e. Tripping: Indicate with operator handle position.

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3. Magnetic Motor Starters:
   a. Full voltage, NEMA ICS 2, Class A, Size O minimum.
   b. Include three-pole bimetallic or eutectic alloy thermal overload relays sized for each motor.
   c. Manual reset type with reset button mounted on panel door.
4. Motor Control: 120V ac (except intrinsically safe circuits where applicable).
   a. Power Control Transformer:
      1) Sufficient capacity to serve connected load, including 200VA for duplex outlet plus 100VA (minimum).
      2) Limit voltage variation to 15 percent during contact pickup.
      3) Fuse one side of secondary winding and ground the other.
      4) Furnish primary winding fuses in ungrounded conductors.
5. Power Monitoring Relay:
   a. Protect three-phase equipment from single phasing, phase imbalance, or phase reversal.
   b. Separate, isolated contact outputs to stop motors and activate alarm light during abnormal conditions.
   c. Transient Voltage Protection: 10,000 volts.
   d. Manufacturer and Product: Furnas; Class 47.
6. Power Distribution Blocks: Furnish to parallel feed tap on branch circuit protective devices. Do not “leap frog” power conductors.
7. Terminations for Power Conductors: Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

E. Wiring:

1. ac Circuits:
   a. Type: 600-volt, Type MTW stranded copper.
   b. Size: For current to be carried, but not less than 14 AWG.
2. Analog Signal Circuits:
   a. Type: 300-volt, Type 2 stranded copper, twisted shielded pairs.
   b. Size: 18 AWG, minimum.
3. Other dc Circuits.
   a. Type: 600-volt, Type MTW stranded copper.
   b. Size: 18 AWG, minimum.
4. Separate analog and other dc circuits by at least 6 inches from ac power and control wiring, except at unavoidable crossover points and at device terminations.
5. Enclose wiring in sheet metal raceways or plastic wiring ducts.
6. Wire Identification: Numbered and tagged at each termination.
   a. Wire Tags: Machine printed, heat shrink.

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b. Manufacturers:
   1) Brady PermaSleeve.
   2) Tyco Electronics.

F. Wiring Interface:

1. For analog and discrete signal, terminate at numbered terminal blocks.
2. For special signals, terminate power (240 volts or greater) at manufacturer's standard connectors.
3. For panel, terminate at equipment on/with which it is mounted.

G. Signal Distribution:

1. Signal Wiring: Separate analog signal cables from power and control within a panel and cross at right angles where necessary.
2. Within Panels: 4 to 20 mA dc signals may be distributed as 1 to 5V dc.
3. Outside Panels: Isolated 4 to 20 mA dc only.
4. Signal Wiring: Twisted shielded pairs.
5. RTD and Thermocouple Extension Cable:
   a. Continuous field to panel with no intermediate junction boxes or terminations.
   b. RTDs in motor windings are considered a 600-volt circuit.
   c. Terminate thermocouple extension wire directly to loop instrument.

H. Signal Switching:

1. Use dry circuit type relays or switches.
2. No interruption of 4 to 20 mA loops during switching.
3. Switching Transients in Associated Signal Circuit:
   a. 4 to 20 mA dc Signals: 0.2 mA, maximum.
   b. 1 to 5V dc Signals: 0.05V, maximum.

I. Push-to-Test Circuitry: Required for all panels. For each push-to-test indicating light, provide a fused push-to-test circuit.

J. Panels with UPS power shall automatically switch over to line power upon UPS power failure.

K. Terminal Blocks for Enclosures:

1. Quantity:
   a. Accommodate present and spare indicated needs.
   b. Wire spare or unused panel mounted elements to their panels' terminal blocks.

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c. Spare Terminals: 20 percent of connected terminals, but not less than 10.

2. General: Group to keep 120V ac circuits separate from 24V dc circuits.
   a. Connection Type: Screw connection clamp.
   b. Compression Clamp:
      1) Hardened steel clamp with transversal grooves penetrating wire strands providing a vibration-proof connection.
      2) Guides strands of wire into terminal.
   c. Screws: Hardened steel, captive, and self-locking.
   d. Current Bar: Copper or treated brass.
   e. Insulation:
      1) Thermoplastic rated for minus 55 to plus 110 degrees C.
      2) Two funnel shaped inputs to facilitate wire entry.
   f. Mounting:
      1) Rail.
      2) Terminal block can be extracted from an assembly without displacing adjacent blocks.
      3) End Stops: One at each end of rail, minimum.
   g. Wire Preparation: Stripping only.
   h. Jumpers: Allow jumper installation without loss of space on terminal or rail.
   i. Marking System:
      1) Terminal number shown on both sides of terminal block.
      2) Allow use of preprinted and field marked tags.
      3) Terminal strip numbers shown on end stops.
      4) Mark terminal block and terminal strip numbers as shown.
3. Terminal Block, 120-Volt Power:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 30 amp.
   c. Wire Size: 22 through 10 AWG.
   d. Rated Wire Size: 10 AWG.
   e. Color: Gray body.
   f. Spacing: 0.25 inch, maximum.
   g. Manufacturer and Product: Entrelec; Type M4/6.
4. Terminal Block, Ground:
   a. Wire Size: 22 through 12 AWG.
   b. Rated Wire Size: 12 AWG.
   c. Color: Green and yellow body.
   d. Spacing: 0.25 inch, maximum.
   e. Grounding: Ground terminal blocks electrically grounded to the mounting rail.
   f. Manufacturer and Product: Entrelec; Type M4/6.P.

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5. Terminal Block, Blade Disconnect Switch:
   a. Use: Provide one for each discrete input and output field interface wire.
   b. Rated Voltage: 600V ac.
   c. Rated Current: 10 amp.
   d. Wire Size: 22 through 12 AWG.
   e. Rated Wire Size: 12 AWG.
   f. Color: Gray body, orange switch.
   g. Spacing: 0.25 inch, maximum.
   h. Manufacturer and Product: Entrelec; Type M4/6.SN.
6. Terminal Block, Fused, 24V dc:
   a. Rated Voltage: 600V dc.
   b. Rated Current: 6.3 amp.
   c. Wire Size: 22 through 12 AWG.
   d. Rated Wire Size: 12 AWG.
   e. Color: Gray body.
   f. Fuse: 5 by 20 GMA fuses.
   g. Fuse Marking: Fuse amperage rating shown on top of terminal block.
   h. Indication: LED diode 24V dc.
   i. Leakage Current: 5.2 mA, maximum.
   j. Spacing: 0.32 inch, maximum.
   k. Manufacturer and Product: Entrelec; Type M4/6.SFD.
7. Terminal Block, Fused, 120V ac:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 6.3 amp.
   c. Wire Size: 22 through 12 AWG
   d. Rated Wire Size: 12 AWG.
   e. Color: Gray body.
   f. Fuse: 5 by 20 GMA fuses.
   g. Fuse Marking: Fuse amperage rating shown on top of terminal block.
   h. Indication: Neon lamp 110V ac.
   i. Leakage Current: 1.8 mA, maximum.
   j. Spacing: 0.32-inch, maximum
   k. Manufacturer and Product: Entrelec; Type M4/6.SFL.

L. Grounding: Internal copper grounding bus for ground connections on panels, consoles, racks, and cabinets.

M. Relays:

1. General:
   a. Relay Mounting: Plug-in type socket.

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b. Relay Enclosure: Provide dust cover.
c. Socket Type: Screw terminal interface with wiring.
d. Socket Mounting: Rail.
e. Furnish holddown clips.

2. Control Circuit Switching Relay, Nonlatching:
   a. Type: Compact general purpose plug-in.
   b. Contact Arrangement: 3 Form C contacts.
   c. Contact Rating: 10A at 28V dc or 240V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 1.8 watts (dc), 2.7VA (ac).
   g. Expected Mechanical Life: 10,000,000 operations.
   h. Expected Electrical Life at Rated Load: 100,000 operations.
   i. Indication Type: Neon or LED indicator lamp.
   j. Push-to-test button.
   k. Manufacturer and Product: Potter and Brumfield; Series KUP.
3. Control Circuit Switching Relay, Latching:
   a. Type: Dual coil mechanical latching relay.
   b. Contact Arrangement: 2 Form C contacts.
   c. Contact Rating: 10A at 28V dc or 120V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 2.7 watts (dc), 5.3VA (ac).
   g. Expected Mechanical Life: 500,000 operations.
   h. Expected Electrical Life at Rated Load: 50,000 operations.
   i. Manufacturer and Product: Potter and Brumfield; Series KB/KBP.
4. Control Circuit Switching Relay, Time Delay:
   a. Type: Adjustable time delay relay.
   b. Contact Arrangement: 2 Form C contacts.
   c. Contact Rating: 10A at 240V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As specified or shown.
   f. Operating Temperature: Minus 10 to 55 degrees C.
   g. Repeatability: Plus or minus 2 percent.
   h. Delay Time Range: Select range such that time delay setpoint fall between 20 to 80 percent or range.
   i. Time Delay Setpoint: As specified or shown.
   j. Mode of Operation: As specified or shown.
   k. Adjustment Type: Integral potentiometer with knob external to dust cover.
   l. Manufacturer and Products: Potter and Brumfield.
      1) Series CB for 0.1-second to 100-minute delay time ranges.
      2) Series CK for 0.1- to 120-second delay time ranges.

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N. Intrinsic Safety Barriers:

1. Comply with NEC Article 504, Intrinsically Safe Systems.
2. Install intrinsically safe (IS) circuits in a separate wire way that:
   a. IS circuits separated from non-intrinsically safe circuits as specified by NEC.
   b. IS circuits colored light blue and has message “Intrinsically Safe Circuits Only” on raceway cover every 6 inches.
3. Intrinsically Safe Relays: Monitor discrete signals that originate in hazardous area and are used in a safe area.
   a. Manufacturer and Product: MTL, Inc.; Series MTL 5000.
4. Intrinsically Safe Barriers: Interface analog signals as they pass from hazardous area to safe area.
   a. Manufacturer and Product: MTL, Inc.; Series MTL 5000.

O. Analog Signal Isolators:

1. Furnish signal isolation for analog signals that are sent from one enclosure to another.
2. Do not wire in series instruments on different panels, cabinets, or enclosures, unless otherwise noted or shown.

P. Power Supplies:

1. Furnish as required to power instruments requiring external dc power, including two-wire transmitters and dc relays. Provide one power supply for each group of up to 8 field instruments or devices. Provide one power supply for each group of 2 DI and 2 DO PLC modules. Dual power supplies with diode auctioneered outputs are not required.
2. Convert 120V ac, 60-Hz power to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.
3. Provide output over voltage and over current protective devices to:
   a. Protect instruments from damage due to power supply failure.
   b. Protect power supply from damage due to external failure.
4. Provide contact closure for power supply failure alarm to PLC. Wire to a DI card that the power supply is not powering.
5. Enclosures: NEMA 1.
6. Mount such that dissipated heat does not adversely affect other components.
7. Capacity: 150 percent of the connected load to account for future expansion. The supplied power supply shall be able to be loaded up to 100 percent of its secondary ampere rating with shunt diode transfer.

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8. Fuses: For each dc supply line to each individual two-wire transmitter.
   a. Type: Indicating.
   b. Mount so fuses can be easily seen and replaced.
9. Manufacturer: Allen-Bradley.

Q. Programmable Logic Controllers:

1. Provide PLC power supplies, I/O modules, processor, cables, etc., for a complete functional system, installed in the Control Panel of a vendor supplied package control system.
2. Provide a minimum of 25 percent spare I/O points for each type of I/O used.
3. Solid state units capable of performing same function as conventional relays, timers, counters, drum sequencers, arithmetic, and other special functions necessary to perform required control functions.
4. Minimum of 64 internal control relays, 16 timer/counters, and four, 16 stop drum sequencers. Furnish minimum of 256 words of nonvolatile memory.
5. Minimum of 12 discrete inputs and 8 discrete outputs, optical isolations rated at 2,500-volt rms. Discrete inputs shall be 120V ac. Discrete outputs shall be rated for 2 amps at 120V ac. Each input and output shall have an LED ON/OFF status indicator.
6. Capable of operating in a hostile industrial environment (for example, heat, electrical transients, RFI, and vibration) without fans, air conditioning, or electrical filtering. Units operate from 0 to 60 degrees C and up to 95 percent humidity, noncondensing.
7. Furnish with a handheld, CRT, or personal computer programmer that plugs into controller. Program using conventional relay ladder diagram notation and drum sequencer chart notation. Programmer shall provide a force function to set inputs or outputs to a given state regardless of program or input conditions. Programmer shall indicate power flow through internal elements.
8. The package system PLC shall communicate with the process SCADA system via Ethernet network and support the common industrial protocol (CIP) used by ODVA Ethernet/IP.
9. Engineer of Record (EOR) will provide IP addresses for the package system PLC.
10. Manufacturers: Allen-Bradley CompactLogix PLC with 5380 PLC controller with no substitutions allowed.
11. PLC Application Software Development Methodology: Where the programmable controller system (PLC) is required to communicate over an Ethernet network with HMI servers and other PLCs, coordinate data communication with the process control application software programmer.

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a. Arrange PLC input/output data into organized groups.
b. Add additional EBNT modules as required to provide 10 percent excess capacity above the final packet transfer rate.
c. Coordinate I/O and internal tag numbering with the process control system applications programmer so that consistent tag numbers are used for all PLCs and HMI.
d. Coordinate engineering units and value ranges and counter ranges with the process control system applications programmer.
e. Use producer/consumer communications between PLCs, except where messaging would be more efficient.
f. Data Exchange with HMI Servers:
    1) Use messaging, unless a more optimal method is available.
    2) Minimize the number of packets required for each PLC.
    3) Work with the process control system applications programmer to organize the data structure in each packet to optimize the HMI communications interface.
    4) Use floating point values scaled in engineering units for analog and counter values.
g. Manual Data Entry:
    1) For operator-adjustable values, provide easy to use well organized displays, including pop-ups where appropriate to reduce clutter for process monitoring and data entry.
    2) For setpoints, tuning parameters, and presets not suitable for operator adjustment, provide password-protected access to additional well-organized screens with each variable well defined and engineering units shown. Provide enough access to allow plant supervision and maintenance staff to maintain and optimize equipment operation without having to use a PLC programming laptop and PLC programming application.
h. Use a combination of function block and ladder logic programming to take best advantage of both methods and the capabilities of the PLC.
i. Provide annotated data exchange look up tables and other information to allow the HMI applications programmer to implement efficient data exchange between HMI and the PLC.

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R. Package Systems Ethernet Switch, Panel Mount:

1. General:
   a. Required for ODVA EtherNet/IP communication internal to the panel and to make the vendor supplied package system a working node on the plant network.
   b. Function: Connect Ethernet devices via high performance, packet switching technology.
   c. Industrial fully managed Ethernet switch is required with the following features. Unmanaged switches are not acceptable:
      1) Simple Network Management Protocol (SNMP) v1, v2, and v3.
      2) Internet Group Management Protocol (IGMP) Snooping and Auto Configuration v1 per RFC 1112 and v2 per RFC 2236.
      3) Port Configuration:
         a) Access Link: Port based Virtual Local Area Network (VLAN).
         b) Trunk Link: IEEE 802.1q VLAN tagging for Ethernet frames.
      4) Link Aggregation (LAG) per IEEE 802.3ad.
      5) Link Layer Discovery Protocol (LLDP) per IEEE 802.1AB.
      6) Port Mirroring.
      7) Spanning Tree Protocol (STP) per IEEE 802.1D.
      8) Rapid Spanning Tree Protocol (RSTP) per IEEE 802.1d, IEEE 802.1w, IEEE 802.1D.
      9) Quality of Service (QoS):
         a) Port Based.
         b) QoS tagging per IEEE 802.1p.
         c) Differentiated Services Field (DS Field) and Differentiated Services Code Point (DSCP) per RFC 2474.
      10) Dynamic Host Configuration Protocol (DHCP):
         a) Client.
         b) Relay Agent.
         c) Server with assignments based on:
            (1) Client MAC address.
            (2) Relay Agent Connection (Option 82).
            (3) Client ID (Option 61).
      11) Connectivity: IPv4 and IPv6.
      12) ODVA EtherNet/IP CIP Messaging for monitoring switch status from PLC.
      13) Port Security - MAC Address Based.
   d. Interface: Web based.
   e. Mounting: DIN rail mounted.

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2. Quantity: Refer to equipment specifications for quantity.
3. Performance:
   a. Capacity: Provide sufficient number of ports to meet the system requirement, with a minimum of 25 percent spare ports. Connection for plant communication is excluded from spare ports. No fewer than eight (8) 10/100BaseTX RJ-45 ports. No less than two (2) Small Form-Factor Pluggable (SFP) gigabit ports.
   b. Auto negotiation of duplex mode, speed, and flow control.
      1) Support automatic configuration of Half or Full-Duplex.
      2) Support automatic speed sensing at 10/100 Mbps.
      3) Support priority-based flow control.
   c. Auto-MDIX or auto media dependent interface crossover.
      1) Support automatic configuration of straight-through or crossover-cable connection.
   d. Electrostatic discharge (ESD) and surge protection diodes on all ports.
   e. Enclosure: NEMA 1 in accordance with NEMA 250.
   f. Minimum operating temperature range: -40 degrees C to 70 degrees C.
   g. Power: 24V dc external power supply.
4. Accessories:
   a. SFP Transceiver: Copper
      1) Two (2) Required.
      2) Function: Connect Ethernet switches over a high speed copper backbone.
      3) 1000BASE-T copper.
      4) Connectors Type: RJ-45.
      5) Shall be of the same manufacturer as the supplied Ethernet switch in which the SFP transceiver is installed.
   b. SFP Transceiver: Fiber.
      1) Two (2) required.
      2) Function: Connect Ethernet switches over a high speed copper backbone.
      3) 1000BASE-SX single-mode fiber.
      4) Connectors Type: LC.
      5) Shall be of the same manufacturer as the supplied Ethernet switch in which the SFP transceiver is installed.
5. Manufacturers and Products:
   a. Allen Bradley Stratix Managed Switch.
   b. Cisco, Model IE-4000 Series.
   c. “Or-equal.”

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S. Operator Interface Terminal (OIT):

1. General:
   a. Color touch screen display with cabling, communication modules and all required accessories.
   b. Size 10 inches.
   c. Provide OIT programming software license registered to Owner.
2. Manufacturers: Allen-Bradley; PanelView Plus 7 OITs with no substitutions allowed.
   a. Equipment vendor's standard OITs will be only considered if specifically indicated in the equipment specifications.

T. Front-of-Panel Devices in Conjunction with NEMA 250, Type 1 and 12 Panels:

1. Potentiometer Units:
   a. Three-terminal, oiltight construction, resolution of 1 percent and linearity of plus or minus 5 percent.
   b. Single-hole, panel mounting accommodating panel thicknesses between 1/8 and 1/4 inch.
   c. Include legend plates with service markings.
   d. Manufacturers and Products:
      1) Allen-Bradley; Model 800T.
      2) Eaton/Cutler-Hammer; Model 10250T.
2. Indicating Lights:
   a. Heavy-duty, push-to-test type, oiltight, industrial type with integral transformer for 120V ac applications.
   b. Screwed on prismatic glass lenses in colors noted and factory engraved legend plates for service legend.
   c. Manufacturers and Products:
      1) Eaton/Cutler-Hammer; Type 10250T.
      2) General Electric; CR2940U.
3. Pushbutton, Momentary:
   a. Heavy-duty, oiltight, industrial type with full guard and momentary contacts rated for 10 amperes continuous at 120V ac.
   b. Standard size legend plates with black field and white markings for service legend.
   c. Manufacturers and Products:
      1) Square D; Class 9001, Type K.
      2) Eaton/Cutler-Hammer; Type T.
      3) General Electric; Type CR-2940.
4. Selector Switch:
   a. Heavy-duty, oiltight, industrial type with contacts rated for 120V ac service at 10 amperes continuous.

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b. Standard size, black field, legend plates with white markings, for service legend.
c. Operators: Black knob type.
d. Single-hole mounting, accommodating panel thicknesses from 1/16 inch to 1/4 inch.
e. Manufacturers and Products for Units with up to Four Selection Positions:
    1) Eaton/Cutler-Hammer; Type T.
    2) Square D; Type K.
f. Manufacturers and Products for Units with up to 12 Selection Positions:
    1) Rundel-Idec; Standard Cam Switch.
    2) Electroswitch; 31.

U. Front-of-Panel Devices Used in Conjunction with NEMA 250, Type 4X Panels:

1. Potentiometer, Watertight:
    a. Three-terminal, heavy-duty NEMA 250, Type 4X watertight construction, resolution of 1 percent and linearity of plus or minus 5 percent.
    b. Single-hole, panel mounting accommodating panel thicknesses between 1/8 and 1/4 inch.
    c. Include engraved legend plates with service markings.
    d. Manufacturer and Product: Allen-Bradley; Bulletin 800H.
2. Indicating Lights, Watertight:
    a. Heavy-duty, push-to-test type, NEMA 250, Type 4X watertight, industrial type with integral transformer for 120V ac applications and corrosion-resistant service.
    b. Screwed on prismatic lenses and factory engraved legend plates for service legend.
    c. Manufacturers and Products:
        1) Square D; Type SK.
        2) Allen-Bradley; Type 800H.
3. Pushbutton, Momentary, Watertight:
    a. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with momentary contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.
    b. Standard size, black field, legend plates with white markings for service legend.
    c. Manufacturers and Products:
        1) Square D; Type SK.
        2) Allen-Bradley; Type 800H.

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4. Selector Switch, Watertight:
   a. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.
   b. Standard size, black field, legend plates with white markings, for service legend.
   c. Operators: Black knob type.
   d. Single-hole mounting, accommodating panel thicknesses from 1/16 to 1/4 inch.
   e. Manufacturer and Products:
      1) Square D; Class 9001, Type SK.
      2) Allen-Bradley; Type 800H.

2.05 INSTRUMENT TAG NUMBERS

A. A shorthand tag number notation is used. For example:

AI-1-12(2)(3)[pH]

Notation	Explanation
AI	ISA designator for Analysis Indicator
1	Unit process number
12	Loop number
(2)	First unit number; number of same component types in a given loop; -1 and 1-2 in this example
(3)	Second unit number; number of same component types with same first unit number in a given loop; -1, -2, and -3 in this example
[pH]	Same notation shown at 2 o'clock position on ISA circle symbol on Process and Instrument Diagram

B. In this example, AI-1-12(2)(3)[pH] is shorthand for:

AI-1-12-1-1[pH], AI-1-12-1-2[pH], AI-1-12-1-3[pH]

AI-1-12-2-1[pH], AI-1-12-2-2[pH], AI-1-12-2-3[pH]

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2.06 NAMEPLATES, NAMETAGS, AND SERVICE LEGENDS

A. Nametags: Permanently mounted bearing entire ISA tag number.

1. Panel Mounted: Plastic, mounted to instrument behind panel face.
2. Field Mounted: Engraved Type 316 stainless steel, 22-gauge minimum thickness, attached with stainless steel.

B. Service Legends (Integrally Mounted with Instrument) and Nameplates:

1. Engraved, rigid, laminated plastic type with adhesive back. Furnish service legends and nameplates to adequately describe functions of panel face mounted instruments.
2. Color: White with black letters.
3. Letter Height: 3/16 inch.
4. For each panel, face mounted laminated nameplate inscribed with the panel name and tag number. Color shall be white with black letters 1/2 inch high.

C. Standard Light Colors and Inscriptions: Unless otherwise specified in individual equipment specifications, use the following color code and inscriptions:

Tag	Inscription(s)	Color
ON	ON	Red
OFF	OFF	Green
OPEN	OPEN	Red
CLOSED	CLOSED	Green
LOW	LOW	Amber
FAIL	FAIL	Amber
HIGH	HIGH	Amber
AUTO	AUTO	White
MANUAL	MANUAL	Yellow
LOCAL	LOCAL	White
REMOTE	REMOTE	Yellow
FORWARD	FORWARD	Red
REVERSE	REVERSE	Blue

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1. Lettering: Black on white and amber lenses; white on red and green lenses.
2. Standard Pushbutton Colors and Inscriptions:
   a. Use following unless otherwise noted:

Tag Function	Inscription(s)	Color
OO	ON OFF	Black Black
OC	OPEN CLOSE	Black Black
OCA	OPEN CLOSE AUTO	Black Black Black
OOA	ON OFF AUTO	Black Black Black
MA	MANUAL AUTO	Black Black
SS	START STOP	Black Black
RESET	RESET	Black
EMERGENCY STOP	EMERGENCY STOP	Red

   b. Lettering Color:
      1) Black on white and yellow buttons.
      2) White on black, red, and green buttons.

2.07 ELECTRICAL SURGE AND TRANSIENT PROTECTION

A. Equip control panels with surge-arresting devices to protect equipment from damage as a result of electrical transients induced in interconnecting lines from lightning discharges and nearby electrical devices.

B. Suppressor Locations:

1. At point of connection between an equipment item, including ac powered transmitters, and power supply conductor (direct-wired equipment).
2. On analog pairs at each end when the pair travels outside of building.

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3. In other locations where equipment sensitivity to surges and transients requires additional protection beyond that inherent to design of equipment.

C. Suppressor Design:

1. Construction: First-stage, high-energy metal oxide varistor and second-stage, bipolar silicon avalanche device separated by series impedance; includes grounding wire, stud, or terminal.
2. Response: 5 nanoseconds maximum.
3. Recovery: Automatic.
4. Temperature Range: Minus 20 degrees C to plus 85 degrees C.
5. Enclosure Mounted: Encapsulated inflame retardant epoxy.

D. Suppressors on 120V ac Power Supply Connections:

1. Occurrences: Tested and rated for a minimum of 50 occurrences of IEEE C62.41 Category B test waveform.
2. First-Stage Clamping Voltage: 350 volts or less.
3. Second-Stage Clamping Voltage: 210 volts or less.
4. Power Supplies for Continuous Operation:
   a. Four-Wire Transmitter or Receiver: Minimum 5 amps at 130V ac.
   b. All Other Applications: Minimum 30 amps at 130V ac.

E. Suppressors on Analog Signal Lines:

1. Test Waveform: Linear 8-microsecond rise in current from 0 amp to a peak current value followed by an exponential decay of current reaching one-half the peak value in 20 microseconds.
2. Surge Rating: Tested and rated for 50 occurrences of 2,000-amp peak test waveform.
   a. dc Clamping Voltage: 20 percent to 40 percent above operating voltage for circuit.
   b. dc Clamping Voltage Tolerance: Plus or minus 10 percent.
   c. Maximum Loop Resistance: 18 ohms per conductor.

F. Manufacturers and Products:

1. Analog Signals Lines: Emerson Edco PC-642 or SRA-64 series.
2. 120V ac Lines: Emerson Edco HSP-121.
3. 480-Volt, Three-Phase Power Supplies: Square D Model SDSA3650.
4. Field Mounted at Two-Wire Instruments:
   a. Encapsulated in stainless steel pipe nipples.
   b. Emerson Edco SS64 series.

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5. Field Mounted at Four-Wire Instruments: With 120V ac outlet, ac circuit breaker, and 10-ohm resistor on signal line, all in enclosure.
   a. Enclosure:
      1) NEMA 4X Type 316 stainless steel with door.
      2) Maximum Size: 12 inches by 12 inches by 8 inches deep.
   b. Emerson Edco; SLAC series.

G. Grounding:

1. Coordinate surge suppressor grounding in field panels and field instrumentation as specified in suppressor manufacturer's requirements.
2. Provide control panels with an integral copper grounding bus for connection of suppressors and other required instrumentation.

PART 3 EXECUTION

3.01 ELECTRICAL POWER AND SIGNAL WIRING

A. Restrain control and signal wiring in control panels by plastic ties or ducts. Secure hinge wiring at each end so bending or twisting will occur around the longitudinal axis of wire. Protect bend area with a sleeve.

B. Arrange wiring neatly, cut to proper length, and remove surplus wire. Install abrasion protection for wire bundles passing through holes or across edges of sheet metal.

C. Use manufacturer's recommended tool with sized anvil for crimp terminations. No more than one wire may be terminated in a single crimp lug. No more than two lugs may be installed on a single screw terminal.

D. Do not splice or tap wiring except at device terminals or terminal blocks.

3.02 SOURCE AND FIELD QUALITY CONTROL

A. Factory Test (Witnessed):

1. Provide Factory Test for each package I&CS panel. Provide test plans for review and approval, to demonstrate the operational functionality of hardware, standard software and communications.
2. Make arrangements with Owner and EOR for a Factory Test for every control panel. No panel shall be delivered to site without getting an official clearance from EOR, based on the successful completion of Factory Test.

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3. Schedule the session(s) with EOR a minimum of 10 working days in advance. Allot enough time for thorough testing and corrections to take place.
4. Panel inspection and Factory Test shall be performed in the presence of, and to the satisfaction of EOR, and is to include all devices necessary to simulate actual operating conditions.
5. Provide temporary PLC and OIT software for the Test.
6. Connect the PLC Panels and OITs. Simulate the final network configuration, install all application programs provided by the EOR, establish communications, temporarily wire digital inputs to test switches and digital outputs to indicating lights, analog inputs to 4 to 20mA generators and analog outputs to panel meters to demonstrate functionality of all hardware and software. The Factory Acceptance Test plan to be submitted to EOR shall define clearly the method used for testing. The plan shall include at a least four-hour period for discretionary tests to be conducted by EOR. Exercise the hardware (i.e., I/O, communications, panel mounted instruments, etc.) to demonstrate/monitor operation of all connected equipment and wiring and to fully demonstrate the process control actions and responses to manually entered process condition changes.
7. Demonstrate all basic functions including I/O processing, communications, alarm handling, OIT display functions, alarm logging, etc.
8. Make the necessary corrections as indicated by the tests, or as directed by EOR. Shipment of equipment to site is contingent on EOR’s prior approval.

B. Software Demonstration Tests (SDT):

1. Scope: Test entire package I&CS PLC and OIT software to demonstrate that it is operational.
2. Location: Equipment Supplier’s facility.
3. OIT Display Tests: The object of the test is to verify all OIT database points. Each OIT display and dynamic object on that display and control shall be tested and verified. Provide a test form for each display that lists all of dynamic objects, controls, pop-up windows and their associated database tags and corresponding PLC address. The test form shall provide a place for a sign off for the EOR and the Owner.
4. OIT Display Navigation Test: The objective of the test is to verify all the display navigation controls.
5. Loop-Specific Functions: This test shall not be started until the Display and Display navigation tests have been successfully completed. This test shall verify all OIT and PLC functions through indications on the OIT. Develop test forms on process and loop basis. The forms shall list all

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controlled equipment, control routines, alarm points, status points, setpoints, controllers, sequences. The test shall demonstrate all manual and automatic functions are operating as specified and verify that the outputs and inputs are configured to the correct PLC I/O point.

6. Make the following documentation available to the EOR and the Owner at test site both before and during SDT:
   a. Process Control Narratives.
   b. O&M material.
   c. Master copy of SDT Sign off sheets.
   d. Applications software documentation.

C. Functional Testing:

1. Prior to the functional testing, inspect and document that entire package I&CS is ready for operation.
2. Check the entire system for proper installation and calibrate/adjust the system on a loop-by-loop and component-by-component basis to ensure that it is in conformance with related submittals and these specifications. This shall include calibration and testing of each field instrument and control device supplied under this procurement package.
3. Tests shall be implemented using approved forms and checklists.
   a. Each loop shall have a report to organize and track its inspection, adjustment, and calibration. These reports shall include the following information:
      1) Project name.
      2) Point identifier.
      3) Point description.
      4) Space for comments.
      5) Space for signoff.
   b. All instruments shall have an Instrument Calibration Sheet. These sheets shall have the following information:
      1) Project name.
      2) Point identifier.
      3) Point description.
      4) Manufacturer.
      5) Model Number/Serial Number.
      6) Summary of Functional Requirements; for example:
         a) For Indicators and Recorders: Scale ranges.
         b) For Transmitters/Converters: Scale ranges.
         c) For Computing Elements: Function.
         d) For Controllers: Action (direct/reverse) control modes (PID).

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7) Calibrations; for example:
a) For Analog Devices: Required and actual inputs and outputs at 0, 25, 50, 75, and 100 percent of span, rising and falling.
b) For Controllers: Mode settings (PID).
8) Space for comments.
9) Space for signoff by the SI and EOR.

c. Conduct application software tests, using real field sensors and equipment. Interlocking and communications with package PLCs and the process SCADA tested on loop-by-loop basis.
d. Test procedures provided by SI.

4. The functional testing requires witnessing as deemed appropriate by Owner. Owner and EOR will review and initial all test sheets and check their entries periodically. Any deficiencies found shall be corrected within 5 working days.

D. Performance Acceptance and Operational Demonstration Tests:

1. Performance Acceptance Test (PAT) shall be performed after successful completion of the Functional Test described in other sections. All preliminary testing, inspection, and calibration shall be complete as defined in the operational readiness tests. Coordinate and schedule this test with Owner and EOR.
a. Each hardware and software function shall be demonstrated on a process-by-process and loop-by-loop basis. Coordinate and schedule this test with Owner and EOR.
b. Perform local and manual tests for each loop before proceeding to remote and automatic modes. Verify test results using visual confirmation of process equipment and actual process variable. Unless otherwise directed, exercise and observe devices supplied by others, as needed to verify correct signals to and from such devices and to confirm overall system functionality. Test verification by means of disconnecting wires or measuring signal levels is acceptable only where direct operation of plant equipment is not possible.
c. The following documentation shall be made available by the SI at the plant site prior to testing:
1) All RFC Drawings and Specifications.
2) Master copy of the test procedure.
3) List of the equipment to be tested including make, model and serial number.
4) Design-related hardware submittal applicable to the equipment being tested.
5) Application Software documentation submittal.

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d. The daily schedule during these tests shall be as follows:
   1) Testing and meetings: Nominally 8 hours per day.
   2) Morning meetings to review the day's test schedule.
   3) Afternoon meetings to review the day's test results and to review or revise the next day's test schedule.

e. All test data and procedure followed during testing shall be logged, and certified copies of the logs shall be provided to Owner and EOR.

f. Success Criteria: All components, subsystems, and overall system have been successfully tested and passed all of their tests and have been approved and signed off by the Owner and EOR.

2. After successful completion of PAT, a witnessed Operational Demonstration Test shall be performed on the complete system to demonstrate that it is operating in compliance with these Specifications and submittals. Refer to Contract Documents Part III, Section 7.

3.03 DELIVERY, STORAGE, AND HANDLING

A. Prior to shipment, include corrosive-inhibitive vapor capsules in shipping containers and related equipment as recommended by capsule manufacturer.

3.04 PROTECTION

A. Protect enclosures and other equipment containing electrical, instrumentation and control devices, including spare parts, from corrosion through the use of corrosion-inhibiting vapor capsules.

B. During Work, periodically replace capsules in accordance with capsule manufacturer’s recommendations. Replace capsules at Substantial Completion.

END OF SECTION

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SECTION 44 42 19.05
ROTARY SCREW POSITIVE DISPLACEMENT BLOWER

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Gear Manufacturers Association (AGMA).
2. American National Standards Institute (ANSI).
3. ASTM International (ASTM):
   a. A48/A48M, Standard Specification for Gray Iron Castings.
   b. A395/A395M, Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
   c. ASTM536, Standard Specification for Ductile Iron Castings.
4. National Electrical Manufacturers Association (NEMA).

1.02 DEFINITIONS

A. Abbreviations:

1. FDT: Factory Demonstration Test.
2. HMI: Human-Machine Interface.
3. I&C: Instrumentation and Control.
4. I/O: Input and Output.
5. O&M: Operation and Maintenance.
6. ORT: Operational Readiness Test
7. P&ID: Process and Instrument Diagram.
8. PIC: Process Instrumentation and Control.
9. PCS: Plant Control System.
10. PLC: Programmable Logic Controller.
11. SAT: Site Acceptance Test.
12. SCADA: Supervisory Control and Data Acquisition.
13. VFD: Variable frequency drive.

B. Actual Cubic Feet per Minute (acfm): Air volume in cubic feet per minute corrected to Site conditions of elevation, temperature, and relative humidity.

C. Ambient (Inlet) Pressure: Absolute pressure of the ambient air measured in the vicinity of the blower inlet measured at the stagnation condition. This will equal barometric pressure under typical conditions.

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D. Ambient (Inlet) Temperature: Total temperature of the ambient air in the vicinity of the blower package, but unaffected by it.

E. Input Power (kW or hp): Input power (wire power) is the total power required to operate the blower package (blower motor and all ancillary equipment).

F. Blower Package: Blower package is defined by the limits of the scope of supply as specified in the overall project contractual agreement pertaining to the blower installation. This shall include all deliverable components including valves, control panels, disconnects, etc. as specified herein to form an operational machine including but not limited to inlet, discharge, and all power devices that affect power consumption.

G. Brake Horsepower (BHP): (Shaft) Standard curve horsepower required, corrected for pressure, temperature, and relative humidity at inlet conditions.

H. Discharge Pressure: Pressure in pounds per square inch gauge (psig) at blower discharge flange at rated capacity. Typically measured downstream of the check valve at rated capacity.

I. Inlet Cubic Feet per Minute (icfm): The rate of flow which is determined by delivered mass flow rate divided by inlet total density as defined by the inlet to the package. Air volume in cubic feet per minute entering blower at inlet pressure and temperature conditions corrected for Site conditions and includes inlet filter and inlet line losses.

J. Overall (Wire to Air) Efficiency: It is the wire to air isentropic efficiency of the entire blower package. This includes energy losses from all components within the blower package. This is the ratio of total measured wire-to-air (system) power demand to the power of compression due to an assumed reversible, adiabatic compression process with constant entropy.

K. Pressure Rise: Difference between pressure at the blower package discharge flange (typically downstream of the check valve) and the package inlet flange in pounds per square inch (psi).

L. Standard Cubic Feet per Minute (scfm): Air volume in cubic feet per minute corrected to standard conditions of 68 degrees F, 14.70 psia, and 36 percent relative humidity.

M. Blower Package Total Wire Power (kW or hp): The blower package total wire power is the electrical power measured at the power input to the blower package. This shall include all power consuming electrical components of the blower package as required for installation and normal operation. i.e., drive motor, motor cooling fan, bearing cooling fans, coolant pump and heat

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exchanger, enclosure and package cooling fan, sine wave filter or output reactor, variable frequency drive and cooling fan, input choke or line reactor, harmonic filter, local control panel, PLC or processor, HMI and miscellaneous electronics, voltage transformer(s), DC power supplies, power conditioner, etc. If the blower package receives multiple power feeds, this is the sum of all wire powers measured individually.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Complete list of system components to be provided.
   b. Make, model, weight, and horsepower of each equipment assembly.
   c. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
   d. Standard and specialized equipment assembly cuts.
   e. System layout, installation, and placing drawings for equipment, drivers, and bases.
   f. Performance data for each type of equipment that will show compliance with specification requirements stated herein.
   g. Horsepower demand over the operating range of the blower.
   h. Detailed structural, mechanical, and electrical drawings showing the equipment fabrications and interface with other items. Include dimensions, size, and locations of connections to other work.
   i. Motor: See requirements of Section 26 05 01, Electrical.
   j. VFDs: See requirements of Section 26 29 23, Low-Voltage Adjustable Speed Drives.
   k. Monitoring System:
      1) Catalog cuts of each blower control system component, including monitoring panel components.
      2) P&ID and wiring diagrams, including customer wiring connections.
      3) Panel construction and face layout drawings.
   l. Anchorage and bracing drawings showing anchor bolt layouts and locations and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.
   m. Sound Enclosure:
      1) Complete description of sound enclosure and accessories.
      2) Calculated noise attenuation.
2. Samples: Color samples for finish coating. If paint manufacturer of finish coat differs from manufacturer of prime coat, provide both manufacturers' written confirmation that materials are compatible.

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B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
3. Factory calculated sound pressure levels (dBA) of blower unit with silencers and sound enclosure.
4. Identification of outside utility requirements for each component such as air, water, power, etc. Include operating parameters for required utilities.
5. Special shipping, storage and protection, and handling instructions.
6. Manufacturer's written installation instructions.
7. List of special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
8. Suggested spare parts list to maintain the equipment in service for a period of 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
9. Routine maintenance requirements prior to plant startup.
10. Factory Test Procedures: Submit factory test plan(s) outlining all required testing activities within this section for the Engineers approval a minimum of 12 weeks prior to testing.
11. Submit a detailed test procedure with complete piping and instrumentation configuration diagram showing inlet and discharge air test pipe size. The location, type, and quantity of all major instruments necessary for performance data, including corresponding distances from reference points as required for proper measurement. As a minimum, the detailed test plan shall include:
    a. Quality control procedures.
    b. Functional testing of entire package, including instrumentation, and ancillary components.
12. Complete factory test report for each blower system.
13. Manufacturer's Field Report:
    a. Field Test Procedure: Submit a detailed test procedure for complete blower system.
    b. Field Test Reports: Complete test report for each blower system.
    c. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
14. Operation and Maintenance Manuals: as specified in Section 01 78 23, Operation and Maintenance Data and include the following additional information in each O&M Manual:
    a. Maintenance Summary Forms.
    b. Certified factory test reports for motor and blower and performance curves for blowers, field startup, and test reports.

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c. Detailed list of maintenance required to maintain validity of Manufacturer's warranty.
d. Technical assistance contact information.

1.04 DESIGN REQUIREMENTS

A. Design equipment with due regard to safety of operation, accessibility, and durability of parts, and complying with applicable OSHA, state, and local safety regulations.

B. Seismic Requirements: In accordance with Section 01 61 00, Common Product Requirements.

C. Blower room access door internal dimensions: 90-inch by 65-inch.

D. Each blower will receive outside air from two existing roof intake structures and a common inlet header.

1. The Contractor shall remove the existing filter media in the existing roof mounted inlet filters; the existing filter frames shall be retained and used as intake structures.
2. New inlet filters mounted inside the blower enclosure.

E. Each blower will discharge into a main air discharge header that will serve separate discharge lines, one for each CPT Reactor.

F. Intermittent and continuous operation in an indoor environment.

G. Blower(s) shall start no more than four times per hour when operating in intermittent service.

H. Blowers shall meet rated performance and sound pressure level when operating at a maximum gear tip speed of 6,100 round per minute feet per minute. Operating speed shall not exceed 80 percent of rated speed.

I. Maximum Sound Pressure Level: 72 dBA, factory calculated, with inlet and discharge silencers, measured with a sound enclosure at 3-foot distance and in an open space with no hard space.

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J. Performance Requirements:

Design Conditions	
Application/Service	Centrate Pretreatment (CPT) Facility
Number Of Blowers	3 (2 duty and 1 standby) B69-2001 B69-2002 B69-2003
Impeller Type	Screw
Altitude, ft	32
Ambient Inlet pressure, psia	14.7 ± 0.2
Ambient (Inlet) air temperature range, degrees F	Winter: 20 – 50 Spring/Fall: 40 – 75 Summer: 65 – 100
Relative humidity range, %	Winter: 60 – 80 Spring/Fall: 50 – 80 Summer: 60 – 85
Airflow Range Required at All Operating Conditions, scfm	240 - 710
Pressure relief valve setting, psig	TBD[1]
Shaft brake horsepower, BHP	TBD[1]
Maximum Input Power, hp	TBD[1]
Maximum Blower Inlet Pressure Losses (air pipes, dirty filter, inlet silencer), psi	0.25
Discharge pressure, psig	10.8
[1]To be determined by the manufacturer.	

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1.05 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts, special tools, and materials:

Item	Quantity
Oil, synthetic	Sufficient for 8,000 hr/year and 2 years of operation
Inlet Air Filter Element	One per unit
Oil Filter Element	One per unit
Control Panel Air Filter Element	One per unit
Drive Coupling	One complete set
Special tools required to maintain or dismantle	One complete set

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. Blower system, featuring rotary screw positive displacement blower(s) to supply air for the Centrate Pretreatment (CPT) Facility.

B. Each blower system provided with motor, local instrumentation and control panels, instruments, components and all accessories and appurtenances. The work includes a communications network for connecting the control panels and interface with the Alex Renew Plant Control System.

C. Provide blower system, including, but not limited to, blowers, control panel, motors, drives, guards, drive couplings, baseplates, vibration isolators, supports, inlet silencers, discharge silencers, relief valves, flexible connectors, noise enclosures, spare parts, outside air filter, and miscellaneous appurtenances as necessary.

D. Each blower shall be located in an acoustical enclosure rated for indoor installation and capable of limiting sound pressure level as specified herein.

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2.02 MANUFACTURERS

A. General:

1. Where possible, provide end products of one manufacturer to achieve standardization for appearance, operation, maintenance, replacement, and manufacturer's service.
2. Manufacture spare parts to United States standard sizes and gauges.

B. Materials, equipment, and accessories specified in this section shall be products of:

1. Variable Speed Rotary Screw Blower – Model ZS 4 VSD+ 37kW 1.0-60, by Atlas Copco.
2. AERZEN Delta Hybrid D 40 S, DN 200 (Pi = 1.8), by Aerzen USA.
3. 60HP EE-PAC ATTENU-PAC Enclosure, by Universal Blower Pac Inc.

2.03 COMPONENTS

A. Blower:

1. Rotary screw positive displacement type, direct driven by horizontal electric motor.
2. Casing: One-piece construction, ASTM A48/A48M, Class 30B close grain cast iron strongly ribbed to prevent distortion at the specified operating conditions. Separate headplates of cast iron.
3. Bearings:
   a. Each rotor/shaft shall be supported by anti-friction bearings and fixed to control the axial location of the rotor/shaft in the unit.
   b. The applied design conditions shall yield a bearing load and minimal L-10 bearing life calculation of 100,000 hours. Calculated bearing life shall be submitted, based on the specified conditions.
4. Impellers:
   a. Provide impeller/shaft assemblies integrally cast from high strength ASTM A395/A395M Type 60-45-15 or ASTM 536 ductile iron with a minimum tensile strength of 60,000 pounds per square inch or coated cast iron, grade GGG40 machined, coated & baked or equivalent
   b. Straight, two-screw involute type, rotating in opposite directions in a common casing without rubbing, liquid seals, or lubrication.
   c. Positioned by timing gears to maintain proper clearances.

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d. Mount impellers and timing gears on shafts supported by antifriction bearings, fixed to control the axial location of impeller/shaft in the casing.
e. Statically and dynamically balanced by removing metal from impeller body.

5. Shafts:
   a. Cast iron, integral with impellers.
   b. Machine labyrinth seals into shaft to minimize air leakage.
6. Direct-Drive Coupling:
   a. Service Factor: 1.5 on horsepower.
   b. Guard over coupling.
   c. Manufacturers:
      1) Hardy Pro Air.
      2) Atlas Copco.
      3) Aerzen
      4) Excelsior Blower Systems.

B. Motor:

1. Motors shall be operated from variable frequency drives (VFDs),
2. Squirrel-cage ac induction type, meeting requirements of Section 26 05 01, Electrical and as specified herein.
3. Motor Horsepower: Specified in Design Condition Table.
4. Rated Voltage: 460 volt, three-phase, 60 Hz.
5. Enclosure Type: TEFC and as specified in Section 26 05 01, Electrical.
6. Inverter duty rated.
7. Drive: Direct-drive coupling.
8. Motor Efficiency: Premium efficiency as specified in Section 26 05 01, Electrical.
9. Service Factor: 1.15.

C. VFD:

1. Meeting requirements of Section 26 29 23, Low-Voltage Adjustable Speed Drives and as specified herein.
2. VFDs shall be provided inside the individual blower control panels.
3. VFDs shall be inverter duty rated.
4. The use of “inverter ready” will not be considered.

D. Blower Support:

1. Baseplate: Cast iron or fabricated steel mounted on concrete equipment pad as shown on Drawings.

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2. Support Stand: Designed by manufacturer and reinforced to withstand anticipated loadings of blower, motor, inlet and discharge silencers, and associated piping.
3. Factory mount blower and motor as a package.
4. Provide vibration isolators to limit transmission of vibration to anchor points at floor.

2.04 ACCESSORIES

A. Blower Inlet Filter:

1. Dry-type inlet air filters for each blower.
2. Filters shall be furnished and installed in the blower enclosure.
3. Filter and silencer performance losses (clean element) shall be included in the entire package performance calculation.
4. The filter media efficiency shall meet the requirements of ASHRAE 52.2 MERV7 50 percent to 70 percent at 3 to 10 microns corresponding to ISO 16890.

B. Silencers:

1. Designed to reduce pulsation noise from blowers at blower operating speeds.
2. Each blower shall be provided with manufacturer standard inlet filter silencer. Inlet/Outlet Air Velocity: 7,000 feet per minute, maximum.
3. Each blower shall be provided with manufacturer standard discharge silencer and connected to the air discharge from the blower compression element. The maximum working pressure and temperature to be determined by the manufacturer.
4. Pressure Loss: 6 inches of WC maximum (0.21 psi), through silencer at design flow rate.
5. Inlet and outlet flanges shall match the piping size shown on Drawings and blower flanges.
6. Mount inside the blower enclosure.
   a. Flange Drilling: 125-pound ANSI standard.
7. Provide drain coupling and plug.
8. Manufacturers and Products:
   a. Discharge Silencer: Aerzen; Universal Silencer, Inc.;. “Or-equal”.

C. Flexible Connectors:

1. Pressure spool, single arch, expansion joint type with 125-pound ANSI flanges, sized to match blower flanges.
2. Operating Temperature Rating: 400 degrees F.
3. Provided on blower’s inlet and outlet flanges.

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4. Thrust restraint rods on discharge if not otherwise restrained.
5. Manufacturers and Products:
    a. Mercer; Style Viton HT500.
    b. General Rubber; Style 101.
    c. Proco.

D. Check Valve:

1. Dual-plate, metal hinged wafer type for each blower; installed in blower discharge piping downstream of silencer and relief valve.
2. Cast iron body, stainless steel pin and spring, and two semicircular bronze or stainless steel plates.
3. Seat: Viton or Silicone for high temperature operation.
4. Elastomeric hinges will not be allowed.
5. Mount inside the blower enclosure.
6. Manufacturer and Product: Cameron; TECHNO, Atlas Copco, Aerzen.

E. Safety Relief Valve:

1. Flanged, spring type.
2. Sized to relieve entire discharge flow without overloading blower.
3. Furnish one for each blower.
4. Mount inside the blower enclosure.

F. Noise Enclosure: Meeting the Design Requirements.

G. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 100 pounds.

H. Equipment Identification Plates: Provide 16-gauge Type 304 stainless steel identification plate securely mounted on each separate equipment component in a readily visible location. Plate shall bear 3/8 block type black enamel filled equipment identification number and letters indicated in this specification.

I. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, 1/2-inch minimum diameter, and as specified in Section 05 50 00, Metal Fabrications. Coat in accordance with Section 09 90 00, Painting and Coating.

2.05 INSTRUMENTATION AND CONTROLS

A. Instrumentation and Controls: In accordance with below requirements. External signal interfaces are required to interface with facility’s wide SCADA system Provide items not specifically called out which are required to implement functions required for the proper system operation.

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B. Refer to Section 40 90 00, Instrumentation and Control for Process Systems and Section 40 99 90, Package Control Systems.

C. Control Panel:

1. Panel Power Requirements: 480V ac, 3-phase.
2. NEMA Rating: 12.
3. Mounting: Wall mounted, independently of the blower enclosure, where shown on Drawings.
4. Programmable Logic Controller:
    a. Provide power supplies, I/O modules, processor, cables, etc., for a complete functional system installed in Blower integrated control panel.
    b. Provide a minimum of 25 percent spare I/O points for each type of I/O used.
    c. For signals originating in hazardous areas, provide intrinsic safety barriers and relays in the PLC panel. Refer to Electrical drawings and Division 1 specifications for area classifications.
    d. Provide individual indicating fuse block for each analog signal (input and output).
    e. The discrete inputs to the Process SCADA system shall be 24V dc. Provide interposing relays for discrete output modules in the PLC panel, as required.
    f. Provide individual fuse block for each digital input card.
    g. The package system PLC shall communicate with the process SCADA system via Ethernet network and support the common industrial protocol (CIP) used by ODVA Ethernet/IP. Provide fully managed Ethernet switch so that Blower can be a working node on the plant network.
    h. Engineer of Record (EOR) will provide IP addresses for the package system PLC.
    i. Vendor to provide the PLC Program of the Blower for record.
    j. Manufacturers: Allen-Bradley CompactLogix PLC with 5380 PLC controller with no substitutions allowed.
5. Operator Interface Terminal (OIT):
    a. Provide color touch screen display with cabling, communication modules and all required accessories.
    b. Size 10 inches.
    c. Provide OIT programming software license registered to Owner.
    d. Manufacturers: Allen-Bradley; PanelView Plus 7 OITs with no substitutions allowed.
6. Uninterruptible Power Supply (UPS):
    a. Provides isolated, regulated uninterrupted ac output power during a complete or partial interruption of incoming line power.

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b. Backup Runtime: 30 minutes runtime at 150 percent of connected load.
c. Manufacturers and Products:
    1) APC; Smart UPS RT series.
    2) "Or approved equal."

7. Vendor to provide annotated data exchange look up tables and other information to allow the plant PLC/ SCADA poll the internal registers of the Blower PLC for real-time monitoring and control of Blower remotely from the plant SCADA.
8. Hand Switches to be shown on OIT:
    a. LOCAL/OFF/REMOTE.
    b. START/STOP.
    c. RESET for blower fail.
9. Indicating Lights to be shown on OIT:
    a. Blower FAIL.
    b. HIGH differential air pressure.
    c. Blower ON.
    d. Blower OFF.
10. Miscellaneous items to be shown on OIT:
    a. Motor High Temperature.
    b. High inlet vacuum shutdown.
    c. Blower Inlet Pressure and associated alarms.
    d. Blower Inlet Temperature and associated alarms.
    e. Blower Discharge Pressure and associated alarms.
    f. Blower Discharge Temperature and associated alarms.
    g. Blower motor over temperature alarm.
    h. Blower runtime (daily, monthly and yearly). All alarm should be time stamped and logged).
    i. Bearings Lubrication Oil System Temperature.
    j. Bearings Lubrication Oil System Pressure.
    k. Log errors and first out indication.
    l. Track and log maintenance.
    m. Fan/Enclosure Temperature.
    n. Blower E-Stop.
11. Blower hardwired interlocks:
    a. Discharge High Temperature Shutdown: Vendor to suggest the threshold for safe operation of Blower.
    b. Discharge High Pressure Shutdown: Vendor to suggest the threshold for safe operation of Blower.

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D. Control Panel External Interfaces:

1. Outputs to Plant PLC/ SCADA via Datalink. The list of information available in the OIT should also be available through the data link to SCADA.
2. Outputs to Plant PLC/ SCADA via hardwire connection. Dry contacts shall be noble metal or hermetically sealed, and suitable for 5 amps at 120V ac.
    a. Blower Fault.
3. Inputs from Plant PLC/ SCADA via Datalink:
    a. Blower speed/airflow command.
    b. START/STOP.
4. Signals that interface with plant PLC shall be wired to a terminal block in each panel.
5. Contacts:
    a. Material: Gold or silver.
    b. Minimum Rating: 5 amps, 28V dc.
    c. Discrete Outputs:
        1) Alarm: Single-pole, double-throw (SPDT) dry type.
        2) Other: Single-pole, single-throw (SPST) dry type.
    d. Wire Blower fail discrete alarm output relay contact to a terminal strip for interfacing to plant PLC.

E. System Operation:

1. Functional Requirements:
    a. Provide at each blower OIT panel:
        1) RESET pushbutton and associated logic for the common FAIL alarms. When alarm condition occurs, indicate associated condition at OIT panel. Local indication of alarm condition shall remain until condition has been corrected and RESET pushbutton on OIT is pressed.
        2) Control logic to monitor operation of blower and provide a contact closure output to motor control center when prestart up or operating conditions are normal. Open contact if a HIGH differential air pressure between blower inlet and outlet condition or HIGH discharge air temperature is detected.
        3) Indicate blower shutdown and problem using latching relays.

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F. Shop/Factory Finishing:

1. Prepare, prime, and finish coat in accordance with Section 09 90 00, Painting and Coating System No. 4. Manufacturer's standard painting system may be used if similar to System No. 4 as approved by the Owner.
2. Furnish manufacturer's standard baked enamel finish, color as selected.

2.06 SOURCE QUALITY CONTROL

A. General Testing Requirements:

1. Blower Testing:
   a. Conduct manufacturer standard test as described herein on all furnished blowers and associated components supplied under this specification. Testing of similar size units and components not actually furnished will not be allowed.
   b. Organize and clearly present testing methods and procedures, testing equipment, test data, calculations and analyses, conclusions, and recommendations.
   c. Submit summarized test results in a certified report for approval.
2. The blower package manufacturer must submit a factory test procedure for approval. Prerequisite for scheduling the factory test is an approved test procedure at least 6 weeks prior to scheduling the factory test.
   a. The test procedure shall include the completed attached Factory Testing Summary Checklists supplements:
      1) Process and Fluid Components.
      2) Electrical Power Related Components.
3. The test procedure shall include a sketch of the test setup showing the piping and instrumentation.
4. All test equipment shall be calibrated and certified by an independent test agency no more than 12 months prior to the test date. Certificates shall show the stability of calibration over a period of at least 1 year per ISO 9001, Paragraph 4.11.
5. Upon completion of assembly, the blower package shall be tested at the place of assembly.
6. The manufacturer shall provide copies of the test data and all certifications of Factory Testing for approval by the engineer prior to shipping equipment.
7. Final approved test results shall be included in the Operation and Maintenance Manual.

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B. Blower Performance Test:

1. Each blower shall be performance tested to verify flow and wire power consumption at design conditions as well as blower minimum and maximum operating conditions. Tests shall be conducted using all components to be installed in the field.
2. Each blower test report shall present computations with the performance curves showing capacity, pressure, and horsepower inputs for each of the flow and pressure conditions and the determination of the maximum operating pressure.
3. The blower package shall be factory tested for duration not less than 4 hours under varying operating conditions.
4. The blower package including pressure relief/blowoff valve shall be tested before shipment.
5. A calibrated wattmeter shall measure the electrical input to the blower system. Measured power shall include all losses associated with electrical shaft power, including but not limited to the motor, inverter, drive, cooling system, etc.
6. Plot flow vs. speed and power vs. speed and flow vs. power at constant pressure, using units as defined herein before. Plots should include one point near the minimum flow as limited by differential temperature and one point near the maximum flow as limited by the lower of motor power, speed, or pressure.
7. Inlet pressure, inlet temperature, inlet humidity, discharge temperature, discharge pressure, and net delivered flow rate shall be recorded for all operating design points outlined within this section.
8. The blower delivered flow rate (scfm) and discharge pressure (psi) shall be guaranteed with no negative tolerance. There shall be no other tolerances or measuring uncertainties used in reporting test results.
    a. Air flow rate shall be measured on the discharge side of the blower.
    b. Discharge pressure (delivered pressure) shall be measured downstream of the check valve.
    c. Input power is the sum of the input electrical power to the blower system (package).
9. Measure power consumption using a calibrated wattmeter.
10. Provide total power consumption calculations for each blower for each specified operating condition.

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C. Additional testing and verification:

1. Velocity vibration versus frequency levels shall be recorded within 10-1,000 and 10-10,000 Hz frequency.
2. The sound pressure level shall be measured in accordance with ASME PTC-36, Measurement of Industrial Sound, and operating at the maximum design capacities during the preliminary equipment tests at the factory.
3. All START/STOP sequences and all safety and alarm systems shall be tested, simulating start of the blower motor. All blowers shall be demonstrated for satisfactory functional operation before shipment.

D. Motor Test: See Section 26 05 01, Electrical.

PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with manufacturer's written instructions. The Contractor shall be responsible for coordinating related items, not covered in this section of the Specifications, such as piping, fittings, additional valves, supports, controls, wiring.

B. Anchor Bolts: Accurately place using templates furnished by manufacturer and as specified in Section 05 50 00, Metal Fabrications.

C. Install blower package on vibration isolators and anchor bolts in strict accordance with manufacturer's written instructions.

3.02 FIELD QUALITY CONTROL

A. In accordance with Section 01 91 00, Equipment Systems Commissioning.

B. Functional Test: Prior to facility startup, conduct on each Blower System assisted by manufacturer's representative, for correct rotation, proper controls and wiring, safety interlocks, proper alignment and connection, quiet operation, and satisfactory specified performance.

3.03 MANUFACTURER'S SERVICES

A. Per Section 01 43 33, Manufacturers' Field Services and Section 01 91 00, Equipment Systems Commissioning, provide:

1. Manufacturer's Certificates of Compliance.
2. Manufacturer's Certificates of Proper Installation.

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3. Training.
4. Other onsite services, requiring on site presence for a minimum person-days listed below, travel time excluded:
    a. 2 person-days for assistance during product installation, inspection, checking and adjustments;
    b. 3 person-days for functional and performance testing.

3.04 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are part of this Specification:

1. Process and Fluid Components – Factory Testing Summary Checklists.
2. Electrical Power Related Component – Factory Testing Summary Checklists.

END OF SECTION

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1. Process and Fluid Components:

Included in Performance Boundary			
	Included in Test	**Determine by Calculation**	**Not Applicable**
Inlet filter			
Inlet silencer			
Discharge silencer			
Inlet isolation valve			
Throttling valve			
After cooler			
Misc. pipe and fittings			
Inlet air cooler			
Discharge check valve			
Discharge isolation valve			
Enclosure doors or panel openings			
Estimated system inlet pressure drop			
Additional components not listed included as forming the blower package			

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2. Electric Power Related Components:

Included in Performance Boundary			
	Included in Test	**Determine by Calculation**	**Not Applicable**
Drive motor			
Motor cooling fan(s)			
Magnetic bearing(s) and controller(s)			
Bearing cooling fan(s)			
Coolant pumps			
Lubrication pump(s) and accessories			
Heat exchanger fan(s)			
Package cooling fan(s)			
VFD(s)			
VFD line-side power- conditioning equipment			
VFD load-side power- conditioning equipment			
Eddy current or variable speed clutch			
Operation control panel(s)			
Power/isolation transformers and power supplies			
Power conditioner(s)			
Blower and motor cooling systems			
VFD cooling			
Additional components not listed included as forming the blower package			

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SECTION 44 42 56.04
SUBMERSIBLE PUMPS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Bearing Manufacturers Association (ABMA):
   a. 9, Load Ratings and Fatigue Life for Ball Bearings.
   b. 11, Load Rating and Fatigue Life for Roller Bearings.
2. American Society of Mechanical Engineers (ASME): B16.1, Gray Iron Pipe Flanges and Flanged Fittings, Class 25, 125, and 150.
3. ASTM International (ASTM):
   a. A48, Standard Specification for Gray Iron Castings.
   b. A576, Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
4. Hydraulic Institute Standards (HIS):
   a. 11.6, Submersible Pump Test.
   b. 14.6, Rotodynamic Pumps for Hydraulic Performance Acceptance Tests.
5. National Electrical Manufacturers Association (NEMA).
6. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code.
   b. 497, Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.
7. Underwriters Laboratories Inc. (UL).

1.02 DEFINITIONS

A. Terminology pertaining to pumping unit performance and construction shall conform to ratings and nomenclature of Hydraulic Institute Standards.

1.03 SUBMITTALS

A. Action Submittals:

1. Make, model, weight, and horsepower of each equipment assembly.
2. Complete catalog information, descriptive literature, specifications, and identification of materials of construction, including cable seal details.
3. Performance data curves showing head, capacity, horsepower demand, and pump efficiency over entire operating range of pump, from shutoff

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to maximum capacity. Indicate separately head, capacity, horsepower demand, overall efficiency, and minimum submergence required at guarantee point.

4. For variable speed motors, provide variable speed curves for every 50 rpm over the operational range.
5. Power and control wiring diagrams, including terminals and numbers.
6. Motor data, in accordance with the requirements of Section 26 05 01, Electrical.
7. Adjustable frequency drive data, in accordance with the requirements of Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.
8. Factory-finish system.
9. L-10 bearing life calculations per ABMA.
10. If required, wiring for motor protection module.
11. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Seismic Anchorage and Bracing.
2. Special shipping, storage and protection, and handling instructions.
3. Manufacturer’s printed installation instructions.
4. Field Performance Test Reports.
5. Suggested spare parts list to maintain equipment in service for period of 1 year of continuous operation. Include list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
6. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
7. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
8. Manufacturer’s Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers’ Field Services.

1.04 EXTRA MATERIALS

A. Furnish for each pump:

1. One set mechanical seals.
2. One complete set of special tools required to dismantle pump.

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PART 2 PRODUCTS

2.01 GENERAL

A. Submersible, vertical shaft, centrifugal nonclog type, for pumping wastewater.

B. Designed for continuous operation under submerged or partially submerged conditions, and intermittent operation when totally dry without damage to pump or motor.

C. Pump and Electrical Driver: Meet requirements for class, group, and division location in accordance with NFPA 70.

D. Pumps furnished under this section to be provided by a single manufacturer.

2.02 SUPPLEMENTS

A. Specific requirements are included to this section as supplements.

2.03 COMPONENTS

A. Equipment consists of pump complete with motor, control system, guide rail, anchoring brackets, base elbow, power cable, and pump lifting cable.

B. Characteristics:

1. Motor and rotating parts shall be removable from motor end of pump.
2. Mating surfaces to be watertight and fitted with nitrile O-rings.
3. Pumps fitted with dynamically balanced nonclog impellers designed to pass course solids and stringy materials.

C. Lifting Arrangement:

1. Stainless steel chain, 2 feet minimum, and one “grip-eye.”
2. Attach chain permanently to pump and CPT Reactor roof deck with stainless steel wire rope.
3. “Grip-eye” capable of being threaded over and engaging links of stainless steel chain so pump and motor may be lifted with “grip-eye” and independent hoist.

D. Sliding Guide Bracket:

1. Integral part of pump unit.
2. Pump unit to be guided by no less than two guide bars, or equivalent cable system, and pressed tightly against discharge connection elbow with metal-to-metal contact or through use of profile-type gasket,

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provided gasket is attached to pump's flange and can be easily accessed for inspection when pump is lifted out of reactor.

E. Oil chamber between seals shall be equipped with drain and inspection plug. Plug shall have positive antileak seal and shall be easily accessible from outside.

F. Motor nameplate horsepower not to be exceeded at head-capacity point on pump curve.

G. Pump motor and sensor cables shall be suitable for submersible pump application and cable sizing shall conform to NFPA 70 specifications for pump motors. Cables shall be of sufficient length to reach junction boxes without strain or splicing.

H. Motor Protection Module: If required, provide pump with a motor protection module for remote mounting. Contract Drawings are based on first named submersible pump manufacturer and motor protection module. If pump and motor protection module other than first named manufacturer is provided, provide revised wiring for the motor protection module.

I. Cable Entry System:

1. Junction chamber and motor separated by stator lead sealing gland or terminal board that prevents foreign material entering through pump top.
2. Utilize cable with factory-installed sealing gland with nonshrink epoxy seal system.
3. O-ring compression seal between sealing gland and cable entry point shall also be acceptable.

2.04 CONTROLS

A. Refer to Section 40 90 00, Instrumentation and Control for Process Systems and Section 40 99 90, Package Control Systems.

B. Control Station: NEMA 4X enclosure, for outdoor duty, with ON/OFF.REMOTE hand-switch (HS) and as shown on Drawings; free standing, post mounted.

C. CAS inside MCC-69-1A:

1. Installed in the electrical room, as shown on Drawings.

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2. Components shown on Schematic Control Diagrams, including but not limited to:
   a. ON/OFF/AUTO switches.
   b. Running lights.
   c. Overload alarm.
   d. Temperature alarm.
   e. Moisture alarm.

D. Prewired and factory tested.

E. Mount control switches, indicating lights, and switches on hinged front panel.

F. Single Feed: 480 volts, three-phase.

2.05 ACCESSORIES

A. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in readily visible location.

B. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications. Coat in accordance with Section 09 90 00, Painting and Coating.

2.06 FACTORY FINISHING

A. Manufacturer’s standard epoxy system for continuous submergence in corrosive water.

2.07 SOURCE QUALITY CONTROL

A. Manufacturer’s standard testing of pump, motors and controls.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s printed instructions.

B. Mount the discharge elbow to the floor of the wetwell floor with stainless steel bolts.

C. Connect piping without imposing strain to flanges.

D. No portion of pump shall bear directly on floor of sump.

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3.02 FIELD FINISHING

A. Equipment as specified in Section 09 90 00, Painting and Coating.

3.03 FIELD QUALITY CONTROL

A. Functional Test: Conduct on each pump.

1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
2. Test for continuous 3-hour period.
3. Throttle discharge valve to obtain pump data points on curve at 2/3, 1/3, and shutoff conditions.

B. Pump Test:

1. General:
   a. Conduct on each pump provided.
   b. Conduct in accordance with HIS 11.6.
2. Routine Production Tests:
   a. Check impeller, motor rating and electrical connections for compliance to specification.
   b. Test motor and cable insulation for moisture content and insulation defects.
   c. Prior to submergence, run pump dry to establish correct rotation and mechanical integrity.
   d. Conduct abbreviated three-point operational performance test.
   e. After operational performance test, perform insulation test again.
3. Factory Seven-Point Plotted, Performance Test:
   a. Level for submersible pump tests.
   b. Include curve test results and performance test logs.
   c. Perform under actual or approved simulated operating conditions.

3.04 MANUFACTURER’S SERVICES

A. Per Section 01 43 33, Manufacturers’ Field Services and Section 01 91 00, Equipment Systems Commissioning, provide:

1. Manufacturer’s Certificates of Compliance.
2. Manufacturer’s Certificates of Proper Installation.
3. Training.
4. Other onsite services, requiring on site presence for a minimum person-days listed below, travel time excluded:
   a. 2 person-days for assistance during product installation, inspection, checking and adjustments.

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b. 2 person-days for field quality control.

3.05 SUPPLEMENTS

A. The supplements listed below, following “End of Section,” are part of this Specification.

1. Data Sheets: Pump and Motor.

END OF SECTION

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SUBMERSIBLE PUMP DATA SHEET, 44 42 56.04-

Tag Numbers: P69-4601, P69-4602

Pump Name: CPT Recycle Pump

Manufacturer and Model Number: (1) Xylem Flygt Concertor N80

(2) KSB Amarex F

SERVICE CONDITIONS

Liquid Pumped (Material and Percent Solids): Wastewater, Mixed Liquor

Pumping Temperature (Fahrenheit): Normal: 95 Max104 Min 40

Specific Gravity at 60 Degrees F: 1 Viscosity Range: <1 cp

pH: 6.5-7.2

Abrasive (Y/N) N Possible Scale Buildup (Y/N): N

Total suspended solids (mg/L) <5,000

Min. NPSH Available (Ft. Absolute): 32

PERFORMANCE REQUIREMENTS

Capacity (US gpm): Rated: 125gpm

Total Dynamic Head (Ft): Rated: 25

Maximum Shutoff Pressure (Ft): 160

Min. Rated Pump Hydraulic Efficiency at Rated Capacity (%):60

Max. Pump Speed at Rated Capacity (rpm): 1250 Constant (Y/N): Y
Adjustable (Y/N): N

DESIGN AND MATERIALS

Pump Type: Heavy-Duty Nonclog (Y/N) N Other:

Volute Material: Cast Iron ASTM A48

Pump Casing Material: Cast Iron ASTM A48

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Motor Housing Material: Cast Iron ASTM A48

Wear Rings Case (Y/N): N Material: _____

Wear Ring Impeller (Y/N): N Material: _____

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SUBMERSIBLE PUMP DATA SHEET, 44 42 56.04-

Tag Numbers: P69-4601,4602

Pump Name: CPT Recycle Pump

Elastomers: Nitrile Rubber

Fasteners: Stainless Steel

Impeller: Type: Double-Shrouded Non-Clog (Y/N): Y Other:
Material: Hard Iron ASTM A532 or Cast Iron ASTM A48

Shaft Material: Stainless Steel, ASTM A479 or Stainless Steel, ASTM A276 with stainless steel sleeve or all stainless steel.

Base Elbow: Cast Iron ASTM A48

Double Mechanical Seal (Y/N): Y Bearing Life (Hrs): 50,000

DRIVE MOTOR (See Section **26 05 01, Electrical**

Horsepower: 7.5 Voltage: 460 Phase: 3 Synchronous Speed (rpm): 1250

Enclosure: EXP

Other Features:

Moisture Detection Switches (Y/N): N

Thermal Protection Embedded in Windings (Y/N): Y

REMARKS:

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SECTION 44 42 56.16
PERISTALTIC PUMP

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. National Electrical Manufacturer's Association (NEMA): MG 1, Motors and Generators.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
   b. Detailed mechanical and electrical drawings showing equipment dimensions, size, and locations of connections and weights of associated equipment.
   c. Make, model, weight, and horsepower of each equipment assembly.
   d. Performance data curves showing head, capacity, and horsepower demand over entire operating range of pump, from shutoff to maximum capacity. Indicate head, capacity, and horsepower demand required at guarantee point.
   e. Complete motor nameplate data, as defined by NEMA, motor manufacturer, and including any motor modifications.
   f. Control panel elevation drawings showing construction and placement of operator interface devices and other elements.
   g. Power and control wiring diagrams, including terminals and numbers.
   h. Listing of extra materials supplied for this section.

B. Informational Submittals:

1. Manufacturer’s Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
2. Special shipping, storage and protection, and handling instructions.
3. Manufacturer’s printed installation instructions.
4. List special tools, materials, and supplies furnished with equipment for use prior to and during startup, and for future maintenance.

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5. Suggested spare parts list to maintain equipment in service for a period of 1 year and 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
6. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
7. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.03 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts, special tools:

Item	Quantity
One complete pump	One shelf spare
Gasket Kit	Two complete sets
Pump-Heads	Four
Special tools required to maintain or dismantle	One complete set

PART 2 PRODUCTS

2.01 GENERAL

A. Design Requirements: In accordance with Section 01 61 00, Common Product Requirements.

B. Peristaltic pump with a replaceable pump head that includes integrally built flexible EPDM element and a rigid polyether ether ketone (PEEK) track. Pumps that require opening the pump head to replace hose and tubes are not acceptable.

2.02 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Watson Marlow, Qdos H-FLO.
2. "Or-equal."

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2.03 ACCESSORIES

A. Equipment Identification Plates: Provide 16-gauge stainless steel identification plate securely mounted on each separate equipment component in a readily visible location with 3/8-inch-high engraved block type enamel filled equipment identification number (P69-6601) indicated in this Specification.

B. Anchor Bolts: Type 316 stainless steel sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications.

C. Leak Detection Switch:

1. Locate near top of pump to detect leakage of pumped product into pump housing.
2. Mount sensor on rear of pump housing.
3. Supply sensor Normally Closed with ability for field adjustment to Normally Open.

D. Revolution Sensor:

1. Provide inductive type revolution sensor located to detect rotor revolutions.
2. Pump manufacturer to supply and mount sensor and triggering device.

E. Controls: Integral to pump and as follows:

Tag No.	Name	NEMA 250 Rating	Material
P69-6601	Micronutrient Pump	4X	N/A

1. External Interfaces:
   a. Inputs from Plant PLC/ SCADA via Datalink:
      1) Pump flow rate command.
      2) Enable.
   b. Outputs to Plant PLC/ SCADA via Datalink:
      1) Pump REMOTE control.
      2) Pump speed.
      3) Pump flow rate feedback.
      4) General Fault Alarm.
      5) Pump/Tubing Runtime.
      6) Leak alarm.

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2. Functional Requirements: Provide at each OIT panel:
   a. Control logic to monitor operation of pump in either Local or Remote control.
   b. RESET pushbutton and associated logic for the common FAIL alarms. When alarm condition occurs, indicate associated condition at OIT panel. Local indication of alarm condition shall remain until condition has been corrected and RESET pushbutton on OIT is pressed.
3. Power Requirements: 120V, 1-phase, 60 Hz.

2.04 FACTORY FINISHING

A. Manufacturer's standard industrial protective coatings.

PART 3 EXECUTION

3.01 INSTALLATION

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

B. Connect suction and discharge piping without imposing strain to pump flanges.

C. Anchor Bolts: Accurately place using equipment templates and as specified in Section 05 50 00, Metal Fabrications.

3.02 FIELD FINISHING

A. Touch up manufacturer's finish using manufacturer's recommended coating repair system.

3.03 FIELD QUALITY CONTROL

A. Perform preoperational checks in accordance with manufacturer's printed instructions.

B. Functional Tests:

1. Conduct on Each Pump: Test complete assemblies for correct rotation, proper connections, and normal operational characteristics.

C. Performance Tests:

1. Conduct on Each Pump:
   a. Perform under simulated or actual operating conditions.
   b. Test for a continuous 30-minute period.

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c. Test and Test Log: Record the following:
   1) Pump flow using pump rpm and gallons per revolution.
   2) Pump flow measured trough the disconnected injector assembly and a temporary line to a bucket at EL. 40.
   3) Motor voltage and amperage measured for each phase.

3.04 MANUFACTURER'S SERVICES

A. Per Section 01 43 33, Manufacturers' Field Services and Section 01 91 00, Equipment Systems Commissioning, provide:

1. Manufacturer's Certificates of Compliance.
2. Manufacturer's Certificates of Proper Installation.
3. Training.
4. Other onsite services, requiring on site presence for a minimum person-days listed below, travel time excluded:
   a. 1 person-day for assistance during product installation, inspection, checking and adjustments.
   b. 1 person-day for field quality control.

END OF SECTION

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SECTION 44 45 17
CENTRATE PRETREATMENT EQUIPMENT

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Mechanical Engineers (ASME): B16.5, Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard.
2. ASTM International (ASTM):
   a. A182/A182M, Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
   b. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and General Applications.
   c. A380/A380M, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   d. D2240, Standard Test Method for Rubber Property–Durometer Hardness.
   e. F441/F441M, Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
   f. F438, Standard Specification for Socket-Type Chlorinated (Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40.
   g. F439, Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.

1.02 DEFINITIONS

A. Aeration System Backpressure: Air pressure at top of dropleg necessary to satisfy air supply and distribution requirements. Account for all pressure losses incurred by aeration system when new.

B. CPT Reactor: Structure within which aeration occurs.

C. Diffuser Assembly: Flexible membrane diffuser with a frame and retaining device.

D. Dropleg: Connection between air source to manifold.

E. Header: Single run of piping that connects to diffuser assemblies.

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F. Manifold: Single run of piping that connects dropleg with header(s).

G. Standard Conditions for Air: 68 degrees FF: 14.7 pounds per square in absolute (psia), and 36 percent relative humidity.

H. Normal Airflow: Airflow at standard conditions, expressed normal cubic meters per hour (Nm3/hr.).

1.03 SERVICE CONDITIONS

A. Anchoring and Support Systems: Allow for expansion and contraction over a temperature range 125 degrees F.

B. Influent Characteristics:

1. Average 600 mg/L of soluble COD and 690 mg/L suspended solids concentration (TSS) and minimum and maximum reactor temperature of 25 and 35 degrees Celcius, respectively.
2. Temperature in Mixed Liquor 30 to 36 degrees C.
3. Basin Sidewater Depth: 21 feet.
4. Available Backpressure at Top of Dropleg: 10.5 psig.
5. Maximum Compressed Air Temperature at Top of Dropleg 270 degrees F.
6. Mixing: existing and original propeller mixing system; one central mixer per CPT reactor.
7. Flows and Ammonia loads:

Design Condition	**Dewatering Centrate (MGD)**	**Ammonia Load (lb/day)**
Design Maximum Month Flow	0.4	4,256
Design Annual Average Flow	0.3	3,079
Design Minimum Month	0.24	2,810
Current Maximum Month	0.175	2,044
Current Annual Average	0.14	1,227
Current Minimum Month	0.1	542

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1.04 PERFORMANCE REQUIREMENTS

A. Annual average ammonia removal in the Centrate Pretreatment Reactors: Minimum 90 percent, based on service conditions and design annual flows and ammonia loads, as listed above.

B. Anammox Seeding: Augment anammox activity in the system to meet design requirements within 12 weeks from startup seeding.

1.05 DESIGN REQUIREMENTS

A. Design a fixed header, fine bubble diffused air aeration equipment system as a complete package including, but not necessarily limited to, dropleg(s); air manifold(s); distribution headers; diffusers; supports; drain line, sump, and airlift purge; header joints; accessories; and miscellaneous appurtenances.

1. Airflow Distribution: Shall not differ by more than 10 percent, at all specified conditions, for any two diffusers supplied from the same dropleg (based on diffuser with lower flow rate).
2. Air Distribution and Balancing: Control using orifices and proper header size selection only. Do not use flow distribution control devices requiring automatic or manual operation.
3. System Aeration Requirements.
4. Diffuser Airflux:
    a. Maximum less than or equal to 20 Nm3/hr/m2.
5. Available Airflow (scfm per Basin): Peak: 710.

B. Design Internal solids settling devices (ISSDs) located inside each CPT reactor to provide a quiescent zone behind a baffle to induce settling and retention of biomass and production of clarified effluent, comprised of baffles and a rectangular effluent launder box.

C. Design two biomass separation microscreens, one for each CPT reactor, for recovering anammox granules, and wasting other mixed liquor solids.

D. Details such as sizes, layout, anchor and supports and spacing, spacers/stiffeners, gaskets, lifting attachments, shall be defined by and be responsibility of Manufacturer and shall be consistent with requirements in this section.

E. Manufacturer shall provide stainless steel pipes with flanged sections with maximum 10-foot length sections and as required to install through the existing structural openings on the concrete deck of the CPT Reactors and without field modifications; field modifications of stainless steel pipe shall not be allowed, including, but not limited to cutting, welding, and threading.

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F. Design Structural Loads: The structural members of the ISSD shall be designed to withstand hydrostatic loading and appurtenance loads. The design shall withstand all loads in submerged and nonsubmerged conditions.

1.06 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Make, model, and weight of each equipment assembly and products specified herein, including valves, instrumentation and other accessories.
   b. Manufacturer's catalog information, descriptive literature, specifications, and identification of materials of construction.
   c. Detailed mechanical drawings showing equipment fabrications and interface with other items. Include dimensions, size, and locations of connections to other work, and weights of associated equipment.
   d. Aeration system: A detailed drawing of proposed aeration equipment layout for each basin showing air line sizes and lengths, distances between air distribution headers (center to center), and location of diffusers, supports, and expansion joints.
   e. Diffuser, diffuser connector, balancing orifices, and system head loss curves covering range of airflow rates specified and required. Include graph showing dynamic wet pressure versus airflow per diffuser, with and without pressure drop through proposed flow control orifice.
   f. Calculations showing distribution and balancing of air to diffusers fed from each dropleg for minimum and peak airflow rates specified and required.

B. Informational Submittals:

1. Continuous-Flow DEMON control descriptions.
   a. Supply loop descriptions to operate the complete system, including, but not limited to the following unit processes:
      1) CPT Aeration and Mixing.
      2) Anammox Retention.
2. Start-up and Commissioning Plan: including functional and performance testing plans, seeding plans, and monitoring and sampling schedules.
3. Calculations relating to proposed anchor spacing, diameter, and embedment.

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4. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
5. Factory test results, reports, and certifications. Include oxygen transfer performance test.
6. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
7. Special shipping, storage and protection, and handling instructions.
8. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
    a. Include manufacturer's printed installation instructions with erection drawings indicating, by piece marking, how entire assembly (for each basin service) is to be shipped and field assembled.
    b. Include manufacturer's printed instructions for functional testing.
9. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
10. Manufacturer's special guarantee.
11. Service records for maintenance performed during construction.

1.07 SPECIAL GUARANTEE

A. Furnish manufacturer's extended guarantee or warranty, which shall be in addition to the Contractor's 1-year correction period, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at option of Owner, replacement of elements, connectors and assemblies found defective during period of 5 years after date of Substantial Completion. Manufacturer shall be responsible for material replacement of parts or materials that fail during warranty period. Duties and obligations for correction and replacement of defective Work shall be as specified in the General Conditions. Down time, labor, or associated costs shall not be included in the extended warranty period beyond the Contractor's 1-year correction period.

1.08 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts and special tools:

Item	Quantity
Aeration system elbow unions	Min. 5% of total number installed
Aeration system connectors	Min. 5% of total number installed

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Item	Quantity
Air supply hose	Min. 5% of total number installed
Aeration panel isolation valves	Min. 5% of total number installed
Tool sets, if required, for removal and replacement of diffuser assemblies.	1

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. World Water Works shall furnish the equipment, services and accessories specified in this section, including but not limited to the following:

1. Membrane Aeration Diffuser System, including droplegs, manifolds, distribution headers.
2. Internal Solids Settling Devices.
3. Anammox Retention Screens.
4. Control Descriptions.
5. Seed Sludge.
6. Micronutrient Solution.
7. Installation and startup assistance, and training.

2.02 MEMBRANE AERATION DIFFUSER ASSEMBLIES

A. Flat aeration panel with thermoplastic polyurethane (TPU) membranes and AISI 316S frames, suitable for the service conditions and continuous and intermittent operation.

B. Manufacturer and Model:

1. Messner Aeration panels Classic HT.
2. “Or-equal” shall not be accepted.

2.03 AERATION DROPLEGS, MANIFOLDS, DISTRIBUTION HEADERS

A. Droplegs:

1. Provide dropleg from air supply (termination point shown on the Drawings) to the manifold.

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2. Construction: Type 304L Schedule 10 stainless steel, with Van Stone flanges with 150-pound bolt pattern; provide materials in maximum 20-foot long sections.
3. Provide sumps connected to 304L Schedule 10, 1-inch diameter lines and solenoid valves installed above the reactor roof slab for automatic diffuser depressurization. Depressurization lines shall discharge to the CPT Reactors.
4. Provide Type 304L supports from its upper connection, with additional support at lower elbow and as needed to limit spacing between supports to maximum 20 feet. Supports shall prevent transmission of lateral loads from dropleg to its connection to air supply.

B. Manifolds and distribution headers:

1. Manifolds shall be perpendicular to air distribution headers, the same nominal pipe size as the dropleg, and located at same centerline elevation as distribution headers.
2. Distribution headers shall provide air to the air supply hoses to the membrane aeration panels.
3. Construction: Type 304L stainless steel, with Van Stone flanges with 150-pound bolt pattern, and factory-welded connections for the aeration diffuser assemblies.
4. The end of the distribution headers shall transition to CPVC Schedule 80 pipe to connect to a CPVC vertical pipe serving as aeration system drain sump connected to CPVC 1” eductor purge lines.

C. Supports and anchoring:

1. Provide suitable supports in locations that diffused aeration equipment could be affected by mixers or other equipment, as shown on Drawings and per Section 40 05 15, Piping Support System.
2. Include expansion/contraction system consisting of fixed or flanged joints and guide supports. Guide supports shall allow for longitudinal movement.

2.04 AERATION SYSTEM DRAINLINE, SUMP, AND PURGE

A. Provide a CPVC sump and an eductor line to drain each the end of the distribution headers in the CPT reactors.

B. Sump: Minimum 4-inch diameter, and 6-inch deep, with top elevation lower than invert of the air distribution headers.

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C. Connect to a 1-inch-diameter airlift eductor line extending from the sump invert elevation and terminate 3 feet above the concrete deck with elbows and CPVC ball valves to discharge to 5-gallon buckets on the CPT reactor deck.

2.05 INTERNAL SOLIDS SETTLING DEVICES

A. Internal Solids Settling Devices (ISSDs) to provide a quiescent zone behind a baffle to induce settling and retention of biomass and production of clarified effluent, comprised of baffles and a rectangular effluent launder box as shown in the drawings.

B. Construction: Type 304L Stainless Steel, including supports, with Type 316L Stainless Steel bolts, and dissimilar metal isolators at all connections.

C. Structural members shall be suitable for long-term service with continuous immersion in the process water.

D. The frames and anchorage shall be designed to allow movement that may result from contraction/expansion.

E. Each frame shall be factory fabricated and shall be delivered to the Site in one piece that fit through the existing CPT Reactor roof openings. No field fabrication of frames will be permitted. The Contractor shall also furnish all accessories required for mounting of frames on concrete walls.

F. The frames shall be structurally designed to span between the concrete supporting walls as indicated on the Drawings and shall support all of the weight of the plates, and water and sludge loads expected.

G. Provide a means of effluent flow balancing to ensure even flow distribution through the effluent collection pipes.

H. Manufacturer and Model:

1. World Water Works.
2. No “Or-equal”.

2.06 ANAMMOX RETENTION SCREENS

A. Provide two biomass separation microscreens, one for each CPT reactor, for recovering anammox granules, and as shown in the Drawings.

B. Parabolic screen biomass separation devices sized for 150 gallons per minute with screen size of 150 micrometer. Screen to be constructed of Type 304L Stainless Steel, with Euro Gray Polypropylene housing, a utility water

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connection and backwash spray manifold for eight nozzles, and one integral high-level switch per Section 40 91 00, Instrumentation and Control Components, and one solenoid valve for backwash spray system per Section 40 27 02, Process Valves and Operators.

C. Manufacturer and Model:

1. World Water Works.
2. No “Or-equal”.

2.07 CONTROL DESCRIPTIONS

A. Supply loop descriptions to operate the complete Centrate Pretreatment system, including, but not limited to, Influent Feed, Aeration, MLSS Mixing, MLSS Wasting and Chemical Feed of micronutrients and alkalinity.

B. The descriptions shall include all the equipment and instrumentation required to operate the centrate pretreatment reactors, including existing equipment (such as the CPT reactor mixers, dissolved oxygen, level and ammonia and nitrate instrumentation) and new equipment provided by others (such as for example, the submersible pumps associated with mixed liquor solids wasting).

C. The descriptions shall include an overview, a list of inputs and outputs, descriptions of manual and automatic controls and interlocks for all equipment, and a list of alarms associated with equipment, valves and instrumentation.

2.08 SEED SLUDGE

A. Provide a minimum of 8,000 gallons of active anammox seed sludge for the start-up of one CPT reactor.

2.09 MICRONUTRIENT SOLUTION

A. Provide 1,300 gallons of micronutrient solution in the tank.

2.10 APPURTENANCES

A. Stainless Steel Pipe, Fittings, and Supports:

1. Shop fabricate welded parts and assemblies from Type 304L stainless steel with a 2D finish conforming to ASTM A240/A240M.
2. Shop fabricate nonwelded parts and pieces from sheets, plates, or bars of Type 304 stainless steel conforming to ASTM A240/A240M, unless specified otherwise.

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3. After fabrication, pickle and passivate stainless steel assemblies and parts in accordance with ASTM A380.

B. Chlorinated Polyvinyl Chloride (PVC) Pipe and Fittings: Per Section 40 27 00, Process Piping--General.

C. Special Flanged Joints or Slip Joints between Sections of Air Distribution Header:

1. Individual header sections shall rotate independently of adjacent header sections for alignment.
2. Flanged Joints for Stainless Steel Piping: Face ring-follower flange type with through-bolts, capable of transmitting longitudinal forces caused by expansion and contraction in air distribution header.
3. Slip joints shall allow for expansion and contraction of air distribution header.

D. Couplings: Van Stone type flanges ASTM A182/A182M stainless steel (same material as pipe) drilled 150-pound ASME B16.5 Standard.

E. Face Rings: Type 304L stainless steel, ASTM A240/A240M, inside diameter (ID) drilled 1/16-inch larger than pipe outside diameter (OD).

F. Gaskets: Viton, PTFE or Neoprene, and rated for the service conditions; locate at expansion joints and couplings to form an airtight connection at 20 psig minimum.

G. Miscellaneous Nuts, Bolts, Washers, and Other Nonwelded Parts: Type 316 stainless steel, ASTM A240/A240M. Threaded assemblies shall be chemically treated or lubricated prior to assembling to prevent galling. Provide double or self-locking nuts.

H. Lifting Lugs: Suitably attached for equipment assemblies and components weighing over 100 pounds.

I. Post-Installed Anchors: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 05 19, Post-Installed Anchors. Coat in accordance with Section 09 90 00, Painting and Coating.

J. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in readily visible location: Applicable to equipment provided with tag numbers, including screens, solenoid valves and instrumentation.

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2.11 SOURCE QUALITY CONTROL

A. Seed Sludge Activity: Seed sludge shall be tested for Anammox activity prior to harvesting.

PART 3 EXECUTION

3.01 STORAGE

A. The time between Seed Sludge harvesting and seeding shall not exceed 5 days.

B. Seed Sludge Temperature shall be maintained between 15 and 35 degrees C.

3.02 INSTALLATION

A. Field modifications of stainless steel pipe, including but not limited to welding, cutting and threading shall not be allowed.

B. In accordance with manufacturer's written instructions.

C. Accurately place anchor bolts using templates furnished by manufacturer and in accordance with Section 05 50 00, Metal Fabrications.

3.03 PREPARATION FOR SHIPMENT

A. Insofar as is practical, the equipment shall be shipped assembled, ready for installation at the Site. Parts and assemblies that are, of necessity, shipped unassembled shall be trial assembled at the factory and marked in a manner to facilitate final assembly in the field. The equipment and materials shall be packaged in a manner that will protect the equipment from damage during shipment.

B. Contractor shall have a manufacturer's representative at the Job Site during receipt of equipment and materials. This representative together with a representative of Contractor and Engineer will inspect all equipment and materials for condition upon arrival at the Job Site. Damaged or otherwise unacceptable equipment and materials will be removed from the Job Site and replaced with new equipment and materials. Accepted equipment and materials will be turned over to Contractor for storage, in accordance with the manufacturer's instructions, until installation is required.

3.04 WELDING

A. All welding shall be done in accordance with the recommendations of the American Welding Society. All welding shall be done by a process suitable

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for the materials to be welded. Welds shall be free of porosity, cracks, holes, and flux. All welds shall be ground smooth and shall have a uniform appearance.

3.05 PASSIVATION

A. After fabrication, all stainless steel components shall be passivated using a nitric acid passivation solution.

1. Each component shall be placed in a solution of 10 to 15 percent nitric acid at 150 degrees F for a period of approximately 30 minutes followed by a thorough water washing.
2. Alternatively, a 15 percent solution of nitric acid at 65 degrees F to 80 degrees F shall be applied for a period of up to 90 minutes. The area shall be thoroughly rinsed with water after the passivating treatment.

B. Post-passivation modifications of stainless steel pipe, including but not limited to welding, cutting and threading shall require passivation.

3.06 CORROSION PROTECTION

A. Atmospheric exposed plastic surfaces shall be field prepared and painted in accordance with Section 09 90 00, Painting and Coating.

B. Dielectric isolators provided for dissimilar metal connections.

3.07 FIELD QUALITY CONTROL

A. Functional Tests: Conduct on each equipment following supplier’s written instructions. Flow Distribution and Diffuser/Piping Integrity Test:

1. When system has been installed and visually inspected, fill tank with clean water (in a manner that ensures diffusers are not damaged) to a level approximately equal to height of diffusers.
2. Inspect level of diffusers, and if any variations are evident beyond tolerances allowed in specification or by manufacturer, drain tank and make necessary adjustments.
3. When diffuser levels have been verified, fill tank with clean water (in a manner that ensures diffusers are not damaged) to a level approximately 1-foot above diffusers.
4. Ensure isolation valves on each aeration grid are closed. Arrange for process air system to be pressurized.
5. Allow air into diffuser grids, one at a time to obtain a near-constant flow at the minimum and maximum service conditions.

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6. Visually check distribution system and diffusers to identify maldistribution and any failures in pipe joints or diffuser holders.
7. Where any failures are noted, drain tank, perform necessary repairs, and repeat test.

B. Seed Sludge: Test for Anammox activity prior to seeding, after seeding, and weekly through the end of the commissioning period.

3.08 MANUFACTURER'S SERVICES

A. Per Section 01 43 33, Manufacturers' Field Services and Section 01 91 00, Equipment Systems Commissioning, provide:

1. Manufacturer's Certificates of Compliance.
2. Manufacturer's Certificates of Proper Installation.
3. Training.
4. Other onsite services, requiring on site presence for a minimum person-days listed below, travel time excluded:
   a. 2 person-days for assistance during product installation, inspection, checking and adjustment.
   b. 3 person-days for functional and performance testing.
   c. 2 person-days for facility startup.

END OF SECTION

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SECTION 46 21 36
EXTERNALLY FED ROTARY SCREENS

PART 1 GENERAL

1.01 REFERENCES

A. The properties of all materials, design, fabrication and performance of the equipment to be furnished under this section shall be in accordance with the latest issue of applicable standard specifications. The governing authorities of these standards are listed below.

1. NEMA: National Electrical Manufacturer's Association.
2. UL: Underwriters Laboratory.

1.02 DEFINITIONS

A. PCS: Plant Control System.

1.03 DESIGN REQUIREMENTS

A. Each screen shall be able to meet the following requirements:

1. Rate Flow: 370 gpm.
2. Average Influent total suspended solids: 500 mg/L.
3. Maximum Influent TSS: 700 mg/L.
4. Wedge wire screen openings: 1.5 mm.

1.04 QUALIFICATIONS

A. All the equipment specified under this section shall be supplied by a single manufacturer involved in manufacturing screening equipment.

B. Manufacturer must provide a list of minimum five references where same equipment model and size has been installed and is in continuous operation in municipal wastewater treatment facilities in the Unites States of America, for at least 5 years.

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1.05 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Make, model, weight and horsepower (hp) of each equipment assembly.
   b. Detailed mechanical, structural, and electrical drawings showing the equipment fabrication and interface with other items. Include dimensions, sizes and anchoring details.
   c. External utility requirements such as air, water, power, drain, etc., for each component.
   d. Motor nameplate data, in accordance with NEMA MG1, motor manufacturer and any motor modifications.
   e. Electrical interconnection diagrams indicating all shop and field wiring requirements between electrical power and control components. Include interlock connections to other systems and numbered terminal designations.
   f. Control panel layout drawings and control schematics.
   g. Performance affidavits.
   h. Shop test results.
2. Informational Submittals:
   a. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.
   b. Manufacturer’s Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers’ Field Services.
   c. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
   d. Provide Operation and Maintenance Manuals and data as specified in Section 01 78 23, Operation and Maintenance Data.

1.06 SPARE PARTS

A. Furnish the following spare parts in clearly identified dust-proof containers:

1. One pair cylinder rim seals with clips and springs.
2. One wiper seal.
3. Two doctor blades.
4. One spare for each size of solenoid valves.
5. Sufficient quantity of oil and lubricants for first lubricant/oil change as required by manufacturer O&M.

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PART 2 PRODUCTS

2.01 GENERAL

A. Two externally fed rotary wedge wire screens for screening trash out of dewatered centrate, including all controls and associated accessories.

B. Each rotary screen shall consist of a headbox assembly, cylindrical screen drum, mounting legs, doctor blade, internal spray system, influent and effluent connections, overflow and odorous air flanged connections, shaft-mounted electric gear drive, enclosure, and solids discharge chute.

2.02 MANUFACTURERS

A. Parkson Hycor Rotostrainer: Model No. RSA2524.

B. “Or-equal.”

2.03 EQUIPMENT LAYOUT

A. The externally fed rotary screens and the wash-press shall be installed inside an existing structure as shown on drawings.

2.04 COMPONENTS

A. Headbox Assembly with Integral Discharge Base: The headbox assembly including headbox integral discharge base and support legs shall be constructed of no thinner than 12-gauge Type 304 stainless steel.

1. Influent connection: 6-inch 304L stainless steel ASME B.16.5 Class 150 flange stainless steel.
2. Internal Baffle: The headbox assembly will be equipped with an internal baffle for the purpose of distributing the influent flow evenly along the length of the cylinder and eliminating splashing. This baffle will run the full width of the headbox. Construction: Type 304 stainless steel.
3. Effluent connection: 8-inch 304L stainless steel ASME B.16.5 Class 150 flange.
4. Overflow connection: 6-inch 304L stainless steel ASME B.16.5 Class 150 flange.
5. Odorous Air connection: 4-inch 304L stainless steel ASME B.16.5 Class 150 flange located on the top of the unit.
6. Location of influent, effluent, and overflow pipe flanges: as shown on Drawings to optimize access clearance around unit and as approved by Engineer during submittal review; effluent flange may be provided at bottom of the unit.

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B. Cylinder:

1. The screen cylinder will be constructed of Type 304 stainless steel with wedge wire screen slot openings of 1.5 mm (0.06”) on the exterior surface of the drum screen.
2. For support, the cylinder will have interior rings welded to the interior ends of the cylinder.
3. Cylinder Rim Seals: Replaceable rim seals will be constructed of high-density polyethylene.
4. The screen drum shall rotate by pillow block housed bearings on either side of the screen drum housing.
5. The cylinder drive system shall consist of a 1/2 HP electric motor, directly connected to the drive shaft, with 230/460 Volt, 3 phase, 60 Hz power supply. The motor shall be mounted in a vertical orientation and as shown on Drawings.

C. Doctor Blade Assembly:

1. An automatic doctor blade cleaner assembly shall be furnished and mounted above the solids discharge doctor blade to aid removal of solids from the primary blade. The automatic doctor blade cleaner assembly shall wipe the primary blade in an upward sliding motion once per screen cylinder revolution. The cleaning action shall be continuous and automatic whenever the machine is in operation.
2. The doctor blade holder and assembly shall be constructed of Type 304 stainless steel with the exception of the blade. The doctor blade shall be constructed of bronze flex, monel or phosphor bronze.
3. The doctor blade shall remove solids from the cylindrical screen surface and be easily removable. The doctor blade and holder shall have sufficient travel or pivot so as to clear the cylinder and flanges to allow for doctor blade changing or inspection.
4. Pressure of the doctor blade against the cylindrical screen surface shall be controlled with a counterweight assembly or bronze locking tension arm assembly.

D. Solids Discharge Chute:

1. A solids discharge chute of Type 304 stainless steel construction mounted a minimum of 45 degrees from horizontal shall be attached to the chassis beneath the doctor blade assembly.
2. The chute will transition from a rectangular opening underneath the doctor blade to 8-inch 304L stainless steel ASME B.16.5 Class 150 flange connection.

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E. Internal Spray System: A spray system shall be provided within the cylinder to assist in cleaning. Spray nozzles shall be installed to deliver 5-10 gpm total of water at 40 psig to the cylinder.

F. Sluice Spray System: A sluice spray bar shall be provided in the solids discharge chute to assist the flow of screenings to the wash-press on the ground level. Spray nozzles shall be installed to deliver 5-20 gpm total of water at 40 psig.

G. Support Legs:

1. The unit shall have support legs constructed of Type 304L stainless steel designed to support the required loads.
2. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications. Coat in accordance with Section 09 90 00, Painting and Coating.

H. Enclosure:

1. An enclosure of Type 304 stainless steel shall be provided over the top of the rotary screen unit, to seal off the headspace of the influent box and drum screen and connect to the discharge chute at the front of the screen underneath the doctor blade.
2. The enclosure shall have an access door over the drums screen section that is able to open by a hinge or rolling.

2.05 ACCESSORIES

A. Manufacturer to provide Spray Solenoid Valves: Per Section 40 27 02, Process Valves and Operators.

B. Upstream of each solenoid, Contractor to provide and support (W3) water line as indicated on drawings, one strainer, one flow indicator, and one V335 per Section 40 27 02, Process Valves and Operator, and Section 40 27 01, Process Piping Specialties.

C. Manufacturer to provide one level switch for minimum level in influent box for the screen to run with signal to PLC per Section 40 91 00, Instrumentation and Control Components.

D. Manufacturer to provide one level switch for overflow level in influent box with overflow signal to PLC per Section 40 91 00, Instrumentation and Control Components.

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2.06 MOTORS AND DRIVES

A. Provide in accordance with Section 26 05 01, Electrical, unless otherwise specified herein.

B. Motors and drives shall be furnished by the equipment Supplier and shall be designed specifically for use with the equipment provided.

C. The cylinder drive system shall consist of a single speed, motor connected to a Eurodrive FA type helical gear reducer.

D. Motor Perimeters:

ITEM NO.	MOTOR PERIMETERS	TAG NUMBERS M69-1011; M69-1012
1	Minimum allowable motor	1/2 hp
2	Motor selection	Type: Vertical Special: None
3	Motor Speed	1800 rpm
4	Minimum allowable motor efficiency	70%
5	NEMA design	B
6	Duty	Intermittent
7	Insulation	Class F
8	Voltage, phase, and Hertz	460V, 3-phase, 60-Hz
9	Service Factor	1.15
10	Motor enclosure	TEFC
11	Protection	Thermal, amperage
12	Maximum starts per hour	10

2.07 CONTROLS

A. General: Each screen shall be supplied with a control system that controls the screen. Each system shall provide signals to the plant PCS system. The control

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panels and the control stations shall be rated for installation in an unclassified area.

B. Control Panels: In accordance with general control requirements and component qualities specified in Section 40 90 00, Instrumentation and Control for Process Systems and Section 40 99 90, Package Control Systems as follows:

PANEL NUMBER	NAME	NEMA RATING	MATERIAL
CP69-1011/1012	CPT influent screen control panel	4X	Stainless steel 316

C. Operator Controls and Indications: A local control panel shall be provided to monitor and control each CPT Influent screens. The panels shall include the following:

1. LOCAL/REMOTE selector switch.
2. ON/AUTO/OFF selector switch.
3. E-STOP.
4. E-STOP indicating light.
5. RUNNING indicating light.
6. Overflow Level Indicating light.
7. FAIL Alarm/Indicating light.
8. INTERNAL SPRAY WATER ON push-button.
9. SLUICE SPRAY WATER ON push-button.
10. RUN time meter.

D. External Interfaces: The following PCS inputs shall be provided at the control panel:

1. Inputs:
   a. ENABLE SCREEN signal from the PCS.
   b. ENABLE SLUICE WATER.
2. Outputs to the PCS:
   a. MODE –REMOTE.
   b. STATUS – OVERFLOW.
   c. ALARM – FAIL.
   d. STATUS SCREEN ON.
   e. SCREEN ALARM E-STOP.
   f. SLUICE WATER ON.

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E. Functional Requirements:

1. The system will recover after a power failure without human intervention.
2. Manual Control: If the unit selector is in the ON position, the motor will run continuously, and the corresponding internal water spray solenoid valve will open. Unit will not be interlocked when controlled locally. Switching selectors to OFF will stop the motor and close the internal spray solenoid valve. The internal and sluice water spray valve will open while the associated push-button are pressed.
3. Auto Control:
   a. Works when selector is set to REMOTE and AUTO and ENABLE signal from SCADA is active.
   b. Works when selectors are set to LOCAL and AUTO.
   c. Motor will run when the water level in the internal box is above the minimum setpoint. Delay, frequency and duration timers shall determine motor running status and when the internal spray wash solenoid valves will close after the motor stops.
   d. The sluice water spray valve will open when the PCS SLUICE WATER OPEN sluice water signal is active.
   e. E-stop functionality as shown on Electrical Detail Drawings.

F. Power Requirements: 460 volts, three phase, 60 Hz supplied to remote control panels.

G. Special Requirements:

1. Provide main power disconnect at control panel.
2. Provide control panel ventilation fans/thermostat for internal circulation of hot spots. No external air exchange.
3. Provide condensation heater.
4. Provide full voltage starter in remote panel for each drive motor. Each motor shall be equipped with thermal overloads in all three phases. Overloads shall be resettable without opening panel door.
5. Raceways and wiring installed on unit at factory shall be in accordance with requirements of applicable sections of Division 26, Electrical for corrosive and hazardous areas as applicable.
6. Provide settable current sensing relay to identify an alarm overload situation.

2.08 FABRICATION REQUIREMENTS

A. Shop coat non-stainless steel metallic components in accordance with manufacturer’s standard finish system and color.

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B. All bolts, nuts, washers, and other fasteners shall be Type 316 stainless steel unless otherwise noted.

C. Welds shall be continuous unless noted otherwise.

D. Grind exposed joints flush and smooth with adjacent finish surface. Make exposed joints butt tight, flush, and hairline. Ease exposed edges to small uniform radius.

E. Surface treatment of Stainless Steel Components: All stainless steel components will remain unpainted, but cleaned of all commercial and shop markings during fabrication.

F. Motor, gear reducer and solenoid valve shall be manufacturer's standard finish.

G. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in readily visible location.

H. Equipment nameplate: stainless steel shall be engraved or stamped and fastened to the equipment and shall include the manufacturer's name, model, serial number, size, characteristics, and appropriate data describing the equipment performance ratings.

PART 3 EXECUTION

3.01 EQUIPMENT INSTALLATION

A. Install in accordance with the Contract Documents and manufacturer’s written instructions.

B. Field verify all dimensions and elevations. Notify Engineer of specific differences.

C. Furnish all necessary materials (including lubricants, chemicals, etc.) and equipment (including measuring devices, etc.) for testing and startup.

D. All bolts, nuts, washers, and other fasteners shall be Type 316 stainless steel unless otherwise noted.

E. Anchor rods (bolts) shall be Type 316 stainless steel HILTI-style adhesive anchors.

F. Isolate dissimilar metals by back-painting or with dielectric connectors/joints.

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3.02 FIELD QUALITY CONTROL

A. Functional Test:

1. Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation, and control functionality.
2. Test for continuous 4-hour period.

3.03 MANUFACTURER'S SERVICES

A. Per Section 01 43 33, Manufacturers' Field Services and Section 01 91 00, Equipment Systems Commissioning, provide:

1. Manufacturer's Certificates of Compliance.
2. Manufacturer's Certificates of Proper Installation.
3. Training.
4. Other onsite services, requiring on site presence for a minimum person-days listed below, travel time excluded:
   a. 1 person-day for assistance during product installation, inspection, checking and adjustments.
   b. 1 person-day for field quality control.

END OF SECTION

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SECTION 46 21 46
SCREENINGS WASH PRESS

PART 1 GENERAL

1.01 REFERENCES

A. American Bearing Manufacturers' Association (ABMA):

1. ABMA 9 load rating and Fatigue Life for Ball Bearings.
2. ABMA Load Rating and Fatigue Life for Roller Bearings.

B. American Society for Testing Materials International (ASTM):

1. ASTM A36, Structural Steel.
2. ASTM A53, Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
3. ASTM A276, Stainless Steel and Heat-Resisting Steel Bars and Shapes.

C. AGMA 6010, Spur, Helical, Herringbone, and Bevel Enclosed Drives.

D. Hydraulic Institute Standards (HIS): Technology pertaining to pumping unit performance and construction shall conform to the rating and nomenclature of the Hydraulic Institute Standards.

E. American Iron and Steel Institute (AISI):

1. 304 Stainless Steel.
2. 316 Stainless Steel.
3. 416 Stainless Steel.
4. 1018 Steel.
5. 1045 Steel.
6. 4140 Alloy Steel.

F. National Fire Protection Association (NFPA) 820: Fire Protection in Wastewater Treatment and Collection Facilities, lasted edition.

G. If there are any discrepancies between details contained in this document and any of the standards listed above, the Engineer is to be informed of the discrepancy and the more stringent of the two will be followed unless instructed otherwise.

1.02 DEFINITIONS

A. PCS: Plant Control System.

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B. Screenings: Comprised of debris, screenings, and other organic and inorganic solids.

1.03 DESIGN REQUIREMENTS

A. Unit shall be able to meet the following requirements:

1. Maximum screen opening: 3 mm.
2. Draining the sluice water added at the external fed rotary screen chute installed at the mezzanine level, and the water added at this unit.
3. Minimum inlet capacity of 35 cubic feet per hour.

1.04 QUALIFICATIONS

A. All the equipment specified under this section shall be supplied by a single manufacturer involved in manufacturing screening equipment.

B. Manufacturer must provide a list of minimum five references where same equipment model and size has been installed and is in continuous operation in municipal wastewater treatment facilities in the Unites States of America, for at least 5 years.

C. Structural and anchorage drawings shall be sealed by a professional engineer licensed in the State of Virginia.

1.05 SUBMITTALS

A. Action Submittals:

1. Make, model, weight and horsepower (hp) of each equipment assembly.
2. Detailed mechanical, structural, and electrical drawings showing the equipment fabrication and interface with other items. Include dimensions, sizes and anchoring details. Drawings showing relationships to equipment feeding presses and to equipment to which presses discharge to.
3. Details of spray wash system, drive end bearings, conveyor support details, gear box, motion detector, and rope switch with complete cross-referenced materials list.
4. Manufacturer’s data including equipment weight and construction details.
5. Detailed, dimensioned layout drawings and elevations clearly indicating that press with all appurtenances, including discharge piping, can fit in available space. Maintain clearance to other equipment as shown on Drawings.
6. Control panel layout drawings and control schematics.

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7. Motor nameplate data, in accordance with NEMA MG1, motor manufacturer and any motor modifications.
8. Electrical interconnection diagrams indicating all shop and field wiring requirements between electrical power and control components. Include interlock connections to other systems and numbered terminal designations.
9. Evidence of Qualifications:
    a. Minimum five references where same equipment model and size has been installed and is in continuous operation in municipal wastewater treatment facilities in the Unites States of America, for at least 5 years.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Special shipping, storage and protection, and handling instructions.
3. Manufacturer's printed installation instructions.
4. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
5. Guarantee of satisfactory performance with proposed discharge configuration.
6. Field testing results.
7. Provide Operation and Maintenance Manuals and data as specified in Section 01 78 23, Operation and Maintenance Data.

1.06 SPARE PARTS

A. Furnish the following spare parts in clearly identified dust-proof containers:

1. One set of wear bars with fasteners.
2. One drain wiper brush with clips and fasteners.

PART 2 PRODUCTS

2.01 GENERAL

A. One wash press (M69-1021) package system. Control system including but not limited to control panel; integrated program for control and monitoring of the screenings wash press to provide a complete operating system for screening of dewatering centrate from centrifuges.

B. Each unit shall include an inlet hopper, tank, auger, discharge pipe, and control panel, and be dedicated to receiving solids from one of two Externally

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Fed Rotary Screens, as specified in Section 46 21 36, Externally Fed Rotary Screens.

C. All components shall be suitable for installation in an unclassified area.

D. The material to be washed/compacted will be the screenings provided by a 1.5 mm rotary screen receiving dewatering centrate.

E. The unit will have a minimum inlet capacity of 35 cubic feet per hour and produce a screenings log with a dry weight of not less than 8 percent solids.

F. Hydraulic capacity sized to handle a minimum of 20 gpm of sluicing water in addition to internal wash sprays. It remains the responsibility of the Contractor and Supplier to confirm the required capacity and ensure that equipment supplied is appropriately sized for the application.

G. The wash press shall be a self-contained, hopper fed system used to wash, compact and dewater screenings that have been captured by screenings removal device. Screenings shall be directly discharged or conveyed to the unit by gravity and fed into the system via a hopper with spray water.

H. The solids shall be passed through the auger, which shall wash and separate the soft organics from the undesirable solids.

I. Screenings wash press will operate intermittently: starting empty and running long enough to clear material from press zone. Press may also operate continuously.

2.02 MANUFACTURERS

A. Parkson: Aqua WashPress AWP8.

B. “Or-equal.”

2.03 COMPONENTS

A. Hopper:

1. Material: 304 stainless steel, minimum 12-gauge.
2. Hopper: will be supplied to direct screenings and sluice water into the tank.

B. Tank:

1. The tank shall be constructed of a minimum 10-gauge-thick AISI Grade Type 304 stainless steel and provided with a drain port.

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2. The tank shall have a removable cover and end plates, and allow for removal or installation of compaction screw from either end or above.
3. The tank shall have a minimum of one inspection port.
4. The tank shall consist of a washing zone and a dewatering zone.

C. Washing Zone:

1. The washing zone will be fitted with a 3 mm perforated screen to serve as the drainage zone separating solids from liquids.
2. The screen shall be removable from the tank.
3. Screen construction: Type 304 stainless steel.

D. Screw and Dewatering Zone:

1. Dewatering shall occur as the rotating spiral conveys the washed screenings.
2. The screw shall be constructed of ASTM A36 carbon steel.

E. Motor:

1. The electric motor shall be a minimum 3 HP, 230-460VAC, 3 phase, 60 Hz TEFC with a shaft power rating determined by the compactor washer unit manufacturer, in accordance with Division 26, Electrical.
2. Provide safety factor of minimum 1.15 for design torque over torque that overloads motor.

2.04 ACCESSORIES

A. Manufacturer to provide Spray Solenoid Valves: Per Section 40 27 02, Process Valves and Operators specification.

B. Upstream of each solenoid, Contractor to provide and support (W3) water line as indicated on Drawings, one strainer, one flow indicator, and one V335 per Section 40 27 02, Process Valves and Operator, and Section 40 27 01, Process Piping Specialties.

2.05 CONTROLS

A. General: Wash Press shall be supplied with a package control system that controls the Wash Press. The system shall provide signals to the plant PCS system.

B. Control Panel: Refer to Section 40 90 00, Instrumentation and Control for Process Systems and Section 40 99 90, Package Control Systems.

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PANEL NUMBER	NAME	NEMA RATING	MATERIAL
CP69-1021	Wash Press control panel	4X	Stainless steel 316

C. Operator Controls and Indications: A local control panel shall be provided to monitor and control dewatering press. The panels shall include the following:

1. LOCAL/REMOTE selector switch.
2. ON/AUTO/OFF selector switch.
3. RUNNING indicating light.
4. E-STOP.
5. E-STOP indicating light.
6. RUNNING indicating light.
7. FAIL Alarm/Indicating Light.
8. INTERNAL SPRAY WATER ON push-button.
9. RUN time meter.

D. External Interfaces: The following PCS inputs shall be provided at the control panel:

1. Inputs:
   a. ENABLE WASH PRESS signal from the PCS.
2. Outputs to the PCS:
   a. WASH PRESS MODE – REMOTE.
   b. STATUS – RUN.
   c. ALARM – FAIL
   d. WASH PRESS ON.
   e. WASH PRESS ALARM E-STOP.

E. Functional Requirements:

1. The system will recover after a power failure without human intervention.
2. Manual Control: If the unit selector is in the ON position, the motor will run continuously. Unit will not be interlocked when controlled locally. Switching selectors to OFF will stop the motor and close the internal spray solenoid valve. The internal spray valve will open while the associated push-button are pressed.

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3. Auto Control:
    a. Works when selector is set to REMOTE and AUTO and ENABLE signal from SCADA is active.
    b. Works when selectors are set to LOCAL and AUTO.
    c. Motor and internal spray water will be active based on delays, frequency and duration timers, adjustable at the control panel.
    d. E-stop functionality as shown on Electrical Detail Drawings.

F. Power Requirements: 460 volts, three phase, 60 Hz supplied to remote control panels.

G. Special Requirements:

1. Provide main power disconnect at control panel.
2. Provide control panel ventilation fans/thermostat for internal circulation of hot spots. No external air exchange.
3. Provide full voltage starter in remote panel for each drive motor. Each motor shall be equipped with thermal overloads in all three phases. Overloads shall be resettable without opening panel door.
4. Raceways and wiring installed on unit at factory shall be in accordance with requirements of applicable sections of Division 26, Electrical for corrosive and hazardous areas as applicable.
5. Provide settable current sensing relay to identify an alarm overload situation.

2.06 FABRICATION REQUIREMENTS

A. Shop coat nonstainless steel metallic components in accordance with manufacturer’s standard finish system and color.

B. All bolts, nuts, washers, and other fasteners shall be Type 316 stainless steel unless otherwise noted.

C. Welds shall be continuous unless noted otherwise.

D. Grind exposed joints flush and smooth with adjacent finish surface. Make exposed joints butt tight, flush, and hairline. Ease exposed edges to small uniform radius.

E. Surface treatment of stainless steel components: All stainless steel components will remain unpainted, but adequately cleaned of all commercial and shop markings during fabrication.

F. Motor, gear reducer and solenoid valve shall be manufacturer's standard finish.

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G. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in readily visible location.

H. Equipment nameplate: stainless steel shall be engraved or stamped and fastened to the equipment and shall include the manufacturer's name, model, serial number, size, characteristics, and appropriate data describing the equipment performance ratings.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with the Contract Documents and manufacturer’s written instructions.

B. No modifications to equipment shall be made without the written consent of the manufacturer and approval of Engineer.

C. Field verify all dimensions and elevations. Notify Engineer of specific differences.

D. Furnish all necessary materials (including lubricants, chemicals, etc.) and equipment (including measuring devices, etc.) for testing and startup.

E. All bolts, nuts, washers, and other fasteners shall be Type 316 stainless steel unless otherwise noted.

F. Anchor rods (bolts) shall be Type 316 stainless steel HILTI-style adhesive anchors.

G. Isolate dissimilar metals by back-painting or with dielectric connectors/joints.

3.02 FIELD QUALITY CONTROL

A. Functional Test:

1. Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation, and control functionality.
2. Test for continuous 4-hour period.

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3.03 MANUFACTURER'S SERVICES

A. Per Section 01 43 33, Manufacturers' Field Services and Section 01 91 00, Equipment Systems Commissioning, provide:

1. Manufacturer's Certificates of Compliance.
2. Manufacturer's Certificates of Proper Installation.
3. Training.
4. Other onsite services, requiring on site presence for a minimum person-days listed below, travel time excluded:
   a. 1 person-day for assistance during product installation, inspection, checking and adjustments.
   b. 1 person-day for field quality control.

END OF SECTION

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