
PART IV

City of Bend Supplemental Standard Specifications for Construction

**City of Bend Supplemental to the
OREGON STANDARD SPECIFICATIONS FOR CONSTRUCTION**

PART 00300 – Roadwork

Section 00333

Section 00333, which is not a Standard Specification, is included in this Project by Special Provision.

Description

00333.00 Scope

This work consists of furnishing and placing aggregate ditch lining at locations shown or directed.

Materials

00333.10 Aggregate Ditch Lining

Provide hard durable rock or gravel with a moisture binder of clay material that provides a tight, erosion-resistant surface meeting the following grading requirements:

Sieve Size Passing	Percentages (By Weight)
6"	100
4"	30-50
2"	20-30
No. 200	15-25

Construction

00333.40 General

Place the aggregate material to the lines and grades established and as shown.

Measurement

00333.80 Measurement

The quantities of aggregate ditch lining will be measured on the area basis of the actual surface area of the wetted perimeter of the lined ditch.

Ditch excavation will be measured according to 00330.80 and 00330.81.

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Payment

00333.90 Payment

The accepted quantities of aggregate ditch lining will be paid for at the Contract unit price, per square yard, for the item "Aggregate Ditch Lining".

Payment will be payment in full for furnishing all materials, and for furnishing all equipment, labor, and incidentals necessary to complete the work as specified.

Ditch excavation will be paid for according to 00330.90, 00330.91, and 00330.93.

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Section 00645 – Recycled Asphalt Products In Base

Section 00645, which is not a Standard Specification, is included in this Project by Special Provision.

Description

00645.00 Scope

This work consists of hauling recycled asphalt products (RAP) from Agency-provided stockpiles specified in Section 00160 and placing one or more layers of RAP, mixed with water, on a prepared surface to the lines, grades, thicknesses, and cross sections shown or established.

Materials

00645.10 Materials

Furnish RAP of the designated sizes from the stockpiles except discard hardened lumps exceeding 2 inches on any measured face at the stockpile site in a separate new stockpile or reprocess to achieve the desired maximum size limit.

Acceptance of the RAP will be by visual inspection.

00645.12 Limits of Mixture

Provide a mixture of RAP and water having a uniform moisture content sufficient to obtain the required compaction. Water may be introduced in a mixing plant, or on the grade.

00645.15 Quality Control

Provide quality control according to Section 00165.

Equipment

00645.21 Hauling Equipment

Provide RAP hauling vehicles capable of hauling and depositing the RAP material with a minimum of material segregation.

00645.22 Watering and Spreading Equipment

Provide equipment to add water to the RAP and spread to the lines and grades shown or as directed.

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00645.23 Compacting Equipment

Provide self-propelled rollers and compactors capable of reversing without backlash and meeting the following requirements:

- A gross static weight of at least 10 tons.
- Adequate to compact to specified density while the RAP is still moist.

Labor

00645.30 Quality Control Personnel

Provide a certified technician in the following field:

- CAT-1

Construction

00645.40 Preparation of Foundation

Provide a firm surface or material on which RAP is to be placed, according to Sections 00320, 00330, 00370, 00380, and 00610 as applicable.

00645.41 Mixing, Hauling, and Placing

Load the RAP into the hauling vehicle without compacting material remaining in the stockpile.

Add water to RAP while mixing to provide moisture content according to 00645.12.

Thoroughly mix the combined RAP and water for as long as necessary to produce a homogeneous mixture. Mix, haul, and place the material by one of the following methods:

(a.) **Stationary Mixing Plant** - Combine materials in a pug mill or rotary mixer.

Deliver and deposit the mixture without delay. Deliver the mixture to the spreading equipment by direct deposit into its receiving device, or by placing in uniform windrows in front of the equipment.

(b.) **Road Mix** - Place materials for each layer, add water, and mix with a motor grader until a homogeneous mixture is achieved.

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00645.43 Thickness and Number of Layers

If the required compacted depth of the course exceeds 6 inches, construct it in two or more layers of nearly equal thickness. The maximum compacted thickness of any one layer shall not exceed 6 inches unless approved by the Engineer.

Place each layer in spreads as wide as practical and to the full width of the course before a succeeding layer is placed.

00645.44 Shaping and Compacting

Begin compaction of each layer immediately after the material is spread. Determine optimum roller pattern according to ODOT TM 306 C "Control Strip Method of Compaction". Maintain optimum roller pattern throughout.

Shape and maintain the surface of each layer, during the compaction operations, to produce a uniform texture, and to meet the requirements of 00645.45.

Apply additional water over the materials for proper compaction.

00645.45 Surface Tolerance

The finished surface of the RAP and the surface of each underlying layer shall parallel the established grade and cross section for the finished surface within 5/8 inch.

The finished surface of the compacted RAP, when tested with a 12 foot straightedge, shall not vary from the testing edge by more than 5/8 inch at any point. Furnish and operate the straightedge as directed.

Maintenance

00645.60 Care of the Work - After construction of each layer and completion of RAP course, maintain the layer to specified conditions, and prevent or repair segregation, raveling, or rutting until it is covered with a following layer or until all work is completed.

Measurement

00645.80 Measurement

The quantities of RAP will be measured on the area basis, to the nearest square yard, of recycled asphalt products constructed to the full nominal thickness. In areas and where the thickness is other than the full nominal thickness, the areas will be adjusted by converting it to an equivalent number of square yards at the full nominal thickness on a proportionate volume basis.

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Payment

00645.90 Payment

The accepted quantities of RAP will be paid for at the contract unit price, per square yard, for the item "Recycled Asphalt Products in Base, _____ Inches Thick".

The thickness of the RAP will be inserted in the blank.

Payment will be payment in full for hauling and placing the Agency provided materials, and for furnishing all equipment, labor, and incidentals necessary to complete the work as specified.

No separate or additional payment will be made for water used to obtain compaction or in care of the work.

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SECTION 00760 – INTERLOCKING CONCRETE PAVERS

Description

00760.00 Scope - This work consists of furnishing and installing masonry unit pavers at locations shown or directed. This work also includes excavating for pavers, preparing subgrade, and furnishing and placing aggregate base and sand laying course beneath concrete pavers.

Materials

00760.10 Unit Paving Material - Furnish pavers and related material meeting the following requirements:

- **Paving Unit Type** - Uni-décor or approved equal
- **Unit Color** - red, black, or red-black Provide sample color for approval
- **Unit Size** - 80mm in streets, driveways, and roadways or 60mm in pedestrian areas
- **Unit Strength** - 8,000 psi with a maximum of 5% absorption (ASTM C 936)
- **Joint Sand** - Fine PCC aggregate conforming to the following:

<u>Sieve Size</u>	<u>ASTM C 144</u> Natural Sand Percent Passing	<u>ASTM C 144</u> Manufactured Sand Percent Passing
No. 4 (4.75 mm)	100	100
No. 8 (2.36 mm)	95 to 100	95 to 100
No. 16 (1.18 mm)	70 to 100	70 to 100
No. 30 (0.600 mm)	40 to 75	40 to 100
No. 50 (0.300 mm)	10 to 35	20 to 40
No. 100 (0.150 mm)	2 to 15	10 to 25
No. 200 (0.075 mm)	0 to 1	0 to 10

- **Leveling Bed** - Fine PCC aggregate conforming to 02690.30(h) or Joint Sand
- **Aggregate Base** - 6" thick, 3/4" – 0
- **Weed Control** - Pre-emergent herbicide conforming to 01040.21

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Submit proposed equivalent products to the City Inspector for consideration.

00760.20 Salvaged Materials – Pavers salvaged as part of removal work on the Project may be reused in new construction if Engineer determines materials conform requirements of 00760.10. Salvaged materials shall be structurally sound, whole, and free from cracks and chips.

Construction

00760.40 General - Install pavers according to the manufacturer's instructions.

00760.41 Aggregate Base - Place and compact aggregate to 95% density.

00760.42 Sand Base - Place a minimum depth 1 inch leveling bed. Screeed to grade and saturate with water to ensure a firm and smooth grade.

00760.43 Weed Control - Apply granular pre-emergent herbicide over the prepared leveling bed according to the manufacturer's instructions.

00760.44 Unit Pavers - Lay out rows so they are straight and parallel to the surrounding lines. Cut pavers with a masonry saw where necessary to fit pattern to edges.

Where new or reinstalled pavers butt up against existing pavers, install whole pavers only. Do not cut pavers to fit where pavers butt up against existing pavers. Make all cuts where pavers butt up against curbs, curb ramps, sidewalks, tree wells, or other similar fixed objects.

00760.45 Joint Sand and Compaction - After placing pavers, sweep joint sand into the joints. Use a vibrating mechanical tamper to compact.

00760.46 Surface Tolerance - Do not deviate the longitudinal and transverse surface grades by more than 1/4 inch in 12 feet. Meet PROWAG requirements for slope and grades in pedestrian areas.

00760.47 Clean Up - Remove excess sand and broken paving material from the site when complete.

Measurement

00760.90 Measurement - The quantities of interlocking pavers will be measured on the area basis.

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Payment

00760.95 Payment - The accepted quantities of unit pavers will be paid for at the Contract unit price, per square foot for the item "Interlocking Concrete Pavers".

Payment will be payment in full for furnishing and placing all materials, and for furnishing all equipment, labor, and incidentals necessary to complete the work as specified.

No separate or additional payment will be made for excavation or base preparation.

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PART 00900 – PERMANENT TRAFFIC CONTROL AND ILLUMINATION SYSTEMS

Section 00902, which is not a Standard Specification, is included in this Project by Special Provision.

Description

00902.00 Scope

This work consists of constructing crosswalk closure barricades as shown.

Materials

00902.10 Materials - Furnish materials meeting the following requirements:

Commercial Grade Concrete.....	00440
Steel.....	02530
Signs	00940

Construction

00902.40 General

Construct crosswalk barricades as shown or directed.

Measurement

00902.80 Measurement

The quantities of crosswalk closure barricades will be measured on the unit basis.

Payment

00902.90 Payment

The accepted quantities of work done under this Section will be paid for at the Contract unit price, per each, for the item "Crosswalk Closure Barricades".

Payment will be payment in full for furnishing and placing all materials, and for furnishing all equipment, labor, and incidentals necessary to complete the work as specified.

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Section 00937 – Preparing and Coating Metal Sign Structures

Section 00937, which is not a Standard Specification, is included in this Project by Special Provision.

Description

00937.00 Scope - This work consists of preparing and coating metallic sign supports, including single post, multi-post, triangular base, and exit number supports, sign backs, and illumination poles and arms as shown or as directed and according to Section 00594.

Materials

00937.10 Materials - Furnish materials meeting the requirements of Section 00594 and the following:

(a) Manufacturing - Coat galvanized and aluminum surfaces with products from the same manufacturer, which are compatible with one another.

Manufactures producing galvanized and aluminum surface coating products conforming to the above requirements include the following:

Xymax	Wasser High-Tech Coatings
Rodda Paint	8041 S 228th
12000 SW Garden Place	Kent, WA 98032
Portland, OR 97219	(253) 850-2967
(503) 521-4300	

Other coating products meeting the above requirements may be used with the approval of the Traffic Engineer.

(b) Coating - The coating for all surfaces to be painted shall consist of one single-component, moisture-cured aliphatic polyurethane.

For galvanized surfaces, provide coatings conforming to the following minimum requirements:

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Topcoat - Matte Finish:

Generic type:	Micaceous iron oxide-filled, single-component, moisture-cured, aliphatic polyurethane
Vehicle type:	Moisture-cured aliphatic polyurethane
Volume of solids:	50% minimum
VOC content:	2.8 lb/gal maximum
Finish:	Matte
Pigment	Minimum of 3.0 lb/gal of micaceous iron oxide
Color:	As specified

Topcoat - Semi-Gloss Finish:

Generic type:	Single-component, moisture-cured, aliphatic polyurethane
Vehicle type:	Moisture-cured aliphatic polyurethane
Volume of solids:	60% minimum
VOC content:	2.8 lb/gal maximum
Finish:	Semi-Gloss
Color:	As specified

Construction

00937.40 General - Prepare metal sign supports and apply coatings according to Section 00594 and the following:

(a) New Galvanized Surfaces - Before coating, clean new galvanized surfaces with solvent (SSPC-SP1) followed by either a light brush blast (SSPC-SP7), surface etching with a 7% - 10% hydrochloric acid solution, or a vinyl wash material (designed to prepare galvanized surfaces for coating application) to produce a slightly abraded or etched appearance. Ensure that the surface is free of all debris or material resulting from the surface preparation procedures before painting. Take care that all oil, grease or similar contaminants are removed by the initial solvent cleaning before acid etching. If using abrasive blasting, do not destroy the integrity of the galvanized surface. If using vinyl wash, use material compatible with the applied coating.

(b) Weathered Galvanized Surfaces - Lightly brush-blast (SSPC-SP7) existing weathered galvanized surfaces with a light abrasive to remove loose delaminating surface contaminants, corrosion, and other deleterious material. Perform the abrasive blasting in a manner that will properly clean the surface but not destroy the integrity of the galvanizing. Provide an adequate surface to which the coating system can adhere.

(c) All Surfaces - Remove tears, slivers, and other surface defects, sharp edges, and edges hardened or damaged by flame cutting, shearing, or similar operations. Grind all welds smooth.

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Clean all surfaces of material detrimental to the application of the coating system as follows:

(1) Cleaning Methods - Use one or any combination of these cleaning methods:

- high-pressure abrasive blasting
- surface etching with a 7% - 10% hydrochloric acid solution
- vinyl wash compatible with coating
- other means approved by the Engineer

Use methods specified in SSPC-SP1 "Solvent Cleaning", SSPC-SP2 "Hand Tool Cleaning", or SSPC-SP3 "Power Tool Cleaning", as necessary to augment primary cleaning procedures.

(2) Abrasives - Perform blast cleaning using an abrasive of a size which does not destroy the integrity of the galvanized surface, but provides an adequate profile for proper adhesion. Remove all materials detrimental to adhesion of the coating system not removed by solvent cleaning.

Use abrasives having no corrosion products, water, oil, or any other material detrimental to the application and adherence of the coatings. Abrasive cleanliness will be tested using ODOT TM 616. Wet abrasives are allowed if wet abrasive blasting methods are used.

(3) Air - For abrasive blasting or blowing down, use high-pressure air that is free of water, oil, or any other material detrimental to the subsequent application of the coating system. Provide adequate separators and traps. The cleanliness of the air will be tested using ODOT TM 618.

(4) Cleaning Procedures - Perform abrasive blasting operations without damaging partially or entirely completed portions of the work. Do not use blast cleaning adjacent to areas being coated.

Examine the prepared surfaces for corrosion, water, oil, grease, or any other material deposited during cleaning operations. Remove any detrimental material by solvent cleaning and reblast or re-etch if necessary.

(5) Final Preparation - Immediately before coating, ensure that the prepared surface is:

- Blown down with high-pressure air supplemented by brushing if necessary
- Free of all residue
- Acceptable to the Engineer

Measurement

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00937.80 Measurement - No measurement of quantities will be made for work done under this Section.

Payment

00937.90 Payment - No separate or additional payment will be made for work done under this Section. Payment will be included in payment made for the appropriate sign support items.

SECTION 02220

PAINTING AND COATING

DESCRIPTION

1.01 SCOPE

A. This section includes the requirements for paint and coatings of metal pipes and other related surfaces

1.02 REFERENCES

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

1. American Water Works Association (AWWA):
 - a. C209, Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
 - b. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
 - c. C214, Tape Coating Systems for the Exterior of Steel Water Pipelines.
2. Environmental Protection Agency (EPA).
3. NACE International (NACE): RP0188, Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
4. NSF International (NSF): 61, Drinking Water System Components - Health Effects.
5. Occupational Safety and Health Act (OSHA).
6. The Society for Protective Coatings (SSPC):
 - a. Surface Preparation Standards:
 - 1) SP 1, Solvent Cleaning.
 - 2) SP 2, Hand Tool Cleaning.
 - 3) SP 3, Power Tool Cleaning.
 - 4) SP 5, White Metal Blast Cleaning.
 - 5) SP 6, Commercial Blast Cleaning.
 - 6) SP 7, Joint Surface Preparation Standard Brush-Off Blast Cleaning.
 - 7) SP 10, Near-White Blast Cleaning.
 - 8) SP 11, Power Tool Cleaning to Bare Metal.

- 9) SP 12, Surface Preparation and Cleaning of Metals Waterjetting Prior to Recoating.
- 10) SP 13, Surface Preparation of Concrete.

b. Paint Application Guides:

- 1) PA 1, Shop, Field, and Maintenance Painting of Steel.
- 2) PA 2, Measurement of Dry Coating Thickness with Magnetic Gages.
- 3) PA Guide 3, A Guide to Safety in Paint Application.

c. Technology Guide: Guide 6, Guide for Containing Debris Generated During Paint Removal Operations.

1.03 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.

1.04 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.

2. Samples:
 - a. Proposed Abrasive Materials: Minimum 0.5-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. Factory Applied Coatings: Manufacturer's certification stating factory applied coating system meets or exceeds requirements specified.
3. Manufacturer's written verification that submitted material is suitable for the intended use.
4. If the manufacturer of finish coating differs from that of shop primer, provide finish coating manufacturer's written confirmation that materials are compatible.
5. Manufacturer's written instructions and special details for applying each type of paint.

1.0A5 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 and for the protection of water quality.
2. Perform surface preparation and painting in accordance with recommendations of the following:
 - a. Paint manufacturer's instructions.
 - b. SSPC PA 3, Guide to Safety in Paint Applications.
 - c. Federal, state, and local agencies having jurisdiction.

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.

1.06 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.

1.07 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 Paints and Coatings: Information regarding the status of the existing paints and coatings will be made available by the Agency.

MATERIALS

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.
- D. Coatings Manufacturers Code A (Able to furnish most heavy-duty industrial coatings and architectural paints):
 - 1. CarboLine Coatings, St. Louis, MO.
 - 2. ICI Devoe Coatings, Louisville, KY.
 - 3. Tnemec Company, Kansas City, MO.
 - 4. Sherwin Williams, Cleveland, OH .
- E. Paint Manufacturers Code B (Able to furnish most architectural and institutional paints):
 - 1. Benjamin Moore Paints, Montvale, NJ.
 - 2. Miller Paints, Portland, OR.
 - 3. Pittsburgh Paints, Pittsburgh, PA.
 - 4. Rodda Paints, Portland, OR.
 - 5. Sherwin Williams, Cleveland, OH.

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.
 - 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. Thinner, Cleaners, Driers, and Other Additives: As recommended by coating manufacturer.

B. Products:

Product	Definition	Manufacturer Code
Acrylic Latex	Single-component, finish as required	B
Acrylic Latex (Flat)	Flat latex	B
Acrylic Sealer	Clear acrylic	B
Alkyd (Semigloss)	Semigloss alkyd	B
Alkyd Enamel	Optimum quality, gloss or semigloss finish as required, medium long oil	B
Alkyd Wood Primer	Flat alkyd	B
Bituminous Paint	Single-component, coal-tar pitch based	A
Block Filler	Primer-sealer designed for rough masonry surfaces, 100% acrylic emulsion	A,B
Coal-Tar Epoxy	Amine, polyamide, or phenolic epoxy type 70% volume solids minimum, suitable for immersion service	A
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	A
Epoxy, High Solids	Polyamidoamine epoxy, 80% volume solids, minimum, suitable for immersion service	A
Epoxy Nonskid (Aggregated)	Polyamidoamine or amine converted epoxies aggregated; aggregate may be packaged separately	A

Product	Definition	Manufacturer Code
Epoxy Primer—Ferrous Metal	Anticorrosive, converted epoxy primer containing rust-inhibitive pigments	A
Epoxy Primer—Other	Epoxy primer, high-build, as recommended by coating manufacturer for specific galvanized metal, copper, or nonferrous metal alloy to be coated	A
Chemical Resistant Coating	A mixture of liquid resin material, wetting agent, and filler designed to be troweled or sprayed into place to cure to a hard state, suitable for application to concrete and exposure to wastewater and hydrogen sulfide gas; as approved by the City Engineer.	A
Fusion Bonded Coating	100% solids, thermosetting, fusion bonded, dry powder epoxy, suitable for the intended service	A
High Build Epoxy	Polyamidoamine epoxy, minimum 69% volume solids, capability of 4 to 8 MDFT per coat	A
NSF Epoxy	Polyamidoamine epoxy, approved for potable water contact and conforming to NSF 61	A
Polyurethane Enamel	Two-component, aliphatic or acrylic based polyurethane; high gloss finish	A
Rust-Inhibitive Primer	Single-package steel primers with anticorrosive pigment loading	A,B
Stain, Concrete	Acrylic, water repellent, penetrating stain	B
Water Base Epoxy	Two-component, polyamide epoxy emulsion, finish as required	A,B

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 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.

CONSTRUCTION

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.
- 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 CONTAINMENT

- A. Provide containment where required for control of lead removal or where required to contain dust from surface preparation activities.
- B. Meet requirements of SSPC – Guide 6 for containment, as modified below:
 1. Design: Reviewed by a structural engineer, licensed in the State of Oregon. Consider load bearing capacity of structure for supporting the containment system.
 2. Provide Class 1 containment structure that prevents the spread of blast media, spent chips, corrosion byproducts, and dust.
 3. Filter exhaust air with appropriately sized dust collectors.
 4. Verify effectiveness using Method A, General Surveillance, Level 2, as described in SSPC – Guide 6.
- C. Protect existing, adjacent storm drain system and downstream system by installing catch basin filter inserts in all catch basins in the vicinity of the work. Maintain or replace damaged filters to prevent construction and painting-related debris and material from entering the storm drainage system.
- D. Where pressure washing is required to clean and prepare existing painted surfaces and the existing paint contains lead, collect washwater and paint chips that are removed by pressure washing, and dispose washwater and paint chips offsite in accordance with local, state, and federal regulations.

3.05 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.
 - 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 12, Surface Preparation and Cleaning of Metals by Waterjetting Prior to Recoating: Surface preparation using high-pressure and ultrahigh-pressure water jetting to achieve specified surface cleanliness condition.

Surface cleanliness conditions are defined in SSPC SP 12 and are designated WJ-1 through WJ-4 for visual surface preparation definitions and SC-1 through SC-3 for nonvisual surface preparation definitions.

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 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 pitting, 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

- b. 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 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. Remove oil and grease by wiping or scrubbing surface with suitable solvent, rag, and brush. Use clean solvent and clean rag for final wiping to avoid contaminating surface.
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.
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. Existing Painted Surfaces to be Repainted Surface Preparation:

1. Detergent wash and freshwater rinse.
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. For ductile iron pipe with asphaltic varnish finish not specified to be abrasive blasted, apply coat of tar stop prior to application of cosmetic finish coat.
8. 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.
9. Perform blasting as required to restore damaged surfaces. Materials, equipment, procedures shall meet requirements of SSPC.

3.06 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

4. distance from surface such that surface is cleaned without pitting, chipping, or other damage.
5. Verify parameter selection by blast cleaning a trial area that will not be exposed to view.
6. Engineer will review acceptable trial blast cleaned area and use area as a representative sample of surface preparation.
7. 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.
 - 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.

3.07 APPLICATION

A. General:

1. The intention of these Specifications is for existing and new, interior and exterior wood, masonry, concrete, and metal, and

submerged 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.
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.
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.

3.08 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. System No. 1 Submerged Metal—Potable Water:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 5, White Metal Blast Cleaning	NSF Epoxy	3 coats, 3 MDFTPC

C. Use on the following items or areas:

1. Metal surfaces new and existing below a plane 1 foot above the maximum liquid surface; metal surfaces above the maximum liquid surface that are a part of the immersed equipment; surfaces of metallic items, such as wall pipes, pipes, pipe sleeves, access manholes, gate guides and thimbles, and structural steel that are embedded in concrete; and the following specific surfaces:
 - a. Interior surfaces of steel piping in contact with potable water.
 - b. Any other metal surfaces that are in contact with potable water.

D. 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	
	High Build Epoxy	2coats, 16 MDFT

E. Use on the following items or areas:

1. Metal surfaces new and existing 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, access manholes, gate guides and thimbles, and structural steel, and the following specific surfaces:
 - a. Interior surfaces of steel piping conveying wastewater, unless different linings are specified in other sections.
 - b. Any other metals in contact with wastewater.

F. 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, and the following specific surfaces:
 - 1) All exposed surfaces of mechanical equipment, including, but not limited to, pipe, valves, pumps, fittings, miscellaneous appurtenances, and structural components associated with equipment.
 - 2) Use this system on all other exposed metal surfaces unless another paint system is specifically listed for other exposure conditions.

G. System No. 7 Concrete Encased Metal:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 6, Commercial Blast Cleaning	Coal-Tar Epoxy	2 coats, 16 MDFT
	OR	
	High Build Epoxy	2 or 3 coats, 16 MDFT

1. Use on the following items or areas:

- a. Use on concrete encased ferrous metals including wall pipes, pipe sleeves, access manholes, gate guides, and thimbles.

H. System No. 8 Buried Metal—General:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Coal-Tar Epoxy	2 coats, 16 MDFT

1. For steel pipe and fittings, follow AWWA C209 and AWWA C214.
2. Use on the following items or areas:
 - a. Buried, belowgrade portions of steel items, except buried stainless steel or ductile iron.

I. System No. 10 Galvanized Metal, Copper, and Nonferrous Metal Alloy Conditioning:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation	Epoxy Primer—Other	As recommended by coating manufacturer Remaining coats as required for exposure

1. Use on the following items or areas:
 - a. Galvanized surfaces requiring painting.
 - b. After application of System No. 10, apply finish coats as required for exposure.

J. System No. 12 Skid-Resistant—Steel:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Epoxy Primer—Ferrous Metal	1 coat, 2.5 MDFT
	Epoxy Nonskid (Aggregated)	1 coat, 16 MDFT

1. Use on the following items or areas:
 - a. Steel surfaces where skid resistance is required.

K. System No. 13 Skid-Resistant—Aluminum and FRP:

Surface Prep.	Paint Material	Min. Coats, Cover
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Aluminum: In accordance with Article Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation -OR- FRP: In accordance with Article Plastic and FRP Surface Preparation	Epoxy Nonskid (Aggregated)	1 coat, 16 MDFT
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1. Use on the following items or areas:

a. Aluminum surfaces where skid resistance is required.

L. System No. 19 Concrete Tank Lining—Domestic Sewage:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Concrete Surface Preparation	Manufacturer's recommended Filler/Surfacer	As required to fill voids and level surface
	Chemical Resistant Coating	50 to 70 MDFT

1. Use on the following items or areas:

a. All concrete surfaces inside wastewater wet wells.

M. System No. 20 Concrete Manhole Coatings:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Concrete Surface Preparation	Manufacturer's Recommended Filler/Surfacer	As required to fill voids and level surface
	Chemical Resistant Coating	50 to 70 MDFT

1. Use on the following items or areas:

a. All interior surfaces of concrete manholes. Seal water leaks and repair damaged concrete in

existing manholes in accordance with the coating manufacturer's recommendations.

N. System No. 21 Skid-Resistant—Concrete:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Concrete Surface Preparation	Epoxy Nonskid (Aggregated)	1 coat, 160 SFPG

1. Use on the following items or areas:

- a. Concrete surfaces where skid resistance is required.

O. System No. 25 Exposed FRP, PVC:

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 exposed-to-view PVC and CPVC surfaces, and FRP surfaces without integral UV-resistant gel coat.

P. 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, and the following items or areas:

- a. Between dissimilar metals.

Q. System No. 29 Fusion Bonded Coating:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Fusion Bonded Coating 100% Solids Epoxy	1 or 2 coats, 7 MDFT

1. For steel pipe and fittings, meet all requirements of AWWA C213.
2. Use on the following items:
 - a. As an optional steel pipe lining material for potable water contact.

3.09 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 Agency before starting work in question.
- B. System No. 102 Wood, Semigloss (Interior or Exterior):

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Wood Surface Preparation	Alkyd Wood Primer	1 coat, 400 SFPG
	Alkyd (Semigloss)	1 coat, 400 SFPG

3. Use on the following items or areas:

- a. Exposed wood.

R. System No. 106 Galvanized Metal:

Surface Prep.	Paint Material	Min. Coats, Cover
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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. Hollow metal frames and doors.

S. System No. 107 Metal Trim and Structural Steel:

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

1. Use on the following items or areas:

a. Metal trim and structural steel associated with building construction.

T. System No. 111 Concrete and Masonry, Stain and Seal:

Surface Prep.	Paint Material	Min. Coats, Cover
Concrete: In accordance with Paragraph Concrete Surface Preparation -OR- Masonry: In accordance with Paragraph Masonry Surface Preparation	Stain, Concrete	2 coats, 250 SFPGPC
	Acrylic Sealer	2 coats, 100 SFPGPC

1. Use on the following items or areas:

- a. Exposed concrete and masonry.

U. System No. 113 Concrete, Semigloss:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Article Concrete Surface Preparation	Acrylic Latex (Semigloss)	2 coats, 240 SFPGPC

1. Use on the following items or areas:

- b. Exposed concrete that requires a specific color.

3.10 COLORS

- A. Provide as selected by Agency.
- 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.

1.11 FIELD QUALITY CONTROL

- A. Testing Equipment:
 1. Provide magnetic type dry film thickness gauge to test coating thickness specified in mils, as manufactured by Nordson Corp., Anaheim, CA, Mikrotest.

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.
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 RP0188.
- c. Holiday detect coatings in excess of 20 mils dry with high voltage spark tester as recommended by coating manufacturer and in accordance with NACE RP0188.
- d. After 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 have 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. Feather edges and repair in accordance with recommendations of paint manufacturer.

2. Hand or power sand visible areas of chipped, peeled, or abraded paint, and feather the edges. Follow with primer and finish coat. Depending on extent of repair and appearance, a finish sanding and topcoat may be required.
3. Apply finish coats, including touchup and damage-repair coats in a manner that will present a uniform texture and color-matched appearance.

3.12 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 one additional Site inspection visit, for a minimum of 2 hours.
 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.

3.13 CLEANUP

- A. Place cloths and waste that might constitute a fire hazard in closed metal containers or destroy at end of each day.
- B. Collect all residual from surface preparation activities, including but not limited to, paint chips and spent abrasive. Dispose in accordance with local regulations. Residual that includes lead or other regulated wastes, such as paint stripping materials and saturated rags, shall be handled, packaged, shipped and disposed of in accordance with local, state, and federal regulations.
- C. Upon completion of the Work, remove staging, scaffolding, and containers from Site or destroy in a legal manner.
- D. Remove paint spots, oil, or stains upon adjacent surfaces and floors and leave entire job clean.

3.14 SUPPLEMENTS

- A. The supplements listed below, following "End of Section," are a part of this Specification:
 1. Paint System Data Sheet.
 2. Paint Product Data Sheet.

END OF SECTION

PAINT SYSTEM DATA SHEET

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

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

PAINT PRODUCT DATA SHEET

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

Product Name: _____

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.

**City of Bend Supplemental to the
OREGON STANDARD SPECIFICATIONS FOR CONSTRUCTION**

SECTION 02230

**STEEL TANK COATINGS
DESCRIPTION**

1.01 SCOPE

A. This section includes the work necessary to paint the interior and exterior of steel water storage tanks and associated piping.

1.02 REFERENCES

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

1. NACE International: RP0188, Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
2. NSF International (NSF): 61, Drinking Water System Components - Health Effects.
3. Society for Protective Coatings (SSPC):
 - a. Surface Preparation Standards:
 - 1) SP 1, Solvent Cleaning.
 - 2) SP 2, Hand Tool Cleaning.
 - 3) SP 3, Power Tool Cleaning.
 - 4) SP 5, White Metal Blast Cleaning.
 - 5) SP 7, Brush-Off Blast Cleaning.
 - 6) SP 10, Near White Blast Cleaning.
 - 7) SP 11, Power Tool Cleaning to Bare Metal.
 - 8) SP 12, Surface Preparation and Cleaning of Metals by Water jetting Prior to Recoating.
 - b. Paint Application Guides:
 - 1) PA 1, Shop, Field, and Maintenance Painting of Steel.
 - 2) PA 2, Measurement of Dry Coating Thickness with Magnetic Gages.
 - 3) PA Guide 3, A Guide to Safety in Paint Application.
 - c. Technology Guide: Guide 6, Guide for Containing Debris Generated During Paint Removal Operations.

1.03 DEFINITIONS

A. Terms used in this section:

1. Coverage: Total minimum dry film thickness in mils, or square feet per gallon.
2. MDFT: Minimum Dry Film Thickness, mils.
3. MDFTPC: Minimum Dry Film Thickness per Coat, mils.
4. Mil: Thousandth of an inch.
5. PPDS: Paint Product Data Sheet.

6. PSDS: Paint System Data Sheet.
7. SC: Stripe coat.
8. SP: Surface preparation.
9. VOC: Volatile Organic Compounds.

1.04 SUBMITTALS

A. Action Submittals:

1. Data Sheets:
 - a. For each paint system used, furnish a Paint System Data Sheet (PSDS), Paint Product Data Sheet (PPDS), and paint colors available (where applicable) for each product used in paint system. The PSDS and PPDS forms are appended to the end of this section.
 - b. Submit required information on a system-by-system basis.
 - c. Provide copies of paint system submittals to coating applicator.
 - d. Also provide copies of paint system submittals to the coating applicator.
 - e. Indiscriminate submittal of manufacturer's literature only is not acceptable.
2. Detailed chemical and gradation analysis for each proposed abrasive material.
3. Samples:
 - a. For each paint system used, furnish colors available (where applicable) for each product used in paint system.
 - b. Proposed Abrasive Materials: Minimum 1/2-pound Sample for each type proposed.
4. Test Equipment: Manufacturer data.

B. Informational Submittals:

1. Coating manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services.
2. Current NSF certification for potable water contact, where applicable.
3. Anticipated tank coating sequence.
4. Dehumidification plan, including equipment and air change rates. Submit plan based on type of equipment used, length of time required to hold blast, reservoir volume, and time of year that coating work is undertaken.
5. Applicator's Qualification: List of references substantiating experience.
6. Independent structural Engineer review of proposed tank containment system.

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7. When self-contained blast cleaning equipment using recycled abrasives is proposed, submit the following:
 - a. List of at least three successful projects within past 3 years where equipment and procedures have been used on steel tank of similar size and dimensions.
 - b. Provide tank agency's name and telephone numbers.
 - c. Description of proposed equipment, procedures, and abrasive blast mix to be used.
8. Field Testing: Daily inspection and test reports.
9. Guarantee Bond and Repair Guarantee Bond.

C. Quality Control Submittals:

1. Shop and field applicator's quality control program, including, but not limited to:
 - a. Environmental test methods and frequency.
 - b. Steel surface temperature and profile measurement procedure and frequency.
 - c. Recordkeeping form.
2. Manufacturer's written instructions for applying each type of coating.
3. Field Testing: Daily inspection and test reports.
 - a. Submit all daily and special inspection and test reports in bound form at the completion of the coating work.

1.05 QUALITY ASSURANCE

- A. Applicator Qualifications: Minimum 5 years' experience in application of specified products.
- B. Regulatory Requirements: Meet federal, state, and local agencies having jurisdiction for Site and types of work activities included in Project, including, but not limited to:
 1. Limitations on emission of volatile organic compounds, dust, and other contaminants.
 2. Requirements for disturbance, handling, and disposal of paint waste and associated debris, including lead, coal tar, abrasive, and other regulated substances.
- C. Industry Best Practices:
 1. Perform surface preparation and painting in accordance with recommendations of the following:
 - a. Paint manufacturer's instructions.
 - b. SSPC-PA Guide 3.

2. Do not apply paint in temperatures outside of manufacturer's recommended maximum or minimum allowable, in dust, in smoke-laden atmosphere, in damp or humid weather.
3. Do not perform abrasive blast cleaning whenever relative humidity exceeds 85 percent or whenever surface temperature is less than 5 degrees F above dewpoint of ambient air.

D. 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 approval, sample spaces or items shall serve as a standard for similar work throughout the Project.

E. Preinstallation Meeting:

1. Prior to beginning painting Work, schedule a meeting and be prepared to discuss the following subjects, as a minimum:
 - a. Required schedule.
 - b. Sequence of critical path work items.
 - c. Use of Site, access, office and storage areas, security, and temporary facilities.
 - d. Major product delivery and priorities.
 - e. Safety plan.
2. Attendees shall include:
 - a. Agency's representatives.
 - b. Contractor's office representative.
 - c. Contractor's resident superintendent.
 - d. Contractor's quality control representative.
 - e. Subcontractors' representatives whom Contractor may desire or Engineer may request to attend.
 - f. Engineer's representative.
 - g. Paint manufacturer's technical representative.
 - h. Others as appropriate.

F. Independent Coatings Inspector: The Agency, at its own discretion, may retain the services of a NACE certified coating inspector. The presence of the coating inspector will be to verify that surfaces are prepared and coatings are applied in accordance with specifications. The presence of a coating inspector will not relieve the Contractor of the responsibility to provide internal quality assurance/quality control measures.

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1.06 DELIVERY, STORAGE, AND HANDLING

A. Shipping:

1. Protect precoated items from damage. Batten coated items to prevent abrasion.
2. Use nonmetallic or padded slings and straps in handling.

B. Deliver materials to Site in unopened containers labeled with designated name, date of manufacture, color, and manufacturer.

C. Store paints in a protected area that is heated or cooled as required to maintain temperatures within range recommended by paint manufacturer.

1.07 SPECIAL GUARANTEE

A. Special guarantee shall provide for correction, or at the option of Agency, removal and replacement of Work specified in this Specification section found defective during a period of 2 years after date of Substantial Completion.

B. Provide a surety bond in the full amount of the painting contract price that guarantees the performance of the work. The bond shall cover a period of two years after acceptance from the Agency. The performance bond shall be furnished by a corporate surety company authorized to do business in the State of Oregon, acceptable to the Agency, and subject to the approval of the attorney as to form.

C. Duties and obligations for correction or removal and replacement of defective Work as specified in General Conditions.

1. 24-Month Warranty Period Inspection: Agency will conduct inspection of interior and exterior coated surfaces prior to the end of warranty period. Agency will notify Contractor in advance of inspection and Contractor may attend at its option. Agency will prepare list of coating defects and failures identified during inspection and transmit to Contractor. List shall serve as notice of repairs required under warranty.

2. Repairs:

a. If repairs are required, requirements of Contract shall apply including, but not limited to, requirements to remove standing water in tanks, perform repair work, and tank cleaning prior to disinfection.

b. Repair defective coatings using coating materials, equipment, and methods similar to those used in original work. Materials shall be of fresh manufacture and within manufacturer's stated shelf life at time of application.

- c. Provide extended warranty of 1 year for repairs.
- d. Provide separate bond for 1-year repair warranty period.
- e. Complete repairs within 30 calendar days of Warranty Period Inspection.

1.08 EXISTING COATING STATUS

- A. Information regarding the status of the existing coating will be made available by the Agency.

MATERIALS

2.01 2230.10MANUFACTURERS

- A. Materials, equipment, and accessories specified in this section shall be products of:
 - 1. CarboLine Coatings Company, St. Louis, MO.
 - 2. ICI Devoe, Louisville, KY.
 - 3. International Protective Coatings, Houston, TX.
 - 4. Sherwin-Williams, Cleveland, OH.
 - 5. Tnemec Coatings, Kansas City, MO.

2.02 MATERIALS

- A. Quality: Manufacturer's highest quality products and suitable for intended use.
- B. Materials Including Primer and Finish Coats: Produced by same paint manufacturer.
- C. Thinners, Cleaners, Driers, and Other Additives: As recommended by paint manufacturer of the particular coating.
- D. NSF Epoxy: Polyamidoamine or phenalkamine cured epoxy coatings approved for potable water contact and conforming to NSF 61.
- E. Epoxy Primer: Two-component, polyamidoamine, phenalkamine, or polyamide cured epoxy, capable of 4-mil to 6-mil dry film thickness, and compatible with specified finish.
- F. Surface Tolerant Epoxy Primer: Two-component, polyamide or polyamidoamine cured epoxy, compatible with existing tank coating and suitable for topcoating with polyurethane enamel.
- G. Polyurethane Enamel: Two-component, aliphatic or acrylic based polyurethane; semi-gloss finish.

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H. Flexible Polyurethane: Modified polyurethane flexible lining membrane, approved for potable water contact conforming to NSF 61 and compatible with the NSF epoxy.

I. Caulking: Two-component polyurethane caulk, suitable for potable water contact conforming to NSF 61 and compatible with the NSF Epoxy.

2.03 COLORS

A. Formulate with colorants free of lead and lead compounds.

B. Furnish as selected by Agency.

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

2.04 MIXING

A. Multiple-Component Coatings:

1. Prepare using contents of container for 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. Keep paint material containers sealed when not in use.

2.05 ABRASIVES

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

B. Select abrasives that conform to federal and state regulations for metals and toxicity.

2.06 SOURCE QUALITY CONTROL

A. Prime coat structural steel surfaces.

- B. Notify Engineer at least 7 days prior to start of shop blast cleaning to allow for inspection of the Work during surface preparation and shop application of paints. Work shall be subject to Engineer's approval before shipment to Site.

CONSTRUCTION

3.01 2230.30 GENERAL

- A. Surface Preparation and Coating Application: Meet or exceed requirements of these Specifications and SSPC-PA 1, whichever is more stringent.
- B. 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.
- C. Paint new and existing interior and exterior exposed metal surfaces whether specifically mentioned or not, except as modified herein.
- D. Provide Engineer a minimum of 7 days' advanced notice prior to start of surface preparation work or coating application work. Perform such work only in the presence of Engineer, unless Engineer grants prior approval to perform such work in Engineer's absence.
- E. Schedule inspection with Engineer in advance for cleaned surfaces and coats prior to succeeding coat.
- F. Do not apply paint in temperatures outside of manufacturer's recommended maximum or minimum allowable, or in dust, smoke-laden atmosphere, damp or humid weather.
- G. Do not perform abrasive blast cleaning whenever relative humidity exceeds 85 percent, or whenever surface temperature is less than 5 degrees F above dewpoint of ambient air.
- H. Ventilation for Coating Cure: Provide fans to continuously ventilate tank interior, as required, to assist with coating cure.

3.02 PREPARATION

- A. For new metal items such as structural steel, metal floor doors, manways, and frames, metal louvers, and similar fabricated items may be shop prepared and primed. Centrifugal wheel blast cleaning is an acceptable alternative to shop blast cleaning.
- B. Remove, mask, or otherwise protect hardware, machined surfaces, nameplates, and other surfaces not intended to be painted.

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- C. Protect surfaces adjacent to or downwind of Work area from overspray.
- D. Protect interior of inlet/outlet and overflow pipes from abrasive blast residue and dust with inflatable pipe plug, as approved by Engineer. Install temporary, appropriately sized polyethylene pig in pipe before installation of plug.

3.03 ENVIRONMENTAL CONTROLS

A. Containment System:

- 1. Provide full containment of blast emissions during entire blast operation for tank exterior. Meet requirements of SSPC-Guide 6 as modified below.
 - a. Design: Reviewed by structural engineer, licensed in the State of Oregon. Consider load bearing capacity of roof for supporting containment system.
 - b. Provide Class 1 containment structure. Completely shroud tank with opaque fabric that prevents spread of blast media, spent chips, corrosion byproducts, and dust.
 - c. Exhaust air shall be filtered by appropriately sized dust collectors.
 - d. Verify effectiveness using Method A, General Surveillance, Level 2, as described in SSPC-Guide 6.
- 2. As an option to containment, consideration will be given to use of self-contained blast cleaning equipment using recycled abrasives.
 - a. Exterior coatings shall be roller-applied to surfaces prepared using contained blast cleaning equipment.

B. Dehumidification Equipment:

- 1. Provide dehumidification for field painting interior of reservoir. Dehumidification and heating equipment shall be provided by a supplier with at least 3 years' experience with necessary equipment.
- 2. Use dehumidification and heating equipment to control environment 24 hours a day during blast cleaning and coating application. At Contractor's option, dehumidification equipment may also be used during curing process.
- 3. Provide desiccant dehumidifiers as manufactured by Cargocaire Corporation, or equal. Desiccant dehumidifiers shall have a single rotary desiccant wheel capable of fully continuous operation. No liquid, granular, or loose lithium chloride drying systems will be allowed.
- 4. Interior space of reservoir shall be sealed and a slight positive pressure maintained as recommended by supplier of dehumidification equipment.

5. During blasting operation, dehumidification equipment shall continuously maintain a dewpoint of air inside tank at least 5 degrees F less than temperature of coldest part of tank where the Work is underway. Inside relative humidity shall not exceed 45 percent, unless specifically required by paint manufacturer for coating application and cure.
6. Auxiliary heat may be necessary to maintain surface temperature at an acceptable level for application of coating. Auxiliary equipment shall be approved for use by dehumidification equipment supplier and shall meet the following requirements:
 - a. Install heaters in process air supply duct between, and blended with, dehumidifier as close to space as possible.
 - b. Use electric, indirect fired combustion, or steam coil auxiliary heaters. Direct fired space heaters will not be allowed during blasting, coating, or curing cycles.
 - c. Equip heaters with controls that automatically turn heater off if airflow is interrupted or internal temperature of heater exceeds its design temperature or design temperature of supply duct.
7. Measure and record ambient temperature, relative humidity, dewpoint and reservoir wall temperature a minimum of twice daily (beginning and end of work shifts) to verify proper environmental levels are achieved inside reservoir. Field-measured test results shall be made available to Engineer upon request.

C. Filtration System:

1. Designed to remove dust from air so that it does not interfere with dehumidification equipment's ability to control dewpoint and relative humidity inside reservoir.
2. Air from reservoir or dust filtration equipment shall not be recirculated through dehumidifier during coating application or when solvent vapors are present.

D. Protect existing, adjacent storm drain system and downstream system by installing catch basin filter inserts in all catch basins in the vicinity of the work. Maintain or replace damaged filters to prevent construction and painting-related debris and material from entering the storm drainage system.

E. Where pressure washing is required to clean and prepare existing painted surfaces and the existing paint contains lead, collect washwater and paint chips that are removed by pressure washing, and package, transport, and dispose washwater and paint chips offsite in accordance with local, state, and federal regulations.

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3.04 PREPARATION OF SURFACES

A. Metal Surfaces:

1. Meet requirements of the following SSPC Specifications:
 - a. Solvent Cleaning: SP 1.
 - b. Hand Tool Cleaning: SP 2.
 - c. Power Tool Cleaning: SP 3.
 - d. White Metal Blast Cleaning: SP 5.
 - e. Brush-Off Blast Cleaning: SP 7.
 - f. Near-White Blast Cleaning: SP 10.
 - g. Power Tool Cleaning to Bare Metal: SP 11.
 - h. High Pressure Water Jetting: SP 12.
2. Wherever the words "solvent cleaning", "hand tool cleaning", "wire brushing", or "blast cleaning", or similar words of equal intent are used in these Specifications or in paint manufacturer's specifications, they shall be understood to refer to the applicable SSPC Specifications listed above.
3. Where OSHA or EPA regulations preclude standard abrasive blast cleaning, wet or vacu-blast methods may be required. Coating manufacturers' recommendations for wet blast additives and first coat application shall apply.
4. 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 solvents and clean cloths.
 - d. Round or chamfer sharp edges and grind smooth burrs, jagged edges, and surface defects.
 - e. Welds and Adjacent Areas:
 - 1) Prepare such that there is:
 - a) No undercutting or reverse ridges on weld bead.
 - b) No pitting.
 - c) No weld spatter on or adjacent to weld or other area to be painted.
 - d) No sharp peaks or ridges along weld bead.
 - 2) Grind embedded pieces of electrode or wire flush with adjacent surface of weld bead.
5. 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 a 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 and disposition of spent aggregate and debris.

6. 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 other areas where dust settling is a problem and wipe with a tack cloth.
- b. Paint surfaces the same day they are blast cleaned. Reblast surfaces that have started to rust before they are coated.

3.05 APPLICATION

A. General:

- 1. The intention of these Specifications is for existing and new, interior and exterior metal and submerged metal surfaces to be painted, whether specifically mentioned or not, except as modified herein.
- 2. Coatings Subject to Immersion:
 - a. Apply coatings to internal vessel, pipe surfaces, nozzle bores, flange gasket sealing surfaces, carbon steel internals, and stainless steel internals unless otherwise specified.
 - b. Curing:
 - 1) Obtain full cure for completed system.
 - 2) Consult coatings manufacturer's written instructions.
 - 3) Do not immerse coating until completion of curing cycle.
- 3. Apply coatings in accordance with paint manufacturer's recommendations. Allow sufficient time between coats to ensure thorough drying of previously applied coat.
- 4. Prior to assembly or installation, paint units to be bolted together and to structures.
- 5. Where more than one coat of a material is applied within a given system, alternate color to provide a visual reference that required number of coats have been applied.
- 6. With brush, work coating into and behind anchor bolts, anchor chairs, and other areas that are difficult to paint by spray.

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B. Shop Primed Surfaces:

1. Hand or power sand areas of chipped, peeled, or abraded coating, feathering the edges. Follow with a spot primer using specified primer.
2. For two-package or converted coatings, consult coatings manufacturer for specific procedures as relates to manufacturer's products.
3. Prior to application of finish coats, clean shop primed surfaces free of dirt, oil, and grease and apply one coat of specified primer.
4. After welding, prepare and prime holdback areas as required for specified paint system. Apply primer in accordance with manufacturer's instructions.

C. Stripe Coating:

1. Consists of one coat, brush applied, to coating thickness specified.
2. Apply between intermediate and final coats.
3. Color shall contrast intermediate coat to allow visual verification of application.
4. Apply to field welds, edges, angles, fasteners, and other irregular surfaces located inside tanks.

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. Maximum film build per coat shall not exceed coating manufacturer's recommendations.

3.06 PROTECTIVE COATINGS SYSTEMS AND APPLICATION SCHEDULE

A. Stripe Coat: One coat, brush applied, only to edges, corners, or to welds and surface irregularities intended to give those areas the required MDFT. Used before, after or in conjunction with full coats applied to the entire surface.

B. System No. 1A Interior Coating System—Potable Water, New Construction:

Surface Prep.	Paint Material	Min. Coats, Cover
Shop: Solvent clean and abrasive blast or centrifugal wheel blast (SP-5) Field: Detergent wash and fresh water rinse. Brush-off blast shop primer, abrasive blast areas of damaged primer, and field weld holdback areas to white metal (SP-5)	NSF Epoxy (Shop Applied, White)	1 coat, 4 MDFT
	NSF Epoxy (white), Spot Repairs and Welds	1 coat, 4 MDFT
	NSF Epoxy Intermediate Coat (grey or beige)	1 coat, 4 MDFT
	Stripe Coat with NSF Epoxy	1 coat, 3 MDFT
	NSF Epoxy Finish Coat (white)	1 coat, 4 MDFT

1. Minimum Dry Film Thickness, Total System:
 - a. Nonstripe Coated Areas: 12 MDFT.
 - b. Stripe Coated Areas: 15 MDFT.
2. Application Schedule:
 - a. Use on all submerged and nonsubmerged metal surfaces inside the tank, including, but not limited to, steel plates and structural steel, exposed surfaces of inlet, outlet, and overflow piping, hatches, covers, ladders, landings, and couplings.
 - b. Coat exposed stainless steel surfaces inside tank. Coat interior surfaces of stainless steel pipe for a distance of 24 inches where stainless steel pipe is connected to coated carbon steel pipe.
 - c. Use on exterior surfaces of direct buried and concrete encased steel pipe.
 - d. Coating is not required for bottom side of floor plates.
 - e. Provide full coating thickness to structural steel surfaces that will be covered by roof plates or otherwise shielded from full coating thickness, before structural members are installed. Not required for surfaces located behind members that are fully seal welded.

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C. System No. 1B Special Coating under Column Baseplate, New Construction:

Surface Prep.	Paint Material	Min. Coats, Cover
Shop: Solvent clean and abrasive blast or centrifugal wheel blast (SP-5)	NSF Epoxy (Shop Applied)	1 coat, 4 MDFT
Field: Detergent wash and fresh water rinse. Brush-off blast shop primer, and as required by paint manufacturer	NSF Epoxy	Field applied, as required by paint manufacturer
	Flexible Polyurethane	1 coat, 50 MDFT

1. Minimum Dry Film Thickness, Total System: 54 mils.
2. Application Schedule:
 - a. For new tanks, use on bottom of column baseplate and top of steel floor surface under baseplate.
 - b. Prepare surfaces and apply coating prior to installation of columns.
 - c. Extend flexible polyurethane coating on floor 2 inches beyond outside perimeter of column baseplate.

D. System No. 1C Interior Coating System—Potable Water, Existing Tanks:

Surface Prep.	Paint Material	Min. Coats, Cover
Detergent wash and fresh water rinse. Abrasive blast to white metal (SP-5)	NSF Epoxy (Shop Applied, White)	1 coat, 4 MDFT
	NSF Epoxy Intermediate Coat (grey or beige)	1 coat, 4 MDFT
	Stripe Coat with NSF Epoxy	1 coat, 3 MDFT
	NSF Epoxy Finish Coat (white)	1 coat, 4 MDFT

1. Minimum Dry Film Thickness, Total System:
 - a. Nonstripe Coated Areas: 12 MDFT.
 - b. Stripe Coated Areas: 15 MDFT.

2. Application Schedule:

- a. Use on all submerged and nonsubmerged metal surfaces inside the tank, including, but not limited to, steel plates and structural steel, exposed surfaces of inlet, outlet, and overflow piping, hatches, covers, ladders, landings, and couplings.
- b. Coat exposed stainless steel surfaces inside tank. Coat interior surfaces of stainless steel pipe for a distance of 24 inches where stainless steel pipe is connected to coated carbon steel pipe.
- c. Use on exterior surfaces of direct buried and concrete encased steel pipe.

E. System No. 5 Exterior Surfaces (Exposed Metal), New Construction or Full Recoat:

Surface Prep.	Paint Material	Min. Coats, Cover
Shop : Abrasive blast, or centrifugal wheel blast (SP 10)	Epoxy Primer	1 coat, 2.5 MDFT
Field: Detergent wash and fresh water rinse. Brush-off blast shop primer, abrasive blast areas of damaged primer and field weld holdback areas to white metal (SP-10)	Epoxy Primer	1 coat, 3 MDFT
	Polyurethane Enamel	1 coat, 3 MDFT

1. Minimum Dry Film Thickness, Total System: 8.5 mils.

2. Application Schedule:

- a. Use on the following:
 - 1) Exposed exterior metal surfaces of tank.
 - 2) For galvanized surfaces to be coated, reference System No. 10.

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F. System No. 5a Exterior Surfaces (Exposed Metal), Overcoating for Existing Tanks:

Surface Prep.	Paint Material	Min. Coats, Cover
Detergent wash and fresh water rinse. Mechanical tool clean spot damage to bare metal (SP-11)	Surface Tolerant Epoxy Primer (Spot Repairs)	1 coat, 3 MDFT
	Epoxy Primer (Full Tank)	1 coat, 3 MDFT
	Polyurethane Enamel	1 coat, 3 MDFT

1. Minimum Dry Film Thickness, Total System: 6 mils.
2. Application Schedule:
 - a. Use on the following:
 - 1) Exposed exterior metal surfaces of tanks where the existing coating is suitable for over-coating.
 - 2) For galvanized surfaces to be coated, reference System No. 10.

G. System No. 10 Galvanized Metal Conditioning:

Surface Prep.	Paint Material	Min. Coats, Cover
Solvent Clean (SP 1) followed by Hand Tool (SP 2), Power Tool (SP 3), or Brush-off Blast (SP 7)	Coating manufacturers' recommended primer followed by System No. 5	

1. Application Schedule: Use on galvanized surfaces, including handrails and gratings, before application of System No. 5.

3.07 TESTING

2230.60 FIELD QUALITY CONTROL

A. Access:

1. Contractor shall provide access to Engineer or designated NACE certified coatings inspector as required to observe surface preparation and coating application, and as required to perform tests for surface profile and cleanliness, paint thickness, holidays, and any other tests deemed necessary to verify that the work complies with the specifications.

2. Leave staging up until Engineer has inspected surface or coating. Replace staging removed prior to approval by Engineer.

B. Test Equipment:

1. Provide a dry film thickness gauge to test coating thickness as specified in mils. Use electronic dry film thickness, as manufactured by DeFelsko, Ogdensburg, NY, Positest, or approved equal.
2. Provide electrical holiday detector, low voltage, wet sponge type to test finish coat, except zinc primer, high-build elastomeric coatings, and galvanizing as manufactured by Tinker and Rasor, San Gabriel, CA; Model M-1.

C. Film Thickness Measurements and Electrical Inspection of Coated Surfaces:

1. Perform with properly calibrated instruments.
2. Repair or recoat defective areas as necessary for compliance with Specifications.
3. All coats are subject to inspection by Engineer and coating manufacturer's representative.
4. 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.
5. Thickness Testing:
 - a. Measure coating thickness specified in mils with magnetic or electronic type dry film thickness gauge in accordance with SSPC-PA 2.
 - b. Check each coat for correct thickness. Do not make measurement before a minimum of 8 hours after application of coating.
 - c. After repaired and recoated areas have dried sufficiently, tests will be conducted by Engineer.
6. Holiday (Pinhole) Testing: Test finish coat on 100 percent of the submerged surfaces for holidays and discontinuities with an electrical holiday detector in accordance with NACE RP0188.

D. Unsatisfactory Application:

1. If 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 are causes for rejection.
3. Repair defects in coating systems in accordance with written recommendations of coating manufacturer.

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E. Damaged Coatings, Pinholes, and Holidays:

1. Feather edges and repair in accordance with recommendations of paint manufacturer.
2. Hand or power sand visible areas of chipped, peeled, or abraded paint, and feather edges. Follow with primer and finish coat in accordance with Specifications. Depending on extent of repair and appearance, a finish sanding and topcoat may be required.
3. Apply finish coats, including touchup and damage-repair coats in a manner that will present a uniform texture and color-matched appearance.

3.08 ACCEPTANCE

3.09 2230.70 MANUFACTURER'S SERVICES

- A. Coating manufacturer's technical representative shall be present at Site as follows:
 1. On the first day of application of coating.
 2. A minimum of three additional Site inspection visits, each for a minimum of 3 hours.
 3. As required for application quality assurance, and to determine compliance with manufacturer's instructions and these Specifications.
 4. As necessary to resolve field problems attributable to or associated with manufacturer's products furnished under this Contract.
 5. To verify full cure of coating prior to placing coated surfaces into immersion service.
- B. The cost for manufacturer's technical representative site visits shall be included in the Contractor's cost for the painting work and shall be provided at no additional cost to the Agency.

3.10 2230.71 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. Completely remove paint spots, oil, or stains upon adjacent surfaces and floors and leave Site clean.

3.11 SUPPLEMENTS

- A. The supplements listed below, following "End of Section," are a part of this Specification:
 1. Paint System Data Sheet.
 2. Paint Product Data Sheet

END OF SECTION

PAINT SYSTEM DATA SHEET

Complete and attach manufacturer's Technical Data Sheet to this PSDS for each coating system.

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

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.

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:

Product _____ Name: _____

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.: _____

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SECTION 02930

ELECTRICAL FACILITIES

DESCRIPTION

SCOPE

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, Standard Test Procedures for Single-Phase Induction Motors.

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6. International Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
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. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - c. CC1, Electrical Power Connectors for Substations.
 - d. ICS 1, Industrial Control and Systems: General Requirements.
 - e. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated Not More Than 2000 Volts AC or 750 Volts DC.
 - f. ICS 2.3, Industrial Control and Systems: Instructions for the Handling, Installation, Operation and Maintenance of Motor Control Centers.
 - g. MG 1, Motors and Generators.
 - h. PB 1, Panelboards.
 - i. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
 - j. ST 20, Dry Type Transformers for General Applications.
 - k. TC 2, Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.
 - l. TC 3, PVC Fittings for Use with Rigid PVC Conduit and Tubing.
 - m. WC 55, Instrumentation Cables and Thermocouple Wire.
 - n. WC 70, Standard for Non-Shielded Power Cables Rated 2000 V or Less for the Distribution of Electrical Energy.
 - o. 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. 854, Service-Entrance Cables.
- t. 870, Wireways, Auxiliary Gutters, and Associated Fittings.
- u. 943, Ground-Fault Circuit Interrupters.
- v. 1059, Terminal Blocks.
- w. 1277, Electrical Power and Control Tray Cables with Optional Optical-Fibre Members.
- x. 1449, Transient Voltage Surge Suppressors.
- y. 1561, Dry-Type General Purpose and Power Transformers.
- z. 2111, Overheating Protection for Motors.

2930.02 Definitions

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 SECTION INCLUDES

- A. This Section covers the work necessary for complete electrical systems. Furnish materials, labor, and equipment in accordance with these Specifications and the accompanying Drawings.

1.04 INSPECTION OF THE SITE AND EXISTING CONDITIONS

- A. Verify all scaled dimensions prior to construction.

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B. Before submitting a bid, visit the site and become familiar with all existing conditions which will, in any way or manner, affect the work required under this Contract. No subsequent increase in Contract cost will be allowed for additional work required because of the Contractor's failure to fulfill this requirement.

1.05 RESPONSIBILITY

A. The Contractor shall be responsible for:

1. Complete systems in accordance with the intent of these Contract Documents.
2. Furnishing and installing all incidental items not actually shown or specified, but which are required by good practice to provide complete functional systems.
3. Verifying actual locations of all equipment that requires power and control circuit connections as shown on the Drawings.
4. Obtaining and paying for all construction permits and licenses.
5. Paying all governmental charges and inspection fees necessary for the prosecution of the Work, which are applicable at the time of opening Bids.

1.06 INTENT OF DRAWINGS

A. Electrical plan drawings are diagrammatic and show only general locations of equipment, devices, and raceway, unless specifically dimensioned. The Contractor shall be responsible for the complete raceway system. Provide as a minimum what is shown on the Drawings, and provide additional raceway, devices, fittings, boxes, etc., needed to fit the equipment size and/or configuration as supplied subject to the approval of the Engineer and at the Contractor's own expense.

B. In general, the background on electrical Drawings has been screened. Electrical work under this contract is shown heavier by contrast.

C. Details are typical for all locations which apply regardless of whether a callout is shown on the Drawing or not.

1.07 DEPARTURES FROM CONTRACT DOCUMENTS

A. Submit to the Engineer in writing details of any necessary, proposed departures from these Contract Documents, and the reasons therefor. Submit such requests as soon as practicable and within 20 days after award of the Contract. Make no such departures without written approval of the Engineer.

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1.08 SUBSTITUTION OF MATERIALS AND EQUIPMENT

- A. Manufacturers' names and catalog numbers stated herein are intended to indicate the type and quality of equipment or materials desired. Unless substitution is specifically forbidden, proposed alternatives may be submitted for approval.
- B. Make requests for approval of alternatives in writing to the Engineer. Provide sufficient material or data to allow evaluation of the proposed alternative and determination of compliance with these Contract Documents. List any proposed deviations from these Contract Documents.

1.09 SUBMITTALS

- A. Provide complete manufacturers' descriptive information and Shop Drawings for all equipment, material, and devices furnished under this specification Section including arrangement drawings, elementary (schematic) diagrams, interconnection and connection diagrams, etc. Provide five copies for the Engineer, Contractor, and Operation and Maintenance Manuals. On general equipment drawings, clearly indicate those items which are part of the submittal to be reviewed, and cross out items that are not applicable.
- B. Submit complete control and interface schematic drawings. These Drawings shall contain diagrams, terminal numbers, device names, tag numbers, control cable conductor colors and numbers, etc., to provide complete identification of the circuits and prove coordination between the equipment.
- C. Action Submittals:
 1. Service entrance and metering equipment.
 2. Boxes and device plates.
 3. Junction and pullboxes.
 4. Precast handholes.
 5. Telephone terminal cabinet.
 6. Wiring devices including special purpose receptacle.
 7. Panelboards and mini-power centers.
 8. Circuit breakers and switches.
 9. Motor-rated switches.
 10. Control devices, terminal blocks, and relays.
 11. Contactors.
 12. Transformers.
 13. Support and framing channels.
 14. Nameplates and nameplate schedule.
 15. Unit heaters and thermostats.
 16. TVSS equipment.

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17. Conduit, fittings, and accessories.
18. Wireways.
19. Conductors, cable, and accessories.
20. Motors: Nameplate data, detailed information on any special features.
21. Grounding materials.
22. Motor Controls: Arrangement drawings, ratings, schematic and wiring diagrams, bill of materials, nameplate schedule, manufacturer information on components.
23. Local Control Panels: Arrangement drawings, schematic and wiring diagrams, bill of materials, nameplate schedule, manufacturer information on components.
24. Luminaires.
25. Lighting controls.
26. Seismic anchorage and bracing drawings and cut sheets.

D. Informational Submittals:

1. Seismic anchorage and bracing calculations.
2. Factory test reports.
3. Field test reports.
4. Signed permits indicating Work is acceptable to regulatory authorities having jurisdiction.
5. 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.

E. Contractor shall review, check, and initial all submittals indicating that the submitted items meet the requirements of the Specifications and Drawings.

F. Review of the submittal information by the Engineer is for the convenience of the Agency and the Contractor to facilitate the satisfactory acceptance of the work required hereunder. This review shall neither relieve the Contractor from the responsibility for deviations from the Drawings and Specifications, nor from errors and omissions in the shop drawings or literature. The Contractor shall obtain Engineer's acceptance of submittals before commencing fabrication or installation of any materials or equipment. Equipment found not meeting the requirements of these Specifications and Drawings shall be removed, repaired, or replaced at the Contractor's own expense. Review by the

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Engineer is limited to one resubmittal per item. Cost of submittal reviews beyond this limit which are required to obtain acceptance shall be reimbursed to the Engineer by the Contractor.

1.10 APPROVAL BY AUTHORITY HAVING JURISDICTION (AHJ)

- A. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). 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.

1.11 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.

1.12 EXTRA MATERIALS

- A. Furnish, tag, and box for shipment and storage the following spare parts and special tools:
 1. Fuses, 0 to 600 Volts: Six of each type and each current rating installed.

1.13 ENERGY SOURCE NAMEPLATES

- A. Furnish and install an energy source nameplate on the front of all equipment (mechanical, electrical, instrumentation and control, HVAC, plumbing, etc.) that is connected to one or more electrical sources of power.
- B. Electrical equipment on which energy source nameplates are required include motors, motor starters, panelboards, disconnect switches, etc., as applicable.
- C. Low voltage power sources include branch circuit breakers in panelboards.
- D. Provide nameplates as specified in Article Nameplates.

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1.14 OPERATION AND MAINTENANCE MANUALS

A. Provide three copies of Operation and Maintenance (O&M) Manuals in commercial quality, permanent, three-post binders with durable, cleanable, plastic covers. Each copy shall contain a neatly typewritten table of contents arranged in a systematic order with the Contractor's name, name of responsible principal, address, and telephone number. The O&M Manuals shall also include:

1. Operation, maintenance, recommended spare parts, and renewal parts information for all equipment furnished under Division 16, Electrical.
2. Set of complete, final, as-reviewed and accepted information herein required to be submitted for review following Contract award.
3. As-built electric circuit, equipment, and installation drawings showing equipment as it was actually installed and connected (include in the final O&M manual drafts).
4. Index of all equipment suppliers listing current names, addresses, and telephone numbers of those who should be contacted for service, information, and assistance.
5. As-built Contract Drawings marked with red indelible pencil on one set of Contract Drawings to show all departures from original Drawings and all electrical work revisions; prepare by obtaining new, clean sets of Contract Drawings from Engineer and pay all costs for same; field marked as-built drawings shall be initialed by the Engineer or his representative (include in the final O&M manual drafts).
6. All field and factory test results (include in the final O&M manual final drafts).
7. Complete interconnection diagrams between all control devices showing field wiring from numbered terminal to numbered terminal in block diagram format.
8. Use only clean material. File under dividers with heading in accordance with Specification item title.
9. Submit material to Engineer for review prior to delivery of the final Operation and Maintenance Manuals to Agency. Make additions or changes required by the reviewer.

1.15 INSPECTION

A. Allow materials, equipment, and workmanship to be inspected at any time by the Engineer, Agency, or their representatives. Correct work, materials, or equipment not in accordance with these Contract Documents or found to be deficient or defective in a manner satisfactory to the Engineer or Agency.

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1.16 GUARANTEE

- A. Guarantee all materials and workmanship furnished to be free from defect for a period of 1 year after final approval. Defective material and workmanship shall be corrected at the Contractor's own expense.

1.17 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 0 degree F to 110 degrees F.
- D. Seismic Zone: Provide materials and equipment suitable for installation and operation under rated conditions in the specified seismic zone.
- E. Hazardous Areas: Products shall be acceptable to the regulatory authority having jurisdiction for the class, division, and group of hazardous area indicated.
- F. Equipment Finish:
 - 1. Manufacturer's standard finish color, except where specific color is indicated.
 - 2. If manufacturer has no standard color, finish equipment in accordance with light gray color finish as approved by Agency or Engineer.

1.18 SERVICE ENTRANCE EQUIPMENT AND METERING

- A. Equipment, installation arrangement, and scope of work shall be provided in accordance with requirements of the local electric utility and approved by the local electric utility.

1.19 OUTLET AND DEVICE BOXES

- A. Sheet Steel: One-piece drawn type, zinc- or cadmium-plated.
- B. Cast Metal:
 - 1. Box: Cast ferrous metal.
 - 2. Cover: Gasketed, weatherproof, and cast ferrous metal with stainless steel screws.

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3. Hubs: Threaded.
4. Lugs: Cast Mounting.
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.

C. 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.

1.20 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 12.
2. Box: Code-gauge, galvanized steel.
3. Cover: Full access, screw type.
4. Machine Screws: Corrosion-resistant.

D. Large Cast Metal Box, Hazardous Locations:

1. NEMA 250, Type 7 as required for Class, Division, and Group involved.
2. Box: Cast ferrous metal, electro-galvanize finished, or copper-free aluminum with drilled and tapped conduit entrances.
3. Cover: Hinged with screws.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers and Products:
 - a. Crouse-Hinds; Type EJB.
 - b. Appleton; Type EJB.

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E. Large Stainless Steel Box:

1. NEMA 250, Type 4X.
2. Box: 14-gauge, ASTM A240, Type 316 stainless steel, with white enamel painted interior mounting panel.
3. Cover: Hinged with clamps.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers:
 - a. Hoffman Engineering Co.
 - b. Robroy Industries.

F. Concrete Box, Nontraffic Areas:

1. Box: Reinforced, cast concrete with extension.
2. Cover: Steel diamond plate with locking bolts.
3. Cover Marking: ELECTRICAL, TELEPHONE, or as shown.
4. Size: 10 inch by 17 inch (minimum).
5. Manufacturer and Product: Utility Vault Co.; Series 36-1017PB, with cover DP.

1.21 PRECAST HANDHOLES

- A. Construction: Precast concrete.
- B. Loading: AASHTO H-10 or H-20, as noted below, in accordance with ASTM C857.
- C. Drainage:
 1. Slope floors toward drain points leaving no pockets or other nondraining areas.
 2. Provide drainage outlet at low point of floor.
- D. Raceway Entrances: Provide knockout panels on all four sides.
- E. Handhole Frames and Covers:
 1. Material: Steel, hot-dipped galvanized.
 2. Cover Type: Solid, bolt-on or hinged, of checkered design, as noted below.
 3. Cover Loading: As noted below.
 4. Cover Designation: Lettering minimum 2 inches in height, as shown.
- F. Hardware: Steel, hot-dip galvanized.
- G. Furnish knockout for ground rod in each handhole.

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H. Manufacturer and Models: Utility Vault Company.

1. Small: H-10 incidental traffic loading; Model 3030-B with 3030-DP cover.
2. Large: H-20 off-street traffic loading; Model 444-LA with 44-332P cover.

1.22 TELEPHONE TERMINAL CABINET

- A. Material: Code-gauge galvanized steel box with gray finish, hinged doors, and 3/4-inch fire-resistant plywood backboard, meeting requirements of telephone service provider.
- B. Minimum Size: 18 inches high by 18 inches wide by 6 inches deep.

1.23 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 5-20R, 20 amps.
7. One-piece mounting strap with integral ground contact (rivetless construction).
8. Manufacturers and Products:
 - a. Leviton; 5362 Series.
 - b. Bryant; 5362 Series.

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- c. Hubbell; 5362 Series.

- C. Receptacle, Ground Fault Circuit Interrupter:
 - 1. Duplex, listed Class A to UL Standard 943, tripping at 5 mA.
 - 2. Color: Ivory.
 - 3. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps.
 - 4. Size: For 2-inch by 4-inch outlet boxes.
 - 5. Standard Model: NEMA WD 1, with screw terminals and provisions for testing.
 - 6. Impact resistant nylon face.
 - 7. Manufacturers:
 - a. Bryant.
 - b. Hubbell.
 - c. Leviton.

- D. Receptacle, Special-Purpose:
 - 1. Mobile Standby Engine Generator Receptacle:
 - a. UL listed.
 - b. Rated for mobile standby engine generator service disconnect duty.
 - c. Weatherproof.
 - d. Heavy-duty metal assembly with back box and angle adapter.
 - e. Reverse contact configured.
 - f. Rated 600V ac, 200 amps, three-phase, three-wire, three-pole, Style 1.
 - g. Crouse-Hinds Arktite Catalog No. AREA204126-S22; Appleton Powertite Catalog No. AJA20044-200-RS.
 - h. Matching plug with cord-grip features for each mobile standby engine generator receptacle.

- E. Receptacle, Explosion-Proof.
 - 1. UL listed.
 - 2. Dead front, interlocked, circuit breaking.
 - 3. Electrical Ratings: 20 amps, 125 volts.
 - 4. Hazardous Area Ratings: NEMA 7BCD, 9FG.
 - 5. Provide matching plug with each receptacle.
 - 6. Manufacturers and Products:
 - a. Crouse-Hinds; Ark Guard 2, Series ENR.
 - b. Appleton; U-Line.
 - c. Killark; Series UGR/UGP.

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1.24 DEVICE PLATES

- A. General: Sectional type plates not permitted.
- B. Plastic:
 - 1. Material: Specification grade, 0.10-inch minimum thickness, noncombustible, thermosetting.
 - 2. Color: To match associated wiring device.
 - 3. Mounting Screw: Oval-head metal, color matched to plate.
- C. Cast Metal:
 - 1. Material: Malleable ferrous metal or copper-free aluminum, with gaskets.
 - 2. Screw: Oval-head stainless steel.
- D. Engraved:
 - 1. Character Height: 1/8 inch.
 - 2. Filler: Black.
- E. Weatherproof:
 - 1. For Receptacles, Damp and 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.
 - 2. 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.

1.25 LIGHTING AND POWER DISTRIBUTION PANELBOARD

- A. NEMA PB 1, NFPA 70, and UL 67.
- B. Panelboards and Circuit Breakers: Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

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- C. Short-Circuit Current Equipment Rating: Fully rated; series connected unacceptable.
- D. Rating: Applicable to a system with available short-circuit current of the indicated value amperes rms symmetrical at 208Y/120 or 120/240 volts and the indicated value amperes rms symmetrical at 480Y/277 volts.
- E. Cabinet:
 - 1. NEMA 250, Type 12.
 - 2. Material: Code-gauge, hot-dip galvanized sheet steel with reinforced steel frame.
 - 3. Wiring Gutter: Minimum 4-inch square; both sides, top and bottom.
 - 4. Front: Fastened with adjustable clamps.
 - a. Trim Size: As required by mounting.
 - b. Finish: Manufacturer's standard.
 - 5. Interior:
 - a. Factory assembled; complete with circuit breakers.
 - b. Spaces: Cover openings with easily removable metal cover.
 - 6. Door Hinges: Concealed.
 - 7. Locking Device:
 - a. Flush type.
 - b. Doors Over 30 Inches in Height: Multipoint.
 - c. Identical keylocks, with two milled keys each lock.
 - 8. Circuit Directory: Metal frame with transparent plastic face and enclosed card on interior of door.
- F. Bus Bar:
 - 1. Material: Copper full sized throughout length.
 - 2. Neutral: Insulated, rated same as phase bus bars with at least one terminal screw for each branch circuit.
 - 3. Ground: Copper, installed on panelboard frame, bonded to box with at least one terminal screw for each circuit.
 - 4. Lugs and Connection Points:
 - a. Suitable for either copper or aluminum conductors.
 - b. Solderless main lugs for main, neutral, and ground bus bars.
 - c. Subfeed or through-feed lugs as shown.
- G. Circuit Breakers:
 - 1. UL 489.
 - 2. Thermal-magnetic, quick-make, quick-break, molded case, of indicating type showing ON/OFF and TRIPPED positions of operating handle.
 - 3. Type: Bolt-on circuit breakers in all panelboards.

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4. Multipole circuit breakers designed to automatically open all poles when an overload occurs on one pole.
5. Do not use tandem or dual circuit breakers in normal single-pole spaces.
6. Ground Fault Equipment Protector (GFEP): 30 mA trip, 10,000 amps interrupting capacity circuit breaker, and UL listed for equipment ground fault protection.
7. Locking: Furnish permanently attached provisions for handle padlocking the main and each branch circuit breaker in the open position with at least one 1/4-inch padlock.

H. Manufacturers:

1. Eaton.
2. General Electric Co.
3. Square D Co.

1.26 MINI-POWER CENTER (MPC)

- A. General: Transformer, primary and secondary main circuit breakers, and secondary panelboard section enclosed in NEMA 250, Type 3R enclosure.
- B. Transformer:
 1. Type: Dry, self-cooled, encapsulated.
 2. Insulation: Manufacturer's standard, with UL 1561 temperature rise.
 3. Full capacity, 2-1/2 percent voltage taps, two above and two below normal voltage.
 4. Primary Voltage: 480, single- or three-phase.
 5. Secondary Voltage: 120/240 or 208Y/120 volts, single- or three-phase, three- or four-wire, respectively.
- C. Panelboard: UL 489, fully-rated.
 1. Type: Thermal-magnetic, quick-make, quick-break, indicating, with noninterchangeable molded case circuit breakers.
 2. Number and Breaker Ampere Ratings: Refer to Panelboard Schedule.
 3. Locking: Furnish permanently attached provisions for handle padlocking the main and each branch circuit breaker in the open position with at least one 1/4-inch padlock.
- D. Manufacturers:
 1. Eaton.

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2. General Electric Co.
3. Square D Co.

1.27 CIRCUIT BREAKER, INDIVIDUAL, 0 TO 600 VOLTS

- A. UL 489 listed for use at location of installation.
- B. Minimum Interrupt Rating: As shown on the 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.

1.28 FUSED SWITCH, INDIVIDUAL, 0 TO 600 VOLTS

- A. UL 98 listed for use and location of installation.
- B. NEMA KS 1 and UL 98 Listed for application to system with available short-circuit current as shown on the Drawings.
- C. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.
- D. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
- E. Fuse mountings shall reject Class H fuses and accept only current-limiting fuses specified.
- F. Enclosure: As specified under Execution.

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G. Interlock: Enclosure and switch to prevent opening cover with switch in ON position.

H. Manufacturers:

1. Eaton.
2. General Electric Co.
3. Square D Co.

1.29 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.

1.30 SWITCH, MOTOR-RATED

A. Type: Two- or three-pole, manual motor starting/disconnect switch without overload protection.

B. Enclosure/Mounting and Rating:

1. General Purpose:

a. Totally enclosed snap-action switch. Quick-make, slow-break design with silver alloy contacts. Listed UL 508.

b. General Purpose Rating: 30 amperes, 600V ac.

c. Minimum Motor Ratings:

1) 2 hp for 120V ac, single-phase, two-pole.

2) 3 hp for 240V ac, single-phase, two-pole.

3) 15 hp for 480V ac, three-phase, three-pole.

d. Screw-type terminals.

2. Explosion-proof:

a. Provide enclosed manual motor starter-type. Three-pole nonreversing contactor.

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- b. Minimum Motor Rating: 10 hp, 480V ac, three-phase, three-pole.
- c. Enclosure: NEMA 250, Type 7.
- d. Provide lockable external handle operator.

C. Manufacturers:

- 1. General Purpose:
 - a. Bryant.
 - b. Hubbell.
- 2. Explosion-proof: Eaton, Type B101.

1.31 FUSE, 0 TO 600 VOLTS

- A. Current-limiting, with 200,000 ampere rms interrupting rating.
- B. Provide to fit mountings specified with switches and features to reject Class H fuses.
- C. Motor and Transformer Circuits, 0 to 600 Volt:
 - 1. Amperage: 0 to 600.
 - 2. UL 198E, Class RK-1, dual element, with time delay.
 - 3. Manufacturers and Products:
 - a. Bussmann; Type LPS-RK.
 - b. Littelfuse, Inc.; Type LLS-RK.
- D. Motor and Transformer Circuits, 0 to 250 Volt:
 - 1. Amperage: 0 to 600.
 - 2. UL 198E, Class RK-1, dual element, with time delay.
 - 3. Manufacturers and Products:
 - a. Bussmann; Type LPN-RK.
 - b. Littelfuse, Inc.; Type LLN-RK.
- E. Feeder and Service Circuits, 0 to 600 Volt:
 - 1. Amperage: 0 to 600.
 - 2. UL 198E, Class RK-1, dual element, with time delay.
 - 3. Manufacturers and Products:
 - a. Bussmann; Type LPS-RK.
 - b. Littelfuse, Inc.; Type LLS-RK.
- F. Feeder and Service Circuits, 0 to 250 Volt:
 - 1. Amperage: 0 to 600.
 - 2. UL 198E, Class RK-1, dual element, with time delay.
 - 3. Manufacturers and Products:
 - a. Bussmann; Type LPN-RK.

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b. Littelfuse, Inc.; Type LLN-RK.

1.32 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.
- 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.

1.33 POWER TERMINAL BLOCKS

- A. Rating: 600V Class B and C, three-pole, tin-plated high conductive copper, UL certified block.
- B. For use with 75 degrees C wire at full 75 degrees C ampacity based on NEC.
- C. Housing Material: General purpose phenolic rated at 150 degrees C maximum and minus 40 degrees C minimum.
- D. Manufacturer and Model: General Electric; Class 9080.

1.34 CONTROL 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.

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- B. Yokes and Clamping Screws: Zinc-plated, hardened steel.
- C. Rating: 600V ac.
- D. Manufacturers:
 - 1. Weidmuller, Inc.
 - 2. Ideal.

1.35 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.

1.36 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.

1.37 ELAPSED TIME METERS

- A. Type: Synchronous motor driven, 0 to 99,999.9 hours range, nonreset, suitable for semiflush, panel mounting.
- B. Manufacturers:
 - 1. General Electric Co.
 - 2. Veeder-Root.

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1.38 PHASE MONITOR RELAY

- A. Voltage and phase monitor relay shall drop out on low voltage, voltage unbalance, loss of phase, or phase reversal.
- B. Contacts: Single-pole, double-throw, 10 amperes, 120/240V ac. Where additional contacts are shown or required, provide magnetic control relays.
- C. Adjustable trip and time delay settings.
- D. Transient Protection: 1,000V ac.
- E. Mounting: Multipin plug-in socket base.
- F. Manufacturer and Product: Automatic Timing and Controls; SLD Series.

1.39 DRY TYPE POWER TRANSFORMERS (0- TO 600-VOLT PRIMARY)

- A. Type: Self-cooled, two-winding.
- B. UL 1561 and NEMA ST 20.
- C. Insulation Class, Temperature Rise, and Impedance: Manufacturer's standard.
- D. Core and Coil:
 - 1. 30 kVA or Less: Encapsulated.
 - 2. 37.5 kVA and Larger: Varnish impregnated.
- E. Enclosure:
 - 1. 30 kVA or Less: NEMA 250, Type 3R, nonventilated.
 - 2. 37.5 kVA and Larger: NEMA 250, Type 2, ventilated.
- F. Voltage Taps: Full capacity, 2-1/2 percent, two above and two below normal voltage rating.
- G. Sound Level: Not to exceed NEMA ST 20 levels.
- H. Vibration isolators to minimize and isolate sound transmission.
- I. Manufacturers:
 - 1. General Electric.
 - 2. Eaton.
 - 3. Square D.

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1.40 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.

1.41 NAMEPLATES

A. Material: Laminated plastic.

B. Attachment: Adhesive.

C. Color: White, engraved to a black core, or as shown on the Drawings.

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.

1.42 ELECTRIC UNIT HEATER

A. Single power source with heating capacity shown.

B. Mounting brackets for permanent mounting.

C. Protective metal barrier on air inlet side.

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- D. Adjustable louvers on discharge side to divert air up or down as desired.
- E. Heat Elements:
 - 1. Discharge side of fan motor.
 - 2. Resistance wire embedded in refractory material, surrounded by metallic sheath with metal heat transfer fins.
- F. Overheat Protection: Automatic, thermal.
- G. Fan Motor: Match phase-to-phase voltage rating of heater unless integral, fused transformer is provided for fan operating voltage.
- H. Control Contactor: Integral, fully rated, with integral control power source.
- I. Thermostat: Integral.
- J. UL listed.
- K. Manufacturer and Product: Chromalox, Inc; Type LUH.

1.43 THERMOSTAT

- A. Rating: 7.4 amps continuous, 44 amps locked rotor current at 120 volts and 3.7 amps continuous, 22 amps locked rotor current at 240 volts.
- B. Line voltage, single-stage, treated to resist corrosion, dust, dirt, and humidity with sealed SPDT contacts.
- C. Heating Adjustment Range: 35 to 100 degrees F.
- D. Cooling or Ventilating Adjustment Range: 70 to 140 degrees F.
- E. Manufacturer and Product: Honeywell, Inc.; Type T631.

1.44 TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS) EQUIPMENT

- A. General:
 - 1. Units shall be suitable for the service voltage and configuration (phases and wires) shown.
 - 2. Protection Modes:
 - a. Normal, differential, and common.
 - b. Bipolar or bi-directional.
 - 3. Ratings: Short-circuit current rating shall equal or exceed that of protected distribution equipment. Surge Voltage Rating (SVR) shall not exceed those specified under UL 1449 for the

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associated nominal system voltage. Maximum Allowable Continuous Operating Voltage (MCOV) shall be at least 115 percent of the nominal system voltage.

4. Unit shall be UL-listed.
5. Provide status indicators for unit ON-LINE and unit operation NORMAL.
6. Provide common alarm contact output.
7. Provide fusible disconnect switch (integral with TVSS unit, where available) where not shown connected via branch circuit device of protected distribution equipment.
8. Minimum Enclosure Rating: NEMA 250, Type 2. Provide Type 4/4X for outdoor or wet locations.

B. Type 1 TVSS:

1. Requirements: High surge current device designed for location/exposure Category C3, per IEEE C62.41. Provide surge current rating per phase as shown. Unit shall utilize symmetrically balanced Metal Oxide Varistor (MOV) technology.
2. Manufacturer and Product: Transtector; Model Aegis SP.

C. Type 2 TVSS:

1. Requirements: Designed for critical loads at service equipment (Category C3/B3) or distribution panelboard (Category C2/B3) locations. Unit shall utilize voltage-matched Silicon Avalanche Suppressor Diode (SASD) technology. Unit shall utilize modular, plug-in suppressor design.
2. Manufacturer and Product: Transtector; Model Apex III (nonservice entrance distribution panelboard) or Apex IV (service equipment).

D. Type 3 TVSS:

1. Requirements: Designed for noncritical loads at distribution panelboards with location/exposure Category C3. Unit shall utilize symmetrically balanced Metal Oxide Varistor (MOV) technology. Unit shall utilize modular, plug-in suppressor design.
2. Manufacturer and Product: Transtector; Model SPD.

1.45 CONDUIT AND FITTINGS

A. Rigid Galvanized Steel Conduit (RGS):

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1. Meet requirements of NEMA C80.1 and UL 6.
2. Material: Hot-dip galvanized, with chromated protective layer.

B. PVC Schedule 40 Conduit:

1. Meet requirements of NEMA TC 2 and UL 651.
2. UL listed for concrete encasement, underground direct burial, concealed, or direct sunlight exposure, and 90 degrees C insulated conductors.

C. 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.

D. Flexible Nonmetallic, Liquid-Tight Conduit:

1. Material: PVC core with fused flexible PVC jacket.
2. UL 1660 listed for:
 - a. Dry Conditions: 80 degrees C insulated conductors.
 - b. Wet Conditions: 60 degrees C insulated conductors.
3. Manufacturers and Products:
 - a. Carlon; Carflex or X-Flex.
 - b. T & B; Xtraflex LTC or EFC.

E. Flexible Metal, Liquid-Tight Conduit:

1. UL 360 listed for 105 degrees C insulated conductors.
2. Material: Galvanized steel, with an extruded PVC jacket.

F. Flexible Conduit, Hazardous Locations:

1. Approved for use in the atmosphere involved.
2. Rating: Watertight and UL listed for use in Class I, Division 1 and Division 2 areas.
3. Outer bronze braid and an insulating liner.
4. Conductivity equal to a similar length of rigid metal conduit.
5. Manufacturers and Products:
 - a. Crouse-Hinds; Type ECGJH or ECLK.

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b. Appleton; EXGJH or EXLK.

G. 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 Conduit:
 - a. Meet requirements of UL 514B.
 - b. Type: Threaded, galvanized.
3. PVC Conduit:
 - a. Meet requirements of NEMA TC 3.
 - b. Type: PVC, slip-on.
4. 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.
5. Flexible Nonmetallic, Liquid-Tight Conduit:
 - a. Meet requirements of UL 514B.
 - b. Type: High strength plastic body, complete with lock nut, O-ring, threaded ferrule, sealing ring, and compression nut.
 - c. Body/compression nut (gland) design to assure high mechanical pullout strength and watertight seal.
 - d. Manufacturers and Products:
 - 1) Carlon; Type LT.
 - 2) O.Z. Gedney; Type 4Q-P.
 - 3) Thomas & Betts; Series 6300.
6. 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.
7. Flexible Coupling, Hazardous Locations:
 - a. Approved for use in the atmosphere involved.
 - b. Rating: Watertight and UL listed for use in Class I, Division 1 and Division 2 areas.

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- c. Outer bronze braid and an insulating liner.
- d. Conductivity equal to a similar length of rigid metal conduit.
- e. Manufacturers and Products:
 - 1) Crouse-Hinds; Type ECGJH or ECLK.
 - 2) Appleton; EXGJH or EXLK.

1.46 METAL WIREWAYS

- A. Meet requirements of UL 870.
- B. Type: Steel-enclosed, with removable, hinged screw type cover.
- C. Rating: Raintight.
- D. Finish: Gray, baked enamel.
- E. Manufacturers:
 - 1. Circle AW.
 - 2. Hoffman.

1.47 CONDUIT ACCESSORIES

- A. Duct Bank Spacers:
 - 1. Type: Nonmetallic, interlocking, for multiple conduit sizes.
 - 2. Suitable for all types of conduit.
 - 3. Manufacturers:
 - a. Underground Device, Inc.
 - b. Carlon.
- B. Identification Devices:
 - 1. Raceway Tags:
 - a. Material: Permanent, nonferrous metal.
 - 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 6 inches.
 - d. Designation: Warning on tape that electric circuit is located below tape.
 - e. Identifying Letters: Minimum 1-inch high permanent black lettering imprinted continuously over entire length.

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C. 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 Scotchrap Pipe Primer.

1.48 CONDUCTORS AND CABLES

A. Conductors 600 Volts and Below:

1. Conform to applicable requirements of NEMA WC 70.
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. Unless noted otherwise, conductor sizes indicated are based on copper conductors at NEC 75 degrees C ampacity. Do not provide conductors smaller than those indicated.
5. Grounding Conductors:
 - a. Equipment:
 - 1) Provide stranded copper conductors, as indicated on the Drawings or as required by NEC, for equipment grounding.
 - 2) Provide conductors with green Type THHN/THWN insulation.
 - b. Direct Buried: Bare stranded copper.
6. 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.
7. 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 1, Multiconductor Control Cable:

a. Conductors:

- 1) 14 AWG, seven-strand copper.
- 2) Insulation: 15-mil PVC with 4-mil nylon.
- 3) UL 1581 listed as Type THHN/THWN rated VW-1.
- 4) Conductor group bound with spiral wrap of barrier tape.
- 5) Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.

b. Cable: Passes the ICEA T-29-520 210,000 Btu per hour Vertical Tray Flame Test.

c. Cable Sizes:

No. of Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
3	0.41	45
5	0.48	45
7	0.52	45
12	0.72	60

d. Manufacturers:

- 1) Okonite Co.
- 2) Southwire.

3. Type 2, 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.

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- 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.
 - 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.

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- 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.

1.49 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 (Class I, Division 1, Group D) or UL 1604 (Class I, Division 2, Group D) 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 50 pounds or more.
- 6. Operating Conditions: Maximum ambient temperature not greater than 40 degrees C and 4,000 feet above sea level, unless otherwise indicated.
- 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.

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10. Suitable for full voltage starting. 100 hp and larger also suitable for reduced voltage starting with 65 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 F with Class B rise 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, CISD-TEFC (chemical-industry severe-duty 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) Integral thermostat opening on excessive motor temperature in accordance with UL 2111 and NFPA 70.
 - 3) Terminate thermostat leads in terminal box separate from main terminal box.
 - 4) TEFC listed to meet UL 1604 and NFPA 70 requirements for Class I, Division 2, Group D hazardous locations.
 - 5) Drain holes with drain and breather fittings.
 - d. Equipment Finish: Manufacturer's standard.
14. Winding Thermal Protection:
 - a. Thermostats:
 - 1) Motors for adjustable speed application 40 horsepower through 100 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.
 - 4) Leads extending to separate terminal box for motors 100 hp and larger.
 - b. Thermistors:
 - 1) Motors for adjustable speed application 125 hp and larger.
 - 2) Thermistor embedded in each stator phase winding before winding dip and bake process.

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- 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. Space Heaters:

- a. Provide winding space heaters for motors larger than 10 hp with leads wired out to motor terminal box.
- b. Provide extra hole or hub on motor terminal box as required.
- c. Unless shown otherwise, heater shall be suitable for 120V ac supply, with wattage suitable for motor frame size.

16. Nameplates: In accordance with NEMA MG1.

17. Multispeed: Meet requirements for speeds, number of windings, and load torque classification indicated in the motor-driven equipment specifications.

18. 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, Parts 30 and 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.
- 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 MG1 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.

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5. Enclosure: Open drip-proof, unless otherwise noted.

C. Manufacturers:

1. General Electric.
2. Reliance Electric.
3. U.S. Electrical Motors.

D. Submersible Pump Motor:

1. Manufacturers:
 - a. Reliance Electric.
 - b. ITT Flygt Corp.
2. At 100 Percent Load:

Submersible Pump Motors		
Horsepower	Guaranteed Minimum Efficiency	Guaranteed Minimum Power Factor
5 through 10	80	82
10.1 through 50	85	82
50.1 through 100	87	82
Over 100	89	82

3. Insulation System: Manufacturer's standard Class B or Class F.
4. Motor capable of running dry continuously.
5. Enclosure:
 - a. Hermetically sealed, watertight, for continuous submergence up to 65-foot depth.
 - b. Listed to meet UL 674 and NFPA 70 requirements for Class I, Division 1, Group D hazardous atmosphere.
 - c. Seals: Tandem mechanical.
6. Bearing and Lubrication:
 - a. Permanently sealed and lubricated, replaceable antifriction guide and thrust bearings.
 - b. Minimum 15,000 hours L-10 bearing life.
7. Inrush kVA/horsepower no greater than NEMA MG 1 and NFPA 70, Code F.
8. Winding Thermal Protection:
 - a. Thermal sensor and switch assembly, one each phase, embedded in stator windings and wired in series.
 - b. Switches normally closed, open upon excessive winding temperature, and automatically reclose when temperature has cooled to safe operating level.
 - c. Switch contacts rated 5 amps, 120V ac.

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9. Motor Seal Failure Moisture Detection:
 - a. Probes or sensors to detect moisture beyond seals.
 - b. Probe or sensor monitoring module for mounting in motor controller, suitable for operation from 120V ac supply.
 - c. Monitoring module with control power transformer, probe test switch and test light, and two independent 120V ac contacts, one opening and one closing when the flux of moisture is detected.
10. Bearing Overtemperature Protection for Motors Larger than 100 hp:
 - a. Sensor on lower bearing housing monitoring bearing temperature.
 - b. Any monitoring relay necessary to provide 120V ac contact opening on bearing overtemperature.
11. Winding thermal protection, moisture detection, and bearing overtemperature specified above may be monitored by a single device providing two independent 120V ac contacts, one closing and one opening on malfunction.
12. Connecting Cables:
 - a. One cable containing power, control, and grounding conductors or two separate cables, one containing power and grounding conductors, and the other containing control and grounding conductors.
 - b. Each cable suitable for hard service, submersible duty with watertight seal where cable enters motor.
 - c. Length: 30 feet minimum or as required by the installation.
 - d. UL 1 listed and sized in accordance with NFPA 70.

E. 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, 75, and 100 percent of rated horsepower:
 - 1) In accordance with IEEE 112, Test Method B, and NEMA MG 1, Paragraphs 12.54 and 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.

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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.

1.50 GROUNDING

- A. Ground Rods: Provide copper-clad steel with minimum diameter of 3/4-inch, and length of 10 feet.
- B. Ground Conductors: As specified in Article Conductors and Cable.
- C. Connectors:
 1. Exothermic Weld Type:
 - a. Outdoor Weld: Suitable for exposure to elements or direct burial.
 - b. Indoor Weld: Utilize low-smoke, low-emission process.
 - c. Manufacturers:
 - 1) Erico Products, Inc.; Cadweld and Cadweld Exolon.
 - 2) Thermoweld.
 2. Compression Type:
 - a. Compress-deforming type; wrought copper extrusion material.
 - b. Single indentation for conductors 6 AWG and smaller.
 - c. Double indentation with extended barrel for conductors 4 AWG and larger.
 - d. Single barrels prefilled with oxide-inhibiting and antiseizing compound.
 - e. Manufacturers:
 - 1) Burndy Corp.
 - 2) Thomas and Betts Co.
 - 3) ILSCO.
 3. Mechanical Type:
 - a. Split-bolt, saddle, or cone screw type; copper alloy material.
 - b. Manufacturers:
 - 1) Burndy Corp.
 - 2) Thomas and Betts Co.

1.51 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.

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3. Thermal Overload Protection:
 - a. Inverse-time-limit characteristic.
 - b. Heater: Bimetallic overload, adjustable trip.
 - c. Relay Trip: Standard, Class 20.
 - d. Manual reset.
 - e. Provide in each ungrounded phase.
 - f. Mount within starter unit.
4. 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.
5. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
6. Lifting lugs on all equipment and devices weighing over 50 pounds.
7. Operating Conditions:
 - a. Ambient Temperature: Maximum 40 degrees C.
 - b. Equipment to be fully rated without any derating for operating conditions listed above.
8. Equipment Finish:
 - a. Electrocoating process applied over rust-inhibiting phosphated base coating.
 - b. Exterior Color: Provide manufacturer's standard finish as approved by Agency or Engineer.
9. Phase Monitoring Relay: Where shown, provide three-phase monitoring relay to protect against low voltage, voltage unbalance, phase loss, and phase reversal.

B. Manually Operated Starter, Fractional Horsepower:

1. Rating: 16 amperes continuous at 277 volts maximum.
2. Single-phase, nonreversing, full voltage with overload protection.
3. Toggle operated.
4. Enclosure: As shown on the Drawings.
5. Neon ON Light: Red.
6. Handle guard/lock-off attachment.

C. Manually Operated Starter, Integral Horsepower:

1. Rating: Horsepower rated to maximum of 10 hp at 600 volts with overload protection.
2. Single-phase or three-phase, nonreversing, full voltage.
3. Control: Toggle or pushbutton.
4. Enclosure: As shown on the Drawings.
5. Red ON pilot light in series with an auxiliary contact.
6. Lockable in OFF position.
7. Two spare auxiliary, field-convertible contacts.

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D. Combination Full-Voltage, Magnetic Starter:

1. Rating: Horsepower rated at 600 volts, UL labeled for short circuit current amperes shown on the Drawings with overload protection.
2. Three-phase, nonreversing, full voltage.
3. Control: As shown on the Drawings.
4. Disconnect Type: Motor circuit protector.
5. Enclosure: As shown on the Drawings.
6. Pilot Lights: Red—ON and Green—OFF push-to-test LED's.
7. Padlockable operating handle.

E. Combination Reduced-Voltage, Solid-State Starter:

1. Rating: Horsepower rated at 600 volts, UL labeled for short circuit current amperes shown on the Drawings with overload protection.
2. Three-phase, nonreversing with bypass run contactor.
3. Control: As shown on the Drawings.
4. Disconnect Type: Motor circuit protector.
5. Class 10/20/30 electronic overload relay, switch, or dip switch selectable.
6. Kick start, with adjustable torque and time settings.
7. Ramp start, selectable current or torque, and adjustable time.
8. Smooth stop ramp, adjustable time.
9. Phase loss, unbalance, and phase reversal protection.
10. LED display or LCD of fault, N.O. contact to communicate fault conditions.
11. Enclosure: As shown on the Drawings.
12. Pilot Lights: Red—ON and Green—OFF push-to-test LED's.
13. Padlockable operating handle, capable of up to three locks.

F. Combination Two-Speed Motor, Magnetic Starter:

1. Rating: Horsepower rated at 600 volts, UL labeled for short circuit current amperes shown on the Drawings with overload protection.
2. Three-phase, nonreversing, full voltage.
3. Control: As shown on the Drawings.
4. Disconnect Type: Motor circuit protector.
5. Suitable for two-speed, two-winding motors.
6. Enclosure: As shown on the Drawings.
7. Pilot Lights: Green—OFF, Red—HIGH SPEED and Amber—LOW SPEED push-to-test LED's.
8. Padlockable operating handle.

G. Manufacturers:

1. Eaton.
2. General Electric.
3. Square D.

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4. Allen Bradley.

H. Combination and Adjustable Frequency Drive:

1. Provide AFDs separately enclosed in accordance with this specification.
2. AFD and all associated optional equipment shall be UL Listed according to UL 508C Power Conversion Equipment. A UL label shall be attached inside each enclosure as verification.
3. The AFD shall be designed constructed and tested in accordance with UL, CSA, NEMA and NEC standards.
4. The AFD shall be the ultra low harmonic type.
 - a. Include a Direct Torque Control (DTC) AC to AC converter utilizing the latest isolated gate bipolar transistor (IGBT) technology.
 - b. Employ a DTC inner loop torque control strategy that mathematically determines motor torque and flux every 25 microseconds (40,000 times per second).
 - c. Include an optional operational mode for scalar or V/Hz operation.
5. Torque Requirements: Variable, unless otherwise indicated.
6. Synchronous Motor Speed: As indicated in the motor-driven equipment specification.
7. Operating Environment: Maximum 40 degrees C (104 degrees F) ambient and 4,000 feet above sea level, unless otherwise indicated.
8. Overall Efficiency: 97 percent, minimum, at full load and full speed.
9. Overall Power Factor: 0.99 at all speeds and loads
10. Rated Capacity: Continuous industrial duty and suitable for use with Standard NEMA MG 1, Design B motors and full load currents per NEC.
11. Maximum Circuit Distance between AFD and Motor: 400 feet.
12. Equipment Short Circuit Rating: Suitable for connection to a system with maximum source three-phase, bolted fault, short-circuit current shown on the Drawings at 480 volts. Include integral overcurrent protective device if required to withstand the available fault current in the indicated configuration.
13. Incoming Line Disconnect: Provide an integral positive means of disconnecting incoming power, and line-side overcurrent protection for the drive system; lockable in the open position with defeatable door interlock.
14. Input Voltage: 460 volts, plus and minus 10 percent.
15. Input Frequency: 60 Hz, nominal (48 Hz to 63 Hz).
16. Output Voltage Range: Zero to 460 volts, three-phase, 0 Hz to 60 Hz.

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17. Maximum Peak Voltage Output Pulse: 1,000 volts, with pulse rise time of not less than 2 microseconds, and a maximum rate of rise of 500 volts per microsecond.
18. Maximum Frequency Output Pulse (Carrier): 4,000 Hz.
19. Motor Audible Noise Level: When operating throughout speed range of 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.
20. Short-Time Overload Capacity: 150 percent of rated load in rms current for 1 minute following full load, full speed operation.
21. Furnish drives with output current-limiting reactors pre-wired and mounted within the drive enclosure.
22. Diagnostics: Manufacturer's standard for drive adjustment and troubleshooting.
23. Drive Protection: Provide manufacturer's standard unless otherwise indicated.
24. Operational Features: Provide manufacturer's standard unless otherwise indicated.
25. Minimum Controls: Alphanumeric keypad and display.
26. Forced Air Ventilation: Size for periodic operation to cool unit with maximum room ambient temperature of 104 degrees F. Furnish filters on ventilation intakes.
27. Component Identification: Selector switches, indicating lights, potentiometers, instruments, protective devices, relays, terminal blocks and other components identified by means of mechanically attached, engraved, laminated nameplates.
28. Operator Interface: Mount drive local control on front door of enclosure; provide membrane type keypad.
29. Control Circuit Disconnect: Provide pull-apart connectors or other means to de-energize circuits in units that are not otherwise de-energized by main power disconnect.
30. Motor Space Heater Provisions: Furnish 120V ac power for motor space heaters automatically controlled to energize when the drive is not running and supplied via a step-down transformer from the drive main power source.
31. Minimum Signal Interface Capabilities: Two programmable digital inputs and three programmable dry-contact outputs, plus two programmable dc analog inputs and two programmable dc outputs.
32. Communications Interface:
 - a. The AFD shall utilize a communications architecture, utilizing plug-in communications cards, for high-speed noise immune connectivity.
 - b. The communications capabilities shall include, but not be limited to, run-stop control, speed set adjustment, proportional/integral/derivative PID control adjustments, current limit, and accel/decel time adjustments.

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- c. The AFD shall have the capability of allowing the Distributed Drive Controller (DDC) to monitor feedback such as process variable feedback, output speed/frequency, current (in amps), percent torque, power (kW), kilowatt hours (resettable), operating hours (resettable), relay outputs, and diagnostic warning and fault information.
- 33. Motor Winding Thermal Protection: Provide space, power, control interlock, and manual reset for the motor winding thermostat or thermistor furnished with the motor and specified in Article Motors.
- 34. Separately-Mounted Enclosure:
 - a. Unless otherwise indicated, provide each separately-mounted AFD in a NEMA 250, Type 1, gasketed, enclosure, front accessible only, and with hinged door(s).
 - b. Provide thermostatically-controlled space heater(s) powered via a step-down transformer from the drive main power source.
 - c. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.
 - d. Drive Identification Nameplates: Provide laminated plastic (white, engraved to black core) for each drive engraved with approved submittal inscription.
 - e. Lifting Lugs: Provide for equipment weighing over 50 pounds.
 - f. Finishes: Manufacturer's standard gray unless otherwise indicated.
- 35. Source Quality Control:
 - a. All printed circuit boards shall be completely tested and burned-in before being assembled into the completed AFD.
 - b. Inspections: Perform manufacturer's standard, all units.
 - c. Functional Test: Perform manufacturer's standard, all units.
 - 1) Preliminary functional test shall include a minimum 1 hour burn-in and computerized final test.
 - 2) Burn-in shall be at 104 degrees F (40 degrees C) at full rated load, or cycled load.
 - 3) AFD input power shall be continuously cycled for maximum stress and thermal variation.
 - d. Load Test: Perform manufacturer's standard.
- 36. Manufacturers:
 - a. ABB, Inc.; ACS800-U31 or ACS800-37.
 - b. Or approved equal.

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1.52 LOCAL CONTROL PANELS

A. Enclosure:

1. NEMA 250, Type 12, or as shown.
2. Minimum Metal Thickness: 14 gauge.
3. Doors: Rubber gasketed with continuous hinge.
4. Finish: Gray.
5. Size panels to adequately dissipate heat generated by equipment mounted in or on panel.
6. Mount internal and door-mounted devices as shown.
7. 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, black letters on white background.

1.53 LUMINAIRES AND ACCESSORIES

A. Specific requirements relating to fixture type, lamp type, and mounting hardware are provided in the Luminaire Schedule on Drawings.

B. Poles:

1. Rating (With Luminaire): 100 mph steady winds, without incurred damage.
2. Material: As specified in Luminaire Schedule.

1.54 LIGHTING CONTROL

A. Photocell:

1. Automatic ON/OFF switching photo control.
2. Housing: Self-contained, die-cast aluminum, unaffected by moisture, vibration, or temperature changes.
3. Setting: ON at dusk and OFF at dawn.
4. Time delay feature to prevent false switching.
5. Field adjustable to control operating levels.

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6. Manufacturers:
 - a. Tork.
 - b. Paragon Electric Company.
- B. Dedicated light switch or ON/OFF/PHOTOCELL selector test switch.

1.55 CONSTRUCTION2930.40 GENERAL

1.56 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.

1.57 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 conduct or box. Where underground or embedded raceways are to be abandoned, remove raceway to 1 inch below surface of structure or 12 inches belowgrade and restore existing surface.

1.58 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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1.59 SERVICE ENTRANCE EQUIPMENT AND METERING

A. Unless otherwise specified or shown, schedule and coordinate work of serving utility as required to provide electric service to the Work.

1.60 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 or Agency in writing.
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 or Agency in writing.
2. Switches: 48 inches above floor.
3. Thermostat: 54 inches above floor.
4. Telephone Outlet: 6 inches above counter tops or 15 inches above floor.
5. Wall Mounted Telephone Outlet: 52 inches above floor.
6. Receptacles:
 - a. General Indoor Areas: 15 inches above floor.
 - b. General Indoor Areas (Counter Tops): Install device plate bottom or side flush with top of splashback, or 6 inches above counter tops without splashback.
 - c. Industrial Areas, Workshops: 24 inches above floor.
 - d. Outdoor, All Areas: 24 inches above finished grade.

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- e. Mobile standby engine generator, 36 inches, minimum, above finished grade and securely fastened to structure with 5/16-inch, minimum, diameter bolts.
- 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.
- 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 Galvanized Steel Conduit: Cast metal.
 - b. Concealed Raceways: Sheet steel.
 - c. Class I Hazardous Areas: Cast metal.
 - 3. Indoor Wet Locations:
 - a. Exposed Raceways: PVC-coated cast metal.
 - b. Concealed Raceways: Cast metal.
 - c. Class I Hazardous Areas: PVC-coated 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.

1.61 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.

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- 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.
- J. At or Belowgrade:
 - 1. Install boxes for belowgrade conduit flush with finished grade in locations outside of paved areas, roadways, or walkways.
 - 2. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location.
 - 3. Obtain Engineer's or Agency's written acceptance prior to installation in paved areas, roadways, or walkways.
 - 4. Use boxes and covers suitable to support anticipated weights.
- K. Flush Mounted:
 - 1. Install with concealed conduit.
 - 2. Holes in surrounding surface shall be no larger than required to receive box.
 - 3. Make edges of boxes flush with final surface.
- L. Mounting Hardware:
 - 1. Noncorrosive Indoor Dry Areas: Galvanized.
 - 2. Outdoor or Noncorrosive Indoor Wet Areas: Stainless steel.
 - 3. Corrosive Areas: Stainless steel.
- M. Location/Type:
 - 1. Indoor, Dry: NEMA 250, Type 12.
 - 2. Indoor and Outdoor, Wet: NEMA 250, Type 4X, stainless steel.
 - 3. Indoor and Outdoor, Wet and Corrosive: NEMA 250, Type 4X, stainless steel.
 - 4. Indoor and Outdoor, Hazardous: NEMA 250, Type 7.
 - 5. Underground Conduit: Concrete.
 - 6. Corrosive: NEMA 250, Type 4X, stainless steel.
 - 7. Outdoor, Where Indicated Weatherproof (WP): NEMA 250, Type 4X.
 - 8. Industrial Use in Areas Not Otherwise Classified: NEMA 250, Type 12, unless otherwise shown.
- N. Install Drain/breather fittings in NEMA 250, Type 4X enclosures.

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1.62 PRECAST HANHOLES

- A. Excavate, shore, brace, backfill, and final grade.
- B. Do not install until final raceway grading has been determined.
- C. Install such that raceways enter at nearly right angles and as near as possible to one end of wall, unless otherwise shown.

1.63 TELEPHONE OUTLET

- A. Provide empty outlet boxes and cover plates meeting requirements of EIA/TIA 569.

1.64 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 down.
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. Special-Purpose Receptacles: Install in accordance with manufacturer's instructions.

1.65 DEVICE PLATES

- A. Securely fasten to wiring device; ensure a tight fit to box.
- 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. Engrave with designated titles.

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F. Types (Unless Otherwise Shown):

1. Outdoor: Weatherproof.
2. Indoor:
 - a. Flush Mounted Boxes: Plastic.
 - b. Surface Mounted, Metal Boxes: Cast metal.

1.66 PANELBOARDS AND MINI-POWER CENTERS

- A. Install securely, plumb, in-line and square with walls.
- B. Install top of panelboard cabinet and top of mini-power center distribution panelboard section 6 feet above floor, unless otherwise shown.
- C. Provide typewritten circuit directory for each panelboard.
- D. For Mini-Power Centers (MPC's), mount the typewritten circuit directory on the front of the MPC next to the distribution panel hinged cover plate, not on the inside of the hinged coverplate.
- E. Cabinet Location/Type:
 1. Indoor Dry: NEMA 250, Type 1.
 2. Wet or Outdoor: NEMA 250, Type 4X, stainless steel.
 3. Industrial Use in Areas Not Otherwise Classified: NEMA 250, Type 12, unless otherwise shown.

1.67 CIRCUIT BREAKERS AND SWITCHES

- A. Location and Enclosure Type:
 1. Hazardous Gas: NEMA 250, Type 7.
 2. Wet or Outdoor: NEMA 250, Type 4X.
 3. Corrosive: NEMA 250, Type 4X.
 4. Wet and Corrosive: NEMA 250, Type 4X.
 5. Indoor Dry, Industrial Use: NEMA 250, Type 12.
 6. Indoor Dry, General Purpose: NEMA 250, Type 1.
 7. Where Denoted WP: NEMA 250, Type 4X.

1.68 SWITCH, MOTOR RATED

- A. Install with switch operation in vertical position such that toggle is in up position when ON.
- B. Install within sight of motor when used as a disconnect switch.
- C. Mounting Height: See Article Outlet and Device Boxes.

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D. Enclosure Type:

1. General Purpose: See Articles Outlet and Device Boxes and Device Plates.
2. Explosion-proof: See product specification.

1.69 TERMINAL BLOCKS

A. Install for termination of power, control, and instrumentation circuits entering or leaving equipment and local control panels.

1.70 DRY TYPE POWER TRANSFORMERS (0- TO 600-VOLT PRIMARY)

- A. Load external vibration isolator such that no direct transformer unit metal is in direct contact with mounting surface.
- B. Provide moisture-proof flexible conduit for electrical connections.
- C. Connect voltage taps to achieve (approximately) rated output voltage under normal plant load conditions.
- D. Provide wall brackets where required.

1.71 SUPPORT AND FRAMING CHANNELS

- A. Install where required for mounting and supporting electrical equipment and raceway systems.
- B. Channel Type:
 1. Interior, Dry, Noncorrosive Locations: Carbon steel.
 2. Interior, Wet, Noncorrosive Locations: Type 316 stainless steel.
 3. Interior, Wet or Dry Corrosive Locations: Type 316 stainless steel.
 4. Outdoor Locations: Type 316 stainless steel.
- C. Paint carbon steel channel cut ends prior to installation with zinc-rich primer.

1.72 NAMEPLATES

A. Provide identifying nameplate on all equipment.

1.73 ELECTRIC UNIT HEATER

A. Attach securely and permanently to prevent objectionable operating noise.

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1.74 TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS) EQUIPMENT

A. Install in accordance with manufacturer's instructions, including lead length, overcurrent protection, and grounding.

1.75 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, of galvanized steel and PVC-coated galvanized steel conduit 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. Installation in Cast-in-Place Structural Concrete:

1. Minimum cover 2 inches, including all fittings.
2. Conduit placement shall not require changes in reinforcing steel location or configuration.

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3. Provide nonmetallic support during placement of concrete to ensure raceways remain in position.
4. Conduit larger than 1 inch shall not be embedded in concrete slabs, walls, foundations, columns or beams, unless approved by Engineer in writing.
5. Slabs and Walls:
 - a. Trade size of conduit not to exceed one-fourth of the slab or wall thickness.
 - b. Install within middle two-fourths of slab or wall.
 - c. Separate conduit by a minimum ten times conduit trade size, center-to-center, unless otherwise shown.
 - d. Cross conduit at an angle greater than 45 degrees, with minimum separation of 1 inch.
 - e. Separate conduit by a minimum six times the outside dimension of expansion and deflection fittings at expansion joints.
 - f. Conduit shall not be installed below the maximum water surface elevation in walls of water holding structures.
6. Columns and Beams:
 - a. Trade size of conduit not to exceed one-fourth of beam thickness.
 - b. Conduit cross-sectional area not to exceed 4 percent of beam or column cross section.

C. Conduit Application:

1. Diameter:
 - a. Exposed and Concealed Minimum: 3/4 inch.
 - b. Underground Minimum: 1 inch.
2. Outdoor, Exposed: PVC-coated rigid galvanized steel.
3. Indoor, Exposed:
 - a. Rigid galvanized steel 5 feet and higher above finished floor.
 - b. PVC-coated rigid galvanized steel below 5 feet above finished floor.
4. Indoor, Concealed (Not Embedded in Concrete): Rigid galvanized steel.
5. Aboveground, Embedded in Concrete Walls, Ceilings, or Floors: Rigid galvanized steel.
6. Direct Earth Burial:
 - a. PVC Schedule 40.
 - b. PVC-coated rigid galvanized steel.
7. Under Slabs-On-Grade: Rigid galvanized steel.
8. Corrosive Areas: PVC-coated rigid galvanized steel.
9. Classified Areas: PVC-coated rigid galvanized steel.

D. Connections:

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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 nonmetallic or metallic, liquid-tight conduit.
 - b. Hazardous Areas: Flexible coupling suitable for Class I, Division 1 and 2 areas.
 - c. Wet or Corrosive Areas: Flexible nonmetallic or metallic 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 nonmetallic or metallic, liquid-tight conduit.
3. Outdoor areas, process areas exposed to moisture, and areas required to be oiltight and dust-tight: Flexible nonmetallic or metallic, liquid-tight conduit.
4. Transition From Underground, Under Floor Slab, Under Equipment Mounting Pad, or Concrete Embedded to Exposed: PVC-coated rigid steel conduit from 6 inches above to 12 or more inches below top of grade or slab.
5. Under Equipment Mounting Pads: Rigid galvanized steel conduit.
6. Exterior Light Pole Foundations: PVC Schedule 40 conduit.

E. 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 using fire penetration seal.
4. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack.
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 conduit attached to exterior surface of equipment prior to penetrating equipment.
 - 3) Seal penetration with Type 5 sealant, a one-part polyurethane, immersible sealant.

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- d. Corrosive-Sensitive Areas:
 - 1) Seal all conduit passing through chlorine and ammonia room walls.
 - 2) Seal conduit entering equipment panelboards and field panels containing electronic equipment.
 - 3) Seal penetration with Type 5 sealant, a one-part polyurethane, immersible sealant.
- e. Existing or Precast Wall (Underground): Core drill wall and install watertight entrance seal device.
- f. 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.
- g. Handholes:
 - 1) Metallic Raceways: Provide insulated grounding bushings.
 - 2) Nonmetallic Raceways: Provide bell ends flush with wall.

F. Support:

- 1. Support from structural members only, at intervals not exceeding NFPA 70 requirements, and in any case not exceeding 8 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, pregalvanized 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.

G. Bends:

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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. PVC Conduit:
 - a. Bends 30 Degrees and Larger: Provide factory-made elbows.
 - b. Use manufacturer's recommended method for forming smaller bends.
8. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

H. Expansion and Deflection Fittings: Provide on all raceways at structural expansion joints and in long tangential runs.

I. PVC Conduit:

1. Solvent Welding:
 - a. Provide manufacturer recommended solvent; apply to all joints.
 - b. Install such that joint is watertight.
2. Adapters:
 - a. PVC to Metallic Fittings: PVC terminal type.
 - b. PVC to Rigid Metal Conduit: PVC female adapter.
3. Belled-End Conduit: Bevel the unbelled end of the joint prior to joining.

J. PVC-Coated Rigid Steel Conduit:

1. Install in accordance with manufacturer's instructions.
2. All tools and equipment used in the cutting, bending, threading, and installation of PVC-coated rigid steel conduit shall be designed to limit damage to the PVC coating.
3. Provide PVC boot to cover all exposed threading.

K. Termination at Enclosures:

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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.
 - 7) Terminate conduits with threaded conduit hubs at NEMA 4X boxes and enclosures.
 - b. Flexible Metal Conduit: Provide two-screw type, insulated, malleable iron connectors.
 - c. PVC-Coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector.
 - d. 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.

L. Underground Raceways:

1. Grade: Maintain minimum grade of 4 inches in 100 feet, either from one handhole or pull box to the next, or from a high point between them, depending on surface contour.
2. Cover: Maintain minimum 2-foot cover above conduit, unless otherwise shown on the Drawings.
3. Make routing changes as necessary to avoid obstructions or conflicts.
4. Couplings: In multiple conduit runs, stagger so couplings in adjacent runs are not in same transverse line.
5. Union type fittings not permitted.

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6. Spacers:
 - a. Provide preformed, nonmetallic spacers, designed for such purpose, to secure and separate parallel conduit runs in a trench.
 - b. Install at intervals not greater than that specified in NFPA 70 for support of the type conduit used, but in no case greater than 10 feet.
7. Support conduit so as to prevent bending or displacement during backfilling.
8. Installation with Other Piping Systems:
 - a. Crossings: Maintain minimum 12-inch vertical separation.
 - b. Parallel Runs: Maintain minimum 12-inch separation.
 - c. Installation over valves or couplings not permitted.
9. Metallic Raceway Coating: Along entire length, coat with raceway coating.
10. Provide expansion fittings that allow minimum of 4 inches of movement in vertical conduit runs from underground where exposed conduit will be fastened to or will enter building or structure.
11. Provide deflectional/expansion fittings in conduit runs that exit building or structure belowgrade. Conduit from building wall to fitting shall be PVC-coated rigid steel.
12. Backfill: Do not backfill until inspected by Engineer.

M. 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.

N. 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 or nylon strap for attachment.
2. Warning Tape: Install approximately 12 inches above underground or concrete-encased raceways. Align parallel to, and within 12 inches of, centerline of runs.

O. Raceway Band:

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1. 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.
 - a. 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.
 - b. Wrap-around Type: Use where slip-on access to conduit is not possible. Clean conduit surface at installation location. Apply primer. Apply wraps to provide two layers of tape. Neatly finish tape end to prevent unraveling.

1.76 METAL WIREWAYS

- A. Install in accordance with manufacturer's instructions.
- B. Locate with cover on accessible vertical face of wireway, unless otherwise shown.

1.77 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 in writing.
- F. Bundling: Where single conductors and cables in handholes, vaults, 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 to 2 inches wide.

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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, 208Y/120-Volt, Three-Phase System: Black, red, or blue.
 - d. Live Wires, 480Y/277-Volt, Three-Phase System: Brown, orange, or yellow.
 - e. Ground Wire: Green.

I. Circuit Identification:

1. 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.
2. 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.

1.78 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.

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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.

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.

1.79 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.

1.80 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 and meeting specified seismic requirements.
- D. Pole Mounted Fixtures: Provide cast-in-place concrete bases as shown on the Drawings.
- E. Install symmetrically with suspended ceiling pattern in finished areas.
- F. Unfinished Areas: Locate luminaires to avoid conflict with other building systems or blockage of luminaire light output.
- G. Building Exterior: Provide flush-mounted back box and concealed conduit, unless otherwise shown.

1.81 LIGHTING CONTROL

- A. Outdoor Luminaires: Photocells shall switch lights ON at dusk and OFF at dawn.

TESTING

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2930.60 FIELD QIUALITY CONTROL

1.82 FIELD QUALITY CONTROL

A. 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 and Agency prior to de-energization.
 - b. Minimized to avoid extended period of interruption to the operating plant equipment.

B. 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.

C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

D. Adjust mechanisms and moving parts for free mechanical movement.

E. Adjust adjustable relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

F. Verify nameplate data for conformance to Contract Documents.

G. Realign equipment not properly aligned and correct unlevelness.

H. Properly anchor electrical equipment found to be inadequately anchored.

I. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench to manufacturer's recommendations, or as otherwise specified.

J. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

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- K. Provide proper lubrication of applicable moving parts.
- L. 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.
- M. Electrical Enclosures:
 - 1. Remove foreign material and moisture from enclosure interior.
 - 2. Vacuum and wipe clean enclosure interior.
 - 3. Remove corrosion found on metal surfaces.
 - 4. Repair or replace, as determined by Engineer, door and panel sections having damaged surfaces.
 - 5. Replace missing or damaged hardware.
- N. Provide certified test report(s) documenting the successful completion of specified testing. Include field test measurement data.
- O. Test the following equipment and materials:
 - 1. Conductors: Insulation resistance on all power circuits with a 500-volt megger.
 - 2. Panelboards, switches, and circuit breakers.
 - 3. Motor controls.
 - 4. Grounding electrodes.
 - 5. Motors.
- P. 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. Functional Tests: Functionally test for proper operation all local and remote controls, indicating lights, protective devices and features, alarms and shut down of all equipment.
 - 4. Demonstrate control, monitoring, and indication functions in presence of Agency and Engineer.
- Q. Balance electrical load between phases on panelboards and mini-power centers after installation.
- R. Voltage Testing:
 - 1. When installation is complete and facility is in operation, check and record voltage at point of termination of electric utility supply system to Project.

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2. Check voltage amplitude and balance between phases for loaded and unloaded conditions and submit a report of the recorded values.
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.

S. 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.

T. Metering:

1. Visual and Mechanical Inspection:
 - a. Verify meter connections in accordance with appropriate diagrams.
 - b. Verify meter multipliers.
 - c. Verify that meter types and scales conform to Contract Documents.
 - d. Check calibration of meters at cardinal points.

U. Grounding Systems:

1. Visual and Mechanical Inspection:
 - a. Equipment and circuit grounds in panelboard for proper connection and tightness.
 - b. Ground bus connections in panelboard for proper termination and tightness.
 - c. Effective equipment grounding.
 - d. Accessible connections to grounding electrodes for proper fit and tightness.
 - e. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.
2. Electrical Tests:
 - a. Fall-of-Potential Test:
 - 1) In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.
 - 2) Main ground electrode system resistance to ground to be no greater than 1 ohm.

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V. Low Voltage Surge Arrestor:

1. Visual and Mechanical Inspection:
 - a. Adequate clearances between arrestors and enclosures.
 - b. Ground connections to ground electrode.
2. Electrical Tests (Varistor Type Arrestors):
 - a. Clamping voltage test.
 - b. Rated RMS voltage test.
3. Rated dc voltage test.
4. Varistor arrestor test values in accordance with ANSI C62.33, Sections 4.4 and 4.7.

END OF SECTION

**City of Bend Supplement to the
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**SECTION 02940
ENGINE GENERATOR SET**

DESCRIPTION

SCOPE

REFERENCES

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

1. ASTM International (ASTM): A335/A335M, Specification for Seamless Ferritic Alloy-Steel Pipe for High-Temperature Service.
2. Code of Federal Regulations (CFR): Title 40 Volume 18, Control of Emissions from New and In-Use Non-road Compression-Ignition Engines.
3. Institute of Electrical and Electronics Engineers (IEEE): C37.90.1, Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.
4. International Organization for Standardization (DIN/ISO): 9001, Quality Management Systems—Fundamentals and Vocabulary.
5. National Electric Manufacturer's Association (NEMA):
 - a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
 - b. ICS 1, General Standards for Industrial Control and Systems: General Requirements.
 - c. ICS 2, Industrial Control and Systems Controllers, Contactors, and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC.
 - d. MG 1, Motors and Generators.
6. National Electrical Contractors Association (NECA): 404, Recommended Practice for Installing Generator Sets.
7. National Fire Protection Association (NFPA):
 - a. 37, Installation and Use of Stationary Combustion Engines and Gas Turbines.
 - b. 70, National Electric Code.
 - c. 110, Emergency and Standby Power Systems.
8. School of Audio Engineering (SAE): J1074, Engine Sound Level Measurement.
9. Underwriters Laboratories, Inc. (UL):
 - a. 508, Industrial Control Equipment.
 - b. 1008, Transfer Switch Equipment.
 - c. 1236, Battery Chargers for Charging Engine-Starter Batteries.
 - d. 2085, Protected Aboveground Tanks for Flammable and Combustible Liquids.
 - e. 2200, Stationary Engine Generator.

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1.02 GENERAL

A. This Section includes the required work to provide and install a totally complete natural gas or diesel engine generator set system. System's equipment includes engine generator set, control panel, batteries, battery charger, automatic or manual transfer switch, and all other equipment required for a fully functional electric generating unit.

1.03 SUBMITTALS

A. Submittals shall be made in accordance with Section 26 05 01, Electrical.

B. Include a copy of this electrical equipment specification section with the electrical equipment submittal. Each paragraph shall be check marked to show specification compliance or marked to show deviations. Attach a cross-referenced letter of explanation for deviations as required.

C. Action Submittals:

1. Dimensioned outline drawing showing plan and elevations of engine generator set and drive system, complete, with weatherproof enclosure and locations of all accessories.
2. Engine and generator weight, and anchoring requirements.
3. Catalog information and technical description; include materials for block, heads, valves, rings, cylinders, pistons, crankshaft, and major bearings and wear surfaces.
 - a. Engine and generator manufacturers' names.
 - b. Number of cylinders/in-line or vee.
 - c. Bore and stroke/piston speed at rated rpm.
 - d. Displacement in cubic inches.
4. Complete list of accessories provided.
5. Performance curves showing engine efficiency (fuel consumed per kWh output), gross fuel consumption rate, and kW output at design rated output, one-half load, and one-quarter load. Account for design altitude, temperature corrections, and engine parasitic loads.
6. Generator descriptive information, transient response characteristics, and transient and subtransient reactances per unit.
7. Type of generator exciter.
8. Output waveform and telephone interference factor (TIF).
9. Generator capacity in kW, kVA, and power factor.
10. NEMA MG 1-22.40 temperature rise rating of generator insulation.
11. Automatic voltage regulator manufacturer performance criteria.
12. Number and type of generator bearings.

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13. Circuit breaker data, including make model, catalog number, settings, and time current curves.
14. Control panel instrument identification inscriptions.
15. Sample guarantee.
16. Electrical schematic and wiring diagrams for the following:
 - a. Generator control panel.
 - b. Main generator.
 - c. Voltage regulator.
 - d. Battery charging system.
 - e. Governing system.
 - f. Generator exciter.
 - g. Interconnection wiring diagram for automatic transfer switch specified in Article Automatic Transfer Switch.
 - h. Enclosed electrical components.
17. Engine generator set motor starting capability and percent voltage dip curve.
18. Block heater size and voltage.
19. Subbase tank size and dimensions.
20. Noise data for enclosed engine generator at 50 percent, 75 percent, and full load.
21. Automatic or Manual Transfer Switch:
 - a. Descriptive product information.
 - b. Dimensional drawings.
 - c. Control diagrams.
 - d. Conduit entrance locations.
 - e. Equipment ratings.
22. Seismic anchorage and bracing drawings and cut sheets for Contractor to provide required anchorage and bracing during installation of the standby engine generator set.

D. Informational Submittals:

1. Seismic anchorage and bracing calculations.
2. Manufacturer's Certificate of compliance with specified EPA emissions requirements.
3. Certification, copies of analyses, or test reports demonstrating appropriate vibration analysis and design in all modes.
4. Certified Factory Test Reports.
5. Manufacturer's Certificate of Performance.
6. Operation and Maintenance Data.
7. Description of parts and service availability within 50 miles of the standby generator location.
8. Manufacturer's Certificate of Proper Installation.
9. Special guarantee.

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1.04 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

B. Manufacturer Special Requirements:

1. Generator set shall be listed to UL 2200 or submitted to an independent third party certification process to verify compliance as installed.
2. Manufacturer of generator set shall be certified to ISO 9001 and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.

1.05 SPECIAL GUARANTEE

- A. Provide manufacturer's guarantee or warranty with no deductibles and including travel time, service hours, repair parts and expendables (oil, filters, antifreeze and other items required for the complete repair) with Agency named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction of the Work specified in this Specification section found defective during a period of 2 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in the General Conditions.
- B. Local warranty repair facility shall be within 50 miles of the standby engine generator set location.

1.06 EXTRA MATERIALS

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

<u>Item</u>	<u>Quantity</u>
Diesel fuel line filter elements (if applicable)	3 complete sets

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Item	Quantity
Lubricating oil filter elements with gasket	3 complete sets
Air cleaner filter element	1 complete set
Auxiliary fuel and jacket water pump packing/seals	1 complete set
Cooling fan drive belt (if applicable)	2 complete sets
Hydrometer	1 each
Two-pronged battery voltmeter	1 each
Spare fuses, if used in control panel	1 complete set
Spare indicating lamps/LED's (if applicable)	4 of each type used
Touch up paint	1 quart each color used
Special tools required to maintain or dismantle engine generator set	1 complete set

B. Engine Repair/Service Manual: Three sets.

MATERIALS

2.01 2940.10 MANUFACTURERS

A. Materials and equipment specified in this section shall be products of:

1. Kohler Power Series.
2. Or approved equal with repair services within 50 miles of the standby engine generator set location.

2.02 SERVICE CONDITIONS

- A. Altitude: 4,000 feet above sea level, maximum.
- B. Ambient Temperature at Air Intake: 110 degrees F maximum.
- C. Ambient Temperature at Engine Generator Set: 110 degrees F maximum.

2.03 GENERAL

A. Ratings:

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1. Operate at 1,800 rpm.
2. Rated kW and kVA at 0.8 PF based on specified service conditions, connected load, and motor starting provisions.
3. Voltage: 480Y/277 or 240/120 volts, three-phase, 4-wire, 60-Hz.
4. Rated based on standby service.

B. Emissions: Engines shall meet emission requirements specified in 40 CFR Chapter I Part 89 for off-highway Internal Combustion (IC) engines.

C. Vibration Design:

1. Use vibration analytical techniques to determine shaft critical speeds, and to develop bearing design and shaft balancing to mitigate vibration.
2. Apply torsional analysis and design to mitigate torsional vibration.
3. Engine and generator, individually, shall not exhibit vibration in any plane exceeding 10 mils at continuous rating point, when measured at attachment points to common steel subbase.

2.04 ENGINE

A. General:

1. Manufacturer's standard design, unless otherwise specified.
2. Engine parts designed with adequate strength for specified duty.

B. Type and Rating:

1. Natural Gas Cycle: 4-stroke type with unit mounted radiator and fan cooling for units rated 25 to 150 kW where natural gas is available as a fuel supply.
2. Diesel Cycle: 4-stroke type with unit mounted radiator and fan cooling for units where natural gas is not available as a fuel supply or for units rated 175 to 750 kW.
3. Suitable for a standby output when driving a synchronous generator at a speed not exceeding 1,800 rpm sufficient to start and power the connected load with maximum starting voltage drop not to exceed 20 percent.
4. Minimum displacement shall be as recommended by generator manufacturer.
5. Minimum number of cylinders shall be as recommended by generator manufacturer.

C. Starting System:

1. Type: Automatic, using 12-volt or 24-volt battery-driven starter acting in response to control panel.

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2. Starter shall be capable of three complete cranking cycles or shall have sufficient capacity to crank the engine at starting speed for 1 minute without overheating.
3. Batteries:
 - a. Sized as recommended by engine manufacturer.
 - b. Lead-acid type.
 - c. Capable of providing 15 seconds minimum of cranking current at 0 degree C and three complete 15-second cranking cycles at 40 degrees C.
 - d. Housed in acid-resistant frame or box mounted in the engine enclosure and isolated from engine generator main frame.
 - e. Located such that maintenance and inspection of engine is not hindered.
 - f. Complete with battery cables and connectors.
4. Battery Charger:
 - a. UL 1236 listed and labeled.
 - b. 10-amp automatic float, taper and equalize charge type, with plus or minus 1 percent voltage regulation over a plus or minus 10 percent input voltage variation.
 - c. Input Voltage: 120V ac.
 - d. Temperature compensated to operate over an ambient range of minus 30 degrees C to 50 degrees C.
 - e. Locate charger adjacent to generator control panel. Generator manufacturer shall coordinate location.
 - f. Include:
 - 1) Ammeter and voltmeter.
 - 2) Fused ac input and dc output.
 - 3) Power ON pilot light.
 - 4) AC failure relay and light.
 - 5) Low and high dc voltage alarm relay and light.
 - g. Alarm relay dry contacts rated 5 amps at 120V ac.
 - h. Wire battery charger status and alarm contacts back to generator control panel, terminate and identify contacts.
 - i. Isolate charger from battery during engine start and run operations.

D. Fuel System:

1. Natural Gas:
 - a. Carburetion shall be suitable for natural gas supply of 0.75 psig.
 - b. Provide natural gas regulator as required.
 - c. Provide flexible connector where gas supply piping connects to engine.
2. Diesel:

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- a. Engine driven, mechanical, positive displacement fuel pump.
- b. Fuel filter with replaceable spin-on canister element.
- c. As specified under Article, Integral Subbase Fuel Tank.
- d. Fuel Connections to Engine: Flexible hose, suitable for application.

E. Governing System:

1. Electronic constant speed type.
2. Regulates speed as required to hold generating frequency within tolerable limits and within 5 percent of nominal design speed.
3. Capable of maintaining isochronous governed speed at 60 Hz at any load from no-load to full-load.
4. Capable of maintaining a steady state band width of not more than plus or minus 0.25 percent at any constant load from no-load to full-load.
5. Accessories:
 - a. Manual speed control device.
 - b. Positive overspeed trip switch.

F. Jacket Water Cooling System:

1. Radiator:
 - a. Consisting of jacket water pump, fan assembly, fan guard, and duct flange outlet.
 - b. Cooling System: Rated for full load operation as specified in Article Service Conditions.
 - c. Fan: Suitable for use in a system with 0.5 in H₂O restriction.
 - d. Sized based on a core temperature that is 20 degrees F higher than rated operation temperature.
2. High coolant temperature device to shut down engine through the engine generator control panel when the engine temperature exceeds 217 degrees F. Provide prealarm annunciation at the engine generator control panel at 215 degrees F.
3. Engine Thermostat: As recommended by manufacturer to regulate engine water temperature.
4. Jacket Water Heater:
 - a. Suitable for operation on 120- or 240-volt, single-phase, 60-Hz current.
 - b. Maintain engine water temperature at 120 degrees F with an ambient temperature of 50 degrees F.
 - c. Thermostatically controlled.
 - d. Externally mounted with inlet and outlet isolation valves.
5. Engine Cooling Liquid: Fill cooling system with a 50/50-ethylene glycol/water mixture prior to shipping.

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G. Lubrication System:

1. Type: Full-pressure.
2. Accessories:
 - a. Pressure switch to initiate shutdown on low oil pressure.
 - b. Oil filter with replaceable element in addition to a bypass valve, which will allow lube oil circulation in the event of a failure of the filtering system.
 - c. Bayonet type oil level stick.
 - d. Valved oil drain extension.
3. Oil Cooling System: Water-cooled heat exchanger utilizing jacket water.

H. Exhaust System:

1. Muffler: Rated for residential silencing.
2. Wrap exposed length of exhaust pipe and silencer with thermal insulating wrap.
3. Exhaust Pipe: ASTM A335, Grade P11, standard wall, with fittings selected to match piping materials.
4. Pipe Connections: Welded.
5. Engine Connection:
 - a. Flanged, flexible, corrugated, Type 321 stainless steel expansion fitting, specifically suited for diesel exhaust service.
 - b. Length as required for flexibility and expansion in piping arrangement shown on Drawings.

I. Air Intake System: Equip with dry type air cleaner with filter service (restriction) indicator.

2.05 GENERATOR

A. General:

1. Meet requirements of NEMA MG 1.
2. Synchronous type with 2/3 pitch, amortisseur winding in rotor, revolving field, drip-proof construction, air cooled by a direct drive centrifugal blower fan.
3. Single bearing flange-mounted design with a sealed, frictionless, cartridge type bearing.
4. Engine generator coupling shall be the laminated steel, semi-flexible, piloting type.
5. Stator Windings:
 - a. Skewed for smooth voltage waveform.
 - b. Reconnectable, 12 lead.
6. Overspeed Capability: 125 percent.
7. Waveform Deviation from Sine Wave: 5 percent maximum.

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8. Telephone Interference Factor: 50 maximum.
9. Total Harmonic Current and Voltage Distortion: 5 percent maximum, measured at generator main circuit breaker.

B. Insulation System:

1. Class H, with a maximum rise of 125 degrees C over 40 degree C ambient in accordance with NEMA MG 1.
2. Vacuum pressure impregnated (VPI) fungus resistant in accordance with MIL E-4970A.

C. Excitation System:

1. Field brushless type or permanent magnet generator (PMG) exciter.
2. PMG and Controls: Capable of providing regulated current, at a rate of 300 percent of nameplate current, to a single-phase or three-phase fault for 10 seconds.

D. Voltage Regulation:

1. Solid state, PWM, automatic voltage regulator with three-phase sensing and over- and under-voltage protection.
2. Adjustable output voltage level to plus or minus 5 percent of rated output voltage. Mount output voltage adjustment control on engine generator control panel.
3. Provisions for proper voltage regulation for existing or future adjustable frequency drives as part of generator load.
4. Conformal coating environmental protection.

E. Voltage and Frequency Regulation Performance:

1. Steady State Voltage Regulation: Less than plus or minus 1 percent from no-load to continuous rating point.
2. NEMA MG 1 Defined Transient Voltage Dip:
 - a. Less than 15 percent at rapid application of rated load.
 - b. Recovery to rated voltage and frequency within 2 seconds following initial load application.
3. Steady State Frequency Regulation: Plus or minus 1.5-Hz overload range.

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F. Motor Starting Capability:

1. Apply loads in the order listed in the following table.

Load Table					
Step	Load Description	Rating	Type (hp, kW)	Starting Type	Largest Motor
1					
2					
3					

- a. Step 1 loads start immediately upon transfer, Step 2 loads start 5 to 10 seconds after transfer, Step 3 loads start 10 to 15 seconds after transfer, etc.
- b. Rating: Rated total horsepower/kW of loads that are started.
- c. Type: "Rating" entry units, e.g., kW or hp.
- d. Starting Type:
 - 1) FVNR – Full Voltage Nonreversing.
 - 2) SSRV – Solid-State Reduced Voltage.
 - 3) AFD – Adjustable Frequency Drive.

G. Short Circuit Capabilities: Sustain 300 percent of rated current for 10 seconds for external three-phase bolted fault without exceeding rated temperatures.

H. Enclosure:

1. Driproof.
2. Anti-condensation heater suitable for operation on 120-volt, 60-Hz current (100W, maximum).

I. Main Circuit Breaker:

1. Type: Molded case or insulated case.
2. Current Rating: As recommended by generator manufacturer.
3. Interrupt Rating: As recommended by generator manufacturer.
4. Short Time Rating: As recommended by generator manufacturer.
5. Trips:
 - a. Molded Case Circuit Breaker: Thermal-magnetic with inverse time characteristics and adjustable magnetic pickup.
 - b. Insulated Case Circuit Breaker Adjustable Functions:
 - 1) Long-time current pickup.
 - 2) Normal range instantaneous and short-time pickup.
 - 3) Short-time delay with I₂t function.
 - 4) Ground fault pickup.
 - 5) Ground fault delay.

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6. Enclosure:
 - a. Rating: NEMA 250, Type 12.
 - b. Mounted with vibration isolation from engine generator set.
7. Surge Protective Devices: Three-phase capacitors and arresters mounted in terminal compartment.
8. Provide one normally open and one normally closed, 5 amps, 120-volt contact for remote indication when circuit breaker has tripped.

2.06 BASEPLATE

- A. Mount engine generator set on a rigid common steel base frame.
- B. Base frame shall be stiffened to minimize deflections.

2.07 INTEGRAL SUBBASE FUEL TANK (DIESEL ENGINE)

- A. General:
 1. Sufficient tank capacity for full load operation of generator set for 24 hours.
 2. UL 2085 listed and labeled.
 3. Installation shall be in compliance to NFPA 37.
 4. Double-walled, steel construction, configured for full coverage of the unit base area, and shall include the following features:
 - a. Emergency tank and basin vents.
 - b. Mechanical level gauge (1-1/4-inch diameter).
 - c. Fuel supply and return lines, connected to generator set with flexible fuel lines as recommended by engine manufacturer and in compliance to UL 2200 and NFPA 37 requirements.
 - d. Leak detection provisions, wired to generator set control for local and remote alarm indication.
 - e. High and low level float switches to indicate fuel level. Wire switches to generator control for local and remote indication of fuel level.
 - f. Basin drain.
 - g. Integral lifting provisions.
 - h. Capacity (e.g., "105 GALLONS") painted on a visible section of the tank with black letters, white letters if tank is black, 2 inches high, minimum.
 - i. Fill line with dry break connection with lockable dust cap and chain, accessible from outside the engine generator weatherproof enclosure without opening the enclosure.

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2.08 VIBRATION ISOLATORS

- A. Performance: To meet code requirements to limit vibration transmissibility to 10 percent at each frequency.
- B. Provide vibration isolators, spring/pad type, with low-profile (height-saving) vibration-isolator brackets suitable for the specified Seismic Design Criteria.
- C. Include seismic restraints if required by Site location.
- D. Manufacturer and Product: Korfund; Series L.

2.09 AUTOMATIC AND MANUAL TRANSFER SWITCHES

- A. Automatic run controls shall be suitable for remote interface and control by an automatic transfer switch. Engine generator set shall start and run upon closure of a remote dry contact provided in the automatic transfer switch.
- B. General:
 - 1. Transfer switch to be product of a single manufacturer in order to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's service.
 - 2. In accordance with applicable standards of NFPA 70, NEMA ICS 1, NEMA ICS 2, IEEE C37.90.1, and UL 1008.
 - 3. Transfer switch consisting of inherently double-throw power switch unit with interconnected control module.
 - 4. Rated 100 percent, in amperes, for total system transfer of motor, electric heating, discharge lamp loads, and tungsten-filament lamp loads.
 - a. Switches rated 400 amperes and below suitable for 100 percent tungsten-filament lamp loads.
 - b. Switches rated above 400 amperes suitable for 30 percent tungsten-filament lamp loads.
 - 5. Main and arcing contacts visible for inspection with cabinet door and barrier covers removed.
 - 6. Suitable for 240/120 or 480 volts, three-phase, three-wire or four-wire, grounded-wye or delta electrical service having an available short circuit current at line terminals as shown on the Drawings.
 - 7. Switch Rating: As shown on the Drawings in nonventilated enclosure.
 - 8. Current carrying capacity of arcing contacts shall not be used to determine the transfer switch rating.
 - 9. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

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10. Operating Conditions:

- a. Maximum Ambient: 40 degrees C.
- b. Elevation: 4,000 feet above sea level.

C. Enclosure:

1. Type: Nonventilated NEMA 250, Type 12 with enclosure grounding terminal.
2. Dead front, front accessible wall or floor mounted cabinet with 14-gauge welded steel construction.
3. Continuously hinged single door, with handle and lock cylinder.
4. Finish: Baked enamel applied over rust-inhibiting, phosphated base coating.
 - a. Exterior and Interior Color: Provide gray finish as approved by Agency or Engineer.
 - b. Unpainted Metal Parts: Plated for corrosion resistance.

D. Transfer Switch:

1. Type: Electrically operated, mechanically held, double-throw.
2. Momentarily energized, single-electrically operated mechanism energized from source to which load is to be transferred.
3. Locking mechanism to maintain constant contact pressure.
4. Mechanical interlock switch to ensure only one of two possible switch positions or time delay in neutral position.
5. Silver alloy contacts protected by arcing contacts.
6. Main and arcing contacts visible when door is open and barrier covers removed.
7. Manual operating handle for transfer in either direction under either loaded or unloaded conditions.
8. Internal control wire connections made with ring or spade type terminals, lock washers, and sleeve type marking labels.

E. Control Module (Automatic Transfer Switch Only):

1. Completely enclosed and mounted separately from the transfer switch unit.
2. Microprocessor for sensing and logic control with inherent digital communications capability.
3. Plug-in, industrial grade interfacing relays with dust covers.
4. Connected to transfer switch by wiring harness having keyed disconnect plug.
5. Plug-in printed circuit boards for sensing and control logic.
6. Adjustable solid state undervoltage sensors for all three phases of utility and for one phase of standby source:
 - a. Pickup 85 to 100 percent nominal.
 - b. Dropout 75 to 98 percent of pickup setting.
7. Adjustable frequency sensors for standby source:

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- a. Pickup 90 to 100 percent nominal.
- b. Dropout 87 to 89 percent of pickup setting.
8. Control module with adjustable time delays:
 - a. 0.5- to 6-second engine start delay.
 - b. 0- to 5-minute load transfer to emergency delay.
 - c. 0- to 30-minute retransfer to normal delay.
 - d. 0- to 30-minute unload running time delay.
 - e. Switch to bypass any of the above time delays during testing.
9. Form-C start contacts, rated 10 amperes, 32-volt dc, for two-wire engine control, wired to terminal block.
10. Exerciser, adjustable in 15-minute increments, 7-day dial clock to automatically exercise generator without load transfer, complete with door mounted NO LOAD and LOAD selector switch.
11. In-phase monitor to control transfer when both sources are within acceptable phase angle limits, or adjustable pneumatic type time delay relay for time-delay-in neutral position.
12. Adjustable 0 to 5 minutes time delay relay for engine starting signal.

F. Metering Instruments:

1. Meters to be connected to load side of transfer switch.
2. Ammeter: 3-1/2-inch, 2 percent accuracy, panel type with current transformers, three-phase, line-to-line, OFF, four-position selector switch.
3. Voltmeter: 3-1/2-inch, 2 percent accuracy, panel type with three-phase, line-to-line, OFF, four-position selector switch and 300- or 600-volt scale.

G. Indicators:

1. Type: Clustered light-emitting diodes.
2. Green lens to indicate switch position for utility power source.
3. Red lens to indicate switch position for standby power source.
4. White lens to indicate utility power source is available within parameters established by pickup and dropout settings.
5. Amber lens to indicate standby power source is available within parameters established by pickup and dropout settings.
6. Provide one normally open and one normally closed, 5 amperes, 120-volt contact for remote indication when transfer switch is in either position.

H. Factory Tests:

1. Test to Ensure Correct:
 - a. Operation of individual components.
 - b. Sequence of operation.

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2.
 - c. Transfer time, voltage, frequency, and time delay settings.
2. Dielectric strength test per NEMA ICS 1.

2.10 CONTROL SYSTEM

A. Control Panel:

1. Rating: NEMA 250, Type 12.
2. Material: Steel.
3. Instrument Identification: Face label or engraved, white, laminated plastic nameplate with black 1/4-inch-high letters, attached with Type 422 stainless steel screws.
4. UL 508 listed.
5. Tested to meet or exceed IEEE 587 requirements for voltage surge resistance.
6. Controls shall be solid-state, microprocessor based. Control panel shall be designed and built by generator manufacturer and shall provide operating, monitoring, and control functions for generator set.
7. Control panel mounting height shall not exceed 6 feet 6 inches above where personnel will access panel. Manufacturer shall modify mounting height if a sub-base fuel tank is used.
8. Platform for control panel shall satisfy all NEC Article 110.26(A)(1) Electrical Equipment Working Space requirements.
9. Anti-condensation heater suitable for operation on 120-volt, 60-Hz current (100W, maximum).

B. Instrumentation:

1. Type: Suitable for engine-mounted vibration environment.
2. Mounting: Nonshock mounted.
3. Alarm and Signal Contacts: Rated 5 amps at 120V ac, dry.
4. Fault Indication Lamps: Push-to-test LED type.
5. Meters: Analog, 3.5 inches, 240-degree scale, plus or minus 2 percent accuracy.

C. Operator Controls and Indicators:

1. HANDCRANK/STOP/AUTO/ENGINE TEST selector switch.
2. Generator voltage adjustment.
3. Voltmeter PHASE SELECTOR switch.
4. Ammeter PHASE SELECTOR switch.
5. Voltmeter.
6. Ammeter.
7. Kilo-Watts (kW).
8. Power Factor.
9. FREQUENCY meter.
10. Engine OIL PRESSURE indicator.

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11. Engine jacket WATER TEMPERATURE indicator.
12. Engine SPEED indicator (RPM).
13. Fuel LEVEL indicator (diesel only).
14. Fuel PRESSURE indicator.
15. Engine OIL TEMPERATURE indicator.
16. RUNNING TIME indicator.
17. DC battery voltage.
18. DC battery charge rate ammeter.
19. Emergency Stop button.

D. Alarm Indicators with Manual Pushbutton RESET:

1. Low oil pressure.
2. High jacket water temperature.
3. Engine overspeed.
4. Engine overcrank.
5. Low/high dc voltage.
6. Fuel tank leak (diesel only).
7. Fuel tank low level (diesel only).

E. External Interfaces:

1. Furnish a single, common DPDT relay output when an alarm (TROUBLE) condition occurs.
2. Furnish a single, common DPDT relay output when an engine shutdown (FAIL) condition occurs.
3. Furnish a single, DPDT relay output when the "ENGINE IS RUNNING" (ON).
4. Furnish a single, DPDT relay output when the HANDCRANK/STOP/AUTO/ENGINE TEST selector switch is NOT in the AUTO position.
5. Furnish a single, DPDT relay output when the "FUEL TANK LEAK" alarm is activated.
6. Furnish a single, DPDT relay output when the "FUEL TANK LOW LEVEL" alarm is activated.
7. Output: Dry contact rated 5 amps at 120V ac.
8. Accept remote dry start contact closure from automatic transfer switch, rated 10 amps at 32V dc.

F. Functional Requirements:

1. LCD text display of alarm/event descriptions.
2. Recranking Lockout: When engine fires, starting control shall automatically disconnect cranking control to prevent recranking for a preset period of time after engine stop.
3. Overcranking Lockout: Initiate after four cranking cycles of 10 seconds on and 10 seconds off or provide continuous cranking cycle with crank time limiter.

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4. Alarms:
 - a. Low coolant level.
 - b. Low fuel level (diesel only).
 - c. Low oil pressure.
 - d. High jacket water temperature.
 - e. Low battery voltage.
 - f. High battery voltage.
 - g. Battery charger failure.
 - h. Fuel tank leak (diesel only).
5. Engine shutdown upon any of the following conditions:
 - a. Engine overspeed.
 - b. Emergency stop button depressed.
 - c. High jacket water temperature alarm setpoint and shutdown setpoint.
 - d. Low oil pressure alarm setpoint and shutdown setpoint.
 - e. Overcrank.
6. Air Inlet Damper Opening:
 - a. Upon engine start sequence initiation, a normally closed, dry contact, rated 5 amps at 120V ac, from engine start circuit shall open to provide a signal to open air inlet dampers.
 - b. Air inlet dampers shall fail open (energized closed).

G. Special Requirements: Mount battery charger adjacent to and facing the same direction as the control panel and match generator instrumentation.

H. Power Requirements: Manufacturer's standard internally connected.

2.11 OUTDOOR WEATHER-PROTECTIVE ENCLOSURE

A. General:

1. Provide generator set with outdoor enclosure, with entire package listed under UL 2200.
2. Package shall comply with requirements of NEC for wiring materials and component spacing.
3. Design total assembly of generator set, enclosure, and subbase fuel tank (when used) to be lifted into place using spreader bars.
4. Housing:
 - a. Provide ample airflow for generator set operation at rated load in ambient temperature of 100 degrees F.
 - b. Doors:
 - 1) Hinged access doors as required to maintain easy access for operating and service functions.
 - 2) Lockable and include retainers to hold door open during service.
5. Roof: Cambered to prevent rainwater accumulation.

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6. Openings: Screened to limit access of birds and rodents into enclosure with gravity-operated air discharge louvers.
7. Electrical power and control interconnections shall be made within perimeter of enclosure.
8. Finishes:
 - a. Prime sheet metal for corrosion protection and finish painted with manufacturer's standard color using a two-step electrocoating paint process, or equal meeting performance requirements specified below.
 - b. Prime and paint surfaces of metal parts. Painting process shall result in coating that meets the following requirements:
 - 1) Primer: 0.5 mil to 2.0 mils thick.
 - 2) Top Coat: 0.8 mil to 1.2 mils thick.
 - 3) Gloss:
 - a) Per ASTM D523, 80 percent plus or minus 5 percent.
 - b) Gloss retention after 1 year shall exceed 50 percent.
 - 4) Crosshatch Adhesion: Per ASTM D3359, 4B-5B.
 - 5) Impact Resistance: Per ASTM D2794, 120-inch to 160-inch pounds.
 - 6) Salt Spray: Per ASTM B117, plus 1,000 hours.
 - 7) Humidity: Per ASTM D2247, plus 1,000 hours.
 - 8) Water Soak: Per ASTM D2247, plus 1,000 hours.
 - c. Painting of hoses, clamps, wiring harnesses, and other nonmetallic service parts shall not be acceptable.
 - d. Fasteners used shall be corrosion-resistant and designed to minimize marring of painted surface when removed for normal installation or service work.
9. Enclosure shall be constructed of minimum 12-gauge steel for framework and 14-gauge steel for panels.
10. Hardware and hinges shall be austenitic stainless steel.
11. Exhaust Silencer:
 - a. Install factory-mounted exhaust silencer inside enclosure.
 - b. Exhaust shall exit enclosure through a rain collar and terminate with a rain cap.
 - c. Exhaust connections to generator set shall be through seamless flexible connections.
12. Maintenance Provisions:
 - a. Flexible coolant and lubricating oil drain lines that extend to exterior of enclosure, with internal drain valves.
 - b. External radiator-fill provision.
 - c. External fuel fill provision (if equipped with a subbased fuel tank). See Subsection 2.07, Integral Subbase Fuel Tank (Diesel Engine).
13. Provide motorized louvers powered off the 120-volt battery charger circuit to minimize air flow through enclosure when

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generator set is not operating. Louvers shall include provisions to prevent accumulation of ice or snow that might prevent operation.

- 14. Inlet ducts shall include rain hoods.
- 15. Provide external emergency stop switch that is protected from accidental actuation.
- 16. Provide factory mounted and wired electrical auxiliary power distribution panel to serve generator set and enclosure. Provisions required include:
 - a. 100-amp distribution panelboard connected to a 120/240V ac utility service.
 - b. Two duplex GFCI receptacles, one inside enclosure, and one weatherproof receptacle on outside of enclosure.
 - c. Two three-way switches controlling three ac lamps mounted in vapor tight and gasketed fixtures.
 - d. Factory-wired normal ac service from panelboard to engine coolant, alternator and control panel heaters, and battery charger.
- 17. Sound Attenuation:
 - a. Provide with sound-attenuated housing which allows generator set to operate at full rated load in an ambient temperature of up to 100 degrees F.
 - b. Enclosure shall reduce sound level of generator set while operating at full rated load to a maximum of 74 dBA at any location 7 meters from generator set in a free field environment when tested in accordance with SAE J1074.
 - c. Insulate enclosure with nonhydroscopic materials.
- 18. Auxiliary Power Receptacle:
 - a. Provide a 12V dc, automotive (cigarette lighter type) receptacle with weatherproof cover. Mount the receptacle on a stationary part of the weatherproof enclosure (accessible from outside the enclosure) near the starting control panel.
 - b. Wire the receptacle directly to the battery.
 - c. Provide two plugs that match the receptacle for use on portable light cords provided by others.

2.12 FACTORY FINISHING

- A. Engine Generator Set and Instrument Panel: Factory-applied primer and two finish coats of manufacturer's standard heat-resistant engine paint.

2.13 FACTORY TESTS

- A. General: Conform to NFPA 110.
- B. Steady Load Test: Test engine generator set at steady load run of 60 minutes minimum duration at 100 percent full-rated load.

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- C. Transient Load Test: Conduct transient load test to demonstrate ability to meet load pickup and load release requirements specified.
- D. Harmonic Test: Conduct at full load conditions.
- E. Record and Report:
 - 1. Strip chart recording and full harmonic analysis measuring up to 50th harmonic for both voltage and current and three phases simultaneously.
 - 2. Transient response.
 - 3. Load/speed stability.
 - 4. Engine fuel consumption.
 - 5. Power output.
 - 6. Harmonic analysis.

CONSTRUCTION

3.01 2940.40 INSTALLATION

- A. Level and securely mount engine generator set in accordance with manufacturer's recommendations.
- B. Install in accordance with NECA 404.
- C. Where applicable, mount engine generator set on vibration isolators in accordance with isolator manufacturer's recommendations.
- D. Automatic and Manual Transfer Switches:
 - 1. Install in accordance with manufacturer's instructions.
 - 2. Secure enclosure to floor using anchor bolts or structural steel channels attached to wall surface of sufficient size and number adequate for specified seismic conditions.

3.02 FIELD FINISHING

- A. Touch up damaged coating with paint system compatible to existing.

TESTING

3.03 2940.60 FIELD TESTS

- A. General: Conform to NFPA 110.
- B. Visual and Mechanical Inspection:
 - 1. Proper grounding.
 - 2. Blockage of ventilating passageways.

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3. Integrity of engine cooling and fuel supply systems.
4. Excessive mechanical and electrical noise.
5. Overheating of engine or generator.
6. Proper installation of vibration isolators.
7. Proper cooling liquid type and level.
8. Operate Engine-Generator and Check For:
 - a. Excessive mechanical and electrical noise.
 - b. Overheating.
 - c. Correct rotation.
 - d. Check resistance temperature detectors or generator inherent thermal protectors for functionality and proper operation.
 - e. Excessive vibration.
9. Verify that voltage regulator and governor operation will cause unit speed and output voltage to stabilize at proper values within reasonable length of time.
10. Proper operation of meters and instruments.
11. Compare generator nameplate rating and connection with one-line diagram.

C. Electrical and Mechanical Tests:

1. Cold start test by interrupting normal power source with test load consisting of connected building load to verify:
 - a. Transfer switch operation.
 - b. Automatic starting operation.
 - c. Operating ability of engine-generator.
 - d. Overcurrent devices capability to withstand inrush currents.
2. Phase rotation tests.
3. Test Engine Protective Shutdown Features For:
 - a. Low oil pressure.
 - b. Overtemperature.
 - c. Overspeed.
4. Vibration base-line test levels in accordance with manufacturer's recommendations.

D. Performance Test:

1. Perform upon completion of installation.
2. Operate 2 hours minimum.
3. Manufacturer's representative shall make necessary adjustments.
4. Demonstrate ability of engine generator set to carry specified loads.
5. Demonstrate engine generator set safety shutdowns.

E. Test Report: Record and report the following:

1. Electric load on generator.

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2. Fuel consumption.
3. Exhaust temperature.
4. Ambient air temperature.
5. Safety shutdown performance results.
6. Noise levels at 7 meters and at the closest property line.

F. Post-test Requirements:

1. Make final adjustments.
2. Replace fuel and oil filters.
3. Check belt drive tensions.
4. Demonstrate proper operation of equipment, including automatic operation with control from automatic transfer switch, to Engineer and Agency.

G. Transfer Switches:

1. Visual and Mechanical Inspection:
 - a. Check doors and panels for proper interlocking.
 - b. Check connections for high resistance by low resistance ohmmeter and calibrated torque wrench applied to bolted joints.
 - c. Check positive mechanical and electrical interlock between normal and alternate sources.
 - d. Check for proper operation:
 - 1) Manual transfer function switch.
 - 2) Generator under load and nonload conditions.
 - 3) Auto-exerciser of generator under load and no-load conditions.
 - e. Verify settings and operation of control devices.
2. Electrical Tests:
 - a. Insulation Resistance Tests:
 - 1) Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1 for each phase with switch CLOSED in both source positions.
 - 2) Phase-to-phase and phase-to-ground for 1 minute.
 - 3) Test values in accordance with manufacturer's published data.
 - b. Contact Resistance Test:
 - 1) Contact resistance in microohms across each switch blade for both source positions.
 - 2) Investigate values exceeding 500 micro-ohms.
 - 3) Investigate values deviating from adjacent pole by more than 50 percent.
 - c. Set and calibrate in accordance with Specifications and Manufacturer's recommendations.
 - 1) Voltage and frequency sensing relays.
 - 2) Time delay relays.

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- 3) Engine start and shutdown relays.
- d. Perform automatic transfer tests by:
 - 1) Simulating loss of normal power.
 - 2) Return to normal power.
 - 3) Simulating loss of alternate power.
 - 4) Simulating single-phase conditions for normal and alternate sources.
- e. Monitor and verify operation and timing of:
 - 1) Normal and alternate voltage sensing relays.
 - 2) Engine-start sequence.
 - 3) Timing delay upon transfer and retransfer.
 - 4) Engine cool down and shutdown.
 - 5) Interlocks and limit switch functions.

H. Battery System:

1. Visual and Mechanical Inspection:
 - a. Physical damage and electrolyte leakage.
 - b. Evidence of corrosion.
 - c. Intercell bus link integrity.
 - d. Battery cable insulation damage and contaminated surfaces.
 - e. Operating conditions of ventilating equipment.
 - f. Visual check of electrolyte level.
2. Electrical Tests:
 - a. Measure:
 - 1) Bank charging voltage.
 - 2) Individual cell voltage.
 - 3) Electrolyte specific gravity in each cell.
 - 4) Measured test values to be in accordance with manufacturer's published data.
 - b. Verify during recharge mode:
 - 1) Charging rates from charger.
 - 2) Individual cell acceptance of charge.
 - c. Load tests for integrity and capacity; test values in accordance with IEEE 450.

2940.70 ACCEPTANCE OF MATERIALS AND EQUIPMENT

Materials and equipment will not be accepted until startup with full functional tests have been completed by the manufacturer representative and training of Agency personnel has been completed.

3.04 2940.71 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by Agency, for minimum person-days listed below, travel time excluded:

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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. 1/2 person-day for prestartup classroom or Site training.
4. 1 person-day for facility startup.
5. 1/2 person-day for post-startup training of Agency's personnel. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by Agency and Engineer.

END OF SECTION

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**SECTION 02950
INSTRUMENTATION AND CONTROL COMPONENTS**

DESCRIPTION

1.01 SCOPE

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. American National Standards Institute (ANSI).
2. Institute of Electrical and Electronics Engineers, Inc. (IEEE): C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
3. The Instrument, Systems, and Automation Society (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.
4. National Electrical Code (NEC).
5. National Electrical Manufacturers Association (NEMA):
 - a. ICS 1, Industrial Control and Systems General Requirements.
6. National Fire Protection Association (NFPA): 820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities.
7. Underwriters Laboratory, Inc. (UL): 508A, Standard for Safety, Industrial Control Panels.

1.03 DEFINITIONS

A. Abbreviations:

1. I&C: Instrumentation and Control.
2. I/O: Input and Output.
3. O&M: Operation and Maintenance.
4. P&ID: Process and Instrument Diagram.
5. PIC: Process Instrumentation and Control.

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- B. 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.
- C. 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.

1.04 SUBMITTALS

- A. General:
 - 1. Submit proposed Submittal breakdown consisting of sequencing and packaging of information in accordance with Project Schedule.
 - 2. Partial Submittals not in accordance with Project Schedule will not be accepted.
 - 3. Submittal Format:
 - a. Hard Copy: Required for all submittals.
 - b. 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.

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- b) Lists: Microsoft Excel, unless otherwise noted for specific items.
 - c) Drawings: AutoCAD.
- 4. Identify proposed items, options, installed spares, and other provisions for future work (for example, reserved panel space; unused components, wiring, and terminals).
- 5. Legends and Abbreviation Lists:
 - a. Definition of symbols and abbreviations used; for example, engineering units, flowstreams, instruments, and other process items used in nameplates, legends, and data sheets.
 - b. Submit updated versions as they occur.
- 6. Activity Completion:
 - a. Action Submittals: Completed when reviewed and approved.
 - b. Informational Submittals: Completed when reviewed and found to meet conditions of the Contract.

B. Action Submittals:

- 1. 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.
 - 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.
 - c. Formats: Hard copy and Microsoft Excel.
- 2. Catalog Cuts:
 - 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.
- 3. Instrument List:
 - a. Engineer 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.

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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.

4. 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.

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- 12) Name, address, and telephone number of manufacturer's local office, representative, distributor, or service facility.
- c. Electronic Copies: Microsoft Excel.
5. 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.
 6. Installation Details: Include modifications or further details required and define installation of I&C components.
 7. Spares, expendables, and test equipment.
 8. Electronic Copies: Microsoft Excel.
 9. Shop Drawings for Changes Impacting PLC Programming:
 - a. Submit details of changes required to PLC monitoring and control resulting from installation of alternative or upgraded process equipment and instrumentation, and other causes.
 - b. Submit changes at 30-day intervals.

C. Informational Submittals:

1. 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.
 - c. Provide the following items as defined under heading Action Submittals:
 - 1) Bill of materials.
 - 2) Catalog cuts.
 - 3) Instrument list.
 - 4) Component data sheets.
 - d. Manufacturer's O&M manuals:
 - 1) Content for Each O&M Manual:
 - a) Table of contents.

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- 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 Calibration Sheets from field quality control calibrations.

- 2) Provide PDF file with linked index to all manuals.

- e. List of spares, expendables, test equipment and tools provided.
- f. List of additional recommended spares, expendables, test equipment, and tools. Include quantities, unit prices, and total costs.

2. Provide Manufacturer's Certificate of Proper Installation where specified.
3. Agency Training Plan: In accordance with Section 01 43 33, Manufacturers' Field Services.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Prior to shipment, include corrosive inhibitive vapor capsules in shipping containers, and related equipment as recommended by capsule manufacturer.
- B. Prior to installation, store items in dry indoor locations. Provide heating in storage areas for items subject to corrosion under damp conditions.
- C. Cover components that are exposed to dusty construction environments.

MATERIALS

2.01 2950.10GENERAL

- 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. Article I&C Components covers requirements for components that are referenced by Instrument Lists or Data Sheets in Section 40 90 00, Instrumentation and Control for Process Systems.

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D. First Named Manufacturer: PIC design is based on first named manufacturers of equipment.

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.
2. If proposed item requires, but not limited to, different installation, wiring, raceway, enclosures, intrinsically safe barriers, and accessories, provide such equipment and work.

E. Like Equipment Items: 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.

F. Service Conditions:

1. 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:
 - a. Computer Room, Air Conditioned:
 - 1) Temperature: 60 degrees F to 80 degrees F.
 - 2) Relative Humidity: 40 percent to 60 percent.
 - 3) NEC Classification: Nonhazardous.
 - b. Inside, Air Conditioned:
 - 1) Temperature:
 - a) Normal: 60 degrees F to 80 degrees F.
 - b) With Up to 4-Hour HVAC System Interruptions: 40 degrees F to 105 degrees F.
 - 2) Relative Humidity:
 - a) Normal: 10 percent (winter) to 70 percent (summer).
 - b) With Up to 4-Hour HVAC System Interruption: 10 percent to 100 percent.
 - 3) NEC Classification: Nonhazardous.
 - c. Inside:
 - 1) Temperature: 20 degrees F to 104 degrees F.
 - 2) Relative Humidity: 10 percent to 95 percent noncondensing
 - 3) NEC Classification: Nonhazardous.
 - d. Inside, Corrosive:
 - 1) Temperature: 20 degrees F to 104 degrees F.
 - 2) Relative Humidity: 10 percent to 95 percent noncondensing
 - 3) Corrosive Environment: As noted (examples include "Hydrogen sulfide gas" or "chlorine gas").

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- 4) NEC Classification: Nonhazardous.
- e. Inside, Hazardous:
 - 1) Temperature: 20 degrees F to 104 degrees F.
 - 2) Relative Humidity: 10 percent to 95 percent noncondensing
 - 3) NEC Classification: As shown on Electrical Drawings.
- f. Outside:
 - 1) Temperature: Minus 20 degrees F to 104 degrees F.
 - 2) Relative Humidity: 10 percent to 95 percent noncondensing, rain, snow, freezing rain.
 - 3) NEC Classification: Nonhazardous.
- g. Outside, Corrosive:
 - 1) Temperature: Minus 20 degrees F to 104 degrees F.
 - 2) Relative Humidity: 10 percent to 95 percent noncondensing, rain, snow, freezing rain.
 - 3) Corrosive Environment: As noted (examples include "Hydrogen sulfide gas" or "chlorine gas").
 - 4) NEC Classification: Nonhazardous.
- h. Outside, Hazardous:
 - 1) Temperature: Minus 20 degrees F to 104 degrees F.
 - 2) Relative Humidity: 10 percent to 95 percent noncondensing, rain, snow, freezing rain.
 - 3) NEC Classification: As shown on Electrical Drawings.

G. Nameplates and Tags:

1. Component Nameplates, Panel Face: Component identification located on panel face under or near component.
 - a. Location and Inscription: As shown on panel drawing.
 - b. Materials: Adhesive-backed, laminated plastic.
 - c. Letters: 3/16-inch-high, white on black background, unless otherwise noted.
2. Component Nameplates, Back of Panel: Component identification located on or near component inside of enclosure.
 - a. Inscription: Component tag number.
 - b. Materials: Adhesive-backed, laminated plastic.
 - c. Letters: 3/16-inch high, white on black background, unless otherwise noted.
3. Legend Plates for Panel Mounted Pushbuttons, Lights, and Switches.
 - a. Inscription:
 - 1) Refer to table under Paragraph Standard Pushbutton Colors and Inscriptions.
 - 2) Refer to table under Paragraph Standard Light Colors and Inscriptions.
 - 3) Refer to P&IDs on Drawings.

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- b. Materials: Stainless steel, keyed legend plates. Secured to panel by mounting nut for pushbutton, light, or switch.
- c. Letters: Black on gray or white background.
- 4. Service Legends: Component identification nameplate located on face of component.
 - a. Inscription: As shown on panel drawing.
 - b. Materials: Adhesive-backed, laminated plastic.
 - c. Letters: 3/16-inch-high, white on black background, unless otherwise noted.
- 5. Nametags: Component identification for field devices.
 - a. Inscription: Component tag number.
 - b. Materials: 16-gauge, Type 304 stainless steel.
 - c. Letters: 3/16-inch-high, imposed.
 - d. Mounting: Affix to component with 16-gauge or 18-gauge stainless steel wire or stainless steel screws.

H. Electrical Requirements:

- 1. I&C and electrical components, terminals, wires, and enclosures UL recognized or UL listed.
- 2. Terminate and identify wires entering or leaving enclosures as follows:
 - a. Analog and discrete signal, terminate at numbered terminal blocks.
 - b. Special signals terminated using manufacturer's standard connectors.
 - c. Identify wiring in accordance with requirements in Section 26 05 05, Conductors.
- 3. Analog Signal Isolators:
 - a. Furnish signal isolation for analog signals that are sent from one enclosure to another.
 - b. Do not wire in series instruments on different panels, cabinets, or enclosures.
- 4. Intrinsic Safety System Installation:
 - a. Comply with NEC Article 504, Intrinsically Safe Systems.
 - b. Install intrinsically safe circuits in a separate wire way that:
 - 1) Is separated from nonintrinsically safe circuits as specified by NEC.
 - 2) Is colored light blue and has message "Intrinsically Safe Circuits Only" on raceway cover every 6 inches.
- 5. Electrical Transient Protection:
 - a. General:
 - 1) Function: Protect elements of PIC against damage due to electrical transients induced in interconnecting lines by lightning and nearby electrical systems.
 - 2) Surge suppressors are not shown for external analog transmitters. Determine quantity and location, and

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show in Shop Drawings. Refer to example wiring in installation details in Drawings.

- 3) Provide, install, coordinate, and inspect grounding of surge suppressors at:
 - a) Connection of ac power to PIC equipment including panels, consoles assemblies, and field-mounted analog transmitters and receivers.
 - b) At the field and panel, console, or assembly connection of signal circuits that have portions of the circuit extending outside of a protective building.
- b. Surge Suppressor Types: Reference Article "Electrical Components".
- c. Installation and Grounding of Suppressors:
 - 1) As shown. See Surge Suppressor Installation Details.
 - 2) Grounding equipment, installation of grounding equipment, and terminations for field mounted devices are provided under Division 26, Electrical.

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.

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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.

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.

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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.
 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; T71DAO0-TSO-TKO.
- J. Solenoid Valve, Two-Way:
 1. Type: Globe valve directly actuated by solenoid and not requiring minimum pressure differential for operation.
 2. Materials:
 - a. Body: Brassed or stainless steel globe valves as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
 - b. Valve Seat: Buna-N.
 3. Size: Normally closed or opened, as noted.
 4. Coil: 24V dc, unless noted otherwise.
 5. Solenoid Enclosure: NEMA 4.
 6. Manufacturer and Product: ASCO; Red Hat Series 8260.
- K. 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:

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- a. Masoneilan; Series 77-4.
- b. Fisher; Series 67FR.

L. 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.

M. 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.

N. 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.

O. 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:

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- 1) Imperial Eastman; Poly-Flo tube fittings.
2) Dekoron; E-Z fittings.
- P. Stainless Steel Tubing: ASTM A312/A312M, Type 316, 0.065-inch wall, seamless, soft annealed, as shown on Drawings.
- Q. 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.
 - 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.
- R. Air Set: Consists of a shutoff valve, pressure regulator, discharge pressure gauge, and interconnecting tubing.
- S. 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.
- T. Tubing Raceways:
 1. Cable tray systems complete with tees, elbows, reducers, and covers.
 2. Size in accordance with manufacturer's recommendations for intended service.

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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.

U. 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.
 - 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. 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.
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.

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- d. Continuous Operation: Power supplies for one four-wire transmitter or receiver: 5 amps minimum at 130V ac. All other applications: 30 amps minimum 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: Less than plus or minus 10 percent.
 - 3) Maximum Loop Resistance: 18 ohms per conductor.
- 4. Physical Characteristics:
 - a. Mounted in Enclosures: Encapsulated inflame retardant epoxy.
 - b. For Analog Signals Lines: EDCO PC-642 or SRA-64 series.
 - c. For 120V ac Lines: EDCO HSP-121.
 - d. Field Mounted at Two-Wire Instruments: Encapsulated in stainless steel pipe nipples. EDCO SS64 Series.
 - e. 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 fiberglass or Type 316 stainless steel with door.
 - b) Maximum Size: 12 inches by 12 inches by 8 inches deep.
 - 2) Manufacturer and Product: EDCO; SLAC series.

B. 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 CORROSION PROTECTION

A. Corrosion-Inhibiting Vapor Capsules:

- 1. Areas Where Required: Refer to Part 3, Article Protection.
- 2. Manufacturers and Products:
 - a. Northern Instruments; Model Zerust VC.

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b. Hoffmann Engineering; Model A-HCI.

2.05 I&C COMPONENTS

A. A7 pH Element and Transmitter:

1. General.
 - a. Function: Measure, indicate, and transmit pH of process fluid.
 - b. Parts: Element, analyzer/transmitter, interconnecting cable, and noted ancillaries.
2. Performance:
 - a. Element:
 - 1) Range: 0 pH to 14 pH.
 - 2) Operating Temperature: 32 degrees F to 158 degrees F.
 - 3) Operating Pressure: 80 psig maximum at 149 degrees F.
 - b. Analyzer/Transmitter:
 - 1) Range: 0 pH to 14 pH units.
 - 2) Accuracy: Plus or minus 0.02 pH units.
 - 3) Repeatability: Plus or minus 0.05 pH units.
 - 4) Stability: Plus or minus 0.01 pH units per month, noncumulative.
 - 5) Operating Temperature: Minus 4 degrees F to plus 104 degrees F.
 - 6) Operating Humidity: 5 percent to 95 percent; relative humidity, noncondensing.
3. Element:
 - a. Process Connection: 1-inch MNPT.
 - b. Body Style: Convertible with 1-inch NPT on both ends.
 - c. Process Fluid: As noted.
 - d. Wetted Materials: Compatible with process fluid.
 - e. No field-replaceable parts, unless otherwise noted.
 - f. Electrode Type: Flat glass or general purpose, unless otherwise noted.
 - g. Integral Preamplifier: Required, unless otherwise noted.
 - h. Mounting/Process Connections: As shown on Drawings or as noted from among the following:
 - 1) Submersion:
 - a) Sensor handrail assembly.
 - b) Handrail mounting kit.
 - 2) Flow-Through:
 - a) 3/4-inch NPT tee.
 - b) 1-inch NPT tee.
 - c) 1-1/2-inch NPT tee.
 - 3) Insertion.

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- 4) Hot-Tap Retractable:
 - a) Suitable for 64-psig line pressure.
 - b) 1-inch ball valve kit.
 - c) Titanium Tube: 21 inches (12-inch insertion).
- i. Suitable for installation in Class I Div 2 hazardous locations:
If noted or shown.
 - 1) Install in accordance with manufacturer's instructions and applicable codes.
4. Analyzer/Transmitter:
 - a. Display: Graphic LCD, with backlighting.
 - b. Signal Interface:
 - 1) Analog Outputs: Two isolated 4 mA to 20 mA dc outputs (pH and temperature).
 - 2) Discrete Outputs:
 - a) Process Alarms: Two SPSTs minimum, normally open.
 - b) Sensor/Analyzer and Process Fault Alarm: SPDT.
 - c) Contact Rating: 120 volts, 5 amps, resistive.
 - c. Enclosure.
 - 1) Type: NEMA 4X.
 - 2) Suitable for panel, 2-inch pipe, or wall mounting.
 - d. Power: 115V ac, 50/60-Hz, unless otherwise noted.
 - e. Interconnecting Cable: Length as required.
 - f. Suitable for installation in Class I Div 2 hazardous locations:
If noted or shown.
5. Expendables (for each unit provided):
 - a. Chemicals: 1 pint each of buffer solution for pH 4, pH 7, and pH 9.
6. Accessories:
 - a. Junction Box: If noted.
 - 1) NEMA 4X box for cable extension.
7. Manufacturers and Products:
 - a. Rosemount Analytical; Model 399 (water), Model 396P (wastewater), or Model 396R (retractable) sensor and Model 1056 pH analyzer.
 - b. Hach; Digital Differential pH sensor and sc100 controller.
 - c. Foxboro; 871A series pH sensor and Model 875 pH Intelligent Analyzer.

B. A22 Chlorine Residual Analyzer, Amperiometric, Type 1WT:

1. General:
 - a. Function:
 - 1) Measure and indicate residual chlorine (free or total, as noted) of sample.
 - 2) Transmit proportional analog signal.

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- b. Type: Amperiometric.
- c. Parts: Analyzer/transmitter, reagent, and accessories.
- 2. Performance:
 - a. Species Measured: Total residual chlorine, unless otherwise noted.
 - b. Process Range: As noted.
 - c. Analyzer Ranges: Selectable, among 0 to 0.10, 0 to 0.20, 0 to 0.5, 0 to 1.0, 0 to 2.0, 0 to 5.0, 0 to 10.0, 0 to 20.0, and 0 to 50.0.
 - d. Accuracy: 0.001 mg/L or 1 percent of full scale, whichever is greater.
 - e. Sensitivity: 0.001 mg/L or 1 percent of full scale, whichever is greater.
 - f. Repeatability: 0.001 mg/L or 1 percent of full scale, whichever is greater.
 - g. Stability: Nominally plus or minus 1 percent of full-scale for 1 month.
 - h. Continuous Operating Range: 100:1 for each measurement range.
 - i. Response Time:
 - 1) 90 seconds with 2 rpm sample pump motor.
 - 2) 180 seconds with 1 rpm sample pump motor.
 - j. Sample Inlet Pressure: 60 psig maximum process pressure and throttled to less than 5 psig at analyzer inlet.
 - k. Sample Flow:
 - 1) Through the Analyzer to its Measuring Cell: 0.5 lpm (0.13 gpm).
 - 2) To the Analyzer: 0.1 gpm to 5 gpm with 2.5 gpm preferred (external bypass line required).
 - l. Sample Temperature Range: 26 degrees F to 125 degrees F.
 - m. Operating Ambient Temperature Range: 35 degrees F to 125 degrees F.
 - n. Salinity: Fresh to seawater.
- 3. Features:
 - a. Three electrode measuring cell.
 - b. Platinum, gold, and copper electrodes.
 - c. Bare electrodes.
 - d. LCD Display:
 - 1) 4-digit numeric display and 16-character alphanumeric display.
 - 2) Five display menus.
 - e. Integral Sample Pump: 2 rpm, unless otherwise noted.
 - f. Mounting: Wall Mount, unless otherwise noted.
 - g. Modular Cabinet Characteristics:
 - 1) Structural foam ABS.
 - 2) Nominal Dimensions: 69H by 28W by 16D, inches.

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- h. Wall Mounting Assembly: 15H by 22W by 11D, inches.
4. Enclosure (Electronics): NEMA 4X.
5. Signal Interface:
 - a. Analog Output: 4 mA to 20 mA dc isolated output suitable for a load impedance up to 600 ohms.
 - b. Discrete Outputs:
 - 1) Three alarm outputs.
 - 2) Each with SPDT contacts rated at 5 amps resistive at 230V ac and 5 amps at 30V dc resistive.
6. Process Connections:
 - a. Wall Mount: 1/2-inch female NPT sample line, 3/8-inch and 1-1/4-inch drain hose connections.
 - b. Modular Cabinet: 3/4-inch female NPT sample line, 1-1/4-inch female NPT drain connection.
7. Power: 115/230V ac, 50/60 Hz, single-phase, switch selectable.
8. Accessories:
 - a. Flushable Y-strainer; manual throttling valve; shutoff valve; inlet flow pressure reducing valve; tubing for inlet, drain, and reagent connections; reagent bottles, and mounting hardware.
 - b. Reagents: Sufficient reagent for 1 year of monitoring configuration (4 months to 6 months operation in control configuration), including:
 - 1) pH 4 Buffer.
 - 2) Potassium iodide crystals (only required for total residual chlorine applications).
 - 3) Detergent; only required for wastewater applications.
 - c. For Mounting on Modular Cabinet:
 - 1) Recorder: If noted.
 - 2) Type: Circular or strip chart, as noted.
 - d. Keyed Lockable Analyzer Enclosures: If noted.
 - e. External Sample Pump: If noted.
 - 1) Self-priming centrifugal.
 - 2) Cast iron.
 - 3) 1/2 hp, TEFC close-coupled motor.
 - 4) Power Requirements: 115/230-volt, single-phase, unless otherwise noted.
 - 5) Sta-Rite Model DPCMS pump.
 - f. Amperimetric titrator with back titrator capability for calibration of unit: If noted.
9. Manufacturer and Product: Siemens Wallace & Tiernan Micro/2000 Residual Analyzer System.

C. F4 Flow Element and Transmitter, Electromagnetic:

1. General:

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- 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.
- 2. Service:
 - a. Stream Fluid:
 - 1) As noted.
 - 2) Suitable for liquids with a minimum conductivity of 5 microS/cm and for demineralized water with a minimum conductivity of 20 microS/cm.
 - b. Flow Stream Descriptions: If and as described below.
- 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: As noted.
 - 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): As noted.
 - 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.

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- c. Flange Material: Carbon steel, unless otherwise noted.
- 7. Power (Transmitter): 120V ac, 60-Hz, unless otherwise noted.
- 8. Element:
 - a. Meter Tube Material: Type 304 or 316 stainless steel, unless otherwise noted.
 - b. Liner Material:
 - 1) Teflon, unless otherwise noted.
 - 2) For potable water service, must have appropriate approvals.
 - 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.
 - h. Submergence:
 - 1) Temporary: If noted.
 - 2) Continuous (up to 10 feet depth), NEMA 6P/IP68: If noted.
 - i. Direct Buried (3 to 10 feet): If noted.
 - j. Hazardous Area Certification:
 - 1) Class 1, Division 2, Groups A, B, C, D: If noted.
 - 2) Class 1, Division 1, Groups A, B, C, D, and FM approved: If noted.
 - 3) Class 1, Division 1, Groups C, D, and FM approved: If noted.
- 9. Transmitter:
 - a. Mounting: Surface (wall), unless otherwise noted.
 - b. Display: Required, unless otherwise noted.
 - 1) Digital LCD display, indicating flow rate and total.
 - 2) Bi-directional Flow Display: Required, unless otherwise noted.
 - a) Forward and reverse flow rate.
 - b) Forward, reverse and net totalization.
 - c. Parameter Adjustments: By keypad or non-intrusive means.
 - d. Enclosure: NEMA 4X, minimum, unless otherwise noted.
 - e. Empty Pipe Detection:
 - 1) If noted.
 - 2) Drives display and outputs to zero when empty pipe detected.
- 10. Signal Interface (at Transmitter):

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- a. Analog Output:
 - 1) Isolated 4 mA to 20 mA dc for load impedance from 0 ohm to at least 500 ohms minimum for 24V dc supply.
 - 2) Supports Superimposed Digital HART protocol: If noted.
- b. Discrete Outputs: If noted.
 - 1) Two discrete outputs, typical, rated for up to 30 volts, typical.
 - 2) Programmable as noted for the following typical parameters:
 - a) Totalizer pulse, high/low flow rates, percent of range, empty pipe zero, fault conditions, forward/reverse, etc.
- c. Discrete Input: If noted.
 - 1) Contact closure, configured as noted for the following typical parameters: reset totalizer, change range, hold output constant, drive output to zero, and low flow cutoff, etc.
- d. Other: As noted.

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.

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.

15. Accessories:

- a. In situ Verification System: If noted.
 - 1) Quantity: One complete system provided for the project.

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- 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.

b. 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.

16. Manufacturers:

- a. Krohne [includes IFC 020K/IFC 090K (integral) or IFC 020F/IFC 090F (remote) signal converter].
 - 1) Aqua Flux Flowmeter (size: 3/8 to 120 inches).
 - 2) EnviroMag, IFS 4000 Flowmeter (size: 2 to 60 inches).
 - 3) IFS 1000 EcoFlux Flowmeter (size: 1/10 to 8 inches).
- b. Emerson Process Management, Rosemount Division:
 - 1) Model 8705 (flanged) and Model 8711(wafer) flow tubes.
 - 2) Model 8712 (surface) and Model 8732 (integral) transmitters.
- c. McCrometer Ultra Mag.

D. F16 Flow Element, Rotameter:

1. General:
 - a. Function: Indicate flow rate.
 - b. Type: Variable area; float and tapered tube.
2. Service Conditions:
 - a. Process Fluid: Water, unless otherwise noted.

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- b. Temperature Range:
 - 1) Process Fluid: 33 degrees F to 250 degrees F.
 - 2) Ambient: 32 degrees F to 125 degrees F.
- c. Maximum Operating Pressure: As noted.
- 3. Performance:
 - a. Flowrate Range: As noted.
 - b. Accuracy: Plus or minus 2 percent of maximum flow, uncalibrated, over 12.5:1 turndown.
 - c. Repeatability: 0.5 percent of full scale.
- 4. Features:
 - a. Nominal Length: 10 inches.
 - b. Float Material: Type 316 stainless steel.
 - c. Tube: Borosilicate glass.
 - d. Seal:
 - 1) Type: O-ring, unless otherwise noted.
 - 2) Material: Buna-N, unless otherwise noted.
 - e. Polycarbonate operator protection shield.
 - f. Mounting: In line, unless otherwise noted.
 - g. Scales: Direct-reading external metal scale, unless otherwise noted.
 - h. Pressure Drop Design: Standard, unless otherwise noted.
- 5. Size and Process Connections:
 - a. Connection Size: As noted.
 - b. Tube Size: As noted.
 - c. Connection Material: Type 316 stainless steel, unless otherwise noted.
 - d. Connection Type: Threaded NPT, unless otherwise noted.
 - e. Connection Orientation: Vertical, unless otherwise noted.
- 6. Signal Interface: None, unless otherwise noted.
- 7. Manufacturers and Products:
 - a. ABB; Series 10A4500.
 - b. Emerson Process Management Brooks; Series 1100.

E. L5 Level Element and Transmitter, Ultrasonic:

- 1. General:
 - a. Function: Continuous, noncontacting level measurement.
 - b. Type: Ultrasonic.
 - c. Parts: Element, transmitter, interconnecting cable, and accessories as noted.
- 2. Service:
 - a. Application: If and as noted.
 - b. Vapor Space Pressure: Atmospheric, unless otherwise noted.
 - c. Operating Temperature Range:
 - 1) Element: Minus 4 degrees F to plus 149 degrees F.
 - 2) Transmitter: Minus 4 degrees F to 113 degrees F.

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3. Performance:
 - a. Range: As noted.
 - b. Zero Reference: As noted.
 - c. Accuracy: Plus or minus 0.25 percent of maximum range or 6 mm, whichever is greater.
 - d. Resolution: 0.1 percent of range or 2 mm, whichever is greater.
 - e. Blanking Distance: Sensor dependent, typically 1 foot.
4. Element:
 - a. NEMA 6P waterproof.
 - b. Housing: PVDF, unless otherwise noted.
 - 1) Other materials subject to Engineer approval.
 - c. Facing: None, unless otherwise noted.
 - d. Integral Flange: If noted.
 - 1) Face: PTFE, unless otherwise noted.
 - 2) Size: As noted.
 - e. Process Connection:
 - 1) 1-inch NPT, unless otherwise noted.
 - 2) Top mounted.
 - f. Electrically Hazardous Rating:
 - 1) Class I, Div 1, Groups A, B, C, and D: If noted.
 - 2) Class II, Div 1, Groups E, F, and G: If noted.
 - 3) Other Ratings: As noted.
 - g. Beam Angle: 12 degrees or less.
 - h. Integral temperature compensation.
5. Transmitter:
 - a. Display.
 - b. Integral keypad or nonintrusive external programming.
 - c. Enclosure: NEMA 4X polycarbonate, unless otherwise noted.
 - d. Power Supply: 115 volts, 50/60-Hz, unless otherwise noted.
 - e. Isolated Analog Output:
 - 1) One Minimum: 4 mA to 20 mA dc for load impedance of 0 to 750 ohms.
 - f. Digital Communication: As noted.
 - g. Discrete Outputs:
 - 1) Minimum, two relay (SPDT) rated for 2 amps continuous at 230V ac.
 - 2) Assignable and as noted.
6. Interconnecting Cable: Weatherproof, UV protected, length as required, and type as recommended by manufacturer.
7. Accessories:
 - a. Submergence Shield: If noted.
 - b. Remote Programming Software: If noted.
 - 1) Allows remote programming via computer and echo traces for troubleshooting.
 - 2) One per lot of units furnished.

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- c. Others: As noted.
- d. If no integral keypad, furnish one handheld programmer per lot of units furnished.
- 8. Manufacturer and Product: Siemens; SITRANS L, Model HydroRanger 200 and Sensor, or equal.

F. L8 Level Switch, Float, Mercury:

- 1. General:
 - a. Function: Actuate contact at preset liquid level.
 - b. Type: Direct-acting float with enclosed mercury switch and integral cable.
- 2. Service (Liquid): Wastewater, unless otherwise noted.
- 3. Performance:
 - a. Setpoint: As noted.
 - b. Differential: 2.5 inches, maximum.
 - c. Temperature: 0 degree F to 160 degrees F.
- 4. Features:
 - a. Entire Assembly: Watertight and impact-resistant.
 - b. Float Material and Size: Polypropylene body; 4.5-inch diameter and 6-inch length.
 - c. Cable:
 - 1) Combination support and signal.
 - 2) Length as noted or as necessary per mounting requirements.
 - 3) PVC cable jacket.
 - d. Mounting: Pipe, unless otherwise noted.
 - 1) Pipe Mounting:
 - a) Cable clamp, suitable for connection to 1-inch pipe.
 - b) Pipe-to-wall bracket, suitable for connection to 1-inch pipe.
 - 2) Suspended Mounting (internal weights): If noted.
 - a) Wall mounting bracket, unless otherwise noted.
 - 3) Anchor Mounting Kit: If noted.
 - a) Compatible with pipe-mounted floats.
 - b) 15-pound vinyl-coated cast iron anchor.
 - c) 1/8-inch, Type 316 stainless steel vinyl-coated wire rope.
 - d) Stainless steel cable clips.
- 5. Signal Interface:
 - a. Switch Type: Mercury tilt.
 - b. Switch Contacts:
 - 1) Isolated, rated 4.5A continuous at 120V ac.
 - 2) Form C contact (one NO, one NC), unless otherwise noted.
- 6. Accessories: As noted.

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7. Manufacturers and Products:
 - a. Siemens Water Technologies; Model LS Direct Acting Float Switch (B100).
 - b. Anchor Scientific; Roto-Float, Type P/Type S/Type W.

G. L10 Level Transmitter, Direct Sensing, Flange Mounted:

1. General:
 - a. Function: Measure level in a process vessel.
 - b. Type:
 - 1) Capacitive differential pressure cell.
 - 2) Diaphragm for process fluid isolation.
 - 3) Flange mounting.
 - 4) Smart electronics.
 - 5) Two-wire device.
2. Service:
 - a. Process Liquid: As noted.
 - b. Process Temperature Range: Minus 20 degrees F to 400 degrees F, unless otherwise noted.
 - c. Ambient Temperature Range: Minus 40 degrees F to 250 degrees F, unless otherwise noted.
 - d. Humidity: 0 percent to 100 percent relative.
3. Performance:
 - a. Range: As noted.
 - b. Accuracy: Plus or minus 0.75 percent of span.
4. Features:
 - a. Zero Suppression or Elevation: As noted.
 - b. Damping: User-selectable; 0 second to 36 seconds time constant of analog output response to step change input.
 - c. Transmitter: Two-wire, powered from external power supply.
 - d. Zero and Span Adjustments: Local, external, noninteractive, unless otherwise noted.
 - e. Process Wetted Parts: Flanged Process Connection (Transmitter High Pressure Side):
 - 1) Flange Size/Type: 3-inch, Class 150, unless otherwise noted.
 - 2) Process Diaphragm: Type 316 stainless steel, unless otherwise noted.
 - 3) Mounting Flange: Stainless steel, unless otherwise noted.
 - 4) Mounting: Flush, unless otherwise noted.
 - 5) Extension Materials (if extension mount noted): Type 316 stainless steel, unless otherwise noted.
 - 6) Extension Length (if extension mount noted): As noted.
 - 7) Process Fill Fluid (High Pressure Side): Dow Corning Silicone 200, unless otherwise noted.

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- f. Reference Process Connection (Transmitter Low Pressure Side) Configuration (Differential, unless otherwise noted):
 - 1) Drain/Vent: Type 316 stainless steel.
 - 2) Flange Adapter: Stainless steel.
 - 3) Diaphragm Material: Type 316 stainless steel, unless otherwise noted.
 - 4) Sensor Fill Fluid (Low Pressure Side): Silicone, unless otherwise noted.
- g. O-Ring: Glass-filled TFE.
- h. Flange and Adapter Bolts: Type 316 stainless steel, unless otherwise noted.
- i. LCD Meter: If noted.
- j. Integral Transient Protection: If noted.
- 5. Signal Output Interface:
 - a. 4 mA to 20 mA dc for load impedance 0 ohm to 580 ohms minimum at 24V dc supply voltage without load adjustment.
 - b. Superimposed digital signal based on HART protocol.
- 6. Enclosure: NEMA 4X, polyurethane-covered aluminum, unless otherwise noted.
- 7. Manufacturers/Model: Emerson Process Rosemount; 3051L, Liquid Level Transmitter.

H. L41 Level Element/Transmitter, Submersible, Water:

- 1. General:
 - a. Function: Measure and transmit signal proportional to level.
 - b. Type: Totally submersible pressure sensor (loop powered).
 - c. Parts: Sensor, interconnecting cable, other parts as noted.
- 2. Service:
 - a. Fluid: Potable water, unless otherwise noted.
- 3. Performance:
 - a. Process Range:
 - 1) As noted.
 - 2) Provide fixed factory range such that noted process range is between 40 percent and 80 percent of fixed factory range.
 - b. Accuracy: 0.10 percent of full scale, unless otherwise noted.
 - c. Temperature, Operating: Minus 4 degrees F to plus 140 degrees F.
 - d. Overpressure:
 - 1) Proof: At least 1.5 times full scale.
 - 2) Burst: At least 2.0 times full scale.
 - e. Long Term Stability: Plus or minus 0.10 percent full scale/year, typical.
- 4. Features:
 - a. Sensor:
 - 1) Silicon pressure-sensing element.

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- 2) Titanium or Type 316 stainless steel pressure module assembly, unless otherwise noted.
 - a) For titanium sensor only; 5-year corrosion warranty, replace sensor if it fails due to corrosion: If noted.
- 3) NEMA 6/IP 68 rating (submersible).
- 4) Temperature compensation.
- 5) Dimensions, Nominal:
 - a) Diameter: 1 inch maximum.
 - b) Length: 10 inches maximum.
- 6) Loop powered, 9 to 30V dc.

b. Interconnecting Cable:

- 1) Length: As required.
- 2) Polyurethane sheathed, unless otherwise noted.
- 3) Kevlar strain relief cord.
- 4) Integral vent tube.

c. Sensor Termination Enclosure: Required, unless otherwise noted.

- 1) Enclosure: NEMA 4X.
- 2) Houses such noted items as desiccant vent, filter, microfilter, aneroid bellows.
- 3) 2-Inch Pipe Mounting Kit: If noted.

d. Accessories:

- 1) Aneroid Bellows: If noted.
 - a) Bellows shall be suitable for application.
- 2) Desiccant Module: Required, unless otherwise noted.
- 3) Spare Desiccant Modules: If noted.
 - a) Quantity: As noted.
- 4) Cable Hanger, Kellems Type Grip: Required, unless otherwise noted.
- 5) Lightning Protection:
 - a) Internal (protects against water lightning strike): Required, unless otherwise noted.
 - b) External (protects 4 to 20 mA dc output): Required, unless otherwise noted.

5. Signal Interface: 4 to 20 mA dc output, for load impedance of 0 ohm to 750 ohms, minimum for 24V dc supply without load adjustment.
6. Certification(s): Class 1, Div 1, Groups C and D: If noted.
7. Manufacturers (provided they can furnish the noted options):
 - a. Esterline; KPSI Series 730.
 - b. GE Sensing; Druck 1830/1835.
 - c. Viatran; Model 611.
 - d. PMC/STS (Process Measurement & Controls and Sensor Technik Sirnach AG).

I. L118 Level Switch, Float, Nonmercury, Type 1A:

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1. General:
 - a. Function: Actuate contact at preset liquid level.
 - b. Type:
 - 1) Direct-acting float with enclosed switch and integral cable.
 - 2) Mercury-free.
2. Service (Liquid): Wastewater, unless otherwise noted.
3. Performance:
 - a. Setpoint: As noted.
 - b. Differential: 3.5 inches for suspended internal weight configuration.
 - c. Temperature: 140 degrees F, maximum.
4. Features:
 - a. Entire Assembly: Watertight and impact-resistant.
 - b. Float Material and Size: Polypropylene body; 3-inch diameter and 4-1/2-inch length.
 - c. Cable:
 - 1) Combination support and signal.
 - 2) Length as noted or as necessary per mounting requirements.
 - 3) Plastic-jacketed cable.
 - d. Mounting: Pipe, unless otherwise noted.
 - 1) Pipe Mounting: Cable clamp, suitable for connection to 1-inch pipe.
 - 2) Suspended Mounting (internal weight): If noted.
 - 3) Suspended Mounting (external weight): If noted.
 - a) External Weight Material: Lead with stainless steel fasteners.
5. Signal Interface:
 - a. Switch Type: Snap-action actuated by rolling steel ball within float.
 - b. Switch Contacts:
 - 1) Isolated, rated 7A continuous at 120V ac.
 - 2) Form C contact (one NO, one NC), unless otherwise noted.
6. Accessories: As Noted.
7. Manufacturer and Product: Anchor Scientific; Eco-Float, Model G.

J. P4 Pressure Gauge:

1. General:
 - a. Function: Local pressure indication.
 - b. Type: Bourdon tube element.
2. Performance:
 - a. Scale Range: As noted.
 - b. Accuracy: Plus or minus 0.50 percent of full scale.
3. Features:

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- a. Dial: 4-1/2-inch diameter.
- b. Pointer Vibration Reduction: Required, unless otherwise noted. Use the following method.
 - 1) Liquid filled gauge front, unless otherwise noted.
 - a) Glycerine fill, unless otherwise noted.
- c. Case Material: Black thermoplastic, unless otherwise noted.
- d. Materials of Wetted Parts (including element, socket/process connection, throttling device (if specified) and secondary components):
 - 1) Stainless steel, unless otherwise noted.
 - e. Pointer: Adjustable by removing ring and window.
 - f. Window: Glass or acrylic, unless otherwise noted.
 - g. Threaded reinforced polypropylene front ring.
 - h. Case Type: Solid front with blow-out back.
- 4. Process Connection:
 - a. Mounting: Lower stem, unless otherwise noted.
 - b. Size: 1/2-inch MNPT, unless otherwise noted.
- 5. Accessories:
 - a. Throttling Device: Required, unless otherwise noted.
 - 1) Type suitable for the intended service.
 - 2) Install in gauge socket bore.
- 6. Manufacturers and Products:
 - a. Ashcroft; Duragauge Model 1259/Model, 1279/Model, 1279 PLUS!
 - b. Ametek U.S. Gauge; Solfrunt Model 19XX/1981Advantatge.
 - c. WIKA, Type 2XX.34.

K. P6 Pressure Seal, Diaphragm:

- 1. General:
 - a. Function: Isolate sensing element from process fluid.
 - b. Type:
 - 1) Diaphragm.
 - 2) Fluid filled between diaphragm and sensing element.
- 2. Service:
 - a. Pressure: Same as associated sensor.
 - b. Temperature Range: If noted.
- 3. Performance:
 - a. Pressure:
 - 1) For threaded process connections, at least 2,500 psig at 100 degrees F.
 - 2) Glycerin Fill: Suitable only for pressure (not vacuum applications).
 - b. Temperature:
 - 1) Dependent upon fill fluid.
 - a) Glycerin (food grade): Zero to 400 degrees F.

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- b) Silicone: Minus 40 degrees F to plus 600 degrees F.
- c) Silicone (food grade): Zero to 375 degrees F.
- d) Halocarbon: Minus 70 degrees F to 300 degrees F.

4. Features:

- a. Materials:
 - 1) Lower Housing: Type 316 stainless steel, unless otherwise noted.
 - 2) Diaphragm Material: Type 316 stainless steel, unless otherwise noted.
 - 3) Top Housing: Steel, unless otherwise noted.
- b. Diaphragm: Welded to upper housing, unless otherwise noted.
- c. Filling screw in upper housing.
- d. Fill Fluid:
 - 1) As noted.
 - 2) Or approved equal.
 - 3) Factory assembled and filled.
- e. Flushing Connection: 1/4-inch NPT in lower housing.
- f. Diaphragm Seal Displacement: 0.1 cubic inch, nominal.

5. Connections:

- a. Instrument: 1/2-inch female NPT, unless otherwise noted or shown.
- b. Process: 1/2-inch female NPT, unless otherwise noted or shown.

6. Manufacturers:

- a. Ashcroft; Type 201.
- b. Ametek; Mansfield and Green Division; Type SG.
- c. WIKA; Type L990.10.

L. P8 Pressure Switch, Fixed Deadband:

- 1. General:
 - a. Function: Monitor pressure.
 - b. Type: Diaphragm actuated switch.
- 2. Performance:
 - a. Setpoint:
 - 1) As noted.
 - 2) Repeatability: Plus or minus 1 percent.
 - b. Range: Noted setpoint shall fall between 20 percent and 80 percent of range.
 - c. Overpressure Proof Pressure: At least 400 percent of rated maximum static pressure.
 - d. Operating Temperature Range:
 - 1) Dependent on actuator seal materials.
 - 2) For Buna-N seal, 0 degrees F to 150 degrees F.

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3. Features:
 - a. Actuator Seal: Buna-N, unless otherwise noted.
 - b. Differential (deadband): Fixed.
 - c. Reset: Automatic, unless otherwise noted.
 - d. Mounting: Surface, unless otherwise noted.
4. Process Connection:
 - a. 1/4-inch NPT female connections, unless otherwise noted.
 - b. Materials: Nickel-plated brass, unless otherwise noted.
5. Enclosure: NEMA 4X.
6. Signal Interface:
 - a. Contact Type:
 - 1) SPDT, unless otherwise noted.
 - 2) Rated for 10 amps minimum at 120V ac.
 - b. Hermetically Sealed Switch: If noted.
7. Manufacturers and Products:
 - a. Ashcroft; Type 400, B Series.
 - b. United Electric; 400 Series.

M. P9 Pressure Transmitter:

1. General:
 - a. Function: Measure pressure and transmit signal proportional to pressure.
 - b. Type:
 - 1) Electronic variable capacitance or silicon strain gauge.
 - 2) Two-wire transmitter; "smart electronics".
 - c. Parts: Transmitter and accessories.
2. Performance:
 - a. Range: As noted.
 - 1) Select transmitter's factory upper range limit (URL) such that upper boundary of noted range is as close as possible to 80 percent of factory URL, but does not exceed it.
 - b. Accuracy: Plus or minus 0.075 percent of span, unless otherwise noted.
 - c. Ambient Operating Temperature: Minus 40 degrees F to plus 175 degrees F, with integral meter.
 - d. Process Operating Temperature: Minus 40 degrees F to plus 250 degrees F.
 - e. Humidity: 0 to 100 percent relative humidity.
 - f. Hazardous Location Certifications: If and as noted.
3. Features:
 - a. Type: Gauge pressure, unless otherwise noted.
 - b. Adjustable damping.
 - c. LCD indicator, unless otherwise noted.
 - 1) Display in either percent or engineering units, field configurable.

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- d. Wetted Metallic Parts: Type 316 stainless steel, unless otherwise noted.
 - 1) Includes drain/vent valves; process flanges and adapters, and process isolating diaphragm.
- e. Wetted O-Rings: Glass filled TFE, graphite filled PTFE, or Viton, unless otherwise noted.
- f. Bolts and Nuts (if required): Type 316 stainless steel, unless otherwise noted.
- g. Fill Fluid: Silicone, unless otherwise noted.
- 4. Process Connections:
 - a. Line Size: 1/2 inch.
 - b. Connection Type: FNPT.
 - c. Direct/remote Diaphragm Seal: If and as noted.
- 5. Signal Interface:
 - a. 4-20 mA dc output with digital signal based on HART protocol, unless otherwise noted below.
 - 1) Nominal Maximum Loop Resistance with External 24V dc Power Supply: 550 ohms.
 - b. FOUNDATION fieldbus protocol: If noted.
 - c. Profibus: If noted.
- 6. Enclosure:
 - a. Type: NEMA 4X.
 - b. Materials: Coated aluminum, unless otherwise noted.
 - c. Mounting bracket, unless otherwise noted.
 - 1) Bracket and Accessories: Stainless steel; suitable for mounting transmitter to panel or 2-inch pipe.
- 7. Accessories:
 - a. Two-valve (isolate and vent) Stainless Steel Manifold: If noted.
- 8. Manufacturers and Products:
 - a. Gauge Pressure Units:
 - 1) Rosemount; Model 3051 TG.
 - 2) Foxboro; Model IGP20.
 - 3) SMAR; LD30XM Series.
 - b. Absolute Pressure Units:
 - 1) Rosemount; Model 3051 TA.
 - 2) Foxboro; Model IAP20.
 - 3) SMAR; LD30XA Series.
 - c. Wika.

N. P15 Pressure Seal, Annular:

- 1. General:
 - a. Function:
 - 1) Sense pressure in a process line and transfer to pressure monitoring device.

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- 2) Protect attached pressure monitoring device from sludge or slurry.
- b. Type: Annular fluid-filled device that senses pressure through flexible sleeve around full pipe circumference.
2. Performance:
 - a. Operating Conditions: Suitable for line pressures up to pipe flange rating.
3. Features:
 - a. Construction:
 - 1) In-Line, 8 Inches and Smaller: Full-faced thru-bolted with outside diameter same as mating flanges, unless otherwise noted.
 - 2) In-Line, 10 Inches and Larger: Wafer style.
 - 3) Offline: Threaded, unless otherwise noted.
 - b. Materials:
 - 1) Body: Carbon steel, unless otherwise noted.
 - 2) Flanges (Where Applicable): Carbon steel, unless otherwise noted.
 - 3) Flexible Sleeve: Buna-N, unless otherwise noted.
 - 4) Fill Fluid: Ethylene glycol/water or propylene glycol, unless otherwise noted.
 - c. Factory Filled System:
 - 1) Filled and assembled with pressure monitoring device(s).
 - 2) Coordinate attached pressure monitoring device(s) with system integrator. Seal vendor's standard pressure monitoring device(s) only acceptable if it meets specification of the related pressure monitoring device.
4. Process Connections:
 - a. Mounting: In-line or offline, as noted or shown.
 - b. Pipe Size:
 - 1) In-Line: As noted or shown.
 - 2) Offline: 2 inches, unless otherwise noted.
 - c. Connections:
 - 1) In-Line, Full-Faced Through-Bolted: ASME B16.5, 150-pound flanges.
 - 2) In-Line, Wafer Style: Compatible with Classes 150/300 flange drilling.
 - 3) Offline: Female NPT Threaded, unless otherwise noted.
5. Manufacturers and Products:
 - a. Onyx.
 - b. Red Valve Company; Series 40, Series 42/742, Series 48.

C.

CONSTRUCTION

3.01 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.

3.02 SUPPLEMENT

- A. The supplement listed below, following "End of Section," is part of this Specification.
 1. Example Instrument List.

END OF SECTION

EXAMPLE INSTRUMENT LIST

Tag Number	Comp Code	Component Title	Options	P&ID	Inst. Detail	Mech/Elec	Panel Number
QL-2-51(12)[00]	M49	Selector Switch & Indicator Light Combination	None	17-I-10			FP-4-50
FIT-3-51(2) FE-3-51(2)	F20	Flow Element & Transmitter, Flume or Weir, Ultrasonic	Range: 0 to 60 mgd; Weir Size: 4 feet	17-I-10	717	6-S-4 16-E-24	
LI-3-52(2)	S10	Indicator, Switchboard	Range: 0 to 16.5 feet edgewise	17-I-10			FP-4-90
LSL-3-53(2)	L99	Level Switch, Encapsulated	Setpoint: Elev 425.5	17-I-10		16-E-24	
FIC-3-54(2)	S4	Controller, CAM, Electronic	Range: 0 to 60 mgd	17-I-10			FP-4-90
FIT-3-54(2) FE-3-54(2)	F4	Flow Element & Transmitter, Electromagnetic	Range: 0 to 60 mgd; Pipe Size: 48 inches; Scale: 0 to 60 mgd	17-I-10	701	16-E-34	
LSHH-3-58(2)	L8	Level Switch, Float Type with Integral Switch	Setpoint: Elev 403.0	17-I-10	702	16-E-34	

SECTION 04010
MANUFACTURERS' FIELD SERVICES

DESCRIPTION

1.01 SCOPE

- A. This section includes requirements for manufacturers field services associated with supplied equipment

1.02 DEFINITIONS

- A. Person-Day: One person for 8 hours within regular Contractor working hours.

1.03 SUBMITTALS

- A. Informational Submittals:

1. Training Schedule: Submit, in accordance with requirements of this specification, not less than 21 days prior to start of equipment installation and revise as necessary for acceptance.
2. Lesson Plan: Submit, in accordance with requirements of this specification, proposed lesson plan not less than 21 days prior to scheduled training and revise as necessary for acceptance.

1.04 QUALIFICATION OF MANUFACTURER'S REPRESENTATIVE

- A. Authorized representative of the manufacturer, factory trained, and experienced in the technical applications, installation, operation, and maintenance of respective equipment, subsystem, or system, with full authority by the equipment manufacturer to issue the certifications required of the manufacturer. Additional qualifications may be specified elsewhere.
- B. Representative subject to acceptance by Agency. No substitute representatives will be allowed unless prior written approval by such has been given.

MATERIALS

2.01 NOT USED

CONSTRUCTION

3.01 4010.30FULFILLMENT OF SPECIFIED MINIMUM SERVICES

- A. Furnish manufacturers' services when required by an individual specification section, to meet the requirements of this section.
- B. Where time is necessary in excess of that stated in the Specifications for manufacturers' services, or when a minimum time is not specified, the time required to perform the specified services shall be considered incidental.
- C. Schedule manufacturer' services to avoid conflict with other onsite testing or other manufacturers' onsite services.
- D. Determine, before scheduling services, that all conditions necessary to allow successful testing have been met.
- E. Only those days of service approved by Agency will be credited to fulfill the specified minimum services.
- F. When specified in individual specification sections, manufacturer's onsite services shall include:
 1. Assistance during product (system, subsystem, or component) installation to include observation, guidance, instruction of Contractor's assembly, erection, installation or application procedures.
 2. Inspection, checking, and adjustment as required for product (system, subsystem, or component) to function as warranted by manufacturer and necessary to furnish Manufacturer's Certificate of Proper Installation.
 3. Providing, on a daily basis, copies of all manufacturers' representatives field notes and data to Agency.
 4. Revisiting the Site as required to correct problems and until installation and operation are acceptable to Agency.
 5. Resolution of assembly or installation problems attributable to, or associated with, respective manufacturer's products and systems.
 6. Assistance during functional and performance testing, and facility startup and evaluation.
 7. Training of Agency's personnel in the operation and maintenance of respective product as required.
 8. Additional requirements may be specified elsewhere.

3.02 MANUFACTURER'S CERTIFICATE OF COMPLIANCE

- A. When so specified, a Manufacturer's Certificate of Compliance, a copy of which is attached to this section, shall be completed in full, signed by the entity supplying the product, material, or service, and submitted prior to shipment of product or material or the execution of the services.
- B. Agency may permit use of certain materials or assemblies prior to sampling and testing if accompanied by accepted certification of compliance.
- C. Such form shall certify that the proposed product, material, or service complies with that specified. Attach supporting reference data, affidavits, and certifications as appropriate.
- D. May reflect recent or previous test results on material or product, if acceptable to Agency.

3.03 MANUFACTURER'S CERTIFICATE OF PROPER INSTALLATION

- A. When so specified, a Manufacturer's Certificate of Proper Installation form, a copy of which is attached to this section, shall be completed and signed by the equipment manufacturer's representative.
- B. Such form shall certify that the signing party is a duly authorized representative of the manufacturer, is empowered by the manufacturer to inspect, approve, and operate their equipment and is authorized to make recommendations required to assure that the equipment is complete and operational.

3.04 TRAINING

- A. General:
 - 1. Furnish manufacturers' representatives for detailed classroom and hands-on training to Agency's personnel on operation and maintenance of specified product (system, subsystem, component) and as may be required in applicable Specifications.
 - 2. Furnish trained, articulate personnel to coordinate and expedite training, to be present during training coordination meetings with Agency.
 - 3. Manufacturer's representative shall be familiar with facility operation and maintenance requirements as well as with specified equipment.
 - 4. Furnish complete training materials, to include operation and maintenance data, and manufacturer's O&M manuals, to be retained by each trainee.

B. Training Schedule:

1. List specified equipment and systems that require training services and show:
 - a. Respective manufacturer.
 - b. Estimated dates for installation completion.
 - c. Estimated training dates.
2. Allow for multiple sessions when several shifts are involved.
3. Adjust schedule to ensure training of appropriate personnel as deemed necessary by Agency, and to allow full participation by manufacturers' representatives. Adjust schedule for interruptions in operability of equipment.

C. Lesson Plan: When manufacturer or vendor training of Agency personnel is specified, prepare a lesson plan for each required course containing the following minimum information:

1. Title and objectives.
2. Recommended attendees (e.g., managers, engineers, operators, maintenance).
3. Course description, outline of course content, and estimated class duration.
4. Format (e.g., lecture, self-study, demonstration, hands-on).
5. Instruction materials and equipment requirements.
6. Resumes of instructors providing the training.

D. Pre-startup Training:

1. Coordinate training sessions with Agency's operating personnel and manufacturers' representatives, and with submission of operation and maintenance manuals.
2. Complete at least 14 days prior to beginning of facility startup.

E. Post-startup Training: If required in Specifications, furnish and coordinate training of Agency's operating personnel by respective manufacturer's representatives.

3.05 SUPPLEMENTS

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

1. Manufacturer's Certificate of Compliance.
2. Manufacturer's Certificate of Proper Installation.

END OF SECTION

MANUFACTURER'S CERTIFICATE OF COMPLIANCE

AGENCY:

**PRODUCT, MATERIAL, OR SERVICE
SUBMITTED:**

PROJECT NAME:

PROJECT NO:

Comments: _____

I hereby certify that the above-referenced product, material, or service called for by the contract for the named project will be furnished in accordance with all applicable requirements. I further certify that the product, material, or service are of the quality specified and conform in all respects with the contract requirements, and are in the quantity shown.

Date of Execution: _____, 20____

Manufacturer: _____

Manufacturer's Authorized Representative (*print*): _____

(Authorized Signature)

MANUFACTURER'S CERTIFICATE OF PROPER INSTALLATION

AGENCY _____ EQPT SERIAL NO: _____

EQPT TAG NO: _____ EQPT/SYSTEM: _____

PROJECT NO: _____ SPEC. SECTION: _____

I hereby certify that the above-referenced equipment/system has been:

(Check Applicable)

- Installed in accordance with Manufacturer's recommendations.
- Inspected, checked, and adjusted.
- Serviced with proper initial lubricants.
- Electrical and mechanical connections meet quality and safety standards.
- All applicable safety equipment has been properly installed.
- Functional tests.
- System has been performance tested, and meets or exceeds specified performance requirements. (When complete system of one manufacturer)

Note: Attach any performance test documentation from manufacturer.

Comments: _____

I, the undersigned Manufacturer's Representative, hereby certify that I am (i) a duly authorized representative of the manufacturer, (ii) empowered by the manufacturer to inspect, approve, and operate his equipment and (iii) authorized to make recommendations required to assure that the equipment furnished by the manufacturer is complete and operational, except as may be otherwise indicated herein. I further certify that all information contained herein is true and accurate.

Date: _____,
20____

Manufacturer: _____

By Manufacturer's Authorized Representative: _____
(Authorized Signature)

**City of Bend Supplemental to the
OREGON STANDARD SPECIFICATIONS FOR CONSTRUCTION**

**SECTION 04020
AGENCY-FURNISHED PRODUCTS**

DESCRIPTION

1.01 SCOPE

A. this section provides requirements for agency furnished products

1.02 DEFINITIONS

A. Seller: The party under separate contract with Agency to furnish the products or special services specified herein.

1.03 AGENCY-FURNISHED PRODUCTS

A. (Item Description):

1. Quantity: [B: .]
2. **[C: Point of receipt: .]**
3. Estimated date of arrival: Between [E:].
4. Equipment or facility necessary for receipt and unloading of product: [F: .]
5. Estimated weight of product: [G: .]
6. Special handling or storage instructions: [H: .]

B. Parts of the Process Instrumentation and Control System (PICS) applications software programming will be performed by Engineer.

1.04 INFORMATION FURNISHED BY AGENCY

- A. Shop drawings related to Agency-furnished products will be made available for Contractor's use in performing the work under this section.
- B. Manufacturer's installation, operation, and maintenance instructions for Agency-furnished products will be made available.

1.05 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
 - a. Show layout, location, and identification of materials provided by Contractor for installation of Agency-furnished products.

- b. Include pipe, fittings, valves, specialties, hangers, supports, equipment, and required specialties.
- c. Accurately show openings in floors, walls, and other parts of structure.
- d. Provide electrical and instrumentation diagrams to indicate connecting and interconnecting electrical and control work.
- e. Submit complete list of materials to be furnished, and include data necessary to allow Agency to determine their fitness for the work.
- f. Samples: [G:]

1.06 TRANSFER OF PRODUCTS

- A. Unless indicated otherwise, items will be furnished f.o.b. the Project Site.
- B. Upon delivery, conduct with Agency a joint inspection for the purpose of identifying product, general verification of quantities, and observation of apparent condition. Such inspection will not be construed as final or as receipt of any product that, as a result of subsequent inspections and tests, are determined to be nonconforming.
- C. Damaged or incomplete products to be returned for replacement will not be unloaded, except as necessary to expedite return shipment. Agency will submit claims for transportation damage and expedite replacement of damaged, defective, or deficient items.
- D. Indicate signed acceptance of delivery on a copy of the invoice.
- E. If Contractor is not prepared to accept delivery of Agency-furnished products by either the specified Estimated Date of Arrival or such Agency-confirmed delivery date, as specified herein, associated costs incurred by Agency shall be borne by Contractor. Such costs may include, but not be limited to, demurrage, interest, insurance costs, additional administrative and engineering costs, additional factory and field technical support, additional storage and reshipping costs, cost escalation, and extended warranty costs due.

1.07 UNLOADING, STORAGE AND MAINTENANCE

- A. Subsequent to transfer, Contractor shall have complete responsibility for unloading Agency-furnished products. Unload product in accordance with manufacturers' instructions, or as specified.

**City of Bend Supplemental to the
OREGON STANDARD SPECIFICATIONS FOR CONSTRUCTION**

- B. Store, protect, and maintain product to prevent damage until final acceptance of completed work. Damage to or loss of products after date of transfer to Contractor shall be repaired to original condition, or replaced with new identical products, at the discretion of Engineer.

- C. Maintain complete inventory of all Agency-furnished products after their transfer to Contractor.

1.08 SCHEDULING AND SEQUENCING

- A. Include sequencing constraints specified herein as part of Progress Schedule.

- B. Agency will keep Contractor informed of probable delivery date changes.

- C. Agency will confirm delivery date with Contractor 10 days prior to scheduled delivery, and within 24 hours of expected delivery time.

- D. Where a preinstallation meeting is required by this Section, provide a minimum of 10 days' advance written notice to Agency of the proposed date for starting installation.

- E. Provide a minimum of 10 days notice to Agency that Agency-furnished product is ready for all special services listed herein to be furnished by Agency through its contract with seller. Contractor shall bear the cost of all damages assessed to Agency by seller resulting from delays caused by Contractor.

1.09 EXTRA MATERIALS

- A. Unless otherwise specified, Agency will take acceptance of, and be responsible for storing associated extra materials and special tools upon delivery.

1.10 PREINSTALLATION MEETING

- A. Arrange and attend a preinstallation meeting with the Agency to review general procedures, erection and installation instructions, and installation sequence.

- B. Additional meetings prior to installation may be required, as determined by Agency, to transmit Agency's installation instructions to Contractor.

MATERIALS

2.01 NOT USED

CONSTRUCTION

3.01 4020.30 INSTALLATION

- A. Install products in conformance with Agency-furnished product shop drawings and installation instructions.
- B. Provide all interconnecting structures, equipment, piping, electrical and instrumentation work, finish painting, and appurtenances to achieve a complete and functional system.
- C. Provide foundation pads for Agency-furnished products as shown. Verify exact dimensions and configuration of all pads, including penetrations, with Agency-furnished product shop drawings.
- D. Anchor Bolts:
 1. Where required, provide anchor bolts, fasteners, washers, and templates needed for installation of Agency-furnished equipment.
 2. Size and locate anchor bolts in accordance with Agency-furnished product shop drawings and installation instructions.
- E. Mechanical and electrical equipment shall be properly aligned, plumb and level, with no stresses on connecting piping or conduit.
- F. Verify direction of motor rotation before starting equipment drives.
- G. Verify operability and safety of electrical system needed to operate equipment. Check electrical system for continuity, phasing, grounding, and proper functions.
- H. Pump Installation:
 1. Level base by means of steel wedges (steel plates and steel shims). Wedge taper not greater than 1/4 inch per foot. Use double wedges to provide level bearing surface for the pump and driver base. Accomplish wedging so there is no change of level or springing of baseplate when anchor bolts are tightened.
 2. Adjust pump assemblies so driving units are properly aligned, plumb, and level with driven units and all interconnecting shafts and couplings. Do not compensate for misalignment by use of flexible couplings.

**City of Bend Supplemental to the
OREGON STANDARD SPECIFICATIONS FOR CONSTRUCTION**

3. After pump and driver have been set in position, aligned, and shimmed to proper elevation, grout space between bottom of baseplate and concrete foundation with a poured, nonshrinking grout of the proper category. Remove wedges after grout is set and pack void with grout.
4. Connect suction and discharge piping without imposing strain to pump flanges. Pump discharge and suction flexible couplings or bellows shall not be considered to compensate for misalignment.
5. Pipe pump drain(s) to hub drain or scupper.

3.02 FIELD FINISHING

- A. Products will be delivered with prime and finish coat(s) applied.
 1. Finish coat as specified in Section 09 90 00, Painting and Coating.
 2. Touch up or repair damage to coatings resulting from unloading, storage, installation, testing, and startup.
 3. If finish coats are damaged extensively after transfer, completely repaint.
 4. Touch up, repair, or complete repainting shall match color of original paint, and shall be fully compatible with applied primers and finish.

3.03 PRODUCT PROTECTION

- A. Immediately after installation, lubricate components in accordance with manufacturer's instructions.
- B. Follow manufacturer's instructions for protection and maintenance during storage, after installation but prior to testing and startup, and after startup but prior to acceptance.
- C. Furnish incidental supplies including lubricants, cleaning fluids, and similar products as needed for protecting and maintaining the Agency-furnished products.

3.04 TESTS AND INSPECTION

- A. Perform tests and inspections of installed products in accordance with requirements shown herein, Section 01 91 14, Equipment Testing and Facility Startup, and manufacturer's instructions.
 1. Functional Test: [A: .]
 2. Performance Test: [A: .]

3.05 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this Specification:

1. Agency Furnished Material, Product, or Equipment Transfer.

END OF SECTION

**City of Bend Supplemental to the
OREGON STANDARD SPECIFICATIONS FOR CONSTRUCTION**



**AGENCY FURNISHED MATERIAL, PRODUCT, OR
EQUIPMENT TRANSFER**

DATE: _____

ATTACHMENT TO DAILY LOG NO: _____

SHEET 7 OF 7

DAY: _____

PROJECT: _____ CITY PROJ: _____

DEVELOPER (IF APPLICABLE): _____

CONTRACTOR: _____

INSPECTOR: _____

THE FOLLOWING MATERIAL, PRODUCT, OR EQUIPMENT IS HEREBY TRANSFERRED FROM AGENCY TO CONTRACTOR WITH THE FOLLOWING PROVISIONS:

1. Transfer of this equipment does not relieve the Contractor of any responsibility under the Contract.
2. If, at any time, other work is necessary on the subject equipment, the Contractor will arrange with the Agency for a suitable time to perform the work.
3. The guarantee warranty period as defined in the Specifications for this Contract shall commence upon this _____ day of _____, 20____ for the equipment itemized below.

EQUIPMENT: _____

(PROVIDE DOCUMENTATION FROM EQUIPMENT MANUFACTURER REGARDING GUARANTEE WARRANTY, AS APPROPRIATE)

DESCRIPTION: *(Include Manufacturer, Serial No., Model No.'s, Location, Appurtenances)*

COMMENTS OR EXCEPTIONS: *(Note Any Required Action and Responsibility)*

City's Consultant (if any) (name & company name)

Date

Contractor's Representative

Date

Agency's Representative

Date

**City of Bend Supplemental to the
OREGON STANDARD SPECIFICATIONS FOR CONSTRUCTION**

**SECTION 04020
AGENCY-FURNISHED PRODUCTS**

DESCRIPTION

1.01 SCOPE

A. this section provides requirements for agency furnished products

1.02 DEFINITIONS

A. Seller: The party under separate contract with Agency to furnish the products or special services specified herein.

1.03 AGENCY-FURNISHED PRODUCTS

A. (Item Description):

1. Quantity: [B: .]
2. [C: Point of receipt: .]
3. Estimated date of arrival: Between [E:].
4. Equipment or facility necessary for receipt and unloading of product: [F: .]
5. Estimated weight of product: [G: .]
6. Special handling or storage instructions: [H: .]

B. Parts of the Process Instrumentation and Control System (PICS) applications software programming will be performed by Engineer.

1.04 INFORMATION FURNISHED BY AGENCY

- A. Shop drawings related to Agency-furnished products will be made available for Contractor's use in performing the work under this section.
- B. Manufacturer's installation, operation, and maintenance instructions for Agency-furnished products will be made available.

1.05 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
 - a. Show layout, location, and identification of materials provided by Contractor for installation of Agency-furnished products.

- b. Include pipe, fittings, valves, specialties, hangers, supports, equipment, and required specialties.
- c. Accurately show openings in floors, walls, and other parts of structure.
- d. Provide electrical and instrumentation diagrams to indicate connecting and interconnecting electrical and control work.
- e. Submit complete list of materials to be furnished, and include data necessary to allow Agency to determine their fitness for the work.
- f. Samples: [G:]

1.06 TRANSFER OF PRODUCTS

- A. Unless indicated otherwise, items will be furnished f.o.b. the Project Site.
- B. Upon delivery, conduct with Agency a joint inspection for the purpose of identifying product, general verification of quantities, and observation of apparent condition. Such inspection will not be construed as final or as receipt of any product that, as a result of subsequent inspections and tests, are determined to be nonconforming.
- C. Damaged or incomplete products to be returned for replacement will not be unloaded, except as necessary to expedite return shipment. Agency will submit claims for transportation damage and expedite replacement of damaged, defective, or deficient items.
- D. Indicate signed acceptance of delivery on a copy of the invoice.
- E. If Contractor is not prepared to accept delivery of Agency-furnished products by either the specified Estimated Date of Arrival or such Agency-confirmed delivery date, as specified herein, associated costs incurred by Agency shall be borne by Contractor. Such costs may include, but not be limited to, demurrage, interest, insurance costs, additional administrative and engineering costs, additional factory and field technical support, additional storage and reshipping costs, cost escalation, and extended warranty costs due.

1.07 UNLOADING, STORAGE AND MAINTENANCE

- A. Subsequent to transfer, Contractor shall have complete responsibility for unloading Agency-furnished products. Unload product in accordance with manufacturers' instructions, or as specified.

**City of Bend Supplemental to the
OREGON STANDARD SPECIFICATIONS FOR CONSTRUCTION**

- B. Store, protect, and maintain product to prevent damage until final acceptance of completed work. Damage to or loss of products after date of transfer to Contractor shall be repaired to original condition, or replaced with new identical products, at the discretion of Engineer.

- C. Maintain complete inventory of all Agency-furnished products after their transfer to Contractor.

1.08 SCHEDULING AND SEQUENCING

- A. Include sequencing constraints specified herein as part of Progress Schedule.

- B. Agency will keep Contractor informed of probable delivery date changes.

- C. Agency will confirm delivery date with Contractor 10 days prior to scheduled delivery, and within 24 hours of expected delivery time.

- D. Where a preinstallation meeting is required by this Section, provide a minimum of 10 days' advance written notice to Agency of the proposed date for starting installation.

- E. Provide a minimum of 10 days notice to Agency that Agency-furnished product is ready for all special services listed herein to be furnished by Agency through its contract with seller. Contractor shall bear the cost of all damages assessed to Agency by seller resulting from delays caused by Contractor.

1.09 EXTRA MATERIALS

- A. Unless otherwise specified, Agency will take acceptance of, and be responsible for storing associated extra materials and special tools upon delivery.

1.10 PREINSTALLATION MEETING

- A. Arrange and attend a preinstallation meeting with the Agency to review general procedures, erection and installation instructions, and installation sequence.

- B. Additional meetings prior to installation may be required, as determined by Agency, to transmit Agency's installation instructions to Contractor.

MATERIALS

2.01 NOT USED

CONSTRUCTION

3.01 4020.30 INSTALLATION

- A. Install products in conformance with Agency-furnished product shop drawings and installation instructions.
- B. Provide all interconnecting structures, equipment, piping, electrical and instrumentation work, finish painting, and appurtenances to achieve a complete and functional system.
- C. Provide foundation pads for Agency-furnished products as shown. Verify exact dimensions and configuration of all pads, including penetrations, with Agency-furnished product shop drawings.
- D. Anchor Bolts:
 1. Where required, provide anchor bolts, fasteners, washers, and templates needed for installation of Agency-furnished equipment.
 2. Size and locate anchor bolts in accordance with Agency-furnished product shop drawings and installation instructions.
- E. Mechanical and electrical equipment shall be properly aligned, plumb and level, with no stresses on connecting piping or conduit.
- F. Verify direction of motor rotation before starting equipment drives.
- G. Verify operability and safety of electrical system needed to operate equipment. Check electrical system for continuity, phasing, grounding, and proper functions.
- H. Pump Installation:
 1. Level base by means of steel wedges (steel plates and steel shims). Wedge taper not greater than 1/4 inch per foot. Use double wedges to provide level bearing surface for the pump and driver base. Accomplish wedging so there is no change of level or springing of baseplate when anchor bolts are tightened.
 2. Adjust pump assemblies so driving units are properly aligned, plumb, and level with driven units and all interconnecting shafts and couplings. Do not compensate for misalignment by use of flexible couplings.

**City of Bend Supplement to the
OREGON STANDARD SPECIFICATIONS FOR CONSTRUCTION**

3. After pump and driver have been set in position, aligned, and shimmed to proper elevation, grout space between bottom of baseplate and concrete foundation with a poured, nonshrinking grout of the proper category. Remove wedges after grout is set and pack void with grout.
4. Connect suction and discharge piping without imposing strain to pump flanges. Pump discharge and suction flexible couplings or bellows shall not be considered to compensate for misalignment.
5. Pipe pump drain(s) to hub drain or scupper.

3.02 FIELD FINISHING

- A. Products will be delivered with prime and finish coat(s) applied.
 1. Finish coat as specified in Section 09 90 00, Painting and Coating.
 2. Touch up or repair damage to coatings resulting from unloading, storage, installation, testing, and startup.
 3. If finish coats are damaged extensively after transfer, completely repaint.
 4. Touch up, repair, or complete repainting shall match color of original paint, and shall be fully compatible with applied primers and finish.

3.03 PRODUCT PROTECTION

- A. Immediately after installation, lubricate components in accordance with manufacturer's instructions.
- B. Follow manufacturer's instructions for protection and maintenance during storage, after installation but prior to testing and startup, and after startup but prior to acceptance.
- C. Furnish incidental supplies including lubricants, cleaning fluids, and similar products as needed for protecting and maintaining the Agency-furnished products.

3.04 TESTS AND INSPECTION

- A. Perform tests and inspections of installed products in accordance with requirements shown herein, Section 01 91 14, Equipment Testing and Facility Startup, and manufacturer's instructions.
 1. Functional Test: [A: .]
 2. Performance Test: [A: .]

3.05 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this Specification:

1. Agency Furnished Material, Product, or Equipment Transfer.

END OF SECTION

**City of Bend Supplemental to the
OREGON STANDARD SPECIFICATIONS FOR CONSTRUCTION**



**AGENCY FURNISHED MATERIAL, PRODUCT, OR
EQUIPMENT TRANSFER**

DATE: _____

ATTACHMENT TO DAILY LOG NO: _____

SHEET 7 OF 7

DAY: _____

PROJECT: _____ CITY PROJ: _____

DEVELOPER (IF APPLICABLE): _____

CONTRACTOR: _____

INSPECTOR: _____

THE FOLLOWING MATERIAL, PRODUCT, OR EQUIPMENT IS HEREBY TRANSFERRED FROM AGENCY TO CONTRACTOR WITH THE FOLLOWING PROVISIONS:

1. Transfer of this equipment does not relieve the Contractor of any responsibility under the Contract.
2. If, at any time, other work is necessary on the subject equipment, the Contractor will arrange with the Agency for a suitable time to perform the work.
3. The guarantee warranty period as defined in the Specifications for this Contract shall commence upon this _____ day of _____, 20 ____ for the equipment itemized below.

EQUIPMENT:

(PROVIDE DOCUMENTATION FROM EQUIPMENT MANUFACTURER REGARDING GUARANTEE WARRANTY, AS APPROPRIATE)

DESCRIPTION: *(Include Manufacturer, Serial No., Model No.'s, Location, Appurtenances)*

COMMENTS OR EXCEPTIONS: *(Note Any Required Action and Responsibility)*

City's Consultant (if any) (name & company name) _____ Date _____

Contractor's Representative _____ Date _____

Agency's Representative _____ Date _____

SECTION 04030
EQUIPMENT TESTING, FACILITY STARTUP, AND COMMISSIONING

DESCRIPTION

1.01 **SCOPE**

- A. This section describes requirements for equipment testing, facility startup, and commissioning

1.02 **PURPOSE**

- A. Applicable Projects: This document applies for projects related to design and construction of freshwater and wastewater facilities. Applicable projects are typically small in size (one or two facilities) and most often located remotely from the main multi-facility treatment plants. Examples include, but are not limited to the following:
 - 1. Freshwater pump stations.
 - 2. Reservoirs.
 - 3. System monitoring and/or control stations (pressure, flow, etc.).
 - 4. Wastewater lift stations.
 - 5. Chemical injection stations.

1.03 **DEFINITIONS**

- A. Facility: Entire Project, or an agreed-upon portion, including all of its unit processes.
- B. Functional Test: Test or tests in presence of Engineer and Agency to demonstrate that installed equipment meets manufacturer's installation, calibration, and adjustment requirements and other requirements as specified.
- C. Performance Test: Test or tests performed after any required functional test in presence of Engineer and Agency to demonstrate and confirm individual equipment meets performance requirements specified in individual sections.
- D. Process Instrumentation and Control System (PICS): The system used for process measurement (flow, level, pressure, temperature, etc), monitoring, and control. Includes field instruments, control panels, programmable logic controllers, workstations, servers, software, networks, and radio system components.
- E. Unit Process: As used in this section, a unit process is a portion of the facility that performs a specific process function, such as pumping, disinfection, and odor control. For meter vaults and small pump

stations, reservoirs, and wells, the facilities are often not subdivided into separate unit processes.

F. Facility Performance Demonstration:

1. A demonstration, conducted by Contractor, with assistance of Agency, to demonstrate and document the performance of the entire operating facility, both manually and automatically (if required), based on criteria developed in conjunction with Agency and as accepted by Engineer.
2. Such demonstration is for the purposes of (i) verifying to Agency entire facility performs as a whole, and (ii) documenting performance characteristics of completed facility for Agency's records. Neither the demonstration nor the evaluation is intended in any way to make performance of a unit process or entire facility the responsibility of Contractor, unless such performance is otherwise specified.

G. 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. P&ID: Process and Instrument Diagram.
7. PC: Personal Computer.
8. PICS: Process Instrumentation and Control System.
9. PLC: Programmable Logic Controller.
10. PMOM: Project Management Operations Manual.
11. SCADA: Supervisory Control and Data Acquisition.

1.04 REFERENCES

- A. Refer to the City of Bend PMOM for additional coordination with City of Bend standard requirements. A copy of Bend's PMOM can be provided by the City's project manager upon request.

1.05 SUBMITTALS

A. Informational Submittals:

1. PICS Integrator Statement of Qualification.
2. Facility Startup and Performance Demonstration Plan.
3. Manufacturer's Certificate of Proper Installation (provide where specified).
4. Functional and performance test results.

5. PICS Testing Related Submittals:
 - a. PICS 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.
 - b. PICS 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.
 - c. PICS 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.
6. Completed Unit Process Startup Form for each unit process.
7. Completed Facility Performance Demonstration/Certification Form.

1.06 PICS QUALITY ASSURANCE

- A. PICS Integrator Qualifications: Minimum of 5 years' experience providing, integrating, installing, and starting up similar systems as required for this Project.
- B. PICS Coordination Meetings:
 1. Engineer will schedule meetings at Site, conducted monthly, to review specific requirements of PICS work.
 2. Additional meetings will be required to coordinate installation, testing, and startup of the PICS per Section 2950 Instrumentation and Control for Process Systems.
 3. Attendees will include:
 - a. Contractor.
 - b. Agency.
 - c. PICS Subcontractor/Installer.
 - d. Engineer's Representatives.

4. Refer to Section 01 31 19, Project Meetings, for additional requirements for project meetings.
5. PICS Schedule Coordination Meeting:
 - a. Timing: Following Engineer review of PICS Schedule.
 - b. Purpose: Discuss Engineer's comments and resolve scheduling issues.

1.07 PICS SEQUENCING AND SCHEDULING

- A. 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. PICS Test Prerequisite: Associated PICS test procedures Submittals completed.
 2. PLC and HMI Shipment to Site (Prerequisites):
 - a. Approval of PICS Shop Drawings and preliminary operation and maintenance data.
 - b. PICS FDT completed.
 3. PICS Functional Test Prerequisites:
 - a. Instruments installed and wired.
 - b. Power available to all PICS components.
 - c. PLC and HMI installation complete.
 - d. Network cabling complete.
 4. PICS Performance Test Prerequisite: PICS Functional Test completed and facility started up.

1.08 FACILITY STARTUP AND PERFORMANCE DEMONSTRATION PLAN

- A. Develop a written plan, in conjunction with Agency's operations personnel; to include the following:
 1. Step-by-step instructions for startup of each unit process and the complete facility.
 2. Unit Process Startup Form (sample attached), to minimally include the following:
 - a. Description of the unit process, including equipment numbers/nomenclature of each item of equipment and all included devices.
 - b. Detailed procedure for startup of the unit process, including valves to be opened/closed, order of equipment startup, etc.
 - c. Startup requirements for each unit process, including water, power, chemicals, etc.
 - d. Space for evaluation comments.
 3. Facility Performance Demonstration/Certification Form (sample attached), to minimally include the following:
 - a. Description of unit processes included in the facility startup.
 - b. Sequence of unit process startup to achieve facility startup.

- c. Description of computerized operations, if any, included in the facility.
- d. Contractor certification facility is capable of performing its intended function(s), including fully automatic operation.
- e. Signature spaces for Contractor and Engineer.

MATERIALS

2.01 NOT USED

CONSTRUCTION

3.01 4030.30 GENERAL

- A. Facility Startup Meetings: Schedule, in accordance with requirements of Section 01 31 19, Project Meetings, to discuss test schedule, test methods, materials, chemicals and liquids required, facilities operations interface, and Agency involvement.
- B. Contractor's Testing and Startup Representative:
 - 1. Designate and furnish one or more personnel to coordinate and expedite testing and facility startup.
 - 2. Representative(s) shall be present during startup meetings and shall be available at all times during testing and startup.
 - 3. PICS Integrator shall observe PICS equipment installation to extent required in order to provide Certificates of Proper Installation.
 - 4. PICS Site representative shall supervise and coordinate onsite PICS activities.
- C. Provide temporary valves, gauges, piping, test equipment and other materials and equipment required for testing and startup.
- D. Provide Subcontractor and equipment manufacturers' staff adequate to prevent delays. Schedule ongoing work so as not to interfere with or delay testing and startup.
- E. Agency will:
 - 1. Provide water, power, chemicals, and other items as required for startup, unless otherwise indicated.
 - 2. Operate process units and facility with support of Contractor.
 - 3. Provide labor and materials as required for laboratory analyses.
 - 4. If Agency-furnished products are to be used on the Project:
 - a. Furnish assistance of manufacturer's representative(s) for Agency-furnished products, as specified in Section 01 64 00, Agency-Furnished Products.

- b. Make available spare parts, special tools, and operation and maintenance information for Agency-furnished products.

3.02 EQUIPMENT TESTING

A. Preparation:

1. Complete installation before testing.
2. Furnish qualified manufacturers' representatives, when required by individual Specification sections.
3. Obtain and submit from equipment manufacturer's representative Manufacturer's Certificate of Proper Installation Form, in accordance with Section 01 43 33, Manufacturers' Field Services, when required by individual Specification sections.
4. Equipment Test Report Form: Provide written test report for each item of equipment to be tested, to include the minimum information:
 - a. Agency/Project Name.
 - b. Equipment or item tested.
 - c. Date and time of test.
 - d. Type of test performed (Functional or Performance).
 - e. Test method.
 - f. Test conditions.
 - g. Test results.
 - h. Signature spaces for Contractor and Engineer as witness.
5. Cleaning and Checking: Prior to beginning functional testing:
 - a. Calibrate testing equipment in accordance with manufacturer's instructions.
 - b. Inspect and clean equipment, devices, connected piping, and structures to ensure they are free of foreign material.
 - c. Lubricate equipment in accordance with manufacturer's instructions.
 - d. Turn rotating equipment by hand when possible to confirm that equipment is not bound.
 - e. Open and close valves by hand and operate other devices to check for binding, interference, or improper functioning.
 - f. Check power supply to electric-powered equipment for correct voltage.
 - g. Adjust clearances and torque.
 - h. Test piping for leaks.
6. Ready-to-test determination will be by Engineer based at least on the following:
 - a. Acceptable Operation and Maintenance Data.
 - b. Notification by Contractor of equipment readiness for testing.
 - c. Receipt of Manufacturer's Certificate of Proper Installation, if so specified.

- d. Adequate completion of work adjacent to, or interfacing with, equipment to be tested, including items to be furnished by Agency.
- e. Availability and acceptability of manufacturer's representative, when specified, to assist in testing of respective equipment.
- f. Satisfactory fulfillment of other specified manufacturer's responsibilities.
- g. Equipment and electrical tagging complete.
- h. Delivery of all spare parts and special tools.

B. Functional Testing:

- 1. Conduct as specified in individual Specification sections.
- 2. Notify Agency and Engineer in writing at least 10 days prior to scheduled date of testing.
- 3. Prepare Equipment Test Report summarizing test method and results.
- 4. When, in Engineer's opinion, equipment meets functional requirements specified, such equipment will be accepted for purposes of advancing to performance testing phase, if so required by individual Specification sections. Such acceptance will be evidenced by Engineer/Agency's signature as witness on Equipment Test Report.
- 5. Special requirements for PICS Functional Testing are included in this Section.

C. Performance Testing:

- 1. Conduct as specified in individual Specification sections.
- 2. Notify Engineer and Agency in writing at least 10 days prior to scheduled date of test.
- 3. Performance testing shall not commence until equipment has been accepted by Engineer as having satisfied functional test requirements specified.
- 4. Type of fluid, gas, or solid for testing shall be as specified.
- 5. Unless otherwise indicated, furnish labor, materials, and supplies for conducting the test and taking samples and performance measurements.
- 6. Prepare Equipment Test Report summarizing test method and results.
- 7. When, in Engineer's opinion, equipment meets performance requirements specified, such equipment will be accepted as to conforming to Contract requirements. Such acceptance will be evidenced by Engineer's signature on Equipment Test Report.
- 8. Special requirements for PICS Performance Testing are included in this Section.

3.03 STARTUP OF UNIT PROCESSES

- A. Prior to unit process startup, equipment within unit process shall be accepted by Engineer as having met functional and performance testing requirements specified.
- B. Startup sequencing of unit processes shall be as chosen by Contractor to meet schedule requirements.
- C. Make adjustments, repairs, and corrections necessary to complete unit process startup.
- D. Startup shall be considered complete when, in opinion of Engineer, unit process has operated in manner intended for 5 continuous days without significant interruption. This period is in addition to functional or performance test periods specified elsewhere.
- E. Significant Interruption: May include any of the following events:
 - 1. Failure of Contractor to provide and maintain qualified onsite startup personnel as scheduled.
 - 2. Failure to meet specified functional operation for more than 2 consecutive hours.
 - 3. Failure of any critical equipment or unit process that is not satisfactorily corrected within 5 hours after failure.
 - 4. Failure of any noncritical equipment or unit process that is not satisfactorily corrected within 8 hours after failure.
 - 5. As determined by Engineer.
- F. A significant interruption will require startup then in progress to be stopped. After corrections are made, startup test period to start from beginning again.

3.04 PICS TESTING

- A. PICS Factory Testing:
 - 1. General:
 - a. Purpose: To confirm that PICS is operational before shipment to the Project Site.
 - b. Scope:
 - 1) Test each control panel to confirm the fabricator's wiring and the panel functions.
 - 2) For control panels with PLCs, include testing for each control panel to confirm the fabricator's wiring between the panel's field terminals and the individual points on PLC I/O modules.
 - 3) Test Operation of Communications:

- a) Between PLCs and remote I/O.
 - b) Between PLCs and computers.
 - c) Radio communication testing is not required.
- 4) The testing is broken into two parts: 1) Unwitnessed Factory Testing and 2) (Witnessed) Factory Demonstration Testing. The panel fabricator will complete unwitnessed factory testing to find and correct problems before executing (witnessed) factory demonstration testing to prove to the Agency's agent that the system is ready for shipment to the Project Site.
- c. Location: PICS Integrator's facility.
- d. Participation and Approvals:
 - 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.
- e. Procedures, Forms, and Checklists:
 - 1) Except for Unwitnessed Factory Test, conduct tests in accordance with, and documented on, Engineer accepted procedures, forms, and checklists.
 - 2) Describe each test item to be performed.
 - 3) Provide space after each test item description for sign off by appropriate party following satisfactory completion.
- f. Required Test Documentation: Test procedures, forms, and checklists signed by Engineer and Contractor.
- g. Conducting Tests:
 - 1) Provide special testing materials and equipment.
 - 2) Wherever possible, perform tests using actual process variables, equipment, and data.
 - 3) If not practical to test with real process variables, equipment, and data provide suitable means of simulation.
 - 4) Define simulation techniques in test procedures.
 - 5) Test Format: Cause and effect.
 - a) Person conducting test initiates an input (cause).
 - b) Specific test requirement is satisfied if correct result (effect), occurs.

2. PICS Unwitnessed Factory Test (UFT):

- a. Purpose: To find and correct problems with PICS components and systems before executing (witnessed) factory demonstration testing.
- b. Scope: Inspect and test PICS to ensure it is operational and ready for FDT.

- c. Integrated Test:
 - 1) Interconnect and test PICS, except for primary elements and smaller panels.
 - 2) Exercise and test functions.
 - 3) Provide standalone testing of smaller panels.
 - 4) Simulate inputs and outputs for primary elements, final control elements, and panels excluded from test.
- d. Correct deficiencies found and complete prior to Factory Demonstration Test.

3. PICS Factory Demonstration Tests (FDT):

- a. Notify Engineer of test schedule 2 weeks prior to start of test.
- b. Scope: Test entire PICS, with exception of primary elements, final control elements, and certain smaller panels, to demonstrate it is operational.
- c. Purpose: To prove to the Agency's agent that the system is ready for shipment to the Project Site.
- d. Tests:
 - 1) Panel Testing:
 - a) Simulate each discrete signal at terminal strip.
 - b) Simulate correctness of each analog signal using current source.
 - c) For PLC panels, execute testing with PLC software to confirm I/O wiring and software addressing
 - 2) Communications Testing: Test operation of communications between PLCs and remote I/O and between PLCs and computers.
 - 3) 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.
 - 4) Nonloop-Specific Functions:
 - a) Capacity: Demonstrate that PICS has 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.
- e. Correct deficiencies found and complete prior to shipment to Site.
- f. Failed Tests:
 - 1) Repeat and witnessed by Engineer.
 - 2) With approval of Engineer, certain tests may be conducted by PICS Integrator and witnessed by Engineer as part of PICS Functional Test.
- g. Make following documentation available to Engineer at test Site both before and during PICS FDT:
 - 1) Drawings, Specifications, Addenda, and Change Orders.
 - 2) Master copy of PICS FDT procedures.
 - 3) List of equipment to be tested including make, model, and serial number.
 - 4) Approved hardware Shop Drawings for equipment being tested.
 - 5) Approved preliminary software documentation Submittal.
- h. Daily Schedule for PICS FDT:
 - 1) Begin each day with meeting to review day's test schedule.
 - 2) End each day with each meeting to review day's test results and to review or revise next day's test schedule.

B. PICS Field Testing:

- 1. General:
 - a. Purpose: To confirm that the entire PICS, operating with actual field equipment and final control system software configuration, provides the functions defined in the design documents.
 - b. Scope:
 - 1) Includes testing of entire PICS, including but not limited to instruments, control panels, PLCs, computers (HMI workstations, servers, etc), control system software, networks, and radio communication.
 - 2) Functional Testing Major Objectives:
 - a) Check installation of PICS components and systems to make sure they are ready for operation.
 - b) Calibrate instruments.
 - c) Adjust valves.
 - d) Test Field Wiring and Software Addressing for all PLC I/O: Perform point-to-point testing for all

PLC I/O associated with the project. The testing will confirm the wiring between each field device and its associated PLC I/O module terminals using actual or simulated I/O at the field terminals and verified in the control system software.

- e) Test Communication Network Functions:
Perform testing to confirm successful network and radio communication between PICS components:
 - (1) Between PLCs and remote I/O.
 - (2) Between PLCs and computers (HMI workstations, servers, etc.).
 - (3) Between remote station and master station.
 - (4) Between remote stations.
- 3) Performance Testing Major Objectives:
 - a) Test Control System Software Functions:
Perform testing to confirm that all automated monitoring and control functions operate as intended.
 - b) Tune loops.
 - c) Make final adjustments to automated monitoring and control parameters.
- 4) For equipment not provided by PICS Integrator, but that directly interfaces with PICS, verify the following conditions:
 - a) Proper installation.
 - b) Calibration and adjustment of positioners and I/P transducers.
 - c) Correct control action.
 - d) Switch settings and dead bands.
 - e) Opening and closing speeds and travel stops.
 - f) Input and output signals.
- 5) Refer to functional testing and performance testing for specific test requirements.
- c. Required Coordination and Notification Prior to Testing:
 - 1) Coordinate PICS testing with Agency and affected Subcontractors.
 - 2) Notify Engineer of Performance Test schedule 4 weeks prior to start of test.
- d. Participation and Approvals:
 - 1) Engineer may actively participate in tests.
 - 2) Engineer reserves right to test or retest specified functions.
 - 3) Engineer's decision will be final regarding acceptability and completeness of testing.

2. Testing Sequence:

- a. Provide Functional Tests and Performance Tests for facilities as required to support staged construction and startup.
- b. Refer to Article Sequence of Work under Section 01 31 13, Project Coordination, for a definition of project milestones.
- c. Refer to Section 01 91 14, Equipment Testing, Facility Startup, and Commissioning, for overall testing requirements.
- d. Completion: When tests (except Functional Test) have been completed and required test documentation has been accepted.

3. PICS Functional Testing:

- a. Scope: Prior to Facility Startup and Performance Evaluation period for each facility, inspect, test, and document that associated PICS equipment, including control system software, is ready for operation.
- b. Required testing includes:
 - 1) Loop/Component Inspections and Tests:
 - a) These inspections and tests do not require witnessing.
 - b) Check PICS for proper installation, calibration, and adjustment on loop-by-loop and component-by-component basis.
 - c) Provide space on forms for signoff by PICS Integrator.
 - d) Use loop status report to organize and track inspection, adjustment, and calibration of each loop and include the following:
 - (1) Project name.
 - (2) Loop number.
 - (3) Tag number for each component.
 - (4) Checkoffs/Signoffs for Each Component:
 - (a) Tag/identification.
 - (b) Installation.
 - (c) Termination wiring.
 - (d) Termination tubing.
 - (e) Calibration/adjustment.
 - (5) Checkoffs/Signoffs for the Loop:
 - (a) Panel interface terminations.
 - (b) I/O interface terminations, with PLCs.
 - (6) I/O Signals for PLCs are Operational: Received/sent, processed, adjusted.
 - (7) Total loop operational.
 - (8) Space for comments.
 - e) Component calibration sheet for each active I&C component (except simple hand switches, lights,

gauges, and similar items) and each PLC I/O module and include the following:

- (1) Project name.
- (2) Loop number.
- (3) Component tag number or I/O module number.
- (4) Component code number for I&C elements.
- (5) Manufacturer for I&C elements.
- (6) Model number/serial number for I&C elements.
- (7) Summary of Functional Requirements; For Example:
 - (a) Indicators and recorders, scale and chart ranges.
 - (b) Transmitters/converters, input and output ranges.
 - (c) Computing elements' function.
 - (d) Controllers, action (direct/reverse) and control modes (P, I, D).
 - (e) Switching elements, unit range, differential (fixed/adjustable), reset (auto/manual).
 - (f) I/O Modules: Input or output.
- (8) Calibrations, for example, but not limited to:
 - (a) Analog Devices: Actual inputs and outputs at 0, 10, 50, and 100 percent of span, rising and falling.
 - (b) Discrete Devices: Actual trip points and reset points.
 - (c) Controllers: Mode settings (P&ID).
 - (d) I/O Modules: Actual inputs or outputs of 0, 10, 50, and 100 percent of span, rising and falling.
 - (e) Space for comments.
- f) Maintain loop status reports, valve adjustment sheets, and component calibration sheets at Site, and make them available to Engineer at all times.
- g) 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.
- h) Test control system software using real field sensors and equipment. Plant interlocking and communications with PLC(s) and HMI tested on loop-by-loop basis.

c. Required Test Documentation:

- 1) Test procedures, forms, and checklists. Signed by Engineer and Contractor except for Functional Test items signed only by Contractor.
 - 2) Forms: See Loop Status Report, Instrument Calibration Sheet, and I&C Valve Adjustment Sheet referenced in Article Supplements.
- d. Requirements for Test Completion:
 - 1) Functional Test has been conducted.
 - 2) Engineer has spot-checked associated test forms and checklists in field.

4. PICS Performance Testing During and After Facility Startup:

- a. Once a facility's Functional Test has been completed and that facility has been started up, perform a witnessed Performance Test on associated PICS 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.
- b. Loop-specific and nonloop-specific tests same as required for FDT except that entire installed PICS tested using actual process variables and functions demonstrated.
- c. Perform local and manual tests for each loop before proceeding to remote and automatic modes.
- d. 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 functionality. Test verification by means of disconnecting wires or measuring signal levels is acceptable only where direct operation of plant equipment is not possible.
- e. Make updated versions of documentation required for Performance Test available to Engineer at Site, both before and during tests.
- f. Make O&M data available to Engineer at Site both before and during testing.
- g. Follow daily schedule required for FDT.
- h. Determination of Ready for Operation: When Functional Test has been completed.
- i. Refer to examples of Performance Test procedures and forms in Article Supplements.

3.05 FACILITY PERFORMANCE DEMONSTRATION

- A. When, in the opinion of Engineer, startup of all unit processes has been achieved, sequence each unit process to the point that facility is operational.
- B. Demonstrate proper operation of required interfaces within and between individual unit processes.
- C. After facility is operating, complete performance testing of equipment and systems not previously tested.
- D. Document, as defined in Facility Startup and Performance Demonstration Plan, the performance of the facility including its computer system.
- E. Certify, on the Facility Performance Demonstration/Certification Form, that facility is capable of performing its intended function(s), including fully automatic and computerized operation.

3.06 MECHANICAL SYSTEM COMMISSIONING

A. Functional Test:

1. Centrifugal Pumps: As specified in individual pump specifications. If no functional test requirements are specified in pump specifications, then the following functional test shall be performed at no additional cost to Agency.
 - a. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
 - b. Flow Output: Measured by plant instrumentation and storage volumes.
 - c. Operating Temperatures: Monitor bearing areas on pump and motor for abnormally high temperatures.
 - d. Test for continuous 3-hour period.
 - e. Test Report Requirements: In accordance with Hydraulic Institute Standards for submersible pump tests HIS 1.6 and 11.6.
 - f. Vibration Test:
 - 1) Test with units installed and in normal operation, and discharging to connected piping systems at rates between low discharge head and high discharge head conditions specified, shall not develop vibration exceeding limits specified in HIS 11.6.
 - 2) If units exhibit vibration in excess of limits specified adjust as necessary. Units that cannot be adjusted or modified to conform as specified shall be replaced.
 - 3) Flow Output: Measured by existing instrumentation and storage volumes.

2. Metering Pumps:

- a. Alignment: Test complete assemblies for correct rotation (as applicable), proper alignment and connection, and quiet operation.

B. Performance Test:

1. Centrifugal Pumps:

- a. Perform under actual or approved simulated operating conditions.
- b. Test for a continuous 3-hour period without malfunction.

2. Metering Pumps:

- a. Perform under actual or approved simulated operating conditions.
- b. Test for a continuous 3-hour period without malfunction.

3.07 SUPPLEMENTS

A. The supplements listed below, following “End of Section,” are a part of this Specification:

1. Unit Process Startup Form.
2. Facility Performance Demonstration/Certification Form.
3. Loop Status Report—Example Format.
4. Instrument Calibration Sheet—Example—Analyzer/Transmitter.
5. I&C Valve Adjustment Sheet—Example.
6. Performance Test Sheet—Example.
7. Manufacturer’s Certificate of Proper Installation.

END OF SECTION

UNIT PROCESS STARTUP FORM

AGENCY: _____ PROJECT: _____

Unit Process Description: (Include description and equipment number of all equipment and devices):

Startup Procedure (Describe procedure for sequential startup and evaluation, including valves be opened/closed, order of equipment startup, etc.):

Startup Requirements (Water, power, chemicals, etc.): _____

Evaluation Comments: _____

FACILITY PERFORMANCE DEMONSTRATION/CERTIFICATION FORM

AGENCY: _____ PROJECT: _____

Unit Processes Description (List unit processes involved in facility startup):

Unit Processes Startup Sequence (Describe sequence for startup, including computerized operations, if any):

Contractor Certification that Facility is capable of performing its intended function(s), including fully automatic operation:

Contractor: _____

Date: _____, 20____

Engineer: _____
(Authorized Signature)

Date: _____, 20____

LOOP STATUS REPORT—EXAMPLE FORMAT

Rev.06.05.92

Project Name: <i>City of Bend</i>				Project No. 123456			
FUNCTIONAL REQUIREMENTS:							
<ol style="list-style-type: none"> 1. Measure, locally indicate, and transmit RAS flow to LP-10. 2. At LP-10 indicate flow and provide flow control by modulation of FCV-10-2. 3. Provide high RAS flow alarm on LP-10. 							
COMPONENT STATUS (Check and initial each item when complete)							
Tag Number	Delivered	Tag ID Checked	Installation	Termination Wiring	Termination Tubing	Calibration	
FE/FIT-10-2	Jan-12-90 DWM	Jan-12-90 DWM	Feb-7-90 DWM	Mar-5-90 DWM	N.A.	May-6-90 VDA	
FIC-10-2	Jan-12-90 DWM	Jan-12-90 DWM	Mar-5-90 DWM	Apr-4-90 DWM		May-4-90 VDA	
FSH-10-2	Jan-12-90 DWM	Jan-12-90 DWM	Mar-5-90 DWM	Apr-4-90 DWM		May-7-90 VDA	
FAH-10-2	Jan-12-90 DWM	Jan-12-90 DWM	Mar-5-90 DWM	Apr-4-90 DWM		May-7-90 VDA	
FCV-10-2	Mar-2-90 DWM	Mar-2-90 DWM	Apr-20-90 DWM	Apr-30-90 DWM		May-16-90 VDA	
REMARKS: None.							
Loop Ready for Operation	By: <i>D.W. Munzer</i>		Date: <i>May-18-90</i>		Loop No.: <i>10-2</i>		

INSTRUMENT CALIBRATION SHEET—EXAMPLE—ANALYZER/TRANSMITTER Rev.06.05.92

COMPONENT			MANUFACTURER				PROJECT					
Code: A7			Name: <i>Leeds & Northrup</i>				Number: 123456					
Name: <i>pH Element & Analyzer/Transmitter</i>			Model: 12429-3-2-1-7		Serial #: 11553322		Name: <i>City of Bend</i>					
FUNCTIONS												
Indicate? Y Record? N	RANGE	VALUE	UNITS	COMPUTING FUNCTIONS? N			CONTROL? N Action? direct / reverse Modes? P / I / D					
	Chart:			Describe:								
Transmit/ Convert? Y	Scale:	1-14	pH units				SWITCH? N Unit Range: Differential: fixed/adjustable Reset? automatic / manual					
	Input:	1-14	pH units									
ANALOG CALIBRATIONS						DISCRETE CALIBRATIONS				Note No.		
REQUIRED			AS CALIBRATED			REQUIRED		AS CALIBRATED				
Input	Indicated	Output	Increasing Input		Decreasing Input		Number	Trip Point	Reset Pt.	Trip Point	Reset Pt.	
			Indicated	Output	Indicated	Output						(note rising or falling)
1.0	1.0	4.0	1.0	4.0	1.0	3.9	1.	N.A.		N.A.		
2.3	2.3	5.6	2.2	5.5	2.3	5.6	2.					1.
7.5	7.5	12.0	7.5	11.9	7.5	12.0	3.					
12.7	12.7	18.4	12.7	18.3	12.6	18.3	4.					
14.0	14.0	20.0	14.0	20.0	14.0	20.0	5.					
CONTROL MODE SETTINGS:			P: N.A.	I:	D:		6.					
#	NOTES: 1. Need to recheck low pH calibration solutions.									Component Calibrated and Ready for Start-up		
										By: <i>J.D. Sewell</i>		
										Date: <i>Jun-6-92</i>		
										Tag No.: <i>AIT-12-6[pH]</i>		

I&C VALVE ADJUSTMENT SHEET—EXAMPLE

Rev.06.05.92

PARTS	Project Name: <i>City of Bend</i>			Project Number: 123456	
Body	Type: <i>Vee-Ball</i>			Mfr: <i>Fisher Controls</i>	
	Size: <i>4-inch</i>			Model: 1049763-2	
	Line Connection: <i>159 # ANSI Flanges</i>		Serial #: 1003220		
Operator	Type: <i>Pneumatic Diaphragm</i>			Mfr: <i>Fisher Controls</i>	
	Action: <i>Linear – Modulated</i>			Model: 4060D	
	Travel: <i>3-inch</i>			Serial #: 2007330	
Positioner	Input Signal: <i>3-15 psi</i>			Mfr: <i>Fisher Controls</i>	
	Action: <i>Direct - air to open</i>			Model: 20472T	
	Cam: <i>Equal percentage</i>			Serial #: 102010	
Pilot	Action:			Mfr:	
Solenoid	Rating: <i>None</i>			Model: Serial #:	
I/P Converter	Input: <i>4-20 mA dc</i>			Mfr: <i>Taylor</i>	
	Output: <i>3-15 psi</i>			Model: 10-T-576-3	
	Action: <i>Direct</i>			Serial #: 1057-330	
Position Switch	Settings: <i>Closed / Open 5 deg, rising</i>			Mfr: <i>National Switch</i>	
	Contacts: <i>Close / Close</i>			Model: 1049-67-3	
				Serial #: 156 & 157	
Power Supply	Type: <i>Pneumatic</i>			Air Set Mfr: <i>Air Products</i>	
	Potential: <i>40 psi</i>			Model: 3210D	
				Serial #: 1107063	
ADJUSTMENTS		Initial	Date	VERIFICATION	Initial Date
Air Set		JDS	Jun-06-92	Valve Action	JDS Jun-03-92
Positioner		JDS	Jun-06-92	Installation	JDS Jun-03-92
Position Switches		JDS	Jun-06-92	Wire Connection	JDS Jun-04-92
I/P Converter		JDS	Jun-07-92	Tube Connection	JDS Jun-04-92
Actual Speed		JDS	Jun-07-92		
REMARKS: Valve was initially installed backwards.				Valve Ready for Start-up	
<i>Observed to be correctly installed May-25-92</i>				By: <i>J.D. Sewell</i>	
				Date: <i>Jun-07-92</i>	
				Tag No.: <i>FCV-10-2-1</i>	

PERFORMANCE TEST SHEET - EXAMPLE

Rev.06.05.92

Project Name: <i>City of Bend</i>		Project No.: <i>123456</i>																												
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.																														
1. MEASURE EFFLUENT FLOW <i>1.a With no flow, water level over weir should be zero and</i> <i>FIT indicator should read zero.</i> <i>Jun-20-92 BDG</i>																														
2. FLOW INDICATION AND TRANSMISSION TO LP & CCS <i>With flow, water level and FIT indicator should be related by expression</i> $Q(MGD) = 429 \cdot H^{2/3} (2/3) \quad (H = \text{height in inches of water over weir}).$ <i>Vary H and observe that following.</i>																														
<i>2.a Reading of FIT indicator.</i>		<i>Jun-6-92 BDG</i>																												
<i>2.b Reading is transmitted to FI on LP-521-1</i> <i>BDG</i>		<i>Jun-6-92</i>																												
<i>2.c Reading is transmitted and displayed to CCS.</i> <i>BDG</i>		<i>Jun-6-92</i>																												
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%;"><i>H(measured)</i></td> <td style="width: 15%; text-align: center;">0</td> <td style="width: 15%; text-align: center;">5</td> <td style="width: 15%; text-align: center;">10</td> <td style="width: 15%; text-align: center;">15</td> </tr> <tr> <td><i>Q(computed)</i></td> <td style="text-align: center;">0</td> <td style="text-align: center;">47.96</td> <td style="text-align: center;">135.7</td> <td style="text-align: center;">251.7</td> </tr> <tr> <td><i>Q(FIT indicator)</i></td> <td style="text-align: center;">0</td> <td style="text-align: center;">48.1</td> <td style="text-align: center;">137</td> <td style="text-align: center;">253</td> </tr> <tr> <td><i>Q(LI on LP-521-1)</i></td> <td style="text-align: center;">0</td> <td style="text-align: center;">48.2</td> <td style="text-align: center;">138</td> <td style="text-align: center;">254</td> </tr> <tr> <td><i>Q(display by CCS)</i></td> <td style="text-align: center;">0</td> <td style="text-align: center;">48.1</td> <td style="text-align: center;">136.2</td> <td style="text-align: center;">252.4</td> </tr> </table>				<i>H(measured)</i>	0	5	10	15	<i>Q(computed)</i>	0	47.96	135.7	251.7	<i>Q(FIT indicator)</i>	0	48.1	137	253	<i>Q(LI on LP-521-1)</i>	0	48.2	138	254	<i>Q(display by CCS)</i>	0	48.1	136.2	252.4		
<i>H(measured)</i>	0	5	10	15																										
<i>Q(computed)</i>	0	47.96	135.7	251.7																										
<i>Q(FIT indicator)</i>	0	48.1	137	253																										
<i>Q(LI on LP-521-1)</i>	0	48.2	138	254																										
<i>Q(display by CCS)</i>	0	48.1	136.2	252.4																										
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MANUFACTURER'S CERTIFICATE OF PROPER INSTALLATION

AGENCY _____

EQPT SERIAL NO: _____

EQPT TAG NO: _____

EQPT/SYSTEM: _____

PROJECT NO: _____

SPEC. SECTION: _____

I hereby certify that the above-referenced equipment/system has been:

(Check Applicable)

Installed in accordance with Manufacturer's recommendations.

Inspected, checked, and adjusted.

Serviced with proper initial lubricants.

Electrical and mechanical connections meet quality and safety standards.

All applicable safety equipment has been properly installed.

Functional tests.

System has been performance tested, and meets or exceeds specified performance requirements. (When complete system of one manufacturer)

Note: Attach any performance test documentation from manufacturer.

Comments: _____

I, the undersigned Manufacturer's Representative, hereby certify that I am (i) a duly authorized representative of the manufacturer, (ii) empowered by the manufacturer to inspect, approve, and operate his equipment and (iii) authorized to make recommendations required to assure that the equipment furnished by the manufacturer is complete and operational, except as may be otherwise indicated herein. I further certify that all information contained herein is true and accurate.

Date: _____, 20____

Manufacturer: _____

By Manufacturer's Authorized Representative: _____
(Authorized Signature)