# CONTRACT DOCUMENTS

# AND

# SPECIFICATIONS

# FOR

# PROJECT NO. RMUA ES 2020-11 & BAMA HC21020 HAIKEY CREEK WWTP BIOSOLIDS IMPROVEMENTS FAP 25-005-L | FAP 24-0002-L | FAP 24-0016L

## ATTENDANCE AT PRE-BID CONFERENCE IS MANDATORY

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CITY OF TULSA
WATER AND SEWER
Engineering Design

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VOLUME III

**SECTION 00 01 07**
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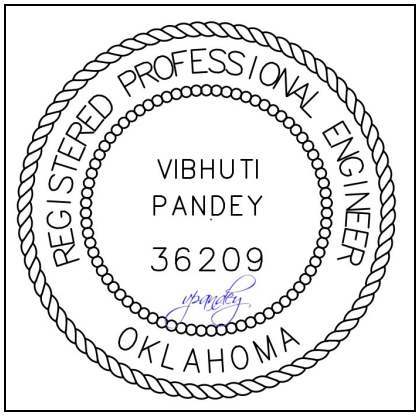
SPECIFICATIONS

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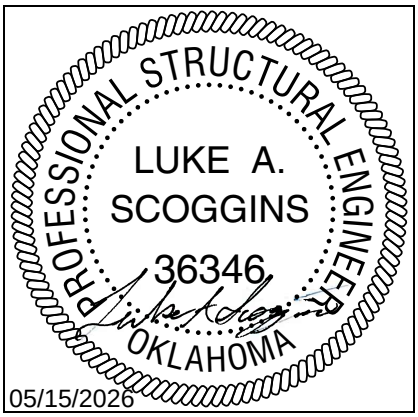


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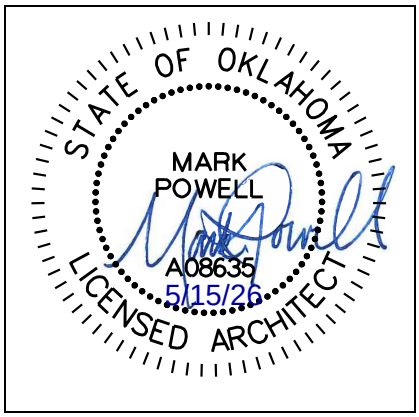


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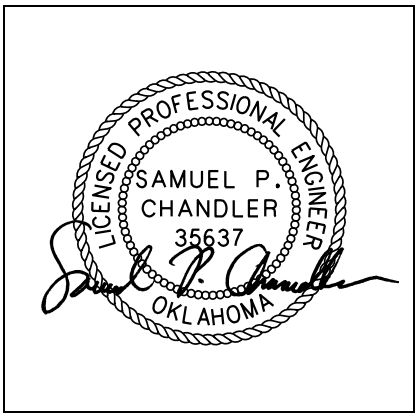


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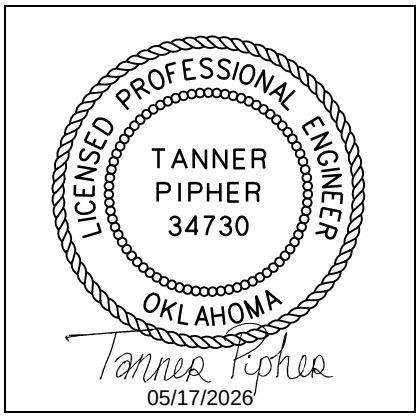


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**END OF SECTION**




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**VOLUME 5**

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# SECTION 22 07 00
# PLUMBING PIPING INSULATION

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American Society of Heating, Refrigerating & Air-Conditioning Engineers Inc. (ASHRAE): 90.1, Energy-Efficient Design of New Buildings except Low-Rise Residential Buildings.
2. ASTM International (ASTM):
   a. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   b. C533, Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
   c. C534, Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
   d. C547, Standard Specification for Mineral Fiber Pipe Insulation.
3. National Fire Protection Association (NFPA): 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.

### 1.02 SUBMITTALS

A. Action Submittals: Product description, include list of materials, thickness for each service scheduled, and locations.

B. Informational Submittals:

1. Proof of compliance for test of products for fire rating, corrosiveness, and compressive strength.
2. Manufacturer’s installation instructions.

### 1.03 QUALITY ASSURANCE

A. Provide standard, cataloged products, new and commercially available, suitable for service requiring high performance and reliability with low maintenance, and free from all defects.

B. Provide materials by firms engaged in the manufacture of insulation products of the types and characteristics specified herein, whose products have been in use for not less than 5 years.


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C. UL Listing or satisfactory certified test report from an approved testing laboratory is required to indicate fire hazard ratings for materials proposed for use do not exceed those specified.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Stamp or Label:

1. Deliver insulation, jackets, cements, adhesives and coatings with a manufacturer's stamp or label attached, giving name of manufacturer, brand, and description of material.
2. Insulation Packages and Containers: Mark "asbestos-free."

**PART 2 PRODUCTS**

2.01 GENERAL

A. Insulation Exterior: Cleanable, grease-resistant, nonflaking, and nonpeeling.

B. Conform to referenced publications and specified temperature ranges and densities in pounds per cubic foot.

C. Insulation for Fittings, Flanges, and Valves: Premolded, precut, or job-fabricated insulation of same thickness and conductivity as used on adjacent piping.

D. Fire Resistance:

1. Provide noncombustible insulation, adhesives, vapor barrier materials and other accessories, except as specified herein.
2. Use no fugitive or corrosive treatments to impart flame resistance.
3. Flame proofing treatments subject to deterioration as a result of effects of moisture or high humidity are not acceptable.
4. Fire Hazard Rating for Materials including Facings, Mastics, and Adhesives: Not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke, developed as per tests conducted in accordance with NFPA 255 methods.
5. Materials exempt from fire-resistant rating:
   a. Nylon anchors.
   b. Treated wood inserts.
6. Materials exempt from fire-resistant rating when installed in outside locations, buried, or encased in concrete:
   a. Polyurethane insulation.
   b. PVC casing.
   c. Fiberglass-reinforced plastic casing.


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## 2.02 PIPE INSULATION

A. Type P1—Fiberglass (ASTM C547, Type 1 (Minus 20 Degrees F to 500 Degrees F):

1. Fiberglass, UL-rated, preformed, sectional rigid, minimum 4 pounds per cubic foot (pcf) density, K factor 0.23 maximum at 75 degrees F mean, with factory-applied all-service jacket (ASJ) composed of reinforced kraft paper and aluminum foil laminate. Provide jacket with self-sealing lap to facilitate closing longitudinal and end joints.
2. Manufacturers and Products:
   a. CertainTeed; Preformed Pipe Insulation.
   b. Johns Manville; Micro-Lok HP-T.
   c. Owens/Corning; Fiberglas Pipe Insulation.
   d. Knauf Pipe Insulation; Crown Pipe Insulation.

B. Type P2—Calcium Silicate (ASTM C533, 1,200 Degrees F, Maximum):

1. Calcium silicate, minimum 12 pcf density, K factor 0.46 maximum at 300 degrees F mean, without factory-applied jacket.
2. Manufacturers and Products:
   a. Owens/Corning Fiberglass; Kaylo 10.
   b. Johns Manville; Thermo-12 Gold.
   c. Calsilite; 1,200-degree thermal insulation.

C. Type P3—Elastomeric (ASTM C534, Minus 40 Degrees F to 220 Degrees F):

1. Flexible, closed cell elastomeric.
2. Nominal 6 pcf density, K factor 0.27 maximum at 75 degrees F mean.
3. Water Vapor Transmission: 0.1-perm-inch, or less.
4. Manufacturers and Products:
   a. Armacell; AP Armaflex.
   b. Nomaco; K-Flex LS.

## 2.03 INSULATION FINISH SYSTEMS

A. Type F1—PVC:

1. Polyvinyl chloride (PVC) jacketing, white, for straight run piping and fitting locations, temperatures to 150 degrees F.
2. Manufacturers and Products:
   a. Johns Manville; Zeston.
   b. Ceel-Co; 550.


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B. Type F2—Paint:

1. Acrylic latex paint, white, and suitable for outdoor use.
2. Manufacturer and Product: Armstrong; WB Armaflex finish.

C. Type F3—Aluminum:

1. Aluminum Roll Jacketing: For straight run piping, wrought aluminum Alloy 3003, Alloy 5005, Alloy 1100, or Alloy 3105 to ASTM B209 with H-14 temper, minimum 0.016-inch thickness, with smooth mill finish.
2. Moisture Barrier: Provide factory-applied moisture barrier, consisting of 40-pound kraft paper with 1-mil-thick low-density polyethylene film, heat and pressure bonded to inner surface of the aluminum jacketing.
3. Fitting Covers: Material as for aluminum roll jacketing, premolded, one- or two-piece covers, which includes elbows, tee/valves, endcaps, mechanical line couplings, and specialty fittings.
4. Manufacturer and Product: RPR Products; INSUL-MATE.

## PART 3 EXECUTION

### 3.01 INSTALLATION OF INSULATION

A. Install insulation products in accordance with manufacturer’s written instructions, and in accordance with recognized industry practices.

B. Apply insulation over clean, finish painted, and dry surfaces.

C. Install insulation after piping system has been pressure tested and leaks corrected.

D. Use insulating cements, lagging adhesives, and weatherproof mastics recommended by insulation manufacturer.

E. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete the run. Do not use cut pieces of scraps abutting each other.

F. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.

G. Maintain integrity of vapor barrier jackets on pipe insulation, and protect to prevent puncture or other damage. Seal open ends of insulation with mastic. Sectionally seal butt ends of chilled water and condensate drain piping insulation at fittings with white vapor barrier coating.


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H. Cover valves, flanges, fittings, and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job-fabricated units. Finish cold pipe fittings with white vapor barrier coating and hot piping with white vinyl acrylic mastic, both reinforced with glass cloth.

I. Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise indicated.

J. Install protective metal shields and foam-glass inserts where pipe hangers bear on outside of insulation.

K. Insulate valve bodies, flanges, and pipe couplings.

L. Insulate and vapor seal hangers, supports, anchors, and other piping appurtenances that are secured directly to cold surfaces.

M. Do not insulate flexible pipe couplings and expansion joints.

N. Do not allow insulation to cover nameplates or code inspection stamps.

O. Install removable insulation sections on devices that require access for maintenance of equipment or removal, such as unions and strainer end plates.

P. Connection to Existing Piping: Cut back existing insulation to remove portion damaged by piping revisions. Install new insulation.

Q. Cold Surfaces: Provide continuous vapor seal on insulation on cold surfaces where vapor barrier jackets are used.

R. Placement:

1. Slip insulation on pipe or tubing before assembly, when practical, to avoid longitudinal seams.
2. Insulate valves and fittings with sleeved or cut pieces of same material.
3. Seal and tape joints.

S. Insulation at Hangers and Supports: Install under piping, centered at each hanger or support.

T. Vapor Barrier:

1. Provide continuous vapor barrier at joints between rigid insulation and pipe insulation.


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2. Install vapor barrier jackets with pipe hangers and supports outside jacket.
3. Do not use staples and screws to secure vapor sealed system components.

3.02 INSTALLATION OF INSULATION FINISH SYSTEMS

A. Use a continuous friction type joint to hold jacket in-place, providing positive weatherproof seal over entire length of jacket.

B. Secure circumferential joints with preformed snap straps containing weatherproof sealant.

C. On exterior piping, apply coating over insulation and vapor barrier to prevent damage when aluminum fitting covers are installed.

D. Do not use screws or rivets to fasten the fitting covers.

E. Install removable prefabricated aluminum covers on exterior flanges and unions.

F. Caulk and seal exterior joints to make watertight.

3.03 INSULATION APPLICATIONS

A. Potable Cold Water:

1. Type P3, elastomeric.
2. 1-inch thickness for all pipe sizes.

B. Non-Potable Water:

1. Type P3, elastomeric.
2. 1-inch thickness for all pipes sizes.

C. Potable Hot Water and Hot Water Return:

1. Type P1, fiberglass.
2. 1-inch thickness for all pipe sizes.

D. Roof Drain and Overflow Drain Sump:

1. Type P1, fiberglass.
2. 1-inch thickness.



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E. Pipe Hangers:

1. Type P1, Fiberglass: UL-rated, preformed rigid pipe insulation inserts of thickness equal to adjoining insulation, 10 inches in length, with factory-applied, vinyl-coated and embossed vapor barrier jacket with self-sealing lap.
2. Type P3, Elastomeric: Rigid insulation section with 9-inch long, 16-gauge galvanized steel saddle.

3.04 INSULATION FINISH APPLICATIONS

A. Piping Insulation (Concealed Areas): Factory finish.

B. Piping Insulation (Exposed to View, Indoors): Type F1, PVC.

C. Piping Insulation (Outdoors):

1. Type F2, paint (for use with Type P3, elastomeric).
2. Type F3, aluminum.

D. Apply coating of insulating cement where needed to obtain smooth and continuous appearance.

3.05 FIELD QUALITY CONTROL

A. Test factory-applied materials assembled. Field-applied materials may be tested individually.

**END OF SECTION**


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# SECTION 22 10 01
# PLUMBING PIPING AND ACCESSORIES

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American Gas Association (AGA):
   a. B109.1, Diaphragm Type Gas Displacement Meters (under 500 Cubic Feet Per Hour Capacity).
   b. B109.2, Diaphragm Type Gas Displacement Meters (500 Cubic Feet Per Hour Capacity and Over).
2. American National Standards Institute (ANSI).
3. American Public Works Association (APWA): Uniform Color Code.
4. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   b. B31.9, Building Services Piping.
5. American Society of Sanitary Engineering (ASSE):
   a. 1010, Performance Requirements for Water Hammer Arresters.
   b. 1050, Performance Requirements for Stack Air Admittance Valves for Sanitary Drainage Systems.
   c. 1051, Performance Requirements for Individual and Branch Type Air Admittance Valves for Sanitary Drainage Systems.
   d. 1070, Performance Requirements for Water Temperature Limiting Devices.
   e. 1071, Performance Requirements for Temperature Actuated Mixing Valves for Plumbed Emergency Equipment.
6. ASTM International (ASTM):
   a. A47/A47M, Standard Specification for Ferritic Malleable Iron Castings.
   b. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   c. A74, Standard Specification for Cast Iron Soil Pipe and Fittings.
   d. A105/A105M, Standard Specification for Carbon Steel Forgings for Piping Applications.
   e. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   f. A179/A179M, Standard Specification for Seamless Cold-Drawn Low-Carbon Steel Heat-Exchanger and Condenser Tubes.
   g. A181/A181M, Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.


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h. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
i. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
j. A197/A197M, Standard Specification for Cupola Malleable Iron.
k. A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
l. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
m. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
n. A518/A518M, Standard Specification for Corrosion-Resistant High-Silicon Iron Castings.
o. A536, Standard Specification for Ductile Iron Castings.
p. A563, Standard Specification for Carbon and Alloy Steel Nuts.
q. A861, Standard Specification for High-Silicon Iron Pipe and Fittings.
r. A888, Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
s. B32, Standard Specification for Solder Metal.
t. B61, Standard Specification for Steam or Valve Bronze Castings.
u. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
v. B75/B75M, Standard Specification for Seamless Copper Tube.
w. B88, Standard Specification for Seamless Copper Water Tube.
x. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.
y. B127, Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip.
z. B139/B139M, Standard Specification for Phosphor Bronze Rod, Bar, and Shapes.
aa. B164, Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire.
bb. B194, Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar.
cc. B306, Standard Specification for Copper Drainage Tube (DWV).
dd. C564, Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
ee. C1173 Standard Specification for Flexible Transition Couplings for Underground Piping Systems.


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ff. C1277, Standard Specification for Shielded Couplings Joining Hubless Cast Iron Soil Pipe and Fittings.
gg. C1460, Standard Specification for Shielded Transition Couplings for use with Dissimilar DWV Pipe and Fittings Above Ground.
hh. C1540, Standard Specification for Heavy Duty Shielded Couplings Joining Hubless Cast Iron Soil Pipe and Fittings.
ii. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
jj. D1785, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
kk. D2000, Standard Classification System for Rubber Products in Automotive Applications.
ll. D2239, Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.
mm. D2466, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
nn. D2513, Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings.
oo. D2564, Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
pp. D2683, Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
qq. D2855, Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.
rr. D3035, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
ss. D3261, Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
tt. D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
uu. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
vv. E438, Standard Specification for Glasses in Laboratory Apparatus.
ww. F656, Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings.
xx. F714, Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.
yy. F876, Standard Specification for Crosslinked Polyethylene (PEX) Tubing.


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zz. F877, Standard Specification for Crosslinked Polyethylene (PEX) Hot- and Cold-Water Distribution Systems.
aaa. F1412, Standard Specification for Polyolefin Pipe and Fittings for Corrosive Waste Drainage Systems.
bbb. F1924, Standard Specification for Plastic Mechanical Fittings for Use on Outside Diameter Controlled Polyethylene Gas Distribution Pipe and Tubing.
ccc. F1973, Standard Specification for Factory Assembled Anodeless Risers and Transition Fittings in Polyethylene (PE) and Polyamide 11 (PA11) and Polyamide 12 (PA12) Fuel Gas Distribution Systems.
ddd. F2023, Standard Test Method for Evaluating the Oxidative Resistance of Crosslinked Polyethylene (PEX) Pipe, Tubing and Systems to Hot Chlorinated Water.
eee. F2080, Standard Specification for Cold-Expansion Fittings with Metal Compression-Sleeves for Crosslinked Polyethylene (PEX) Pipe and SDR9 Polyethylene of Raised Temperature (PE-RT) Pipe.

7. American Water Works Association (AWWA):
   a. C104/A21.4, Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
   b. C110/A21.10, Standard for Ductile-Iron and Gray-Iron Fittings.
   c. C111/A21.11, Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   d. C115/A21.15, Standard for Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
   e. C151/A21.51, Standard for Ductile-Iron Pipe, Centrifugally Cast.
   f. C203, Coal-Tar Protective Coatings and Linings for Steel Water Pipelines, Enamel and Tape, Hot-Applied.
   g. C207, Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm).
   h. C505, Resilient-Seated Gate Valves for Water Supply Service.
   i. C550, Protective Interior Coatings for Valves and Hydrants.
   j. C606, Grooved and Shouldered Joints.
   k. C651, Disinfecting Water Mains.
   l. C904, Crosslinked Polyethylene (PEX) Pressure Pipe, 1/2 In. (13 mm) Through 3 In. (76 mm), for Water Service.
8. Canadian Gas Association CGA 3.11, Lever-Operated Pressure-Lubricated Plug-Type Gas Shut-Off Valves.
9. Cast Iron Soil Pipe Institute (CISPI):
   a. 301, Standard Specification for Hubless Cast Iron Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.


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b. 310, Specification for Couplings for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Strom Drain, Waste, and Vent Piping Applications.

10. CSA Group.
11. FM Global (FM).
12. International Association of Plumbing and Mechanical Officials (IAPMO).
13. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS):
    a. SP-58, Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.
    b. SP-69, Pipe Hangers And Supports - Selection And Application.
    c. SP-80, Bronze Gate, Globe, Angle, and Check Valves.
    d. SP-110, Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.
14. NSF International (NSF):
    a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
    b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
15. Plumbing and Drainage Institute (PDI): WH 201, Water Hammer Arresters Standard.
16. UL.
17. United States Department of Transportation (USDOT), 49 CFR Part 192, Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards.

## 1.02 DESIGN REQUIREMENTS

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

1. Building Service Piping: ASME B31.9, as applicable.
2. Sanitary Building Drainage and Vent Systems: ICC International Plumbing Code.

## 1.03 SUBMITTALS

A. Action Submittals:

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


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b. Anchorage and bracing drawings and data sheets, as required by Section 01 88 15, Anchorage and Bracing.

3. Isometric riser diagrams.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Changes in location of equipment or piping that affect connecting or adjacent work, before proceeding with the Work.
3. Complete list of products proposed for installation.
4. Test records produced during testing.
5. For Polyethylene (PE) Pipe:
   a. Certificates of qualification for persons to be fusing PE pipe.
   b. Experience and training record of persons to be fusing PE pipe.
   c. Testing Plan:
      1) Submit at least 15 days prior to testing; include following as a minimum:
         a) Testing dates.
         b) Piping systems and section(s) to be tested.
         c) Method of isolation.
         d) Method of conveying water from source to system being tested.
   d. Certifications of Calibration: Approved testing laboratory certificate if pressure gauge for hydrostatic test has been previously used. If pressure gauge is new, no certificate is required.
   e. Test report documentation.

## PART 2 PRODUCTS

### 2.01 GENERAL

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

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


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2.02 PIPING

A. Piping Schedule: Refer to the Drawings.

B. Piping Material: Refer to Piping Data Sheet, Article Supplements.

2.03 PIPE HANGERS AND SUPPORTS

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

2.04 INSULATION

A. As specified in Section 22 07 00, Plumbing Piping Insulation.

B. As specified in Section 23 07 00, HVAC Insulation.

2.05 VALVES

A. Refer to Section 40 27 02, Process Valves and Operators.

B. General:

1. Furnish complete with necessary operating hand wheels, chain wheels, extension stems, floor stands, worm and gear operators, operating nuts, chains, and wrenches.
2. Renewable Parts Including Discs, Packing, and Seats: Types as recommended by valve manufacturer for intended service.
3. Units shall have name of manufacturer and size of valve cast on body or bonnet or shown on a permanently attached plate in raised letters.

C. Design Features:

1. Brass and bronze components, including appurtenances in contact with water.
2. Alloys containing less than 16 percent zinc and 2 percent aluminum.
3. Alloys are of the following ASTM designations:
   a. B61, B62, B98/B98M (Alloy A, B, or D), B127, B139 (Alloy A), B164, and B194.
   b. Stainless steel Alloy 18-8 may be substituted for bronze as an option with approval of Engineer.
4. Gland Bolts on Iron Body Valves: Bronze, fitted with brass nuts.

D. Valve Operators:

1. Open by turning counterclockwise.
2. Worm and Gear Operators on Manually Operated Valves: Totally enclosed design, proportioned as to permit operation of valve under full


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operating head with maximum pull of 40 pounds on handwheel or crank.

3. Self-locking type to prevent the disc or plug from creeping.
4. Self-Locking Worm Gears:
   a. One-piece design of gear bronze material, accurately machine cut.
   b. Worm: Hardened alloy steel, with thread ground and polished.
   c. Reduction gearing shall run in a proper lubricant.
5. Galvanize handwheels.

E. Gate Valves:

1. Type V108, 4 Inches and Larger for Water and Air Services:
   a. Iron body, bronze mounted, with flanged ends, solid wedge gate with nonrising stem, and handwheel operator.
   b. Rated 125-pound SWP, 200-pound WOG.
   c. Manufacturers and Products:
      1) Crane; No. 461.
      2) Nibco; Model No. F-619.

F. Hose Valves and Hydrants:

1. HV-1, Hydrant:
   a. Sill faucet with removable T-handle, polished chrome finish, and 3/4-inch inlet and hose connection.
   b. Manufacturers and Products:
      1) Chicago; No. 387, with No. E27 vacuum breaker.
      2) Acorn; No. 8121.
2. HV-2, Wall Hydrant:
   a. Nonfreeze exposed with chrome-plated face, integral vacuum breaker, bronze casing, T-handle key, and 3/4-inch inlet and hose connection.
   b. Manufacturers and Products:
      1) J. R. Smith; Figure 5609QT, Non-Freeze.
      2) Josam; 71050 Series.

G. Ball Valves:

1. Type V300 Ball Valve 3 Inches and Smaller for General Water and Air Service:
   a. Two-piece, standard port, NPT threaded ends, bronze body and end piece, hard chrome-plated solid bronze or brass ball, RTFE seats and packing, blowout-proof stem, adjustable packing gland, zinc-coated steel hand lever operator with vinyl grip, rated 600-pound CWP, 150-pound SWP, complies with MSS SP-110.


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b. Manufacturers and Products:
1) Threaded:
a) Conbraco Apollo; 70-100.
b) Nibco; T-580-70.

H. Balancing Valves (Recirculating Hot Water):

1. Bronze, calibrated balancing type with provisions for connecting a portable differential pressure meter. Meter connections shall have built-in check valves.
2. An integral pointer shall register degree of valve opening.
3. Construct with internal seals to prevent leakage around rotating element.
4. Rated for 125 psig working pressure at maximum temperature of 250 degrees F.
5. Furnish one pressure gauge type readout meter in carrying case.
6. Furnish with preformed polyurethane insulation valve enclosure, suitable for use on hot water systems.
7. Manufacturers and Products:
a. Bell & Gossett; No. CB circuit setter.
b. TACO; Series 790.

I. Water Pressure Reducing Valves 1/2 Inch Through 2-1/2 Inches:

1. Spring controlled, with a neoprene diaphragm.
2. Sizes and Ratings:
a. PRV-1: Size to line size shown on drawings, with inlet pressure 170 psig; outlet pressure 80 psig.
3. Manufacturers and Products:
a. Fisher; Type 75.
1) Strainer not included.
b. Watts; No. LF223-S.
1) Include strainer option.

J. Type V714 Pressure-Reducing Valve 3 Inches and Larger:

1. Hydraulically operated, diaphragm actuated, pilot controlled globe valve, ductile iron body, ASME B16.1 Class 150 flanged ends, rated 250 psi, bronze or stainless steel trim, stainless steel stem, externally mounted strainers with cocks, maintains a constant downstream pressure regardless of fluctuations in flow or upstream pressure.
2. FDA approved fusion bonded epoxy lining and coating installed in accordance with AWWA C550.
3. Size: See drawings for size, with inlet pressure of 150 psig to 170 psig. Outlet pressure set at 80 psig (ADJ).


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4. Manufacturers and Products:
    a. Cla-Val; 90-01 Series.
    b. Singer; Model 106PR.

K. Manual Air Vent Valves:

1. With coin-operated air vent.
2. Manufacturers and Products:
    a. Bell & Gossett; No. 4V.
    b. Dole; No. 9.

L. Point of Use Thermostatic Mixing Valve Assembly (3/8-inch Under Sink):

1. Function: Provide tempered water at 0.5 gpm to 2.25 gpm.
2. Listed per ASSE 1070. Bronze body, lead free construction rated to 150 psig maximum inlet pressure.
3. Inlets: One each, 3/8-inch compression fittings, cold and hot water.
4. Outlet: 3/8-inch compression fittings.
5. Self-contained; no electrical requirements.
6. Performance: With 120 degrees F to 180 degrees F hot inlet and 39 degrees F to 85 degrees F cold inlet, deliver 80 degrees F to 100 degrees F at inlet pressures between 30 psig and 100 psig.
7. Set outlet at 105 degrees F maximum unless otherwise noted.
8. Manufacturers and Products:
    a. Watts; LFUSG-B-M2.
    b. Powers; LFe480.
    c. Leonard Valve; Model 170-LF.

## 2.06 MISCELLANEOUS PIPING SPECIALTIES

A. Strainers for Water Service (STR-1):

1. Iron body, Y-pattern, 125-pound rated, with screwed bronze or bolted iron cap.
    a. Screen: Heavy-gauge stainless steel or monel, 30 mesh.
    b. Manufacturers and Products:
        1) Crane; No. 988-1/2.
        2) Mueller; No. 758.

B. Vacuum Breakers 2 Inches and Smaller:

1. Angle type, as required.
2. Manufacturers:
    a. Febco.
    b. Watts.


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C. Water Hammer Arresters:

1. Materials: ASSE 1010 certified, Type L copper tube, HHPP piston with two lubricated EPDM O-rings, FDA approved lubricant, rolled piston stop, wrought copper male thread adapter.
2. Manufacturers and Products:
   a. Sioux Chief Mfg. Co., Inc.; Series 650 and Series 660.
   b. Precision Plumbing Products, Inc.

D. Water Hose:

1. Furnish 50-foot length(s) of 1-inch and 50-foot length(s) of 1-1/2-inch, EPDM black cover and EPDM tube, reinforced with two textile braids. Furnish each length with brass male and female NST hose thread couplings to fit hose nozzle(s) and hose valve(s) specified.
2. Rated minimum working pressure of 200 psi.
3. Provide at each hose valve as shown on the Drawings.
4. Manufacturers:
   a. Goodyear.
   b. Boston.

E. Hose Nozzles:

1. Furnish 1-inch and 1-1/2-inch cast brass satin finish nozzle(s) with adjustable fog, straight-stream, and shutoff features and rubber bumper. Provide nozzle(s) with female NST hose thread.
2. Provide at each hose valve as shown on the Drawings.
3. Manufacturers:
   a. Croker.
   b. Elkhart.

F. Sleeves:

1. Manufacturers and Products:
   a. J. R. Smith; Figure 1720.
   b. Josam; No. 26400.

G. Flashing Sleeves for Roof Penetrations:

1. Built-Up Bituminous Roofing: Fabricate of lead as specified in Section 07 62 00, Sheet Metal Flashing and Trim.
2. Single-Ply Membrane Roofing: Pipe seals as specified in Section 07 70 01, Roof Specialties and Accessories.


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H. Insulating Dielectric Unions and Flanges:

1. Galvanically compatible with piping to which attached and pressure ratings suitable for system working pressures.
2. Unions 2 Inches and Smaller: Screwed or solder-joint type.
3. Unions 2-1/2 Inches and Larger: Flanged type, complete with bolt insulators, dielectric gasket, bolts, and nuts.
4. Manufacturers:
   a. Epco Sales, Inc., Cleveland, OH.
   b. Capitol Insulation Unions.

I. Air Admittance Valve (AAV):

1. PVC construction with internal air check valve and insect screen.
2. Unit shall meet ASSE 1051 for fixture and branch air admittance valves.
3. Unit shall bear seal of ASSE approval.
4. Manufacturer and Product: Studor, Inc., Dunedin, Florida; Maxi-Vent (2 inches to 4 inches).

J. Joint Solder: 95-5 wire solder, ASTM B32, Grade 95 TA. Lead free, NSF certified. Do not use cored solder.

K. Pipe Joint Sealer: Compound insoluble in water or Teflon tape; approved by NFS for use in potable water.

L. Rubber Gaskets: ASTM C564.

2.07 MEASURING DEVICES

A. Thermometer:

1. Adjustable angle, organic spirit type, blue in color, with 9-inch case and scale range in degrees F, as shown.
2. Furnish with 3-1/2-inch stem length and separable NPT lead-free brass thermowell.
3. For locations above 6 feet off floor or grade.
4. Manufacturers and Product:
   a. Trerice Co.; Model BX9140304.
   b. Weksler.

B. Pressure Gauges:

1. Construction: 3-1/2-inch gauge size, 0 kPa to 690 kPa, 0 psi to 160 psi range, steel case, glass crystal, brass movement, and 1/4-inch NPT lower connection.
2. Furnish with 1/4-inch brass gauge cock.


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3. Manufacturers and Products:
   a. Ashcroft; Type 1008.
   b. Marsh; J80.
   c. Marshalltown.

## PART 3 EXECUTION

3.01 GENERAL

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

B. Install plumbing systems to meet applicable plumbing code.

C. Field Obstructions:

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

D. Sleeves:

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

E. Provide unions in piping systems at connections to equipment.

F. Provide shielded transition couplings, insulating dielectric unions and flanges between ferrous and nonferrous piping and where otherwise required for electrically insulated connection.

G. Pipe air release valves, water-lubricated bearings, and other appurtenances having water effluent with copper tubing to nearest drain.

H. Provide isolation valves and strainers at pressure regulators.


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## 3.02 INSTALLATION

A. Copper Tubing:

1. Cut tubing square and remove burrs.
2. Clean both inside of fittings and outside of tubing with steel wool and hydrochloric acid before soldering.
3. Prevent annealing of fittings and hard-drawn tubing when making connections.
4. Do not use mitered joints for elbows or notching of straight runs of pipe for tees.
5. Underground shall be pit wrapped.

B. Rigid PVC or CPVC:

1. Cut, make up, and install in accordance with pipe manufacturer's recommendations.
2. Ream, clean, and remove burrs from cut ends before joining pipe.
3. Lay in trench by snaking pipe from one side to other.
4. Offset: As recommended by manufacturer for maximum temperature variation between time of solvent welding and final use.
5. Do not lay pipe when temperature is below 40 degrees F or above 90 degrees F when exposed to direct sunlight.
6. Shield ends to be joined from direct sunlight prior to and during laying operation.
7. Use strap wrenches only for tightening threaded plastic joints. Do not over tighten fittings.

C. Water System Balancing: Provide a qualified registered engineer or firm specializing in testing and balancing to adjust domestic water system. Balance system for required water flows at each plumbing fixture, terminal device, and recirculating hot water loop.

D. Water Hammer Arresters:

1. Install in piping systems where quick closing valves are installed.
2. Size and install in accordance with PDI-WH201.
3. Shock arresters to have access panels or to be otherwise accessible.

E. Valves: Install in accordance with manufacturer's recommendations.

F. Miscellaneous Piping Specialties: Install in accordance with manufacturer's recommendations.

G. Measuring Devices: Install in accordance with manufacturer's recommendations.




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## 3.03 SANITARY AND WASTE DRAINS AND VENTS PIPING

A. Installation:

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

## 3.04 HVAC CONDENSATE PIPING

A. Set piping true and plumb.

B. Slope piping 1/8 inch per foot minimum.

## 3.05 WATER SUPPLY PIPING

A. Water supply piping includes potable and nonpotable systems as indicated.

B. Flush water piping systems clean of internal debris, clean faucet aerators, and adjust plumbing fixture valves for manufacturer’s recommended flow.

C. Do not run water piping through electrical rooms, stairwells, or immediately over or within a 3-foot horizontal clearance of electrical panels, motor starters, or environmental control panels.

D. Provide exterior water piping with minimum 2 feet of cover or install below frost line, whichever is greater.

E. Hose Valves and Hydrants: Attach handle with setscrew and provide manufacturer’s recommended gravel fill around drain hole of post hydrants.

F. Provide valve operators with position indicators, where indicated, to show position of valve disc or plug.

G. Provide bypass with globe valve for emergency throttling around each reducing valve.

H. Protect buried copper and steel pipe and fittings with a single wrap of coal-tar saturated felt in accordance with AWWA C203.


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I. Vacuum Breakers 2 Inches and Smaller: Install minimum 6 inches above flood line of equipment they serve.

J. Provide manual air vents at high points in domestic hot water system.

3.06 INSULATION

A. As specified in Section 22 07 00, Plumbing Piping Insulation.

3.07 PIPE HANGERS AND SUPPORTS

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

B. Install pre-engineered support equipment in accordance with manufacturer's recommendations.

C. Hanger Rod Sizing and Spacing for:

1. Steel Pipe:

| Pipe Size | Max. Hanger Spacing (feet) | Min. Rod Size (inches) |
|---|---|---|
| 1 inch and smaller | 6 | 1/4 |
| 1-1/4 through 2-1/2 inches | 8 | 1/4 |
| 3 and 4 inches | 10 | 3/8 |
| 6 inches | 12 | 3/8 |
| 8 inches | 12 | 1/2 |

2. Copper Pipe:
   a. Rod Size: Same as for steel pipe.
   b. Spacing: 2 feet less per size than for steel pipe, except pipe 1-1/4 inches and smaller shall be supported every 6 feet.
3. Plastic Pipe:
   a. Rod Size: Same as for steel pipe.
   b. Spacing: As recommended by manufacturer and required by applicable plumbing code for flow and temperature in pipe.
   c. No metal portion of hanger shall contact pipe directly.

D. Attach Support Rods for Horizontal Piping:

1. To steel beams with I-clamps.
2. To concrete with inserts or with flanges fastened with flush shells.
3. To wood with thickness of 2-1/2 inches or more with bolts or angle clips.



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E. Trapeze Hangers:

1. Trapeze hangers may be used in lieu of individual hangers where horizontal piping is arranged with two or more parallel lines.
2. Attach lines to horizontal with U-bolts or one-hole clamps.

F. Vertical Piping:

1. Support by channel type support system and pipe clamps on 10-foot maximum centers.
2. Copper and Plastic Piping: Isolate from channels and pipe clamps with pipe isolators.

G. Insulated Piping: Furnish galvanized protection shield and oversized hangers under insulated piping.

## 3.08 INSTALLATION—CONCRETE ENCASED

A. Where horizontal piping is encased in concrete such as a floor or equipment slab, rigidly mount pipe to rebar and subbase to prevent lateral movement, sagging, and uplifting during concrete installation and finishing. Provide at least two temporary strut supports wired to rebar and supported from the engineered fill or subbase below for each section of pipe.

B. To account for building settling where construction joints occur, or where piping leaves concrete encasements at buildings, utility trenches, vaults, slabs and other structures, provide elastomeric foam insulation wrap around the pipe at the transition point.

1. Minimum Wrap: Five pipe diameters of 1/2-inch thick insulation on each side of the transition.

C. Provide flexible piping joints to coincide with structure joints to prevent excessive pipe stress and breakage.

## 3.09 INTERIM CLEANING

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

B. Prevent accumulation of weld rod, weld spatter, pipe cuttings and filings, gravel, cleaning rags, and other foreign material within piping during fabrication and assembly.

C. Examine piping to assure removal of foreign objects prior to assembly.


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D. Conventional commercial cleaning methods of cleaning are acceptable if method and cleaning material does not corrode, deform, swell, or otherwise alter physical properties of material being cleaned.

3.10 TESTING

A. As specified in Section 40 80 01, Process Piping Leakage Testing.

3.11 CLEANING AND DISINFECTION

A. Prior to final acceptance, following assembly and testing, flush pipelines with water, except for plant process air lines and instrument air lines, and remove accumulated construction debris and other foreign matter.

B. Minimum Flushing Velocity: 2.5 feet per second.

C. Insert cone strainers in the connections to attached equipment and leave until cleaning has been accomplished.

D. Remove accumulated debris through drains 2 inches and larger or by dropping spools and valves.

E. Immediately after draining flushed lines, dry piping with compressed air.

F. Use compressed air to remove loose debris from plant process air and instrument air piping.

G. Disinfect potable water pipelines before placing in service:

1. Meet the requirements of AWWA C651, unless otherwise specified.
2. Disinfecting Mixture:
    a. A chlorine-water solution having a free chlorine residual of 40 ppm to 50 ppm.
    b. Prepare by injecting one of the following:
        1) Liquid chlorine gas-water mixture.
        2) Dry chlorine gas.
        3) Calcium or sodium hypochlorite and water mixture.
    c. Inject mixture into pipeline at a measured rate while freshwater is allowed to flow through the pipeline at a measured rate so the combined mixture of freshwater and chlorine solution or gas is of the specified strength.
    d. Apply liquid chlorine gas-water mixture by means of a chlorinating device.
    e. Feed dry chlorine gas through proper devices for regulating the rate of flow and providing effective diffusion of gas into water within pipe being treated.


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f. Chlorinating devices for feeding solutions of chlorine gas or gas itself must prevent backflow of water into chlorine cylinder.
g. Calcium Hypochlorite: If this procedure is used, first mix dry powder with water to make a thick paste, then thin to approximately a 1 percent solution (10,000 ppm chlorine).
h. Sodium Hypochlorite: If this procedure is used, dilute liquid with water to obtain a 1 percent solution.
i. The following proportions of hypochlorite to water will be required:

| Product | Quantity | Water |
|---|---|---|
| Calcium Hypochlorite[1] (65 - 70 percent C1) | 1 lb | 7.5 gal |
| Sodium Hypochlorite[2] (5.25 percent C1) | 1 gal | 4.25 gal |
| [1]Comparable to commercial products known as HTH, Perchloron, and Pittchlor.<br>[2]Known as liquid laundry bleach, Clorox, and Purex. | | |

H. Point of Application:

1. Inject chlorine mixture into pipeline to be treated at the beginning of the line through a corporation stop or suitable tap in the top of pipeline.
2. Control clean water from existing system or another source so it flows slowly into newly installed piping during chlorine application.
3. Manipulate valves so the strong chlorine solution in the line being treated will not flow back into line supplying the water. Use check valves, if necessary.

I. Retention Period:

1. Retain treated water in pipeline for a minimum of 24 hours or long enough to destroy nonspore-forming bacteria.
2. At the end of the retention period, the disinfecting mixture shall have strength of at least 10 ppm of chlorine.
3. Operate valves, hydrants, and other appurtenances during disinfection to assure disinfecting mixture is dispersed into all parts of the pipeline including dead ends, new services, and similar areas that otherwise may not receive the disinfecting solution.
4. Do not place concentrated quantities of commercial disinfectants in pipeline before filling with water.
5. After chlorination, flush water from permanent source of supply until water through pipeline is equal chemically and bacteriologically to permanent source of supply.


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J. Disposal of Disinfecting Water:

1. Dispose of disinfecting water in accordance with permits and regulations. Protect the public and receiving waters from harmful or toxic concentrations of chlorine.
2. Do not allow disinfecting water to flow into a waterway without adequate dilution or other satisfactory method of reducing chlorine concentrations to a safe level.

3.12 CORROSION PROTECTION

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

3.13 PROTECTION OF INSTALLED WORK

A. Protective Covers:

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

3.14 FIELD FINISHING

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

3.15 PIPING IDENTIFICATION

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

3.16 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Plumbing Piping Data Sheet.

| Section Number | Title |
|---|---|
| 22 10 01.02 | Polyvinyl Chloride Drain Waste and Vent (PVC-DWV) Pipe and Fittings |

**END OF SECTION**




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**SECTION 22 10 01.02**
**POLYVINYL CHLORIDE**
**DRAIN WASTE AND VENT (PVC-DWV)**
**PIPE AND FITTINGS**

| Item | Size | Description |
|---|---|---|
| Pipe and Fittings | All | PVC-DWV Schedule 40 nonpressure application, Class 12454B conforming to ASTM D2665 and ANSI/NSF Standard 14 system. |
| Joints | All | Solvent cemented conforming to ASTM D2855 except where connection to equipment may require future removal. |
| Solvent Cement | All | As recommended by the pipe and fitting manufacturer conforming to ASTM D2564. |

**END OF SECTION**


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# SECTION 22 30 00
# PLUMBING EQUIPMENT

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American Gas Association (AGA).
2. American Society of Heating, Refrigerating & Air-Conditioning Engineers, Inc. (ASHRAE): 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
3. American Society of Mechanical Engineer's (ASME).
4. American Society of Sanitary Engineering (ASSE):
   a. 1013, Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Fire Protection Backflow Preventers.
   b. 1015, Performance Requirements for Double Check Backflow Prevention Assemblies and Double Check Backflow Fire Protection Assemblies.
5. American Water Works Association (AWWA):
   a. C510, Double Check Valve Backflow Prevention Assembly.
   b. C511, Reduced-Pressure Principle Backflow Prevention Assembly.
   c. C550, Protective Interior Coatings for Valves and Hydrants.
6. ASTM International (ASTM):
   a. A48/A48M, Standard Specification for Gray Iron Castings.
   b. D4101, Standard Specification for Polypropylene Injection and Extrusion Materials.
7. Canadian Standards Association (CSA):
   a. B64.4, Backflow Preventers, Reduced Pressure Principle Type (RP).
   b. B64.5, Backflow Preventers, Double Check Valve Type (DCVA).
8. FM Global (FM).
9. Food and Drug Administration (FDA).
10. Foundation for Cross-Connection Control and Hydraulic Research at University of Southern California (FCCHR): Manual of Cross-Connection Control.
11. International Code Council (ICC): International Plumbing Code (IPC).
12. National Electrical Code (NEC).
13. National Electrical Manufacturers Association, (NEMA): MG 1, Motors and Generators.


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14. NSF International (NSF):
    a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
    b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
15. UL.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer’s product data.
2. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals: Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.

1.03 SPECIAL GUARANTEE

A. Where note below, provide manufacturer’s extended guarantee in writing with Owner named as beneficiary. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of products found defective during the stated period after date of Substantial Completion.

**PART 2 PRODUCTS**

2.01 GENERAL

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

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


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## 2.02 WATER HEATERS

A. Electric Water Heater (Residential):

1. Description:
   a. Operating temperature of 140 degrees F.
   b. automatic, vertical, electric storage type.
   c. Regulatory Compliance: UL listed, ASHRAE 90.1.
   d. Tank: steel, glass-lined, 150 psig working pressure.
   e. Insulation: foam or fiberglass type with minimum R value per ASHRAE 90.1.
   f. Thermal Trap: factory installed on inlet and outlet.
   g. Dip Tube: required on inlet connection down to bottom section of tank.
   h. Anode: heavy-duty, tank-mounted screw-in type.
   i. Pressure/Temperature Relief Valve: ASME rated.
   j. Connections: inlet and outlet with factory-installed dielectric unions and brass drain valve with hose thread.
   k. Heating Elements: Upper and lower low-watt-density (maximum of 75 watts per square inch) incoloy sheath; immersion type.
   l. Guarantee: 5 years.
2. Capacity: See data sheet at end of section.
3. Manufacturers:
   a. AO Smith.
   b. Bradford White Corporation.
   c. Lochinvar Corporation.

## 2.03 DOMESTIC WATER EXPANSION TANK

A. Description:

1. Type: Prepressurized diaphragm type, horizontal or vertical per expansion tank data sheet at end of section.
2. Shell: Welded steel.
3. Diaphragm: FDA-approved, heavy-duty butyl with polypropylene liner.
4. Connection Size: Per expansion tank data sheet at end of section.
5. Maximum Operating Pressure: Per expansion tank data sheet at end of section.
6. Maximum Operating Temperature: Per expansion tank data sheet at end of section.
7. Finish: Manufacturer’s standard air-dry enamel.

B. Capacity: See data sheet at end of section.

C. Manufacturer: AMTROL, Inc.; Model AST.


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## 2.04 DOMESTIC HOT WATER CIRCULATING PUMP

A. Description:

1. Type: In-line, direct-drive, close-coupled centrifugal pump.
2. Construction: Bronze body, stainless steel face plate, glass-filled noryl impeller, carbon steel shaft, mechanical carbon on ceramic seals, and bronze oil lubricated motor bearings.
3. Motor: Permanent split-capacitor with thermal overload protection.
4. Accessories: Aquastat and automatic timer kit.

B. Capacity: See data sheet at end of section.

C. Manufacturers:

1. Bell & Gossett.
2. Taco, Inc.
3. Grundfos Pump Corporation.

## 2.05 BACKFLOW PREVENTERS

A. Double Check Backflow Preventer (3/4 Inch Through 2 Inches):

1. Description:
   a. Regulatory Compliance: AWWA C510, CSA B64.5, FCCHR of USC Section 10, ASSE 1015, ICC (IPC).
   b. Valve Body: Bronze.
   c. End Connections: Threaded, NPT.
   d. Maximum Working Pressure: 175 psi (350 psi test).
   e. Temperature Range: 32 degrees F to 140 degrees F.
   f. Shutoff Valve: Full port, resilient seated, bronze ball valve with bronze ball valve test cock.
   g. Inlet Strainer: Bronze wye strainer, 40-mesh perforated, Type 304 stainless steel.
2. Sizes: See data sheet at end of section.
3. Manufacturers and Products:
   a. Febco; Model 850.
   b. Watts Regulator Company; Model 709.

B. Double Check Backflow Preventer (2-1/2 Inches Through 10 Inches):

1. Description:
   a. Regulatory Compliance: AWWA C510, CSA B64.5, FCCHR of USC Section 10, ASSE 1015, ICC (IPC).
   b. Valve Body: Ductile or cast iron, Class 125, epoxy-coated (FDA approved).



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c. End Connections: Flanged.
d. Maximum Working Pressure: 175 psi (350 psi test).
e. Temperature Range: 32 degrees F to 140 degrees F.
f. Shutoff Valve: Nonrising stem, resilient seated gate valve with bronze ball valve test cock.
g. Inlet Strainer: Cast-iron wye strainer, Class 125 flanged, fusion epoxy AWWA C550 coated, perforated stainless steel screen (1/16-inch perforations on 2-1/2 inches to 4 inches; 1/8-inch perforation on 6 inches to 10 inches), threaded cap plug blowout opening.

2. Sizes: See data sheet at end of section.
3. Manufacturers and Products:
   a. Febco; Model 850.
   b. Watts Regulator Company; Model 709.

C. Reduced Pressure Backflow Preventers (2-1/2 Inches Through 10 Inches):

1. Description:
   a. Regulatory Compliance: AWWA C511, CSA B64.4, FCCHR of USC Section 10, ASSE 1013, IAPMO (UPC), SBCCI.
   b. Valve Body: Ductile or cast iron, Class 125, epoxy-coated (FDA-approved).
   c. End Connections: Flanged.
   d. Maximum Working Pressure: 175 psi (350 psi test).
   e. Temperature Range: 32 degrees F to 140 degrees F.
   f. Shutoff Valve: non-rising stem, resilient seated gate valve with bronze ball valve test cock.
   g. Accessories: drain line air gap fitting.
2. Flood protection:
   a. Watts Cellular Gateway.
   b. Two flood sensor activation modules.
   c. 24V power.
3. Sizes: See data sheet at end of this section.
4. Manufacturers and Products:
   a. Febco; Model 860.
   b. Watts; Model 909.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. Install, arrange, and connect equipment as shown on the Drawings and in accordance with manufacturer’s recommendations.


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3.02 FIELD QUALITY CONTROL

A. Pumps: Do not hydrostatic test pumps with mechanical seals.

B. Startup:

1. In accordance with Section 01 91 14, Equipment Testing and Facility Startup, and Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.
2. Piping Systems: Verify that flushing, cleaning, and testing has been completed prior to startup.

3.03 SUPPLEMENTS

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

1. Electric Water Heater (Residential) Data Sheet.
2. Domestic Water Expansion Tank Data Sheet.
3. Domestic Hot Water Circulating Pump Data Sheet.
4. Backflow Preventers Data Sheet.

**END OF SECTION**




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| Electric Water Heater (Residential) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Tag Number** | **Storage Capacity (gallons)** | **Upper Element (kW)** | **Lower Element (kW)** | **Simultaneous Element Operation** | **Power** | **Diameter (inches)** | **Height (inches)** | **Manufacturer and Model No.** |
| H095-COM1-HWH-01 | 51 | 4 | 4 | No | 480V/3ph | 26.5 | 36 | AO Smith; Model DEL-50 |
| H090-DEW1-HWH-01 | 38 | 4 | 4 | No | 480V/3ph | 23 | 32 | AO Smith; Model DEL-40 |
| Notes:<br>1. Maximum element wattage of 3.0 kW for 120V and 6.0 kW for 240V units. | | | | | | | | |


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| Domestic Water Expansion Tank | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Tag Number** | **Facility Served** | **Configuration (horiz/vert)** | **Total Volume (gallons)** | **Acceptance Volume (gallons)** | **Air Pre-charge (psi)** | **Diameter (inches)** | **Height (inches)** | **Manufacturer, Model No.** |
| ET01 | DEW1 | Vertical | 2.1 | 0.9 | 12 | 10 | 9 | Amtrol; Model AST-5 |
| ET01 | COM1 | Vertical | 4.7 | 2.4 | 12 | 12 | 12 | Amtrol; Model AST-12 |


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| Domestic Hot Water Circulating Pump | | | | | |
|---|---|---|---|---|---|
| **Tag Number** | **Flow Rate (gpm)** | **Pressure (feet head)** | **Motor (hp)** | **Power (volts/phase)** | **Manufacturer, Model No.** |
| H095-COM1-RCP-01 | 10 | 10 | 1/12 | 120V/1ph | Bell & Gossett; Model LR-15B |


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| Backflow Preventers | | | | | | |
|---|---|---|---|---|---|---|
| **Tag Number** | **Valve Type[1]** | **Size (inches)** | **Flow Stream** | **Maximum Operating Flow (gpm)** | **Maximum Pressure Drop (psi)** | **Manufacturer, Model No.** |
| H095-COM1-BFL-01 | DC | 2 | W1 | 75 | 6 | Febco; Model 825Y |
| H090-DEW1-BFL-01 | DC | 1-1/2 | W1 | 45 | 6 | Febco; Model 850 |
| H090-DEW1-BFL-02 | RP | 6 | W2 | 1200 | 11 | Febco; Model 825Y |
| H090-DEW1-BFL-03 | RP | 6 | W2 | 1200 | 11 | Febco; Model 825Y |
| H090-DEW2-BFL-01 | RP | 2 | W1 | 75 | 6 | Febco; Model 825Y |

Notes:

1. Valve Type: RP - Reduced Pressure, DC - Double Check.

2. Flow Streams: DIW - Deionized Water, FP - Fire Protection, IRR - Irrigation Water, LCW - Laboratory Cold Water, TWS - Tempered Water Supply, W1 - Potable Water, W2 - Nonpotable Water, W3 - Plant Water.


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# SECTION 22 40 00
# PLUMBING FIXTURES

## PART 1 GENERAL

### 1.01 REFERENCES

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

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

### 1.02 SUBMITTALS

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

### 1.03 REGULATORY REQUIREMENTS

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

## PART 2 PRODUCTS

### 2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the


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Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

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

2.02 MANUFACTURERS

A. Fixture Trim:

1. Supply Stops and Traps:
   a. McGuire.
   b. American Standard.
   c. Kohler.
2. Flush Valves: Sloan.
3. Water Closet Seats:
   a. Bemis.
   b. Church.
   c. Olsonite.
4. Lavatory Supply, Tailpiece, and Trap Insulation:
   a. McGuire.
   b. Trap Wrap.
   c. Truebro.

B. Plumbing Fixtures:

1. Water Closets, Lavatories, and Urinals:
   a. American Standard.
   b. Kohler.
   c. Eljer.
2. Service Sinks:
   a. Kohler.
   b. Eljer.
3. Faucet Fittings:
   a. Sinks:
      1) Chicago.
      2) T&S Brass.
   b. Lavatories:
      1) Chicago.
      2) Symmons.
4. Shower Trim:
   a. Symmons.
   b. Powers.



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5. Shower Stalls:
   a. Aqua Glass.
   b. Fixture Manufacturers.
6. Mop Sinks:
   a. Stern-Williams.
   b. Fiat Products Inc.
   c. Fixture Manufacturers.
7. Drinking Fountains and Electric Water Coolers:
   a. Elkay.
   b. Haws.
   c. Western.
8. Wash Fountains:
   a. Bradly.
   b. Acorn.
   c. Intersan.
   d. Willoughby.

C. Drainage Products:

1. General:
   a. Smith.
   b. Wade.
   c. Zurn.

D. Plumbing Specialties:

1. Shock Arresters:
   a. Smith.
   b. Sioux Chief.
   c. Precision Plumbing Products.
2. Trap Primers:
   a. Precision Plumbing Products.
   b. Smith.
   c. Wade.
3. Pressure/Temperature Relief Valves:
   a. Cash-Acme.
   b. Kunkle Valve.
   c. Watts.
4. Pressure Gauges:
   a. Ashcroft.
   b. Marsh.
   c. Marshalltown.
5. Thermometers:
   a. Trerice.
   b. Weksler.


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6. Automatic Washer Supplies:
    a. Guy Gray.
    b. Symmons.

2.03 GENERAL

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

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

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

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

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

2.04 MATERIALS

A. Fixture Trim:

1. Supply Stop:
    a. Flexible supply with heavy cast brass, loose key, 1/2-inch IPS by 3/8-inch outside diameter tubing angle stop to wall with escutcheon plate; chrome-plated finish.
    b. Provide stop with stuffing box.
    c. Manufacturer: McGuire Manufacturing Company, Inc.
2. Trap:
    a. Chrome-plated, 17-gauge, semicast P-trap with compression ring cast brass waste and vent connection and cleanout.
    b. 1-1/2 inches for lavatories and drinking fountains.
    c. 1-1/2 inches for sinks.
    d. Manufacturer: McGuire Manufacturing Company, Inc.
3. Water Closet and Urinal Flush Valves: Sloan Valve Co., Royal Continental, low flush, quiet action with screwdriver stop and vacuum breaker.

B. Plumbing Fixtures:

1. EWC-1, Electric Water Cooler (ADA Compliant, Dual Height):
    a. Finish: No. 4 satin finish stainless steel round receptors, back panel, and grille.
    b. Valve: Front pushbutton operated with automatic stream regulation.
    c. Trim: Screwdriver stop, strainer, and P-trap with cleanout.
    d. Cooler: NonCFC, air-cooled.


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e. Mount: Wall mounting can.
f. Manufacturer and Product: Haws Drinking Faucet Co.; Model H1011.8.

2. LAV-1, Lavatory (Wall-Hung Type, ADA Compliant):
   a. Fixture: 20 inches by 18 inches, vitreous china, for floor-mounted concealed arm carrier, three-hole punched on 4-inch centers for faucet additional hole for soap dispenser. American Standard Companies, Inc.; Lucerne, Model 0355.012.
   b. Faucet: Chicago Faucet Co.; Model 2200-4CP with 0.5-gpm flow restricter.
   c. Trim: 3/8-inch supply stop with loose key, 17-gauge chrome-plated cast brass P-trap.
   d. Insulation: McGuire Manufacturing Company, Inc.; Prowrap antimicrobial PVC resin seamless insulation for trap, tailpiece, and hot and cold water supply piping.
   e. Strainer: McGuire Manufacturing Company, Inc.; Model 155A chrome-plated grid strainer with tailpiece.
   f. Carrier: Jay R. Smith Mfg. Co.; 700 series concealed arm.
3. MS-1, Mop Sink (Floor Mounted):
   a. Fixture: Molded stone, corner set, 24 inches by 24 inches by 12 inches deep with stainless steel bumper guard, back panels and chrome-plated brass drain. Stern-Williams Co. Inc.; Model SBC-1700-BP.
   b. Faucet: Chicago Faucet Co.; Model 835-CP, exposed top supplies with hose threads, vacuum breaker, and rod support. Faucet mounted 36 inches above finish floor.
   c. Accessories: Stern-Williams Co. Inc.; Model T-35 hose and T-40 stainless steel mop hanger.
4. S-1, Sink (Counter, Stainless Steel, Double Compartment):
   a. Fixture: 21 inches by 33 inches overall by 8 inches deep, 18-gauge, Type 304 stainless steel, three-hole punch, self-rimming, undercoated, ledge-type. Just Mfg. Co.; Model DL-2133-A-GR.
   b. Faucet: Chicago Faucet Co.; Model 1201A, double handle.
   c. Trim: 1-1/2-inch outside diameter, 17-gauge chrome-plated cast tailpiece and cast brass P-trap with cleanout, and 1/2-inch wall supply stop with loose key.
   d. Strainer: Just Mfg. Co.; Model J-35, stainless steel crumb-type.
   e. Disposer: IES (In-Sink-Erator); Model 77, 3/4 horsepower, stainless steel.
5. SH-1, Shower (Trim Only, ADA Compliant):
   a. Showerhead: Sloan Valve Co.; Model AC-11-B-2.5, with 2.5-gpm flow restricter.


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b. Hand Spray: 2.5-gpm flow restricter, 60-inch flexible stainless steel hose with in-line vacuum breaker, quick disconnect, and 24-inch chrome-plated glide bar.
c. Mixing Valve: Powers Process Control; Model L425E-1-5-Y-W-QD, thermostatic-type.
d. Trim: Inlet strainer, check, integral stop, temperature limit stop, two wall hooks, and diverter valve.

6. SSK-1, Service Sink (Trim Only):
   a. Faucet: Chicago Faucet Co.; Model 835-CP, exposed top supplies, with hose threads, vacuum breaker, and rod support.
   b. Accessories: Kohler; Model K-6673, 3-inch trap standard with grid strainer.
7. WC-1, Water Closet (Flush Valve, Wall-Hung Type):
   a. Fixture: Vitreous china, siphon jet action, top spud, elongated bowl. American Standard Companies, Inc.; Afwall EL 1.6, Model 2257.103;
   b. Trim: Sloan Valve Co.; Royal Continental, Model 111-1 ES-S, 1.6 gallon per flush with 24-volt infrared sensor, Model EL-1500-L; 24-volt solenoid operator and 120 volt/24 volt, UL listed transformer, Model EL-154.
   c. Seat: Olsonite Corp.; 10-CC-SS; white open front.
   d. Carrier: Jay R. Smith Mfg. Co.; Model 200/400, commercial type.
8. WC-2, Water Closet (Flush Valve, Wall-Hung Type, ADA Compliant): Same as WC-1 but mounted for handicap access with flush valve handle pointed to wide side of stall enclosure and meeting ADA requirements.

C. Drainage Products:

1. FCO-1, Floor Cleanout (Finished Areas):
   a. Material: Tapered thread, bronze plug with round adjustable scoriated secured nickel bronze top.
   b. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 4103S.
2. FCO-2, Floor Cleanout (Unfinished Areas):
   a. Material: Tapered thread, bronze plug with round adjustable scoriated secured cast-iron top.
   b. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 4243S.
3. FD-1, Floor Drain (Finished Areas):
   a. Materials: Cast-iron body, adjustable nickel bronze strainer.
   b. Options: Jay R. Smith Mfg. Co.; Model 2696, trap primer connection, vandalproof screws.
   c. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 2005T-U-round.


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4. FD-2, Floor Drain (Unfinished Areas, General Drainage):
   a. Materials: Cast-iron body and grate.
   b. Options: Sediment bucket, Jay R. Smith Mfg. Co.; Model 2696, trap primer connection, vandalproof screws.
   c. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 2210T-U.
5. WCO, Wall Cleanout:
   a. Material: Stainless steel cover and screw.
   b. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 4472.
6. DCO-1, Double Cleanout: Use FCO-2 for the construction of double cleanout.

D. Hose Valves: Refer to Section 22 10 01, Plumbing Piping and Accessories.

E. Plumbing Specialties:

1. TP-1, Trap Priming Valve:
   a. Materials: Cast bronze, line pressure drop activated, antisiphon port, 1/2-inch connection.
   b. Manufacturer and Product: Precision Plumbing Products, Inc.; Model P-1 trap priming valve and Model DU-4, distribution unit.
2. TP-2, Trap Priming Valve:
   a. Materials: Cast bronze, line pressure drop activated, antisiphon port, 1/2-inch connection.
   b. Manufacturer and Product: Jay R. Smith Mfg. Co.; Figure 2699.
3. TP-3, Trap Priming Valve:
   a. Materials: Lead Free Brass, line pressure drop activated, antisiphon ports, 1/2-inch connection.
   b. Manufacturer and Product: Jay R. Smith Mfg. Co.; Figure 2694.
4. Pressure/Temperature Relief Valve:
   a. Materials: ASME/AGA rated, bronze body construction, vacuum relief valve vent in drain, backup emergency safety fuse plug, tamper-resistant bonnet screws, test lever, short thermostat, and automatic reseating.
   b. Manufacturer and Product: Watts Industries, Inc.; Series 40.
5. Pressure Gauge:
   a. Materials: 3-1/2-inch gauge size, 0 to 160 psi range, steel case, glass crystal, brass movement, and 1/3-inch NPT lower connection.
   b. Manufacturer and Product: Ashcroft Dresser Instrument Division, Dresser Industries, Inc.; Type 1008.


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6. Thermometer:
   a. Materials: Adjustable angle, red reading mercury type with 9-inch case and 30 degrees F to 180 degrees F range, 3-1/2-inch aluminum stem, and separate NPT brass thermowell.
   b. Manufacturer and Product: H.O. Trerice Co.; Model A005.
7. WS-1, Automatic Washer Supply:
   a. Materials: Recessed box with 2-inch drain connection, single lever shutoff with 1/2-inch hot and cold water connections, and with shock arresters on both hot and cold water supplies.
   b. Manufacturer and Product: Guy Gray Manufacturing Co. Specialty Products; Model WB-200HA.

F. Sealant: In accordance with Section 07 92 00, Joint Sealants.

## PART 3 EXECUTION

### 3.01 PREPARATION

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

### 3.02 INSTALLATION

A. Fixture Trim: Install fixture trim where applicable on fixtures.

B. Plumbing Fixtures, Mounting Heights:

1. Standard rough-in catalogued heights, unless shown otherwise on the Drawings.
2. Caulk fixtures in contact with finished walls with waterproof, white, nonhardening sealant which will not crack, shrink, or change color with age. See Section 07 92 00, Joint Sealants.

C. Exact fixture location and mounting arrangement shall be as indicated on toilet room elevations and details as shown on the Drawings.

D. Unless noted otherwise and as a minimum, fixtures shall be supported as indicated in PDI Code Guide 302.

E. Drainage Products:

1. Floor Drains: Set top flush with floor. Provide membrane clamps where required.



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2. Cleanouts: Install where shown or required for purposes intended. Set cover flush with finished floor.
3. Hub Drains: Set top of hub 2 inches above finished floor.

F. Plumbing Specialties:

1. Drain P-Trap Priming:
   a. Pipe: Type K, soft copper.
   b. Trap and prime floor drains and hub drains, unless shown otherwise on the Drawings. No attempt has been made to show trap primer valve locations or trap primer pipe routing.
   c. Field route trap primer piping during installation of floor drains and hub drains, and install trap primer valves in mechanical rooms, janitor rooms, or other locations acceptable to Engineer.
   d. Priming System: Complete with connection to serving W1 cold water system.
2. Trap Priming Valves:
   a. Floor drain traps primed with priming valves, 1/2-inch copper to floor drain.
   b. Two traps maximum primed from one priming valve or as recommended by manufacturer. Locate in mechanical spaces or janitor’s rooms and as indicated on the Drawings.
   c. Provide shutoff valve ahead of priming valves.
3. Thermometers and Pressure Gauges:
   a. Arrange devices to facilitate use and observation.
   b. Install in orientation that will allow clear observation from ground level.
   c. Provide pressure gauges with block valves.
   d. Install thermometers in thermowells.

G. Caulk penetrations of exterior walls with weatherproof sealant in accordance with Section 07 92 00, Joint Sealants.

H. Adjust water flows in domestic water systems for reasonable water flows at each plumbing fixture, terminal device, and recirculation loop. Flush valve fixtures shall be adjusted for proper flush cycle time and water quantity.

## 3.03 FIELD QUALITY CONTROL

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


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B. Notify Owner and Engineer 48 hours prior to shower testing. Owner and Engineer reserve the right to witness all tempered water and safety shower testing.

C. Verify alarm operation both locally and systemwide. Notify security prior to test if alarm is connected systemwide.

**END OF SECTION**


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

## PART 1 GENERAL

### 1.01 SCOPE OF WORK

A. The following applies to all HVAC systems including the Dewatering Building, Composting Facilities, Sludge Mixing Building, and RAS/WAS Facilities.

B. The specification applies to the odor control systems in the Dewatering Building and Composting Facilities, unless otherwise noted.

1. The balancing narrative for the Dewatering Building odor control (H090-DEW1-OFC01 system) can be found in Section 23 31 13.05, Process Ductwork.

### 1.02 REFERENCES

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

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

### 1.03 SUBMITTALS

A. Informational Submittals:

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


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5. Balancing Log Report following completion of system adjustments including test results, adjustments, and rebalancing procedures.

1.04 QUALITY ASSURANCE

A. Air Balancing and Test Agency Qualifications:

1. Certification by AABC of NEBB for testing, adjusting and balancing of HVAC systems.
2. Corporately and financially independent organization functioning as an unbiased testing authority.
3. Professionally independent of manufacturers, suppliers, and installers of HVAC equipment being tested.
4. Have a proven record of at least five similar projects.
5. Employer of engineers and technicians regularly engaged in testing, adjusting and balancing of HVAC equipment and systems.

## PART 2 PRODUCTS

2.01 MATERIALS

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

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

C. Drives for Belt-Driven Fans:

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

## PART 3 EXECUTION

3.01 GENERAL

A. Adjust and balance air and water systems in accordance with standard procedures and recognized practices of the AABC or SMACNA.
B. Adjust and balance the following systems:
1. Supply, return and exhaust air systems.
2. Heating, cooling, dehumidification/glycol, condenser, and heat recovery water systems.


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## 3.02 ADJUSTING AND BALANCING AIR SIDE

A. Preparation:

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

B. General:

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

C. Equipment Data:

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

D. Fan Systems:

1. Measure fan system performance in accordance with AMCA 203.
2. In each system at least one airpath from fan to final branch duct termination shall have dampers fully open. Achieve final air quantities by adjusting fan speed.


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3. Adjust Fan Air Volumes:
    a. Adjust fan speeds and motor drives for required equipment air volumes, with allowable variation of plus 10 percent minus 0 percent.
    b. After final adjustments, do not operate motor above nameplate amperage on any phase.
    c. After final adjustments, do not operate fan above maximum rated speed.
    d. Perform airflow test readings under simulated or actual conditions of full cooling, full heating, minimum outside air, full outside air and exhaust, and full return air.
    e. Provide and make drive and belt changes on motors or fans as required to adjust equipment to specified conditions. Drives shall be able to deliver 150 percent of motor horsepower. Provide written notice to air handling unit manufacturer and Engineer if drive or belt changes were made.
4. Adjust outside air dampers, return air dampers, relief air dampers, exhaust air dampers, and motorized louvers for maximum and minimum air requirements.
5. Read and record static pressures at unit inlet and discharge, each filter set, coils, dampers, plenums, and mixing dual-duct or adjustable-volume boxes, on every supply, return, and exhaust fan for each test condition.
6. Read and record motor amperage on all phases for each test condition.

E. Air Outlets and Inlets:

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

F. Building Static Pressure:

1. Measure building static pressure relative to outside in perimeter entrances during normal system conditions that would yield widest range in internal building pressure.
2. Adjust building static pressure control parameters to ensure perimeter entrances are positive to outdoors by 0.10-inch WC with entrance doors closed.


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3. For multi-story buildings, test pressure conditions at ground, intermediate, and upper levels.

G. Zone Differential Pressure:

1. Test and adjust differential pressures by setting design flows to meet required flow direction and pressure differential during worst case conditions of systems serving zone being adjusted and of adjacent zones.
2. Zone differentials for this Project include:
   a. Process Area: Positive, 0.100-inch WC.
   b. Restroom: Negative, 0.100-inch WC.
3. Provide written notice to Engineer of zone leakage conditions preventing design differential requirements to be met.

3.03 FIELD QUALITY CONTROL

A. General: Perform functional tests as required by Section 01 91 14, Equipment Testing and Facility Startup.

B. Performance Testing:

1. Electric Heating Coil Testing:
   a. Adjust system as required to achieve full output from coil.
   b. Read and record amperages and voltages for all phases.

C. Balancing Log Report Requirements:

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


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D. Quality Control Verification:

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

**END OF SECTION**


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# SECTION 23 07 00
# HVAC INSULATION

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American Society of Heating, Refrigerating & Air-Conditioning Engineers Inc. (ASHRAE): 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
2. Association of the Nonwoven Fabric Industry (INDA). IST 80.6, Water Resistance (Hydrostatic Pressure).
3. ASTM International (ASTM):
    a. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
    b. C547, Standard Specification for Mineral Fiber Pipe Insulation.
    c. C553, Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
    d. C1071, Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
    e. C1139, Standard Specification for Fibrous Glass Thermal Insulation for Sound Absorbing Blanket and Board for Military Applications.
    f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
    g. G21, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
    h. G22, Standard Practice for Determining Resistance of Plastics to Bacteria.
4. National Fire Protection Association (NFPA):
    a. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
    b. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
    c. 259, Standard Test Method for Potential Heat of Building Materials.
5. UL.


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1.02 DEFINITIONS

A. Cold Air Ductwork: Designed to convey mechanically cooled air or return ducts in such systems.

B. Warm Air Ductwork: Designed to convey mechanically heated air or return ducts in such systems.

1.03 SUBMITTALS

A. Action Submittals: Product description, list of materials and thickness for each service or equipment scheduled, locations, and manufacturer's installation instructions.

B. Informational Submittals:

1. Proof of compliance for test of products for fire rating, corrosiveness, and compressive strength.
2. Operation and maintenance data as specified in Section 01 78 23, Operation and Maintenance Data.

1.04 QUALITY ASSURANCE

A. Materials furnished under this specification shall be standard, cataloged products, new and commercially available, suitable for service requiring high performance and reliability with low maintenance, and free from all defects.

B. Provide materials by firms engaged in the manufacture of insulation products of the types and characteristics specified herein, whose products have been in use for not less than 5 years.

C. UL listing or satisfactory certified test report from an approved testing laboratory is required to indicate fire hazard ratings for materials proposed for use do not exceed those specified.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Stamp or Label:

1. Every package or standard container of insulation, jackets, cements, adhesives and coatings delivered to Project Site for use must have manufacturer's stamp or label attached, giving name of manufacturer, brand, and description of material.
2. Insulation Packages and Containers: Marked "asbestos-free."



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## PART 2 PRODUCTS

2.01 GENERAL

A. Insulation Exterior: Cleanable, grease-resistant, nonflaking, and nonpeeling.

B. Insulation: Conform to referenced publications and specified temperature ranges and densities in pounds per cubic foot.

C. Insulation for Fittings, Flanges, and Valves: Premolded, precut, or job-fabricated insulation of same thickness and conductivity as used on adjacent piping.

D. Fire Resistance:

1. Insulation, Adhesives, Vapor Barrier Materials and Other Accessories, Except as Specified Herein: Noncombustible.
2. Do not use fugitive or corrosive treatments to impart flame resistance.
3. Flame proofing treatments subject to deterioration resulting from the effects of moisture or high humidity are not acceptable.
4. Provide materials including facings, mastics, and adhesives, with fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke, developed as per tests conducted in accordance with ASTM E84 (NFPA 255) methods.

E. Materials exempt from fire-resistant rating:

1. Nylon anchors.
2. Treated wood inserts.

F. Materials exempt from fire-resistant rating when installed in outside locations, buried, or encased in concrete:

1. Polyurethane insulation.
2. PVC casing.
3. Fiberglass-reinforced plastic casing.

2.02 PIPE INSULATION

A. Type P1—Fiberglass (ASTM C547, Type 1 Minus 20 Degrees F to 500 Degrees F):

1. Fiberglass, UL-rated, preformed, sectional rigid, minimum 4 pounds per cubic foot (pcf) density, K factor 0.23 maximum at 75 degrees F mean, with factory-applied all-service jacket (ASJ).


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2. All-service Jacket:
    a. Composed of reinforced kraft paper and aluminum foil laminate.
    b. Provide self-sealing lap to facilitate closing longitudinal and end joints.
3. Manufacturers and Products:
    a. CertainTeed; Preformed Pipe Insulation.
    b. Johns Manville; Micro-Lok HP.
    c. Owens/Corning; Fiberglas Pipe Insulation.
    d. Knauf; Crown Pipe Insulation.

B. Type P2—Elastomeric (ASTM C534, Minus 40 Degrees F to 220 Degrees F):

1. Flexible, closed cell elastomeric.
2. Nominal 6 pcf density, K factor 0.27 maximum at 75 degrees F mean.
3. Water vapor transmission 0.1 perm-inch, or less.
4. Manufacturers and Products:
    a. Armacell; AP Armaflex.
    b. Nomaco; K-Flex LS.

2.03 DUCT INSULATION

A. Type D1—Blanket (ASTM C553, Type 1, Class B3):

1. Fiberglass, nominal 1 pcf density blanket, K factor 0.31 maximum at 75 degrees F mean, with factory-applied FSK (foil-scrim-kraft) vapor barrier jacket, for temperatures to 250 degrees F.
2. Manufacturers and Products:
    a. CertainTeed; Duct Wrap.
    b. Johns Manville; Microlite.
    c. Owens/Corning Fiberglass; Soft R.
    d. Knauf; Ductwrap.

2.04 INSULATION FINISH SYSTEMS

A. Type F1—PVC:

1. Polyvinyl chloride (PVC) jacketing, white, for straight run piping and fitting locations, temperatures to 150 degrees F.
2. Manufacturers and Products:
    a. Johns Manville; Zeston.
    b. Ceel-Co; 550.

B. Type F2—Paint:

1. Acrylic latex paint, white, and suitable for outdoor use.
2. Manufacturer and Product: Armstrong; WB Armaflex finish.


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C. Type F3—Aluminum:

1. Aluminum Roll Jacketing: For straight run piping, wrought aluminum Alloy 3003, 5005, 1100 or 3105 to ASTM B209 with H-14 temper, minimum 0.016-inch thickness, with smooth mill finish.
2. Moisture Barrier: Provide factory applied moisture barrier, consisting of 40-pound kraft paper with 1-mil-thick low-density polyethylene film, heat and pressure bonded to inner surface of the aluminum jacketing.
3. Fitting Covers: Material as for aluminum roll jacketing, premolded, one or two piece covers, which includes elbows, tee/valves, end caps, mechanical line couplings, and specialty fittings.
4. Manufacturer and Product:
   a. RPR Products; INSUL-MATE.
   b. ITW, Pabco-Childers.

## PART 3 EXECUTION

### 3.01 APPLICATION OF PIPING INSULATION

A. Install insulation products in accordance with manufacturer’s written instructions, and in accordance with recognized industry practices.

B. Apply insulation over clean, finish painted, and dry surfaces.

C. Install insulation after piping system has been pressure tested and leaks corrected.

D. Use insulating cements, lagging adhesives, and weatherproof mastics recommended by insulation manufacturer.

E. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete the run. Do not use cut pieces of scraps abutting each other.

F. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.

G. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage. Seal open ends of insulation with mastic. Sectionally seal all butt ends of chilled water and condensate drain piping insulation at fittings with white vapor barrier coating.

H. Cover valves, flanges, fittings, and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job-fabricated units. Finish cold


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pipe fittings with white vapor barrier coating and hot piping with white vinyl acrylic mastic, both reinforced with glass cloth.

I. Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise indicated.

J. Install protective metal shields and foamglass inserts where pipe hangers bear on outside of insulation.

K. Insulate valve bodies, flanges, and pipe couplings.

L. Insulate and vapor seal hangers, supports, anchors, and other piping appurtenances that are secured directly to cold surfaces.

M. Do not insulate flexible pipe couplings and expansion joints.

N. Do not allow insulation to cover nameplates or code inspection stamps.

O. Install removable insulation sections on devices that require access for maintenance of equipment or removal, such as unions and strainer end plates.

P. Connection to Existing Piping: Cut back existing insulation to remove portion damaged by piping revisions. Install new insulation.

Q. Cold Surfaces: Provide continuous vapor seal on insulation on cold surfaces where vapor barrier jackets are used.

R. Placement:

1. Slip insulation on pipe or tubing before assembly, when practical, to avoid longitudinal seams.
2. Insulate valves and fittings with sleeved or cut pieces of same material.
3. Seal and tape joints.

S. Insulation at Hangers and Supports: Install under piping, centered at each hanger or support.

T. Vapor Barrier:

1. Provide continuous vapor barrier at joints between rigid insulation and pipe insulation.
2. Install vapor barrier jackets with pipe hangers and supports outside jacket.
3. Do not use staples and screws to secure vapor sealed system components.


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## 3.02 INSTALLATION OF DUCTWORK INSULATION

A. General: Install insulation products in accordance with the manufacturer's written instructions and in accordance with recognized industry practices.

B. Install insulation materials with smooth and even surfaces.

C. Clean and dry ductwork prior to insulation. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

D. Maintain integrity of vapor-barrier on ductwork insulation and protect it to prevent puncture and other damage. Tape all punctures.

E. Seal longitudinal and circumferential joints with FSK tape, and finish with fiberglass mesh fabric embedded in vapor barrier mastic.

F. Extend ductwork insulation without interruption through walls, floors, and similar ductwork penetrations, except where otherwise indicated.

G. Except as otherwise indicated, omit insulation on ductwork where internal insulation or sound absorbing linings have been installed.

## 3.03 INSTALLATION OF INSULATION FINISH SYSTEMS

A. Use a continuous friction type joint to hold jacket in-place, providing positive weatherproof seal over entire length of jacket.

B. Secure circumferential joints with preformed snap straps containing weatherproof sealant.

C. On exterior piping, apply coating over insulation and vapor barrier to prevent damage when aluminum fitting covers are installed.

D. Do not use screws or rivets to fasten the fitting covers.

E. Install removable prefabricated aluminum covers on exterior flanges and unions.

F. Caulk and seal all exterior joints to make watertight.

## 3.04 PIPING INSULATION REQUIREMENTS

A. Refrigeration Suction:

1. Type P2, elastomeric.
2. 1/2-inch thickness for pipe sizes up to 1 inch.
3. 3/4-inch thickness for pipe sizes over 1 inch.


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B. Condensate Drain:

1. Type P2, elastomeric.
2. 1/2-inch thickness for pipe sizes up to 2-5/8 inches ID.
3. 3/4-inch thickness for pipe sizes over 2-5/8 inches ID.

C. Condenser Water (Exposed to Weather):

1. Type P1, fiberglass.
2. 1-1/2-inch thickness for all pipe sizes.

D. Pipe Hangers:

1. Type P1, Fiberglass: UL-rated, preformed rigid pipe insulation inserts of thickness equal to adjoining insulation, 10 inches in length, with factory-applied, vinyl-coated and embossed vapor barrier jacket with self-sealing lap.
2. Type P3, Elastomeric: Rigid insulation section with 9-inch long, 16-gauge galvanized steel saddle.

3.05 DUCTWORK INSULATION REQUIREMENTS

A. Mechanically Cooled and Heated Supply and Return Air; (Indoors Concealed):

1. Type D1, blanket.
2. 2-inch thickness.

B. Mechanically Cooled and Heated Supply and Return Air, (Outdoors):

1. Type D1, blanket.
2. 2-1/2-inch thickness.

C. Mechanically Heated Supply Air; (Outdoors):

1. Type D1, blanket.
2. 2-inch thickness.

D. Process Areas Heated Supply Air, (Indoors Exposed to View): Insulation not required.

E. Air Distribution Devices: Refer to Section 23 37 00, Air Outlets and Inlets, for requirements.


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3.06 INSULATION FINISH REQUIREMENTS

A. Piping and Duct Insulation (Concealed Areas): Factory finish.

B. Piping Insulation (Exposed to View, Indoors): Type F1, PVC.

C. Piping Insulation (Outdoors):

1. Type F2, paint (for use with Type P2, elastomeric).
2. Type F3, aluminum.

D. Ductwork Insulation (Outdoors): Type F3, aluminum jacketing.

E. Apply coating of insulating cement where needed to obtain smooth and continuous appearance.

3.07 FIELD QUALITY CONTROL

A. Test factory-applied materials assembled. Field-applied materials may be tested individually.

**END OF SECTION**


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# SECTION 23 09 00
# INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American National Standards Institute (ANSI): INCITS 4, Information Systems - Coded Character Sets - 7-Bit American National Standard Code for Information Interchange (7-Bit ASCII).
2. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE):
   a. Handbook Fundamentals.
   b. Guideline 3, Reducing Emission of Fully Halogenated Refrigerants in Refrigeration and Air-Conditioning Equipment and Systems.
   c. 135, Data Communication Protocol for Building Automation and Control Networks.
3. American Society of Mechanical Engineers (ASME): B19.3, Safety Standard for Compressors for Process Industries.
4. American Water Works Association (AWWA): C704, Propeller-Type Meters for Waterworks Applications.
5. Electronic Industries Alliance (EIA):
   a. TIA-232-F, Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
   b. 485, Standard for Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multi-point Systems.
6. Federal Communications Commission (FCC).
7. IECC, International Energy Conservation Code.
8. International Organization for Standardization (ISO): 8802-3, Information Technology - Telecommunication and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Carrier Sense Multiple Access with Detection (CSMA/CD) Access Method and Physical Layer Specifications.
9. National Electrical Manufacturers' Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
10. National Fire Protection Association (NFPA):
    a. 70, National Electrical Code.
    b. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
11. UL: 916, Standard for Safety Energy Management Equipment.


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1.02 DEFINITIONS

A. The terms “HVAC Control System,” “Automatic Temperature Control System,” “Building Automation System,” and “Environmental Management and Control System” shall be considered equivalent and used interchangeably for the purposes of this Contract.

B. Algorithm: A software procedure for solving a recurrent mathematical or logical problem.

C. Analog: A continuously varying signal or value (temperature, current, velocity, etc.).

D. Binary: A two-state system where an “ON” condition is represented by a high signal level and an “OFF” condition is represented by a low signal level.

E. Control Wiring:

1. Wiring, high or low voltage other than power wiring required for proper operation of mechanical systems.
2. Includes conduit, wire and wiring devices to install complete control system including motor control circuits, interlocks, thermostats, PE and EP switches and like devices.
3. Includes wiring from DDC cabinet to all sensors and points defined in the Points List summary or specified herein and required to execute sequence of operation.
4. Includes necessary power wiring to HVAC control devices, digital controllers including terminal units and actuators.

F. Control Process: Software required to complete control loop from input signal to interlock logic and process calculation to final output signal control.

G. Deadband: Temperature range over which no heating or cooling energy is supplied, such as 72 degrees F to 78 degrees F; as opposed to single point changeover or overlap, or a range from set point over which no control action is taken.

H. Direct Digital Control (DDC): Consists of microprocessor-based controllers with control logic performed by software. Analog-to-digital (A/D) converters transform analog values into digital signals that microprocessor can use.

I. Point: Electronic representation of value or signal. Type can be virtual, analog or digital.


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J. Power Wiring: Line voltage wiring to mechanical equipment. Line voltage wiring that also serves as control circuit, such as line voltage thermostat or involves interlocking with damper shall be considered control wiring.

K. Abbreviations that may be used in this section:

1. AC: Air Conditioning.
2. ATC: Automatic Temperature Control.
3. CMOS: Complementary Metal Oxide Semiconductor.
4. DB: Dry Bulb
5. DDC: Direct Digital Control.
6. DX: Direct Expansion.
7. EEPROM: Electronic Erasable Programmable Read Only Memory.
8. EMCS: Environmental Management and Control System.
9. HCP: HVAC Control Panel.
10. HGS/R: Hot Glycol Supply/Return.
11. HMI: Human-Machine Interface.
12. HOA: Hand-Off-Auto (Switch).
13. HVAC: Heating, Ventilation, and Air Conditioning.
14. IP: Current (I) - Pressure (P), as in IP transducer.
15. LCD: Liquid Crystal Display.
16. LED: Light Emitting Diode.
17. PE: Pneumatic-Electric
18. PLC: Programmable Logic Controller.
19. RAM: Random Access Memory.
20. RH: Relative Humidity
21. RTD: Resistance Temperature Detectors.
22. VAV: Variable Air Volume.
23. W3: Nonpotable Water.
24. WB: Wet Bulb.

## 1.03 SYSTEM DESCRIPTION

A. General Requirements:

1. Provide control wiring, power wiring, conduit, hardware, and electrical work associated with the HVAC control system.
2. Provide control wiring between HVAC control panel contacts and field control devices, such as duct smoke detectors and motor starter control coil contacts.
3. Provide controls necessary for entire system to have fail-safe operation.
4. Control sequences and functions including alarms, monitoring and resetting functions, and operational sequences shall not be limited to point schedules and sequences of operation shown on the Drawings.


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5. Provide sequences and functions as required to deliver a fully functioning HVAC system.

B. Control System Types:

1. The following control system types may be used in this Project:
   a. Electric/Electronic Control System (ELECTRIC):
      1) System using simple electric or electronic control devices.
      2) User interface at control device.
2. Provide control system(s) of architecture defined in Control Type Schedule, below:

| Control Type Schedule | | |
|---|---|---|
| **Location** | **System** | **Control Type** |
| All | Where operating sequences call for simple thermostatic or interlock control | ELECTRIC |

1.04 ENVIRONMENTAL REQUIREMENTS

1. Refer to Section 01 61 00, Common Product Requirements, for additional environmental requirements.
2. Indoor design temperature requirements will be as required on the Drawings.

1.05 SUBMITTALS

A. Action Submittals:

1. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature that includes make, model, dimensions, weight of equipment, and electrical schematics, for all control system components.
2. Complete system power, interlock, control, and data transmission wiring diagrams no smaller than 11 inches by 17 inches.
3. Complete drawings and schematics of proposed control system, including panel power requirements.
4. System operating sequences to be programmed, in exact English language.
5. Complete points list in schedule form. Format to include point type (analog, binary, etc.) and numeric identification in alpha-numeric format and correlated to submittal drawings.




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6. Interfaces with HVAC equipment.
    a. Schematic diagram of each equipment item.
    b. Indicate location of each control item in equipment.
    c. Show equipment manufacturer controls where installed.
7. Panel face layout drawings.
8. Panel dimensional drawings for each panel required.
9. Plan layout drawing(s) showing panel location(s).
10. Damper actuator sizing calculations, in schedule form.
11. Automatic control valve sizing calculations, in schedule form.
12. Refer to Section 01 88 15, Anchorage and Bracing, for Action and Informational Submittals.

B. Informational Submittals:

1. Table identifying which member of Contractor's team is responsible for furnishing and setting in-place power wiring and control wiring of each item or component of HVAC equipment.
2. Recommended procedures for protection and handling of equipment and materials prior to installation.
3. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
4. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
5. Confirmation that control system Supplier has received, and coordinated with all approved HVAC equipment submittals.
6. Experience and qualifications of control system Supplier's proposed representative who will supervise installation, adjustment, and calibration of control systems.
7. Performance test plan and schedule.
8. Test Results:
    a. Functional and performance test documentation.
    b. Component calibration sheets for each instrument and panel component as described in Section 40 90 00, Process Instrumentation and Control Systems.
9. Operation and Maintenance Data:
    a. In accordance with Section 01 78 23, Operation and Maintenance Data. In addition, include the following detailed information:
        1) Operation and maintenance instructions for control system as furnished and installed, including control of associated mechanical and electrical equipment.
        2) Record of system adjustments and calibration methods.
        3) Performance test results.
10. Refer to Section 01 88 15, Anchorage and Bracing, for Action and Informational Submittals.


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## 1.06 QUALITY ASSURANCE

A. Materials, devices, appliances, and equipment used shall be indicated as acceptable by established standards of UL.

B. Codes and Standards: Meet requirements of applicable standards and codes, except when more detailed or stringent requirements are indicated by Contract Documents, including requirements of this section.

1. UL: Products shall be UL 916-PAZX listed.
2. National Electrical Code NFPA 70.
3. Federal Communications Commission Part J.

C. Qualifications of HVAC Controls System Supplier:

1. Minimum of 15 years' experience in design, installation, and maintenance of fully electronic building automation systems.
2. Minimum of 10 years' experience in design, installation, and maintenance of computer based, direct digital control, facility automation systems.
3. Minimum of 5 years' experience as manufacturer's authorized representative in design, installation, and maintenance of manufacturer's system and products.
4. Capable of furnishing factory-trained technicians, competent to provide instruction, routine maintenance, and emergency service onsite within 4 hours after receipt of request.
5. Factory trained certified engineering and commissioning staff, and complete offsite training facilities.
6. Necessary facilities to provide Owner with complete maintenance, periodic inspection, and service contract.

D. FCC Regulation: Electronic equipment shall conform to requirements of FCC Regulation, Part 15, Section 15, Governing Radio Frequency Electromagnetic Interference, and be so labeled.

E. Compatibility:

1. System shall have documented history of compatibility by design for minimum of 15 years. Future compatibility shall be supported for no less than 10 years.
2. Compatibility shall be defined as:
   a. Ability to upgrade existing field panels to current level of technology, and extend new field panels on previously installed network.




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b. Ability for any existing field panel microprocessor to be connected and directly communicate with new field panels without bridges, routers, or protocol converters.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Comply with Section 01 61 00, Common Product Requirements.

B. Corrosion Protection:

1. Control panels, enclosures, and other equipment containing electrical or instrumentation and control devices, including spare parts, shall be protected from corrosion through use of corrosion-inhibiting vapor capsules.
2. Prior to shipment, capsules shall be provided within shipping containers and equipment as recommended by capsule manufacturer.
3. During construction period, capsules shall be replaced in accordance with capsule manufacturer's recommendations.

**PART 2 PRODUCTS**

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified shall be products of the following manufacturers, unless indicated otherwise:

1. Allen Bradley.
2. Siemens Building Technologies.
3. Johnson Controls.
4. The Trane Company.
5. Honeywell.
6. Invensys.
7. Alerton Technologies.
8. Delta Controls.
9. Automated Logic Corporation.
10. Andover.

2.02 MATERIALS

A. General:

1. Products used in this installation shall be new, currently under manufacture, and shall have been applied in similar installations for minimum of 2 years.
2. System shall not be used as test Site for new products, unless explicitly approved by Owner's representative, in writing.


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B. Control Components:

1. Control range to obtain specified capacities.
2. Sensitivity to maintain control points close enough to set point for acceptable offset, without cycling equipment more frequently than recommended by manufacturer.
3. Field or computer adjustable to actual set point, ranges. Adjustable to other settings that will provide proper operation of entire control system.

C. Controls Interfacing:

1. Interface controls properly with factory supplied components of mechanical systems. Coordinate special control interfacing requirements.
2. For equipment that requires special interfacing with control system, provide equipment with integral controls or provide accessory devices required for operation of total mechanical system.
3. Coordinate interfaces with electrical work as necessary.
4. Provide electric, electronic, and mechanical devices as required to properly interface with prewired control panels furnished with HVAC equipment and with other mechanical and electrical components.

2.03 LABELING

A. All products, namely electrical materials, devices, appliances, and equipment used, shall be indicated as acceptable by established standards of UL and Factory Mutual (FM).

B. Valid label affixed to item shall provide indication of product acceptance by required agencies.

C. HVAC control panels and control components that consist of multiple components shall bear UL listing mark on unit.

2.04 SERVICE CONDITIONS

A. Refer to Section 01 61 00, Common Product Requirements, Section 26 05 02, Basic Electrical Requirements, the Area Classification and Materials Selection Table in the General Section of the Drawings, and Electrical Drawings for classification of areas as hazardous, corrosive, wet, indoor dry, and dust-tight.

B. Use materials and methods, and enclose devices in NEMA enclosure types suitable for classification indicated, and as required by NFPA 70.

C. Exhaust ductwork shall be considered same classification as area served.




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D. Instruments within 3 feet of ducts conveying air from spaces classified as Class I, Division 1 or Division 2 (in accordance with NFPA 70) shall be suitable for same area classification as space exhausted.

2.05 ELECTRICAL COMPONENTS AND ACCESSORIES

A. Electrical components shall be provided in accordance with requirements of Division 26, Electrical.

B. Wiring:

1. In accordance with Section 26 05 05, Conductors, and NFPA 70.
2. Insulation shall be rated 600 volts, minimum.

C. Electrical Raceways: In accordance with Section 26 05 33, Raceway and Boxes, and NFPA 70.

D. Relay Contacts: Form C rated 5.0 amps at 120V and 1.0 amp at 24V dc, minimum.

E. Provide surge suppressors on each power connection, meeting applicable requirements of Section 40 90 00, Instrumentation and Control for Process Systems.

2.06 FIELD COMPONENTS AND INSTRUMENTS

A. Refer to HVAC controls detailed specification, Section 23 09 13, HVAC Controls, Field Components, and Instruments.

2.07 ACCESSORIES

A. Corrosion-inhibiting vapor capsules as manufactured by:

1. Northern Instruments; Model Zerust VC.
2. Hoffman; Model A-HCI.

B. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 100 pounds.

C. Equipment Identification Plates:

1. Provide 16-gauge, Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch high engraved block type black enamel filled equipment identification number and letters indicated in this specification and as shown.


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2. Provide adjacent to the following control devices, and for equipment whose function is not readily apparent.
   a. Night low limit thermostats.
   b. Manual override timers.
   c. START/STOP switches.
   d. Humidistats.
   e. Emergency STOP switches.
   f. Special purpose devices.
   g. HVAC control panels.
   h. Instrument devices shown on the Drawings.

D. Instrument Identification Plates: Provide 16-gauge Type 316 stainless steel identification plate securely mounted on or near each separate instrument component in a readily visible location. Plate to bear 3/8-inch-high engraved block type black enamel filled with instrument tag number and sensor purpose or function. Instrument tag number as shown in this Specification and as shown on the Drawings.

E. Anchor Bolts: Sized by equipment manufacturer, 1/2-inch minimum diameter. Refer to Section 05 50 00, Metal Fabrications, for anchor bolt and post-installed concrete anchor requirements. Quantity as recommended by manufacturer.

2.08 EQUIPMENT FINISH

A. Provide materials and equipment with manufacturer's standard finish system. Provide manufacturer's standard finish color, except where specific color is indicated.

B. If manufacturer has no standard color, provide gray finish as approved by Owner.

## PART 3 EXECUTION

3.01 SEQUENCES OF OPERATION

A. Reference the Drawings.

3.02 INSTALLATION

A. General:

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




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2. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings, and equipment details.
3. Changes in location or installation of control devices or equipment shall be approved by Engineer before proceeding with the Work.
4. Mount devices requiring manual reset and all other user serviceable control devices in readily accessible locations.

B. Hazardous and Corrosive Areas:

1. Reference the Area Classification and Materials Selection Table in the General Section of the Drawings for instillation and material requirements.
2. Protect control equipment located in areas identified as being corrosive as follows:
    a. Use corrosion-inhibiting vapor capsules inside control equipment enclosures and HCP.
    b. Replace capsules prior to Owner's acceptance of equipment.

C. Wiring:

1. General:
    a. Install electric wire, cable, fittings, and conduit associated with systems specified in this section, in accordance with requirements of NFPA 70.
    b. Install control and interlock wiring separate from power wiring.
    c. Number code or color code conductors, excluding those used for individual zone controls, appropriately for future identification and servicing of control system.
    d. Provide wire markers on each conductor in panel and at load connections. Identify circuit with control wire number.
    e. Restrain wiring in control panels by plastic ties or ducts.
    f. Hinge wiring shall be secured at each end so that any bending or twisting will be around longitudinal axis of wire and bend area shall be protected with sleeve.
    g. Arrange wiring neatly, cut to length, and remove surplus wiring. Provide abrasion protection for any wire bundles that pass through holes or across edges of sheet metal.
    h. Use manufacturer's recommended tool with proper sized anvil for crimp terminations. No more than two wires may be terminated in single crimp lug and no more than two lugs may be installed on single screw terminal.
    i. Wiring shall not be spliced or tapped except at device terminals or terminal blocks.
    j. Properly support and run wiring in a neat manner.
    k. Run wiring parallel or at right angles to building structure.


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2. Concealment:
    a. Generally conceal wiring from view, except in mechanical rooms and areas where other conduit and piping are exposed; install exposed wiring and conduit to be as unobtrusive as possible.
    b. Install line voltage control wiring, wiring exposed to view, surface-mounted wiring, and wiring concealed within walls in conduit, in accordance with Division 26, Electrical.
    c. Install exposed and concealed low voltage control wiring systems in conduit.
    d. Wiring within enclosures shall be neatly bundled and anchored to prevent obstruction to devices and terminals.
    e. Conduit shall be sized to suit the number, type, and size of conductors as specified in Section 26 05 05, Conductors.

D. End-User Accessible Control Components:

1. Do not mark room thermostats.
2. Mount user adjustable control components (room thermostats, humidistats, temperature sensors, humidity sensors, etc.) level and in accordance with applicable accessibility requirements of local Building Code.

E. Adjustable Frequency Drives:

1. Verify control wiring installed to adjustable frequency drive.
2. Calibrate and adjust remote speed control loop and feedback loop.
3. Verify control actions and interlocks.
4. Adjust minimum and maximum speed settings.
5. Ramp adjustable frequency drive by simulation of associated controller output.

F. DDC Controllers:

1. Verify control wiring for correctness.
2. Verify power wiring.
3. Calibrate and adjust manual and auto control actions of controllers.
4. Tune control loop.
5. Stroke associated final element through controller output.
6. Verify set points and alarm functions.

G. HVAC Control Panel (HCP) Equipment:

1. Mount HCPs level, plumb, and securely to wall or column. Verify that adequate clearance is provided to allow for full front panel swing.
2. Provide field terminations and conduit knockouts for control/instrumentation wiring.


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3. Field termination wiring shall have designated instrument tag.
4. Panel cutouts shall be cut, punched, or drilled and smoothly finished with round edges.
5. Provide separate conduit entry for each power feeder circuit.
6. Signals requiring grounding shall be grounded within panel.
7. Field end of conductor shield/drain wires shall be folded back and placed under heat-shrink tubing without being grounded.
8. Panel end of conductor shield/drain wires shall be covered with clear tubing at panel and grounded.
9. Calibrate instrumentation provided on control panels.
10. Provide labels for internal panel material (such as, terminal blocks, power supplies, relays, PLC racks).

## 3.03 FIELD QUALITY CONTROL

A. Performance and Functional Testing:

1. Tests and certification shall be as specified in Section 01 91 14, Equipment Testing and Facility Startup, and Section 01 43 33, Manufacturers' Field Services.
2. HVAC controls interface with process control system shall be coordinated with the Work of Section 40 90 00, Instrumentation and Control for Process Systems.

## 3.04 MANUFACTURER'S SERVICES

1. Provide manufacturer's services in conformance with requirements of Section 01 43 33, Manufacturers' Field Services.
2. Manufacturer's Representative:
   a. Present at Site or classroom as designated by Owner, for minimum person-days listed below, travel time excluded:
      1) 1 person-day for installation, assistance, and inspection.
      2) 1 person-day for functional and performance testing and Manufacturer's Certificate of Proper Installation.
      3) 1 person-day for prestartup classroom or Site training.
      4) 1 person-day for facility startup.
      5) 1 person-day for post-startup training.

## 3.05 TRAINING

A. Provide training of Owner's personnel to enable them to operate HVAC equipment in available modes, to adjust set points, and to interpret alarm signals.

B. Training sessions shall be prepared in advance, and arranged for clear, effective transfer of information in minimum time.


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## 3.06 ADJUSTING AND CALIBRATING

A. Control system shall be adjusted and calibrated by qualified manufacturer's representative.

B. Calibrate control devices at time of installation to ensure measuring and reading accuracy.

C. Adjustment Record:

1. Prepare complete record of system adjustments for each control system.
2. Indicate deviations from specified temperatures.
3. Include copy of completed record in each copy of Operation and Maintenance Manual.

## 3.07 CLEANING AND TOUCHUP PAINTING

A. Touchup scratches, scrapes, or chips in exterior surfaces with finish matching type, color, consistency, and type of surface of original finish.

**END OF SECTION**




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# SECTION 23 09 13
# HVAC CONTROLS, FIELD COMPONENTS, AND INSTRUMENTS

## PART 1 GENERAL

1.01 GENERAL

A. This section is a supplement to Section 23 09 00, Instrumentation and Control Devices for HVAC.

B. The requirements of this section shall be provided in addition to those listed in Section 23 09 00, Instrumentation and Control Devices for HVAC.

1.02 SUBMITTALS

A. Action Submittals:

1. Product Data:
   a. Include only those sheets that are pertinent to the submitted products.
   b. Clearly annotate each sheet to:
      1) Identify data applicable to submitted product.
      2) Identify data application to submitted product.
      3) Delete or cross out references to inapplicable information.
2. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature that include make, model dimensions, wight of equipment, and electrical schematics, for all control system components.
3. Complete HCP power, interlock, control, and data transmission wiring diagrams no smaller than 11 inches by 17 inches.
4. Panel face layout drawings.
5. Individual panel interior and exterior layout drawings, including cabinet overall dimensions.
6. Shop Drawings: Seismic anchorage and bracing drawings and data sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals: Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.


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1.03 SYSTEM DESCRIPTION

A. Actuation of alarm (smoke or heat detector, flow switch, or other normally open initiating device contact) or trouble (trouble or supervisory switch) shall cause the following operations:

1. Audible and visual indications of alarmed devices on fire alarm control panel display, and on remote annunciator.
2. For remote buildings with subpanels, transmit common alarm or trouble signal to light appropriate zone lamp at master fire alarm control panel.
3. Master fire alarm control panel shall transmit common alarm or trouble signal to plant control panel.
4. Actuation of duct smoke detectors shall, send signal (contact closure) to environmental control panel (ECP) to shut off HVAC equipment.

**PART 2 PRODUCTS**

2.01 GENERAL

A. Refer to the Area Classification and Materials Selection Tables in the General Section of Drawings for additional requirements.

2.02 HVAC CONTROL PANELS (HCP)

A. Provide at locations shown on the Drawings for convenient operator interface with control system.

B. A single 120-volt, 20-amp feeder shall serve each HCP, unless otherwise indicated.

C. HCP Contents: Set point adjustment dials, gauges, receiver controllers, manual timers, time clocks, microprocessor control modules, electronic indication relays, control switches, transformers, pilot lights, alarm lights, display screens, keypads, and other devices necessary for particular system.

D. HCP Construction:

1. Metal enclosure to accommodate secure conduit fittings and protect against electrical transients.
2. Hinged front door with locking handle.
3. Flush-mount manual switches, pilot lights, and direct-reading gauges on front panel face.
4. Identify front panel mounted devices and HCP with labeling in accordance with Section 23 09 00, Instrumentation and Control Devices for HVAC.


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E. Panel Listing: Panels shall bear UL or ETL listing mark stating, “LISTED ENCLOSED INDUSTRIAL CONTROL PANEL”.

F. Control Devices:

1. Mount inside HCP.
2. Prewired internally.
3. Terminate wires leaving HCP at separately numbered terminal strips (one terminal pair per circuit).
4. Furnish individual connectors for every item of mechanical equipment, integral and remote pilot lights, and other devices described for each panel.
5. Refer to the Drawings for power and control circuit requirements.
6. Identify wires by color coding or numerical tags at both ends.
7. Wire control devices without splices to the terminal strip.
8. Furnish integral circuit protection for panel mounted control devices.

G. Terminal Blocks:

1. One-piece molded plastic blocks with screw type terminals and barriers rated for 600 volts.
2. Double sided and supplied with removable covers to prevent accidental contact with live circuits.
3. Furnish permanent, legible identification, clearly visible with protective cover removed.
4. Terminate wires at terminal blocks with crimp type, preinsulated, ring-tongue lugs.
5. Size lugs for terminal block screws and for the number and size of wires terminated.
6. Provide screwdriver access for blade width of a minimum of 3/16 inch or Klein 601 Series screwdrivers. Terminals requiring use of special screwdrivers are not acceptable.

H. Miscellaneous Accessories:

1. Furnish panel as-built electrical wiring diagrams and schematics, secured to inside of panel door, or enclosed in plastic jackets placed inside each panel.
2. Install plastic or stick-on labels on interior control devices to identify them in conjunction with control schematics.


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## 2.03 ELECTRIC THERMOSTATS (T)

A. Office Area Room Thermostat:

1. Modulating electric type, except where two-position action is required.
2. Temperature Scale: Furnish 50 degrees F to 90 degrees F dial.
3. Concealed adjustments.
4. Adjustable sensitivity.
5. Nonlocking cover.
6. Insulating back, where exterior wall mounting is indicated.

## 2.04 ELECTRONIC SENSORS

A. Temperature:

1. General Requirements:
   a. Sensors and transmitters shall be provided, as outlined in input/output summary and sequence of operations.
   b. Temperature sensor shall resistance type, and shall be either two-wire 1,000-ohm nickel RTD or two-wire 1,000-ohm platinum RTD.
   c. The following point types (and accuracy of each) are required, and their associated accuracy values include errors associated with sensor, lead wire, and A to D conversion:

| Point Type | Accuracy |
|---|---|
| Room Temperature | ± 0.5°F |
| Duct Temperature | ± 0.5°F |
| All Others | ± 0.75°F |

2. Room Temperature (TT):
   a. Constructed for either surface or wall box mounting.
   b. Nonlocking wire protective guards for room temperature sensors installed in process areas.
   c. Shall have the following options when specified:
      1) Set point reset slide switch providing plus or minus 3 degrees F (adjustable) range.
      2) Individual heating/cooling set point slide switches.
      3) Momentary override request pushbutton for activation of after-hours operation.
      4) Analog thermometer.
3. Room Temperature Sensors with Integral Display (TIT):
   a. Constructed for either surface or wall box mounting.
   b. Nonlocking wire protective guards for room temperature sensors installed in process areas.


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c. Integral LCD display and four button keypad with the following capabilities:
   1) Display room and outside air temperatures.
   2) Display and adjust room comfort set point.
   3) Display and adjust fan operation status.
   4) Timed override request pushbutton with LED status for activation of after-hours operation.
   5) Display controller mode.
   6) Password selectable adjustment of set point and override modes.

4. Duct Temperature (DTS):
   a. Accuracy: Plus or minus 1 degree F.
   b. Range:
      1) Heating: 40 degrees F to 140 degrees F.
      2) Cooling: 30 degrees F to 100 degrees F.
   c. Element:
      1) Rigid insertion, 12-inch length, through sealed opening in center of duct.
      2) Averaging, for ducts or plenums with any dimension greater than 36 inches. Sealed opening in duct. Sensing element incorporated in copper capillary a minimum of 20 feet long, serpentined across full area of airflow.

B. Room Temperature and Humidity Indicating Transmitter (THI):

1. Digital room sensor for temperature and humidity indoor environment with LCD screen.
2. Shall have the following options:
   a. Temperature range: 32 degrees F to 122 degrees F.
   b. Humidity Range: 0 percent to 95 percent RH (non-condensing).
   c. Accuracy:
      1) Temperature: plus or minus 0.5 degrees F.
      2) Humidity: 3 percent RH.
   d. Power: 24V ac/dc.
3. Constructed for either surface or wall mounting.

C. Duct Temperature and Humidity Sensor (DTH):

1. Digital sensor for monitoring return air temperature and humidity.
2. Shall have the following options:
   a. Temperature Range: 40 degrees F to 120 degrees F.
   b. Humidity Range: 0 percent to 95 percent RH (non-condensing).
   c. Accuracy:
      1) Temperature: plus or minus 0.5 degrees F.
      2) Humidity: 3 percent RH.


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d. Power: 24V ac/dc.
e. Mounting: Duct mounted with probe and housing.

D. Outdoor Temperature and Humidity Sensor (OTH):

1. Digital Sensor for monitoring outdoor air temperature and humidity.
2. Shall have the following options:
   a. Temperature range: Minus 40 degrees F to 120 degrees F.
   b. Humidity range: 0 percent to 95 percent RH (non-condensing).
   c. Accuracy:
      1) Temperature: Plus or minus 0.5 degrees F.
      2) Humidity: 3 percent RH.
   d. Power: 24V ac/dc.
   e. Mounting: Weather-resistant housing for outdoor installation with probe.

E. Differential Pressure (DP):

1. General:
   a. Temperature compensated.
   b. Vary output voltage with change in differential pressure. Voltage shall vary linearly from 0V dc to 10V dc according to differential pressure between high and low pressure ports.
   c. Sensing range shall be suitable for application with linearity of 1.5 percent of full scale and offset of less than 1 percent of full scale.
   d. Capable of withstanding up to 150 percent of rated pressure without damage.
   e. Compatible with 14V dc to 30V dc supply voltage range.
2. Duct Air Static Differential Pressure:
   a. Dwyer; 605.
   b. Dwyer; A302 duct probe.
   c. Install static pressure fittings for differential pressure sensors and switches at a right angle to the flow.
   d. Space Air Static Differential Pressure: Dwyer; 605.

F. Differential Pressure Switch (DPS):

1. General:
   a. Function: Monitor pressure.
   b. Type: Diaphragm actuated switch.
2. Performance:
   a. Setpoint:
      1) 1.0 in-wg.
      2) Repeatability: Plus or minus 1 percent.


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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 degree F to 150 degrees F.

3. Features:
a. Actuator Seal: Buna-N, unless otherwise noted.
b. Differential (deadband): Fixed at 0.2 in-wg.
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, B420BXTM10IW Series.
b. United Electric; 400 Series.

G. Current Sensors (CS):

1. Adjustable Setpoint, Digital Output Current Switch:
a. Application: Monitoring status of belt drive equipment.
b. Current-operated solid state relay.
c. Split core design.
d. Trip Setpoint: Adjustable.
e. Output: Digital switch, with status LED.
f. Sensor Power: Induced from line.
g. Manufacturer and Product: Veris; Hawkeye 708/908.

H. Switch Current (SC):

1. Adjustable Setpoint, Digital Output, ECM Switch Current:
a. Application: Monitoring status of EC motor.
b. Amperage range: 0.5 amps to 175 amps continuous.
c. Split core design.
d. Output: Digital switch, with status LED.
e. Sensor Power: Induced from monitor conductor.
f. Manufacturer and Product: Veris; Hawkeye H6ECM05.


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## 2.05 MISCELLANEOUS DEVICES

A. General:

1. RTD to voltage (0-volt to 5-volt) converters with zero span adjustments for use with analog inputs.
2. Limited range thermistors are acceptable provided they sense expected range for point at specified accuracy with 0-volt to 5-volt output.
3. Auxiliary contacts in each motor starter, Work of Division 26, Electrical.
4. START/STOP relay module for either momentary or maintained switch action as indicated.

B. Pilot Relays:

1. Plug-in type.
2. Interchangeable.
3. Mounted on a circuit board.
4. Wired to numbered terminal strips.

C. Electronic Indication:

1. Furnish temperature-indicating dials or digital read-outs on HCP.
2. 2-1/2-inch minimum rectangular.
3. Temperature sensing dc bridge circuit.

D. Air Duct Smoke Detector (SD): See Section 28 31 00, Fire Detection and Alarm.

**END OF SECTION**


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# SECTION 23 13 00
# ABOVEGROUND FUEL STORAGE TANK AND ACCESSORIES

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American Petroleum Institute (API): 607, Fire Test for Quarter-turn Valves and Valves Equipped with Nonmetallic Seats.
2. American Welding Society (AWS).
3. FM Global (FM).
4. International Code Council (ICC): International Fire Code (IFC).
5. National Electrical Manufacturers Association (NEMA).
6. National Fire Protection Association (NFPA):
   a. 30, Flammable and Combustible Liquids Code.
   b. 30A, Motor Fuel Dispensing Facilities.
   c. 704, Standard System for the Identification of the Hazards of Materials for Emergency Response.
7. The Society for Protective Coatings (SSPC): SP-10, Near-White Blast Cleaning.
8. Steel Tank Institute/Steel Plate Fabricators Association (STI/SPFA):
   a. Quality Assurance Program.
   b. 130-50-1000, Fireguard: Specification for Fireguard Protected Aboveground Storage Tank.
9. UL:
   a. 142, Standard for Safety for Steel Aboveground Tanks for Flammable and Combustible Liquids.
   b. 2085, Standard for Safety for Protected Aboveground Tanks for Flammable and Combustible Liquids.

### 1.02 DEFINITIONS

A. Aboveground Storage Tank (AST): Tank that is installed abovegrade, at grade, or belowgrade without backfill.

B. Atmospheric Tank: Horizontal storage tank designed to operate at pressures from atmospheric through 1.0 psig measured at top of tank under normal venting conditions and up to 2.5 psig under emergency venting conditions.

C. Authority Having Jurisdiction (AHJ): Organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.


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D. Combustible Liquid: Liquid with a closed-cup flash point at or above 100 degrees F as determined by procedures set forth in NFPA 30; includes Class II, Class IIIA, and Class IIIB combustible liquids as defined in NFPA 30.

E. Secondary Containment Tank: Tank with an inner and outer wall with interstitial space (annulus) between walls and has means for monitoring interstitial space for a leak.

F. Fleet and Commercial: Per OAC 165:26; means any facility that uses aboveground storage tanks to store regulated substances for use in its own vehicles or equipment.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Design data, including:
      1) Tank size, overall dimensions, and inside dimensions of inner tank for secondary containment tank.
      2) Tank steel thickness.
      3) Locations, sizes, and details of nozzles and tank openings.
      4) Construction details plainly identifying materials of construction.
      5) Dimensions and details of supports of legs.
      6) Data sheets on tank coatings.
      7) Verification tank is in accordance with specified standards.
      8) Required emergency venting capacity.
   b. Cut sheets for tank accessories showing materials of construction, dimensions, details of construction, and connection details.
      1) Tank strapping table for mechanical clock gauge.
   c. Descriptive literature for tank instrumentation describing in detail the function, setpoints, available input and output signals, wiring diagrams, and field connection points.
   d. Detailed programming and set up procedures for control panels and monitoring instruments.
   e. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Description of quality assurance program to be utilized, including verification of manufacturer’s licensing agreement or certification program, if required, to manufacture tanks to a given standard or to carry a given trademark.


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2. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
3. Installation details in accordance with manufacturer's recommendations and instructions.
4. Tank field repair procedures.
5. Manufacturer's list of proposed spares and expendables.
6. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
7. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.04 REGULATORY REQUIREMENTS:

1. AHJ.
2. Governing Codes and Standards: Oklahoma Corporation Commission: OAC 165:26.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping: Provide galvanized steel caps or plugs on threaded ports and 12-gauge minimum steel or 1/2-inch minimum plywood blind flanges on flanged ports.

**PART 2 PRODUCTS**

2.01 GENERAL

A. Fuel Criteria:

1. Fuel Stored: Diesel.
2. Fuel Classification: Combustible, Class II liquid.

2.02 SECONDARY CONTAINMENT TANK

A. Tank Manufacturer: Steel fabricator certified to fabricate tanks in accordance with listed standards.

B. Tank Construction:

1. Horizontal, cylindrical, or rectangular atmospheric storage tank in accordance with UL 142, with steel inner tank, and fully enclosed steel outer tank.
2. Continuous welds at all joints, conforming to AWS Standards for continuous welds.
3. Steel Thickness: Per UL 142.


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4. Tank Design and Support Legs: Suitable for conditions listed in Section 01 61 00, Common Product Requirements.
5. Capacity: 2,000 gallons, with dimensions of 12 feet long by 5 foot 4 inches diameter.
6. Tank Openings:
    a. Provide minimum number of tank openings as listed herein under Article Tank Openings and Attachments and arranged as shown on the Drawings.
    b. Make piping connections to tank above normal maximum liquid level.
7. Corrosion Protection:
    a. Outer Tank Exterior Coating: As specified herein under Article Corrosion Protection.
    b. Inner Tank Interior Coating: As specified herein under Article Corrosion Protection over entire interior of tank.
8. Venting: Conform to NFPA fire codes and UL Standards.
9. Support Legs: Fabricated steel saddle supports with flat bottoms, not less than 4 inches or more than 12 inches tall at bottom centerline of tank, located as shown on the Drawings.

## 2.03 TANK OPENINGS AND ATTACHMENTS

A. General: For secondary containment tank or protected tank with outer steel tank, seal weld tank openings to both inner and outer tank walls.

B. Manway: 30-inch flanged steel with lifting handles and fuel resistant gasket.

C. Primary Normal Vent: 2-inch female NPT coupling.

1. OAC 165:26-2-6.(f): Vent height requirements.

D. Primary Emergency Vent:

1. Fuel Holding Tank: Male NPT nozzle sized to match required emergency vent valve.

E. Secondary Emergency Vent:

1. Fuel Holding Tank: Male NPT nozzle sized to match required emergency vent valve.

F. Fill Port:

1. 4-inch male NPT threaded port on top of tank for installation of containment sump, as specified under Article Accessories.


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2. Fill port shall have a drop pipe that extends to within 4 inches of the bottom of the tank.
3. Fill Port Marking: Per OAC 126:26-2-5.(a).

G. Level Gauge Port: 2-inch female NPT port.

H. Fuel Supply Port: 4-inch female NPT port with double-tapped bushing for 2-inch fuel supply drop pipe with foot valve, as specified under Article Valves, located with inlet 4 inches above bottom of tank.

I. Spare Ports: Provide the following spare ports with galvanized steel caps or plugs.

1. 2-inch Female NPT.
2. 2-inch Female NPT.

J. Lifting Eyes: Provide tank with minimum of two lifting eyes. Lifting eyes shall consist of plate steel welded to steel tank with hole for attaching shackle.

## 2.04 ACCESSORIES

A. Spill Containment Sump:

1. 5 gallons UL listed, powder-coated steel overfill/spill containment sump.
2. Surround fill pipe.
3. Provide hinged, padlockable lid.
4. Provide threaded connection to fill port on top of tank.
5. Provide 4-inch NPT port for installation of fill limiter valve specified under Article Valves.
6. Provide built-in spring-loaded valve to release spilled product back to primary tank.
7. Manufacturers and Products:
   a. Morrison Brothers; Figure 518.
   b. EBW; Model 706.

B. Normal Vent Cap for Class II and Class III Liquids:

1. Metal body, 2-inch female NPT connection, upward opening vent with screened opening.
2. Manufacturer and Product: Universal Valve; Model 45.


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C. Combination Vent and Overfill Alarm:

1. Metal body, 2-inch female NPT connection, with pressure and vacuum poppets to allow tank to breathe during filling or withdrawal operations. Poppets to close when tank pressure is equalized.
2. Provide screen over vent opening.
3. Vent cap to have brass seat, 8-ounce pressure setting, and 1-ounce vacuum setting.
4. Vent to include float and cable assembly that operates a whistle in vent body and creates audible alarm when level in tank reaches predetermined level.
5. Manufacturer and Product: Morrison Brothers; Figure 922.

D. Mechanical Level Gauge:

1. Clock Gauge:
   a. Float-operated, liquid level gauge, for tanks up to 12 feet tall.
   b. Aluminum body with 2-inch male NPT connection.
   c. Stainless steel float and cable.
   d. Standard faceplate.
   e. Manufacturer and Product: Morrison Brothers; Figure 818, fully mechanical.

E. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications.

F. Equipment Identification:

1. Identify tank with manufacturer’s name, manufacturer’s location, and capacity in gallons, manufacturer’s model number, and date of manufacture.
2. UL Mark: Include file number, product classification, and product serial number.
3. Mark tanks on all sides with warning signs reading “COMBUSTIBLE,” “NO SMOKING,” product identification, and other signs as required by applicable codes. Product identification in accordance with NFPA 704.
   a. OAC 165:26-2-132. Required Signs. Provide all signage and meet signage requirements listed.
4. Provide 16-gauge, Type 304 stainless steel identification plate securely mounted on each separate equipment component in a readily visible location. Engraved plate 3/8-inch high block type black enamel filled equipment identification number and letters indicated in this specification and as shown on the Drawings.


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G. Transfer Fuel Pump: 115V, 20 gpm minimum, tank mounted pump.

1. Include a fuel filter kit.
2. Provide hard piping from tank mounted pump to dispenser.

H. Dispenser: Side-mounted to fuel tank.

I. Retractable Hose Reel: Tank mounted with 25-foot hose on a spring-reel.

1. Tank mounted, with enclosed nozzle holder as a dust cap.

J. Ladder and Platform: Provide integral mounted ladder with standing platform at the end of the tank for tank filling operator.

## 2.05 VALVES

A. Fill Limiter Valve:

1. Float-operated to close fill pipe when liquid level in fuel tank reaches 95 percent capacity. Adjust nipple length and tank riser pipe height to achieve required valve setting corresponding to this level.
2. Provide 2-inch fill pipe and 4-inch female threaded tank connection.
3. Terminate at top in male aluminum camlock style coupling with chained dust cap.
4. Allows attachment of drop pipe to bottom to extend fill pipe to within 6 inches of tank bottom. If drop pipe is manufactured accessory to fill limiter valve, rather than a length of threaded steel pipe, then furnish drop pipe with fill limiter valve.
5. Manufacturers and Products:
   a. Morrison Brothers; Figure 9095A.
   b. Universal Valve; Model 49.

B. Antisiphon Valve:

1. Cast iron, angle pattern, spring loaded valve to prevent fuel siphoning in the event of supply line rupture below fuel level in tank.
2. Head setting adjustable from 0 foot to 20 feet through field adjustment or spring selection.
3. Provide with built-in thermal expansion relief valve.
4. Manufacturers and Products:
   a. Universal Valve; Model 403PR.
   b. EBW; 605, 606, 616, or 636.


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C. Emergency Vent Valve:

1. Painted cast-iron body and lid with male NPT connection and O-ring seat.
2. Sized by tank manufacturer to provide required venting capacity.
3. Pressure Setting: 1 psi.
4. Manufacturers and Products:
   a. Morrison Brothers; Figure 244.
   b. Universal Valve; Model 48.

D. Solenoid Valve:

1. Normally-closed solenoid valve with threaded stainless steel body and stainless steel trim, Viton seat and Viton or Buna seals.
2. Class H, 120V ac, 60-Hz solenoid coil with NEMA 4, NEMA 7, and NEMA 9 Group C and Group D watertight enclosure, threaded conduit connection and 12-inch minimum leads.
3. Rated for a maximum differential of 100 psi and require no differential pressure to open.
4. Manufacturers and Products:
   a. Morrison Brothers; Figure 710 SS.
   b. Magnatrol; Type K (stainless steel).

E. Foot Valve:

1. Double poppet, metal-seated bronze, brass or plated cast-iron foot valve with inlet screen and threaded pipe connection.
2. Manufacturers and Products:
   a. OPW; Model 86 or Model 92.
   b. EBW; Model 50-201.

F. Expansion Relief Valve:

1. Spring-loaded, angle-pattern with ductile-iron threaded body with 1/2-inch port.
   a. Manufacturer and Product: Morrison Brothers; Figure 78 DI.
2. Spring-loaded with 1/4-inch tubing and threaded pipe connections.
   a. Manufacturer and Product: Morrison Brothers; Figure 77.

G. Ball Valve:

1. Two-piece or end entry threaded, bronze body with chrome plated brass ball, reinforced TFE seats, and UL Listed for flammable liquid shut off.
   a. Manufacturers and Products:
      1) Nibco; T580/585-70-UL.
      2) Apollo; 80-100.


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H. Check Valve:

1. Y-pattern swing check with threaded bronze body and metal seat.
2. Manufacturers and Products:
   a. Nibco; T-413.
   b. Watts; CVY.

2.06 PIPE AND PIPE FITTINGS

A. Fuel Oil Pipe and Fittings: Refer to Section 40 27 00 Process Piping—General.

2.07 RACEWAYS AND CONDUCTORS

A. Refer to Section 26 05 05, Conductors, and Section 26 05 33, Raceway and Boxes.

2.08 CORROSION PROTECTION

A. Steel Tank Exterior Coating:

1. Surface Preparation: Blast clean in accordance with SSPC SP-10.
2. Prime Coat: Epoxy primer containing rust-inhibitive pigments, 6-mil to 8-mil dry film thickness.
3. Finish Coat: Two-component, aliphatic- or acrylic-based polyurethane enamel; high-gloss finish, 3-mil dry film thickness.

B. Steel Tank Interior Coating:

1. Surface Preparation: Blast clean in accordance with SSPC SP-10.
2. Prime Coat: Epoxy primer containing rust-inhibitive pigments, 6-mil to 8-mil dry film thickness.
3. Finish Coat: Polyamidoamine epoxy, minimum 69 percent volume solids, capability of 6 MDFT to 8 MDFT per coat, 6-mil dry film thickness.

C. Exterior Coating for Inner Steel Tanks of Double-Wall and Protected Tanks:

1. Surface Preparation: Blast clean in accordance with SSPC SP-10.
2. Prime Coat: Anticorrosive, converted epoxy primer containing rust-inhibitive pigments, 6-mil to 8-mil dry film thickness.


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## PART 3 EXECUTION

3.01 PREPARATION

A. Prior to installation, visually inspect tank for impact damage that may have occurred during storage. Repair damage as approved by Engineer.

3.02 INSTALLATION

A. In accordance with manufacturer's written instructions.

B. Lift tanks using manufacturer provided lifting points or with nylon slings as recommended by manufacturer.

C. Install tanks on a reinforced concrete slab as specified on the Drawings.

D. Attach tanks with steel legs to concrete pad with anchor bolts sized to match holes provided in tank legs.

E. Install valves in accordance with manufacturer's instructions.

3.03 FIELD TESTING

A. General:

1. Supply fuel for testing.
2. Prior to startup, inspect equipment for proper installation and connection by means of a functional test. Demonstrate proper operation of normal vent valves, remote fill boxes, antisiphon valves, and solenoid valves.
3. Perform testing as specified below and in accordance with manufacturer's written procedures. If manufacturer's written procedures conflict with instructions below, notify Engineer of discrepancy.

B. Primary Tank:

1. Test for leaks by pressurizing with air or inert gas at a minimum pressure of 3 psig and a maximum pressure of 5 psig for a minimum of 2 hours.
2. If drop in pressure or leak is detected, repair leaks in accordance with manufacturer's written recommendations.
3. While under pressure, apply soap solution to piping connections to aid in detection of leaks.
4. Repair and retest until no leaks are detected.


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5. Shade tank and allow temperature of test medium to equalize prior to start of test, as required to mitigate effects of tank heat loss or heat gain on test results.
6. For secondary contained tanks, vent secondary containment to atmospheric pressure during testing of primary tank.

C. Secondary Tank:

1. After primary tank has been successfully tested, test for leaks by pressurizing at a minimum pressure of 3 psig and a maximum pressure of 5 psig. Vacuum test in accordance with manufacturer's written procedures may be performed in lieu of pressure testing.
2. During testing of secondary tank, maintain a minimum pressure of 3 psig on primary tank.
3. While under pressure, apply soap solution to piping connections to aid in leak detection.
4. If pressure drop or leak is detected, repair leaks in accordance with manufacturer's written recommendations.
5. Repair and retest until no leaks are detected.

D. Level and Leak Instrumentation:

1. Demonstrate tank high level instrumentation indication and alarm functions.
2. Fill tank with fuel to demonstrate alarm and level indications that occur on rising fuel level.
3. Set tank high level alarm to activate at 90 percent of tank capacity, unless otherwise noted.
4. Pump fuel from tank using a temporary pump and portable tank to demonstrate tank low level alarm.
5. Demonstrate secondary tank leak detector function by removing leak sensor from tank annulus and placing it in both fuel and water to simulate a leak.

E. Overfill Limiter Valve:

1. Fill tank with fuel to demonstrate functioning of overfill limiter valve.
2. Set overfill limiter valve to shut off fuel flow to tank at 95 percent of tank capacity, unless otherwise noted.

F. Grounding: Measure and record resistance from tank to ground in accordance with Section 26 05 26, Grounding and Bonding for Electrical Systems.

G. Fuel Pipe Valves: Pressure test at time of pipe testing in accordance with Section 40 27 02, Process Valves and Operators.


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3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative:

1. Present at Site or classroom designated by Owner for minimum person-days listed below, travel time excluded:
   a. 1 person-day for installation assistance and inspection.

B. See Section 01 43 33, Manufacturers' Field Services, and Section 01 91 14, Equipment Testing and Facility Startup.

**END OF SECTION**


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# SECTION 23 23 00
# REFRIGERANT PIPING

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 760, Performance Rating of Solenoid Valves for Use with Volatile Refrigerants.
2. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE): 15, Safety Standard for Refrigeration Systems.
3. American Society of Mechanical Engineers (ASME):
   a. B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
   b. B31.5, Refrigeration Piping and Heat Transfer Components.
4. American Welding Society (AWS):
   a. A5.8M/A5.8, Specification for Filler Metals for Brazing and Braze Welding.
   b. BRH, Brazing Handbook.
5. ASTM International (ASTM): B280, Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
6. National Electrical Manufacturers Association (NEMA).
7. UL.

### 1.02 DEFINITIONS

A. ACR: Air conditioning and refrigeration.

B. NRTL: National Recognized Testing Laboratory.

### 1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings in 1/4-inch scale for refrigerant piping showing pipe and tube sizes, flow capacities location, elevations, fittings, accessories, and piping connections.
2. Manufacturer’s data on refrigerant piping, piping products, thermostatic expansion valves, solenoid valves, hot-gas bypass valves, filter dryers, strainers, pressure regulating valves and accessories.
3. Reference Section 01 88 15, Anchorage and Bracing.


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B. Informational Submittals:

1. Welding certificates.
2. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
3. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
4. Field quality control; test report.
5. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.04 QUALITY ASSURANCE

A. Safety Code Compliance: Comply with applicable portions of ASHRAE 15.

1. Contractor to note implication of phasing out refrigerant(s) R-410A and R-134A. Equipment shall operate with approved refrigerant such as R-32 or R-454A starting January 1, 2025.

B. Brazing: Comply with applicable requirements of ASME B31.5 pertaining to brazing of refrigerant piping for shop and Project Site locations.

C. Installer: A firm with at least 5 years of successful installation experience on projects with refrigerant piping similar to that required for this Project.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Refrigerant piping shall be cleaned, dehydrated, and sealed when delivered.

B. Store piping in clean and protected area with end caps in place.

**PART 2 PRODUCTS**

2.01 MATERIALS

A. Refer to the Area Classification and Materials Selection Table in the General Section of Drawings for additional requirements.

B. Material and dimensional requirements for field assembled refrigerant piping, valves, fittings and accessories shall conform to ASHRAE 15 and ASME B31.5, except as hereinafter specified.

C. Piping, 3 Inches and Smaller: Copper, Type ACR tube, ASTM B280, copper No. 122, hard-drawn temper. Brazed joints required.



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D. Fittings for Copper Tube: Wrought-copper/bronze solder-joint fittings in accordance with ASME B16.22.

E. Pipe Insulation: Refer to Section 23 07 00, HVAC Insulation.

2.02 MISCELLANEOUS PIPING PRODUCTS

A. Brazing Materials:

1. Except as otherwise indicated, provide 15 percent silver alloy brazing material for copper to copper and copper to brass fittings.
2. Comply with AWS A5.8M/A5.8 for brazing filler materials.

B. Refrigerant Specialties:

1. Refrigerant Suction Line Filter-Dryer:
   a. Provide steel shell, corrosion-resistant finish filter-dryer, with molded felt core with 10-micron particle retention, in size and working pressure indicated, with copper connectors, and access valve (not applicable for heat pump system).
   b. Operating Temperature Rating: 240 degrees F.
   c. Working Pressure: 500 psi.
   d. Provide size recommended by refrigeration equipment manufacturer.
2. Refrigerant Liquid Line Dryer:
   a. Provide refrigerant liquid line filter-dryer for all units.
   b. Operating Temperature Rating: 240 degrees F.
   c. Working Pressure: 500 psi.
   d. For heat pumps, provide biflow directional types (not required if included with air-conditioning equipment).
   e. Provide size recommended by refrigeration equipment manufacturer.

C. Refrigerant Valves:

1. Globe and Check Valves: Listed and labeled by an NRTL.
   a. Shutoff Valves:
      1) Forged brass, packed, back seating winged seal cap, 300 degrees F (140 degrees C) temperature rating 500 psi working pressure.
      2) Maximum Opening Pressure: 0.5 psig.
      3) Valve required only if shutoff service valves are not included with package air-conditioning equipment.
   b. Manufacturers:
      1) Henry Technologies.
      2) Parker Hannifin Corp.


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2. Solenoid Valve: Listed and labeled by an NRTL.
    a. Two-Way Solenoid Valves: Forged brass, designed to conform to AHRI 760, normally closed, Teflon valve seat, NEMA 1 solenoid enclosure, 24 volts, 60-Hz, UL Listed, 1/2-inch conduit adapter, 250 degrees F (121 degrees C) temperature rating 500 psi working pressure.
    b. Provide valve only if recommended by air-conditioning equipment manufacturer.
    c. Manual Operator: Provide optional manual operator to open valve.
    d. Manufacturers:
        1) Alco Controls Div.; Emerson Electric Co.
        2) Automatic Switch Co.
        3) Parker Hannifin Corp.
3. Thermostatic Expansion Valve:
    a. Body Bonnet and Seal Cap: Forged brass or steel.
    b. Diaphragm, Piston, Closing Spring and Seat Insert: Stainless steel.
    c. Capillary and Bulb: Copper tubing filled with refrigerant.
    d. Suction Temperature: 40 degrees F.
    e. End Connections: Socket or flare.
    f. Working Pressure: 700 psig.
    g. Manufacturers:
        1) Henry Technologies.
        2) Parker Hannifin Corp.
        3) Danfoss Group Global.
4. Safety Relief Valve:
    a. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
    b. Seat Disk: Polytetrafluoroethylene.
    c. Working Pressure: 500 psig.
    d. Operating Temperature: 240 degrees F, maximum.
    e. Manufacturers:
        1) Henry Technologies.
        2) Parker Hannifin Corp.
        3) Danfoss Group Global.

## 2.03 PIPE HANGERS AND SUPPORTS

A. Refer to Section 40 05 15, Piping Support Systems, for piping shields and piping support requirements.


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## PART 3 EXECUTION

### 3.01 INSTALLATION OF PIPING SYSTEM

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

B. Install piping products in accordance with manufacturer's written instructions, applicable requirements of ASME B31.5, ASHRAE 15, and in accordance with recognized industry practices to ensure products serve intended function.

C. Install dryers on liquid and suction lines.

D. Refrigerant Piping:

1. Cut pipe accurately to measurements established at Site and work into place without springing or forcing.
2. Install piping with sufficient flexibility to adequately provide for expansion and contraction as a result of temperature fluctuation inherent in its operation.
3. Where pipe passes through building structure, pipe joints shall not be concealed, but located where they may be readily inspected.
4. Run pipe to be insulated as shown and as required with sufficient clearance to permit application of insulation.
5. Run piping as shown on the Drawings, taking care to avoid interference with other piping, conduit, or equipment. Except where specifically indicated otherwise, run piping plumb, and straight and parallel to walls and ceilings.
6. Trapping of lines shall not be permitted, except where indicated.
7. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
8. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
9. Install piping free of sags and bends.
10. Install fittings for changes in direction and branch connections.
11. Install refrigerant piping in protective conduit where installed belowground.
12. Install accumulator in suction line near condensing unit.
13. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
14. Slope refrigerant piping as follows:
    a. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
    b. Install horizontal suction lines with a uniform slope downward to compressor.


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c. Install traps and double risers to entrain oil in vertical runs.
d. Liquid lines may be installed level.

E. Pipe Sleeves:

1. Provide pipe sleeves of suitable size for pipe and tubing that penetrate building structure.
2. Secure sleeves in position and location before and during construction. Space between pipe and sleeves, or between insulation and pipe sleeves, shall be not less than 1/4 inch between outside of pipe or insulation, and inside wall of sleeves.
3. Sleeves for uninsulated pipes shall have ends flush with finished wall surfaces; provide pipe or tubing as above with outside perimeter of pipe caulked to sleeve.
4. Extend sleeves for insulated pipes 1/2 inch from wall faces and caulk to sleeve on both sides.
5. Seal terminal ends of pipe insulation with mastic.
6. Extend sleeves for lines passing through floors 3 inches above finished floor slab and caulk to slab.

F. Braze cap (seal) ends of piping when not connected to mechanical equipment.

3.02 SOLDER JOINTS

A. Solder joints shall not be used for joining refrigerant piping systems.

3.03 BRAZED JOINTS

A. Braze copper piping with silver solder complying with AWS A5.8M/A5.8.

B. Brazed Joints:

1. Construct joints according to AWS *Brazing Handbook* Chapter “Pipe and Tube”.
2. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
3. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

C. Inside of tubing and fittings shall be free of flux.

D. Clean parts to be joined with emery cloth and keep hot until solder has penetrated full depth of fitting and extra flux has been expelled.

E. Cool joints in air and remove flame marks and traces of flux.


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F. During brazing operation, prevent an oxide film from forming on inside of tubing by slowly flowing dry nitrogen to expel air.

G. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion valve bulb.

3.04 PIPE HANGERS AND SUPPORTS

A. Refer to Section 40 05 15, Piping Support Systems, for piping shields and piping support requirements.

3.05 PIPE INSULATION

A. Refer to Section 23 07 00, HVAC Insulation.

3.06 EQUIPMENT CONNECTIONS

A. Connect refrigerant piping to mechanical equipment in the manner shown, and comply with equipment manufacturer’s instructions where not otherwise indicated.

3.07 FIELD QUALITY CONTROL

A. General:

1. Notify Engineer at least 48 hours before testing is performed.
2. Furnish equipment required for tests.
3. Group as many systems together as possible when testing in order to consolidate number of test inspections.

B. Leak Test:

1. Prior to initial operation, clean and test refrigerant piping in accordance with ASME B31.5.
2. Perform initial test with dry nitrogen to 300 psig minimum using soap solution to test joints.
3. Evacuate system after initial test and charge system with dry nitrogen, to 600 psig minimum.
4. Upon completion of initial system test, test factory, as well as field, refrigerant piping joints with electronic-type leak detector to acquire a leak-tight refrigerant system.
    a. If leaks are detected, remove entire refrigerant charge for the system, replace defective pipe or fitting, and retest entire system as specified above.


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C. Evacuation, Dehydration, and Charging:

1. After system is found to be without leaks, evacuate system using reliable gauge and vacuum pump capable of pulling a vacuum of at least 1-mm Hg absolute (29.88-inch Hg gauge).
2. Evacuate system with vacuum pump until temperature of 35 degrees F (2 degrees C) is indicated on vacuum dehydration indicator.
3. During evacuation, apply heat to pockets, elbows, and low spots in piping.
4. Maintain vacuum on system for minimum of 12 hours after closing valve between vacuum pump and system. If system holds vacuum for 12 hours it is ready for charging.
5. Break vacuum with refrigerant gas or dry nitrogen gas, allowing pressure to build up to 2 psi (15 kPa).
6. Install new filter-dryer core in charging line.
7. Repeat evacuation procedure and complete charging of system; provide full operating charge.

3.08 ADJUSTING

A. General:

1. Adjust high-pressure and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
2. Adjust setpoint temperature of air-conditioning or chilled-water controllers to system design temperature.
3. Perform following adjustments according to manufacturer’s written instructions before operating refrigeration system:
   a. Open shutoff valves in condenser water circuit.
   b. Verify compressor oil level is correct.
   c. Open compressor suction and discharge valves.
   d. Open refrigerant valves, except bypass valves that are used for other purposes.
   e. Check open compressor-motor alignment and verify lubrication for motors and bearings.

B. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

**END OF SECTION**



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# SECTION 23 31 13
# METAL DUCTS AND ACCESSORIES

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. Air Movement and Control Association (AMCA): 500, Test Methods for Louvers, Dampers and Shutters.
2. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Handbook.
3. American Society of Mechanical Engineers (ASME): A13.1, Scheme for the Identification of Piping Systems.
4. Association of the Nonwoven Fabrics Industry (INDA): IST 80.6, Water Resistance (Hydrostatic Pressure).
5. ASTM International (ASTM):
    a. A36/A36M, Standard Specification for Carbon Structural Steel.
    b. A90/A90M, Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
    c. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
    d. A176, Standard Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip.
    e. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
    f. A480/A480M, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip.
    g. A568/A568M, Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for.
    h. A653/A653M, Standard Specifications for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
    i. A700, Standard Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment.
    j. A924/A924M, Specification for General Requirements for Sheet Steel, Metallic-Coated by the Hot-Dip Process.
    k. A1008/A1008M, Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-


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Strength Low-Alloy with Improved Formability, Required Hardness, Solution Hardened, and Bake Hardenable.

l. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High- Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.

m. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

n. C423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.

o. C916, Standard Specification for Adhesives for Duct Thermal Insulation.

p. C1071, Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).

q. C1139, Standard Specification for Fibrous Glass Thermal Insulation for Sound Absorbing Blanket and Board for Military Applications.

r. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.

s. E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.

6. National Air Duct Cleaners Association (NADCA): General Specifications for the Cleaning of Commercial Heating, Ventilation and Air Conditioning Systems.

7. National Fire Protection Association (NFPA):
   a. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
   b. 90B Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
   c. 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
   d. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
   e. 259, Standard Test Method for Potential Heat of Building Materials.
   f. 701, Standard Methods of Fire Tests for Flame Propagation of Textiles and Films.

8. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
   a. Duct Construction Standards.
   b. Guidelines for Seismic Restraints of Mechanical Systems.
   c. Fibrous Glass Duct Construction Standards.
   d. Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems.
   e. HVAC Air Duct Leakage Test Manual.


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9. UL:
    a. 181, Standard for Safety Factory-Made Air Ducts and Connectors.
    b. 214, Standard for Tests for Flame-Propagation of Fabrics and Films.
    c. 555, Standard for Safety Fire Dampers.
    d. D.E.723, Standard for Safety Test for Surface Burning Characteristics of Building Materials.
    e. 555S, Standard for Safety Smoke Dampers.

1.02 DEFINITIONS

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

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

B. Sealing Requirements:

1. For duct systems sealing requirements specified in this section, the following definitions apply:
    a. Seams: Joining of two longitudinally (in direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on perimeter are deemed to be joints.
    b. Joints, duct surface connections including:
        1) Girth joints.
        2) Branch and subbranch intersections.
        3) Duct collar tap-ins.
        4) Fitting subsections.
        5) Louver and air terminal connections to ducts.
        6) Access door, and access panel frames and jambs.
        7) Duct, plenum, and casing abutments to building structures.

1.03 SUBMITTALS

A. Action Submittals:

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


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

b. Ductwork Accessories:

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

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

2. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Sound Attenuators Certified Test Data:
   a. Dynamic insertion loss.
   b. Self-noise power levels.
   c. Static pressure loss.
   d. Dimensions and weights.
3. Record Drawings: Include duct systems routing, fittings details, and installed accessories and devices.

## 1.04 QUALITY ASSURANCE

A. Industry Standards:

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



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

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

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

D. Installer Qualifications: 3 years' minimum experience of successful installation of ductwork systems similar to that required for this Project.

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

1. Specifically approved in writing by Engineer.
2. Proposed layout shall provide original design results, without increasing system total pressure.

1.05 DELIVERY, STORAGE, AND HANDLING

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

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

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

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

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


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## PART 2 PRODUCTS

2.01 SCHEDULES

A. Ductwork Schedule: Refer to the Drawings.

2.02 GENERAL

A. Refer to the Area Classification and Materials Selection Tables in the General Section of Drawings for additional requirements.

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

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

D. Ductwork Interior Surfaces:

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

2.03 SHEET METAL MATERIALS

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

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

C. Galvanized Steel Ductwork:

1. Comply with ASTM A653/A653M and ASTM A924/924M.
2. Product Name: Steel Sheet, Zinc Coated (Galvanized Steel).
3. Sheet Designation: CS Type B.
4. Applicable Specification: ASTM A653/A653M.
5. (Zinc) Coating Designation: G90.
6. Coating designation in accordance with Test Method A, ASTM A90/A90M. and ASTM A924/A924M.


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7. Provide mill-phosphatized finish for ducts exposed to view and for ducts scheduled to be painted.
8. Provide sheet metal packaged and marked as specified in ASTM A700.

D. Aluminum Ductwork:

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

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

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

## 2.04 DUCT SEALING MATERIALS

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

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

C. Solvent-Based Sealants:

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

D. Water-Based Sealants:

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


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## 2.05 DUCTWORK FASTENERS

A. General:

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

B. Self-Drilling Screws:

1. Galvanized Steel Ductwork System: Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated carbon steel with zinc electroplated finish.
2. Aluminum Ductwork System: Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated Type 410 stainless steel, complete with bonded metal and fiber washer for dielectric separation.

## 2.06 DUCTWORK PRESSURE CLASS

A. Construct duct systems to pressure classifications indicated as follows:

1. Supply Ducts: 3-inch WC.
2. Return Ducts: 2-inch WC, negative pressure.
3. Exhaust Ducts: 2-inch WC, negative pressure.

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

## 2.07 RECTANGULAR DUCTWORK

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

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

C. Air Handling Unit Discharge Ductwork: Ductwork extending from air handling units up to and including first elbow or terminal tap outside air handling unit room shall be constructed as specified on the Drawings.



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## 2.08 RECTANGULAR DUCTWORK FITTINGS

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

B. Elbows:

1. Fit square-turn elbows with vane side rails.
2. Shop fabricate double-blade turning vanes of same material as ductwork.
3. Fabricate with equal inlet and outlet.
4. Rectangular radius elbows with inside radius of 3/4 of duct width in direction of turn.
5. Manufacturers and Products:
    a. Elgen; All-Tight.
    b. Duro-Dyne; Type TR.

C. Turning Vanes:

1. Double thickness, 4-inch radius except that 2-inch radius may be used on ducts 12 inches and smaller.
2. Airfoil vanes minimum 3.5-inch radius.
3. Vane metal thickness shall be minimum 24-gauge steel, and minimum G660 galvanized or equivalent. Vane material to be same as duct material.
4. Vane rails on 20 inch and larger ducts shall be 242-gauge or heavier.
5. Acoustic turning vanes shall be provided on acoustically lined elbows, and elsewhere as indicated.
6. Acoustic turning vanes shall be dimpled with slotted perforations and filled with 1.3-pound minimum density insulation.
7. Manufacturers:
    a. Aero-Dyne HEP.
    b. Ductmate.
    c. Sheet Metal Connectors, Inc; EZ Rail.

## 2.09 RECTANGULAR DUCTWORK BRANCH CONNECTIONS

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

## 2.10 RIGID ROUND DUCTWORK

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


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

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

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

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

## 2.11 RIGID ROUND DUCTWORK FITTINGS

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

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

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

D. Elbows:

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


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## 2.12 ROUND DUCTWORK BRANCH CONNECTIONS

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

## 2.13 INSULATED FLEXIBLE DUCT

A. Fabricate in accordance with:

1. UL 181, Class 1.
2. NFPA 90A and NFPA 90B.

B. Construction:

1. Outer Jacket: Fire retardant reinforced metalized vapor barrier jacket with reinforced cross-hatched scrim having a permeance of not greater than 0.1 perm when tested in accordance with ASTM E96/E96M, Procedure A.
2. Inner Liner: Tri-laminate of aluminum foil, fiberglass, and aluminized polyester.
3. Reinforcing: Galvanized steel wire helix, mechanically locked to and encapsulated by inner liner fabric.
4. Insulation:
   a. Factory insulated with fiberglass insulation.
   b. R-value: 6.0 minimum at a mean temperature of 75 degrees F.
5. Internal Working Pressure: Rating shall be minimum 4-inch WC positive and 5-inch WC negative, with bursting pressure of at least 2-1/2 times working pressure.
6. Air Velocity Rating: 4,000 fpm, minimum.

C. Environment: Suitable for continuous operation at temperature range of minus 20 degrees F to plus 200 degrees F.

D. Manufacturers and Products:

1. Flex-Master; Type 5M.
2. Thermaflex; Type M-KC.
3. Hart & Cooley; Type F216.

## 2.14 DUCTWORK HANGERS AND SUPPORTS

A. General:

1. Materials: Refer to the Area Classification and Materials Selection Tables(s) in the General Section of the Drawings.


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

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

1. Galvanized Steel Ductwork:
    a. Indoors: Carbon steel, zinc electroplated.
    b. Outdoors: Carbon steel, hot-dipped galvanized after fabrication.
2. Aluminum Ductwork Indoors and Outdoors:
    a. Carbon steel, hot-dipped galvanized after fabrication.
    b. Non-metallic pad between lower attachment and ductwork, to achieve dielectric separation.

C. Building Attachments:

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

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

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


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## 2.15 DUCTWORK FLEXIBLE CONNECTIONS

A. General:

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

B. Materials:

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

C. Construction:

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

D. Manufacturers:

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

## 2.16 CEILING ACCESS DOORS

A. As specified in Section 08 30 00, Specialty Doors.


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## 2.17 DUCT INSPECTION DOORS

A. General:

1. Insulated, gasketed, and at least 15 inches by 15 inches when duct dimensions are large enough.
2. On ductwork where largest side dimension is less then 16 inches, furnish inspection doors at least 8 inches by 8 inches.
3. Complete with necessary hardware and Ventlock No. 100 latches, and Ventlock Series No. 100 hinges.
4. Fabricated of same material as ductwork.

## 2.18 MANUAL DAMPERS

A. Butterfly Manual Dampers(for Round or Oval Ducts):

1. Fabricate from two gauges heavier than duct in which installed, of same material as ductwork.
2. Align operating handle with damper blade.
3. Provide 2-inch standoff bracket for insulated duct systems.
4. Damper Manufacturers:
   a. Ruskin.
   b. American Warming and Ventilating.
5. Operator Manufacturers and Products:
   a. Accessible Ductwork: Ventlok; Type 620 or 635.
   b. Accessible Insulated Ductwork: Ventlok; Type 639.
   c. Concealed Ductwork: Ventlok; Type 677 with extended operating rod and concealed regulator with plain cover.

B. Manual Opposed-Blade Balancing Dampers(for Rectangular Ducts):

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

## 2.19 BACK DRAFT DAMPERS

A. General: Damper pressure drop ratings shall be based on tests and procedures performed in accordance with AMCA 500-D Figure 5.3.



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B. Steel Frame, Nonmetallic Blades:

1. Fabrication:
   a. Frame: 2 inches by minimum 18-gauge (51 mm by minimum 1.6 mm) galvanized steel with windstops to reduce backflow.
   b. Blades:
      1) Style: Single piece, independent.
      2) Action: Parallel.
      3) Material: Noncombustible, neoprene coated fiberglass.
      4) Orientation: Horizontal.
      5) Width: Maximum 6 inches (152 mm).
   c. Rear Bird Screen: Galvanized expanded metal.
   d. Mounting:
      1) Suitable for mounting in vertical or horizontal airflow up positions.
      2) Configured for positions as shown on the Drawings.
   e. Finish: Mill galvanized.
2. Performance Data:
   a. Temperature Rating: Withstand minus 30 degrees F to 200 degrees F (minus 34 degrees C to 93 degrees C).
   b. Maximum Back Pressure: 4-inch WC (1.0 kPa).
   c. Maximum System Air Velocity: 1,000 fpm (5.1 m/s).
   d. Maximum Spot Air Velocity: 1,200 fpm (6.1 m/s).
3. Accessories:
   a. Duct Transition Connection: Rectangular.
   b. Factory Sleeve: Minimum 20-gauge (1.0 mm) thickness, minimum 8 inch (203 mm) length.
   c. Screen:
      1) Type: Bird.
      2) Location: Rear.
      3) Material: Galvanized steel.
4. Manufacturers and Products:
   a. Ruskin; Model NMS2.
   b. Vent Products, Co.

## 2.20 EXTERNAL DUCT INSULATION

A. Refer to Section 23 07 00, HVAC Insulation.

## 2.21 MISCELLANEOUS ACCESSORIES

A. Anchor Bolts: 1/2-inch minimum diameter. Refer to Section 05 50 00, Metal Fabrications, for anchor bolt and post-installed concrete anchor requirements.


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B. Louver and Grille Blank-Off Sections:

1. Fabricate from 20-gauge sheets of same material as louver/grille.
2. Line with sound attenuation/insulating material.
3. Shop-prime and paint outside face of blank-off section with two coats of flat black exterior paint.

C. Auxiliary Drain Pans:

1. Dimensions: Minimum 6 inches larger in both dimensions than equipment it is serving and 2 inches high, minimum.
2. Construction: 16-gauge stainless steel with welded joints. watertight with hemmed edges.
3. Drain Connection:
   a. Minimum 1-inch IPS or as shown on the Drawings.
   b. Locate at lowest point of drain pan.
   c. In lieu of drain connection, float switch may be installed. Float switch shall shut down air handling equipment upon sensing water.

D. Prefabricated Roof Curb:

1. Prefabricated roof curbs, flashing and counterflashing shall be constructed of minimum 0.08-inch aluminum.
2. Internal Insulation:
   a. Minimum of 1-1/2-inch thick, 1-pound density, glass fiber insulation.
   b. Seams sealed to prevent condensation.
3. Welded or tabbed and riveted construction will be acceptable. Both types of construction shall be manufactured and sealed as required to be watertight and weatherproof.
4. Lower section of roof curb that will be integrated with roofing system shall be constructed to accommodate roofing system provided including cant strip as required.
5. Top surface of curb shall have closed-cell rubber weather-seal pad. Provide wooden nailer sections as required for installation.
6. Sheet metal counterflashing shall be provided to accommodate rectangular or round ductwork.
7. Sheet metal screws and rivets shall be stainless steel or coated with corrosion-resistant material.
8. Height of roof curb shall be 12 inches, unless otherwise indicated herein or on the Drawings.
9. Length and width of roof curb shall be sized by Contractor for particular application.


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10. Roof curb shall be pre-sloped to accommodate roof pitch and allow equipment to set level.
11. Manufacturer:
    a. Thycurb.
    b. Factory fabricated by equipment manufacturer.

E. Accessories Hardware:

1. Instrument Test Holes:
    a. Cast metal, material to suit duct material, including screw cap and gasket and flat mounting gasket.
    b. Size to allow insertion of pitot tube and other testing instruments.
    c. Provide in length to suit duct insulation thickness.
2. Flexible Duct Clamps:
    a. Stainless steel band with cadmium-plated hex screw to tighten band with worm-gear action.
    b. Provide in sizes from 3 inches to 18 inches to suit duct size.
3. Adhesives: High strength, quick setting, neoprene based, waterproof and resistant to gasoline, and grease.

## 2.22 DUCTWORK IDENTIFICATION

A. Painted Identification Materials:

1. Stencils: Standard metal stencils, prepared for required applications with letter sizes generally comply with recommendations of ASME A13.1 for piping and similar applications, but not less than 1-1/4-inch high letters for ductwork and not less than 3/4-inch high letters for access door signs and similar operational instructions.
2. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray can form and grade.
3. Identification Paint: Standard identification enamel of colors indicated or in accordance with ASME A13.1 for colors for systems not identified herein.

B. Plastic Duct Markers

1. General:
    a. Provide manufacturer’s standard laminated plastic, color coded duct markers. Conform to the following color code:
        1) Black Text on Yellow Background: Odorous Air.
        2) White Text on Green Background: Services other than hazardous exhaust and odorous air.
        3) For other hazardous exhausts, use colors and designs recommended by ASME A13.1.


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C. Nomenclature:

1. Include the following:
   a. Direction of air flow.
   b. Duct service (supply, return, outside, transfer exhaust).

D. Manufacturers:

1. W.H. Brady, Co.
2. Seton Identification Products.
3. Craftmark.
4. Brimar Industries, Inc.

## PART 3 EXECUTION

### 3.01 GENERAL INSTALLATION

A. General: Refer to the Area Classification and Material Selection Tables in the General Section of the Drawings for instillation material requirements.

B. Miscellaneous:

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

C. Ductwork Location:

1. Locate ductwork runs vertically and horizontally, unless otherwise indicated.
2. Avoid diagonal runs wherever possible.
3. As indicated by diagrams, details, and notations or, if not otherwise indicated, run ductwork in shortest route that does not obstruct usable space or block access for servicing building and equipment.
4. In general, install as close to bottom of structure as possible.
5. For ductwork concealed above ceiling, maximize clearance between bottom of ductwork and top of ceiling construction.


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6. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
7. Transition ductwork that must drop below piping or other ductwork back to bottom of structure immediately adjacent to obstruction.

D. Penetrations:

1. Provide duct sleeves or prepared openings for duct mains, duct branches, and ducts passing through roofs, walls and ceilings.
2. Clearances:
   a. For uninsulated ducts, allow 1-inch clearance between duct and sleeve, except at grilles, registers, and diffusers.
   b. For insulated ducts, allow 1-inch clearance between insulation and sleeve, except at grilles, registers, and diffusers.
3. Closure Collars:
   a. Minimum 4 inches wide on each side of walls or floors where sleeves or prepared openings are installed.
   b. Fit collars snugly around ducts and insulation.
   c. Same gauge and material as duct.
   d. Grind edges of collar smooth to preclude tearing or puncturing insulation covering or vapor barrier.
   e. Use fasteners with maximum 6-inch centers on collars.
4. Packing: Mineral fiber in spaces between sleeve or opening and duct or duct insulation.

E. Concealment:

1. Wherever possible in finished and occupied spaces, conceal ductwork from view by locating in mechanical shafts, hollow wall construction, or above suspended ceiling.
2. Do not encase horizontal runs in solid partitions, except as specifically shown.
3. Limit clearance to 1 inch where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any.

F. Coordination with Other Trades:

1. Coordinate duct installation with installation of accessories, dampers, coil frames, equipment, controls, and other associated work of ductwork system.
2. Ductwork shall be configured, positioned, and installed to permit installation of light fixtures as indicated on the Drawings.
3. Coordinate ductwork layout with suspended ceiling, lighting and sprinkler head layouts and similar finished work.


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4. Electrical Equipment Spaces: Do not run ductwork through transformer vaults and other electrical equipment spaces and enclosures.

G. Shower Room and Toilet Room Exhaust Ductwork:

1. Joints and Seams: Seal watertight.
2. Slope branch ducts downward to grille.

3.02 RECTANGULAR DUCTWORK

A. General:

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

B. Low Pressure Taps:

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

C. Fittings:

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

D. Rectangular Ductwork Transverse Joints:

1. Install each run with a minimum of joints.
2. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.
3. Mechanical Joint Option:
    a. Construct transverse joints with Ductmate 25/35 duct connector systems, Ductmate W.D.C.I. Heavy/Lite duct connector systems, or Ductlok J/E duct connector system. Provide slip-on duct flange



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connectors with integral sealant pocket with permanently flexible sealant.

b. When using Ductmate W.D.C.I. Heavy/Lite system, construct ductwork in accordance to the Ductmate W.D.C.I. Heavy J and Light H Assembly Manual and Duct Construction Standards.

c. When using Ductlok J/E duct connector system, construct ductwork in accordance with Ductlok's Rectangular Duct Construction Manual for Low, Medium, and High Pressure.

d. For longitudinal seams, use Pittsburgh lock seam sealed internally with permanently elastic sealer such as Ductmate 5511M mastic.

e. Conform to SMACNA Class A sealing requirements.

## 3.03 RIGID ROUND OR OVAL DUCTWORK

A. General: Except where interrupted by fittings, install round ducts in lengths as long as possible to minimize joints.

B. Rigid Round or Oval Ductwork Joints:

1. Rigid round ductwork joints inserted in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible unless otherwise specified.
2. Single and Double Wall Supply and Return System Joints:
   a. Less than 36 Inches: Slip coupling.
   b. 36 Inches and Larger: Flanged connector, Van Stone, or welded companion flange type.
3. Single and Double Wall Exhaust and Return System Joints:
   a. Spiral Seam Duct: Welded flanged connector.
   b. Longitudinal Seam Duct: Van Stone flange connector.

## 3.04 INSULATED FLEXIBLE DUCT

A. Installation:

1. Where shown, between branch duct and ceiling diffusers and grilles.
2. Without sags, kinks, sharp offsets, or elbows.
3. Straight and taut.

B. Connection: Connect flexible ductwork to round collars, air distribution devices, and terminal units in accordance with flexible duct manufacturer's recommendations.

C. Length:

1. Maximum length of low-pressure flexible duct (construction pressure class up to 2-inch WC) to be 8 feet.


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2. Maximum length of medium pressure flexible duct (construction pressure class up to 4-inch WC) to be 4 feet.

D. Do not install flexible ductwork through wall, floor, or fire resistant rated assembly.

## 3.05 DUCTWORK HANGERS AND SUPPORTS

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

B. Support ducts rigidly with ties, braces, hangers, and anchors to hold ducts true-to-shape and to prevent buckling.

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

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

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

F. Design upper attachments to structures with an allowable load not exceeding 1/4 of failure (proof test) load. Attachments are not limited to specific methods indicated on the Drawings, but must be submitted for review prior to installation.

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

H. Install seismic restraints on ductwork systems and sway bracing as described in SMACNA Guidelines for Seismic Restraints of Mechanical Systems.

## 3.06 FLEXIBLE CONNECTIONS

A. Flexible Collars and Connections:

1. Use on ductwork between any HVAC equipment utilizing a fan and the connecting ductwork. Services include outside air, supply air, exhaust, and return air.
2. For round ducts, securely fasten flexible connections by zinc-coated steel clinch-type draw bands.
3. For rectangular ducts, lock flexible connections to metal collars.


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## 3.07 DAMPERS

A. General:

1. Inspection:
   a. Inspect areas to receive dampers.
   b. Notify Engineer of conditions that would adversely affect installation or subsequent utilization of dampers.
   c. Do not proceed with installation until unsatisfactory conditions are corrected.
2. Install dampers at locations indicated on the Drawings and in accordance with manufacturer's installation instructions.
3. Install square and level.
4. Handle damper using sleeve or frame. Do not lift damper using blades or jack-shaft.
5. Install damper blades and hardware to operate freely without obstruction.
6. Damper blades and hardware that bind within frame or obstructed by adjacent construction will not be acceptable.
7. Install gasket or caulk to eliminate leakage between duct and damper frames.
8. Provide head and sill stops.
9. Suitable for installation in mounting arrangement shown.
10. Do not compress or stretch damper frame into duct or opening.

B. Manual Dampers:

1. Provide balancing dampers for grilles and diffusers in branch duct as near main as possible.
2. Add or remove balancing dampers as requested by air balancing firm for necessary control of air.
3. Provide remote manual damper actuator assembly at an accessible location as detailed where duct mounted manual damper height exceeds 12 feet above the local working surface and when manual damper does not have sufficient clear access space on the working surface to position a portable stair assembly.

C. Back Draft Dampers:

1. Install dampers square and free from racking with blades running horizontally.
2. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.


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## 3.08 ACCESS DOORS

A. Ceilings: Install in nonaccessible ceilings below each electric duct heater, booster coil, motorized damper, terminal unit, smoke detector, and fire damper.

B. Ductwork:

1. Install access doors in ductwork, in accordance with manufacturer's instructions, at each:
   a. Duct mounted smoke or ionization detector.
   b. Electric duct heater.
   c. Booster coil.
   d. Humidifier.
   e. Motorized damper.
   f. Sail switch.
   g. Turning vane.
   h. Volume damper.
   i. Automatic damper.
   j. Temperature controller.
   k. Coil, on both upstream and downstream side.

## 3.09 EXTERNAL DUCT INSULATION

A. Refer to Section 23 07 00, HVAC Insulation.

## 3.10 MISCELLANEOUS ACCESSORIES

A. Auxiliary Drain Pans:

1. Under equipment for which pan is shown on the Drawings and under all horizontal air handling units located above ceilings and piping located in ceiling space directly above computer facility areas; furnish and install auxiliary drain pans.
2. Route drain lines to nearest floor or hub drain independent of any other drain.
3. Slope drain pans toward drain connection to promote drainage.

B. Louver and Grille Blank-Off Sections: Attach airtight to louver or grille and install to allow for easy removal.

C. Prefabricated Roof Curb:

1. Provide for ductwork roof penetrations and curb-mounted roof fans.
2. Roof curb installation, including flashing and counterflashing, shall provide watertight weatherproof enclosure.



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3. Attach counterflashing to ductwork via rubber gasketed sheet metal screws.
4. Fill space between counterflashing and ductwork with silicon-based sealant. Sealant shall also be applied at all sheet metal screw locations.

D. Inspection Plates and Test Holes:

1. Where required in ductwork for balance measurements.
2. Test holes shall be airtight and noncorrosive with screw cap and gasket.
3. Extend cap through insulation.

## 3.11 DUCT SEALING

A. Seal duct seams and joints as follows:

1. In accordance with SMACNA requirements.
2. In accordance with the following:
   a. Pressure Classifications Greater than 3-Inch WC: Transverse joints, longitudinal seams, and duct penetrations.
   b. Pressure Classification Between 2-Inch and 3-Inch WC: Transverse joints and longitudinal seams.
   c. Pressure Classification Less than 2-Inch WC: Transverse joints only.
3. In addition to other requirements, provide the following duct sealing:
   a. For interior ductwork, tape joints with Hardcast Lag-Rite tape and bonder or Ray-Chem shrink tape.
   b. For exterior ductwork, tape joints with Hardcast outdoor tape and rosin.

B. If no specific duct sealing requirements are specified, requirements of SMACNA manual shall govern.

C. Seal externally insulated ducts prior to insulation installation.

D. Seal all audible leaks.

## 3.12 BALANCING OF AIR SYSTEMS

A. Perform air balancing in accordance with requirements of Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

## 3.13 PROTECTION OF INSTALLED WORK

A. Cover open ends of installed ductwork systems to prevent dust, foreign objects and water from entering ductwork.


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B. Do not use ductwork systems for air conveyance until air filtration devices are installed in air handling equipment, to prevent ingress of construction dust.

3.14 CLEANING

A. Clean ductwork and remove rust, dust, and debris, both internally and externally, before placing in operation.

B. Before installing air outlets, use air handler to blow dry air through entire system at maximum attainable velocity. Provide temporary air filters for this operation.

C. If duct systems are found to contain construction debris at time of construction completion, provide complete ductwork system cleaning in accordance with NADCA Standards.

**END OF SECTION**




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# SECTION 23 31 13.05
# METALLIC PROCESS DUCTWORK

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. Air Movement and Control Association (AMCA): 500, Test Methods for Louvers, Dampers, and Shutters.
2. American Iron and Steel Institute (AISI).
3. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE):
   a. HVAC Systems and Equipment Handbook, Duct Construction Chapter.
   b. Fundamentals Handbook.
4. American Society of Mechanical Engineers (ASME): A13.1, Scheme for the Identification of Piping Systems.
5. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   c. A176, Standard Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip.
   d. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   e. A480/A480M, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip.
   f. A568/A568M, Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for.
   g. A653/A653M, Standard Specifications for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   h. A666, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
   i. A924/A924M, Specification for General Requirements for Sheet Steel, Metallic-Coated by the Hot-Dip Process.
   j. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.


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k. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.

6. American Society for Nondestructive Testing (ASNT): SNT TC 1A, Recommended Practice for Personal Qualification and Certification in Nondestructive Testing.
7. American Welding Society (AWS):
   a. D1.1/D1.1M, Structural Welding Code - Steel.
   b. D9.1/D9.1M, Sheet Metal Welding Code.
   c. QC1, Standard for AWS Certification of Welding Inspectors.
8. Factory Mutual Research: 4922, Fume Exhaust Ducts or Fume and Smoke Exhaust Ducts.
9. National Fire Protection Association (NFPA):
   a. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
   b. 90B Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
   c. 91, Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids.
   d. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
   e. 259, Standard Test Method for Potential Heat of Building Materials.
   f. 701, Standard Methods of Fire Tests for Flame Propagation of Textiles and Films.
10. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
    a. Accepted Industry Practice for Industrial Duct Construction.
    b. HVAC Air Duct Leakage Test Manual.
    c. HVAC Duct Construction Standards – Metal and Flexible.
    d. HVAC Rectangular Industrial Duct Construction Standards.
    e. HVAC Round Industrial Duct Construction Standards.
    f. Seismic Restraint Manual: Guidelines for Mechanical Systems.
11. UL 181, Standard for Safety Factory-Made Air Ducts and Connectors.

1.02 DEFINITIONS

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

1. CFM: Cubic feet per minute.
2. FPM: Feet per minute.
3. MDFT: Mean dry film thickness.
4. PCF: Pounds per cubic foot.
5. ppm: Parts per million by volume.
6. WC: Water column.


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B. Ductwork Dimensions: Net free, inside dimensions of duct.

C. Sealing Requirements:

1. For non-welded duct systems and components, the following definitions apply:
   a. Joints, duct surface connections including:
      1) Girth joints.
      2) Branch and subbranch intersections.
      3) Duct collar tap-ins.
      4) Fitting subsections.
      5) Louver and air terminal connections to ducts.
      6) Access door, and access panel frames and jambs.
      7) Duct, plenum, and casing abutments to building structures.
   b. Seams: Joining of two longitudinally (in direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on perimeter are deemed to be joints.

1.03 SUBMITTALS

A. Action Submittals:

1. Product Data:
   a. Ductwork:
      1) Schedules of duct systems, materials, joints, sealing, gage and reinforcement, coatings.
      2) SMACNA figure numbers for each shop fabricated item.
      3) Reinforcing details and spacing.
      4) Seam and joint construction details.
      5) Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.
   b. Ductwork Accessories:
      1) Manufacturer’s product data including catalog sheets, diagrams, standard schematic drawings, installation instructions and details, details of materials, construction, dimensions of individual components, and finishes, including the following items:
         a) Fittings and volume control damper installation (both manual and automatic) details.
         b) Gasket and sealing materials.
         c) Test Ports for coated ducts.
         d) Drains for ducts carrying mists or condensate.
         e) Dampers: Include leakage, pressure drop, and maximum back pressure data.


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f) Duct-mounted access panels and doors.
g) Flexible ducts.

2. Duct Fabrication Drawings:
   a. Prepare after actual Job measurements are obtained.
   b. Draw to a scale not smaller than 1/4 inch equals 1 foot, on drawing sheets same size as Contract Drawings.
   c. Include the following features:
      1) Fabrication, assembly, and installation details including plans, elevations, sections, details of components, and attachments to other work.
      2) Ductwork layout, indicating pressure classifications, slopes, drain and test port locations, and sizes in plan view.
      3) Interface and relationship between coated ductwork and adjacent equipment.
      4) Ductwork material and thickness.
      5) Fittings and volume control damper installation (both manual and automatic) details.
      6) Reinforcing details and spacing.
      7) Seam and joint construction details.
      8) Penetrations through fire-rated and other partitions.
      9) Ductwork accessories and control devices such as automatic dampers, terminal units, smoke detectors, regulators, and air distribution devices.
      10) Hangers and supports, including methods for building attachment, seismic bracing, vibration isolation, and ductwork attachment.
      11) Coordination with ceiling suspension members.
      12) Spatial coordination with other systems installed in same space with duct systems.
      13) Coordination of ceiling-mounted and wall-mounted access doors and panels required for access to dampers and other operating devices.
      14) Coordination with ceiling-mounted lighting fixtures, air outlets, and inlets.
      15) Coordination of ductwork with sprinkler piping and other mechanical and electrical services, and equipment.
3. Shop Fabricated Welded Duct:
   a. Detailed fabrication or spool drawings showing special fittings and bends, dimensions, coatings, and other pertinent information.
   b. Layout drawing showing location of each pipe section and each special length; number or otherwise designate laying sequence on each piece.
4. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.


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5. Equipment anchorage and support drawings and cut sheets indicating size, material, spacing, embedment and edge distances of anchors and other relevant information. Provide drawings reflecting results of calculations specified below.
6. Provide duct, fitting, and coating performance data upon request.

B. Informational Submittals:

1. Qualifications:
   a. Manufacturer: List of references substantiating experience.
   b. Installer: Manufacturer's certification that installer is qualified for installation work.
   c. Nondestructive Testing Personnel: SNT-TC-1A, Level II certification and qualifications.
   d. AWS QC1 Certified Welding Inspector: Submit evidence of current certification prior to commencement of welding activities.
   e. Welders:
      1) Continuity log for welders and welding operators.
      2) Welder qualification test records conducted by Contractor or manufacturer.
2. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
   a. Anchorage, bracing, and support design criteria and calculations:
      1) Stamped by an Engineer licensed in the State of Oklahoma.
      2) Conform to manufacturer's requirements as well as design criteria provided in Structural General Notes on the Drawings and other referenced standards.
   b. Indicate edge distance, embedment, concrete thickness and strength, and other conditions assumed in anchor calculations.
   c. Verify assumed field conditions prior to anchor and bracing installation.
3. Welder certifications for sheet metal welders per AWS D9.1/D9.1M, Sheet Metal Welding Code.
4. Operation and Maintenance Data: In accordance with Section 01 78 23, Operation and Maintenance Data.
5. Record Drawings: Include duct systems routing, fittings details, and installed accessories and devices.

## 1.04 QUALITY ASSURANCE

A. Industry Standards:

1. Unless otherwise indicated, provide supports and seismic restraint in compliance with SMACNA, Seismic Restraint Manual: Guidelines for Mechanical Systems. Use Seismic Hazard Level (SHL) C.


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2. Unless otherwise indicated or specified, provide ductwork and supports constructed and installed in accordance with:
   a. SMACNA HVAC Rectangular Industrial Duct Construction Standards.
   b. SMACNA HVAC Round Industrial Duct Construction Standards.
3. Comply with ASHRAE Fundamentals Handbook and ASHRAE HVAC Systems and Equipment Handbook recommendations, except as otherwise indicated.
4. Comply with NFPA 90A and NFPA 90B.

B. Manufacturers:

1. Factory Fabricated Ductwork: Firms regularly engaged in manufacture of ductwork products of types, materials, and sizes required, whose products have been satisfactorily used in service similar to that required for this Project for not less than 5 years.

C. Suppliers of Duct and Fitting Components:

1. Provide the following information on request:
   a. Laboratory performance data for duct, including leakage rate, bursting strength, collapse strength, seam strength, and pressure loss.
   b. Laboratory performance data for fittings, including zero-length dynamic losses.
   c. Laboratory performance data for coating corrosion performance for intended service.

D. Qualifications:

1. Independent Inspection and Testing Agency:
   a. Ten years' experience in field of welding and welded duct and fittings' testing required for this Project.
   b. Calibrated instruments and equipment, and documented standard procedures for performing specified testing.
   c. Certified in accordance with ASNT SNT-TC-1A for testing procedures required for this Project.
   d. Testing Agency: Personnel performing tests shall be NDT Level II certified in accordance with ASNT SNT-TC-1A.
   e. Verification Welding Inspector: AWS QC1 Certified.
2. Welding Procedures: In accordance with ASME BPVC SEC IX (Forms QW-482 and QW-483) or AWS D9.1/D9.1M (Annex N Forms).
3. Welder Qualifications: In accordance ASME BPVC SEC IX (Form QW-484) or AWS D1.1/D1.1M (Annex N Forms).


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4. Contractor's CWI: Certified in accordance with AWS QC1, and having prior experience with specified welding codes. Alternate welding inspector qualifications require approval by Engineer.

E. Quality Assurance: Provide services of independent inspection and testing agency for welding operations.

1. Presence of Owner's Special Inspector or Verification CWI does not relieve Contractor from performing their own quality control, including 100 percent visual inspection of welds.

F. Installation Firm: 5 years' minimum experience of successful installation on ductwork systems similar to that required for this Project.

G. Changes or alterations to layout or configuration of duct system:

1. Specifically approved in writing by Engineer.
2. Provide designer's confirmation that proposed layout will provide original design results, without increasing system total pressure.

1.05 DELIVERY, STORAGE, AND HANDLING

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

B. Protect fabricated ductwork and fittings from damage during shipping, storage, and handling. Provide shrink-wrapped duct seal, applied to ends of ductwork and fittings to prevent end damage and prevent dirt and moisture from entering.

C. Separately package each piece of ductwork without internal nesting of ductwork or fitting pieces.

D. For nonflanged components, use either rigid plugs inside ends to prevent deflection or protect with wooden boxes.

E. Crate materials whenever practical prior to shipment.

F. Firmly fasten and pad components shipped to prevent shifting or flexing of components while in transit.

G. Inspect shipments upon delivery. Note damages and discrepancies on bill of lading and notify manufacturer within 24 hours.


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H. Store coated ductwork on cardboard, Styrofoam, or similar material, out of traffic areas. Where possible, store ductwork indoors. Where necessary to store outdoors, store above grade and enclose with waterproof wrapping.

I. If ductwork coating is scratched, contact coating manufacturer for repair instructions. Repair or replace as determined by manufacturer.

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

K. Store and handle sealant materials in compliance with manufacturers' recommendations to prevent deterioration or damage as a result of moisture, high or low temperatures, contaminants, or other causes.

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

## PART 2 PRODUCTS

2.01 SCHEDULES

A. Ductwork Schedule: Refer to Article Supplements.

2.02 GENERAL

A. Service Conditions:

1. Materials suitable for inside airstream and outside environment containing, foul air with H2S concentration exceeding 1 ppm.
2. SMACNA Pressure Class: Minus 30 to plus 50 inches of water column as indicated on the Drawings.
3. SMACNA Duct System Class: Class 5 (corrosive, moist, nonabrasive), for duct system(s) Compost Foul Air.
4. Location: Outside.
5. Ambient Temperature: Minus 30 degrees F to 120 degrees F.
6. Seismic Requirements: As indicated on structural drawings.
7. Wind and Snow Loads: As indicated on structural drawings.

B. For indicated Pressure Class and System Class, design and install ductwork, fittings, and components to meet applicable requirements of:

1. SMACNA HVAC Rectangular Industrial Duct Construction Standards.
2. SMACNA HVAC Round Industrial Duct Construction Standards.


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C. Provide components of this ductwork system, including facings, mastics, and adhesives, with a fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke developed, tested in accordance with ASTM E84 and NFPA 255 methods.

D. Minimize number of joints in ductwork system.

E. Ductwork thinner than 20-gauge will not be allowed.

F. Ductwork Interior Surfaces:

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

G. Supports, Anchorage, and Restraints:

1. General:
   a. When supports, anchorages, and seismic restraints for equipment and supports and seismic restraints for ductwork are not shown on the Drawings, Contractor is responsible for their design.
   b. Design seismic restraints to avoid introducing stresses in ductwork caused by thermal expansion or contraction.
   c. Design connections to structural framing to avoid introducing twisting, torsion, or lateral bending in framing members. Provide supplementary steel as required.
2. Supports:
   a. Provide supports for ductwork in accordance with SMACNA RIDC, Section 40 05 15, Piping Support Systems, as described herein.
   b. Type: As indicated on the Drawings.
   c. Maximum Duct Deflection: 1/2 inch.
   d. Support spacing as indicated on the Drawings and the following maximum spacing:
      1) Interior Ductwork: 10 feet, maximum.
      2) Exterior Ductwork: 15 feet, maximum.
3. Suspended Ductwork: Provide seismic restraints in accordance with latest edition of the SMACNA Seismic Restraint Manual, Guidelines for Mechanical Systems, for seismic hazard level (SHL) as specified for the Project.
   a. Hanger Spacing: 8 feet, maximum.


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## 2.03 FACTORY FABRICATED STAINLESS DUCTWORK

A. Factory Stainless Duct, Coated and Uncoated:

1. Factory fabricated from stainless steel sheet, AISI Type 304L or Type 316L.
2. Gauge and reinforcing to meet designated system class and pressure class in accordance SMACNA Round Industrial Duct Construction Standards.
3. Exterior Finish: No. 2 B (cold-rolled, bright) finish conforming to ASTM A167 and ASTM A480.
4. Comply with ASTM A167, ASTM A176, ASTM A240/A240M, and ASTM A480/A480M.
5. Duct material shall be factory-rolled and fused with laser weld along longitudinal seam.
6. Each pipe shall be factory-checked with light apparatus for welding flaws or gaps.
7. Rolled edge of pipe section shall be die-formed after inspection by rolling each end of pipe simultaneously.
8. Gauge and reinforcing to meet designated system class and pressure class in accordance SMACNA Round Industrial Duct Construction Standards.
9. Exterior Finish: No. 2 B (cold-rolled, bright), or No. 4 polished, or No. 6 dull satin.
10. Material to comply with ASTM A240.
11. SMACNA Duct pressure class for un-coated duct, fittings and joints shall be minus 18-inch WC.

B. Fabrication:

1. Fittings:
   a. Fabricate elbows, transitions, offsets, branch connections, and other ductwork construction in accordance with SMACNA Construction Manuals.
   b. Coating and material to match ductwork requirements.
   c. Elbows, Tees, Bends: Minimum centerline radius of 1-1/2 times ductwork diameter whenever possible.
   d. Elbows above 45 degrees through 90 degrees to have a minimum of five gore construction.
   e. Mitered elbows not permitted.
   f. 90-Degree Tees, Laterals, and Conical Tees: Fabricate to conform to SMACNA Construction Standards with metal thicknesses specified for longitudinal seam straight duct.


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g. Diverging Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from body onto branch tap entrance.
h. Transitions: Limit taper angle to 30 degrees for contracting and to 20 degrees for expanding transitions.
i. Branch Takeoff Connections: Unless specifically detailed otherwise, provide 45-degree laterals and 45-degree elbows.
j. 90-Degree Branch Takeoffs: Shoe-tap-type tees.
k. Provide single-thickness turning vanes for rectangular elbows.
l. Field installed taps are not acceptable.

C. Joints:

1. Flanged Joints:
   a. Use companion angle ring bolted flange (Van Stone) ductwork joints consisting of rolled or pressed angle rings, and Gore-Tex or envelope-style gaskets.
   b. Shall be used for negative pressure ducts 14 inches in diameter and greater, for all positive pressure ducts, and elsewhere as indicated.
   c. Flange Ring Materials: AISI Type 304 or Type 316 stainless steel.
   d. Elongated bolt holes.
   e. Flange dimensions and bolt pattern for duct-to-duct connections shall be factory standard.
   f. Flange dimensions and bolt patterns for flanges that connect to equipment, flexible connections, dampers, and new or existing FRP ductwork shall match opposing connection flange.
2. Lever Type Clamp Joints:
   a. Proprietary reusable “Speed” clamp or “Quick-Fit” clamp joints are allowed over rolled edge duct where indicated or approved.
   b. Clamps: AISI Series 300 stainless steel for ducts 14 inches and smaller in diameter with manufacturer’s recommended gaskets.
   c. For negative pressure installations only. Not allowed for positive pressure systems.
   d. Clamp Seal Material: Nitrile to meet or exceed ASTM D1056 standards with temperature rating not to exceed 158 degrees F constant temperature (or intermittent temperature of 194 degrees F).
   e. Clamp Gasketing:
      1) Rock River Silicone Sealant or Dow-Corning 999-A, or equivalent (400 degrees F or lower).
      2) Sealing O-rings, Buna-N, 70 Duro-Meter hardness (250 degrees F or lower).
      3) Molded Sealing Gaskets per ASTM D2000 M2BG510 A24 B34 EO14 EO34 EF11 EF21 for use in systems where


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temperature is 225 degrees F or less and electrical conductivity is required.

4) Sponge O-ring shall meet material classification of either ASTM D1056-68 – SBE43 or ASTM D1056-85, 91, 98 – 2B3.

3. Slip Joints:
   a. Spiral duct installations may use seam welded slip joint fittings, specifically designed for high-pressure spiral duct being used.
   b. Spiral Manufacturing, Hranec, Industrial Duct Systems, others as approved.

## 2.04 FABRICATED DUCTWORK

A. Ductwork, Fittings, and Accessories: Construct and install in accordance with SMACNA Round Industrial or Rectangular Industrial duct construction standards, as applies, for pressure and system classification indicated.

B. Round Ducts:

1. Spiral-lock, grooved seam lock, or butt-welded seam construction.
2. Joints: Butt welded except provide Van Stone type connections to facilitate assembly and future maintenance. Designate proposed locations on the Shop Drawings.

C. Elbows: Radius type, stamped or multiple gore, minimum 1.5 radius to diameter ratio.

1. Provide a minimum radius to diameter ratio of 2.0 or above for ducts with velocities above 2,000 feet per minute.

D. Provide gradual transitions and branches. Design ducts with velocities above 2,000 feet per minute for constant velocity.

E. Field-welded Ductwork Seams, Joints, and Stiffeners:

1. Welded by AWS certified welders.
2. Welds: Full penetration welds in accordance with SMACNA Managers Guide to Welding, and per AWS D9.1.

F. Stainless Steel Ductwork:

1. Comply with ASTM A167, ASTM A176, ASTM A240/A240M, and ASTM A480/A480M.
2. Stainless Steel Sheet: Type 304, unless indicated otherwise.
3. Gauge: Comply with SMACNA manual, unless specified otherwise.
4. Finish: No. 2 B (cold-rolled, bright) finish, except as otherwise noted.


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

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

2.05 MISCELLANEOUS MATERIALS

A. General: Provide miscellaneous materials and products of types and sizes indicated and, where not otherwise indicated, provide type and size required to comply with ductwork system requirements, including proper connection of ductwork and equipment.

B. Nuts, Bolts, and Washers: AISI Type 316 stainless steel.

C. Structural Members: Matching type conforming to ASTM A666.

D. Provide nonmetallic pad between lower attachment and ductwork to achieve dielectric separation.

E. Gaskets:

1. Use on all flanged joints.
2. Gore-Tex Joint Sealant; W.L. Gore and Associates, Inc., Elkton, MD.
3. Description: Form in-place, fully expanded 100 percent PTFE gasket material, size as recommended by manufacturer.
4. Full-face, thickness as recommended by ductwork manufacturer.

F. Drains:

1. Provide at low points on SMACNA System Class 5 duct systems.
2. On factory-coated systems, attach drains prior to coating.
3. Weld couplings to bottom of main and branch ducts that are trapped and/or where shown on the Drawings, to allow removal of condensed liquids.
4. Predetermine locations of ductwork drains prior to manufacturer’s fabrication.

G. Sample and Test Ports:

1. Predetermine locations of pitot ports prior to manufacturer’s fabrication. At minimum, provide pitot ports in each branch duct to equipment, in each major main duct, at each fan and scrubber inlet and outlet, and where shown on the Drawings.


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2. Materials of Construction: PVC, fluoropolymer or fluoropolymer coated stainless steel.
3. Bulkhead fittings with threaded cap configured to allow free passage of a Dwyer 160 series pitot tube.
4. Where possible locate ports in side of ductwork. Port location in bottom 90 degree arc of horizontal ductwork is prohibited.

## 2.06 DUCTWORK HANGERS AND SUPPORTS

A. General:

1. Materials: Refer to Area Classification Table in General Section of Drawings.
2. Provide attachments, hangers, and supports for ductwork in accordance with SMACNA Manual referenced for type of duct system being installed.
3. Provide duct hanging system composed of three elements; upper attachment to building, hanger itself, and lower attachment to duct.
4. Wire hangers are not acceptable.
5. Class 5 Duct Supports: Design to support accumulation of water in duct.

B. Construction Materials:

1. Supporting devices including, but not limited to, angles used for support and bracing, baseplates, rods, hangers, straps, screws, bolts shall be as follows:
   a. Type 304 or Type 316 stainless steel.

C. Building Attachments:

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


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D. Vibration Isolation:

1. Provide at each support location and where contact with ductwork is made.
2. Configure supports to allow for vibration isolation material thickness.
3. Material: Minimum 3/16 inch thickness EPDM-bonded to support structure. Do not bond material to ductwork.

E. Trapeze and Riser Supports: Steel shapes conforming to Refer to Area Classification Table in General Section of Drawings.

2.07 EXPANSION JOINTS/ FLEXIBLE CONNECTIONS

A. Provide where indicated on the Drawings or as required for proper ductwork installation or thermal expansion.

B. Configuration:

1. Type: W-design configuration with integral flanges suitable for service with duct.
2. Material: Hypalon.
3. Backing Rings: 3/8 inch thick, 2 inches wide, AISI Type 316 stainless steel.
4. Drilling Pattern: Match adjacent ductwork or equipment connection.
5. Length: 6 inches, flange-to-flange.
6. Extension: 2 inches.
7. Compression: 1/2 inch.
8. Lateral Offset: 1 inch.
9. Thickness: 1/4 inch, minimum.

C. Manufacturer and Product: Holz Rubber Company, Inc.; Style 945.

2.08 DUCT ACCESS DOORS

A. General:

1. Bolted, gasketed, of same material and pressure rating as duct, and at least 15 inches by 15 inches when duct dimensions are large enough.
2. On ductwork where largest side dimension is less than 16 inches, furnish access doors at least 8 inches by 8 inches.
3. Provide where shown or required by code or Authority Having Jurisdiction.


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## 2.09 MANUAL DAMPERS

A. Butterfly Manual Dampers:

1. Fabricate from two gauges heavier than duct in which installed.
2. Coating and materials to match ductwork requirements.
3. AISI Series 300 stainless steel shaft.
4. PTFE or Viton blade seals.
5. PTFE or Viton shaft seals.
6. Flange layout and dimensions to match ductwork flanges.
7. Actuators:
   a. Sizes 24 inches and Smaller:
      1) Manual multi-position locking quadrant handle with no larger than 5 degree increments or continuous slot quadrant.
      2) Align locking operating handle with damper blade.
      3) Provide locking bolt.
   b. Sizes Larger than 24 Inches:
      1) Manual gear drive hand wheel actuator.
      2) Axle lock with no larger than 5 degree increments.
      3) Provide locking nut.

B. Blastgate Dampers:

1. Blast Gates: Non-binding when blade is inserted and extracted. Design and install so that blade is supported when in open position with blastgate mounted in vertical or horizontal duct.
2. Segment damper blade to limit weight of blade sections to 40 pounds maximum.
3. Industrial Single Blade Isolation Dampers—Sizes 6-inch to 48-inch-Diameter: Certified and bear AMCA Seal.
4. Damper Ratings:
   a. Based on tests and procedures performed in accordance with AMCA Publication 511.
   b. Comply with requirements of AMCA Certified Ratings Program.
   c. Test Method: AMCA Standard 500-89.
5. Air leakage based on operation between 50 degrees F and 104 degrees F (10 degrees C to 40 degrees C) and data corrected to represent standard air density 0.075 pound per cubic foot.

C. Counter Balanced Backdraft Dampers:

1. Externally operated gang damper blades with linkage located outside airstream.
2. Coating and materials to match ductwork requirements.
3. AISI Series 300 stainless steel shaft and linkage materials.


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4. Liquid tight PTFE or Viton shaft seals.
5. AISI Series 300 stainless steel or PTFE sleeve bearings.
6. Manually adjustable stainless steel counterweights.
7. Construct with interlocking edges and maximum 10-inch blade width.
8. Design and install so that no portion of damper blade extends past either flange face when operated over full range of actuation.
9. Flange layout and dimensions to match fan outlet flanges.

## 2.10 DUCTWORK IDENTIFICATION

A. Painted Identification Materials:

1. Stencils: Standard metal stencils, prepared for required applications with letter sizes generally comply with recommendations of ASME A13.1 for piping and similar applications, but not less than 1-1/4-inch-high letters for ductwork and not less than 3/4-inch-high letters for access door signs and similar operational instructions.
2. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray can form and grade.
3. Identification Paint: Standard identification enamel of colors indicated or in accordance with ASME A13.1 for colors for systems not identified herein.

B. Plastic Duct Markers:

1. General:
   a. Provide manufacturer’s standard laminated plastic, color-coded duct markers. Conform to the following color code:
      1) Black Text on Yellow Background: Odorous air.
      2) For other hazardous exhausts, use colors and designs recommended by ASME A13.1.

C. Nomenclature:

1. Include the following:
   a. Direction of air flow.
   b. Duct service (supply, return, exhaust).

D. Manufacturers:

1. W.H. Brady, Co.
2. Seton Identification Products.
3. Craftmark.
4. Brimar Industries, Inc.


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2.11 SOURCE QUALITY CONTROL

A. Factory Inspection: Inspect fabrications for required construction, intended function, and conformance with referenced standards.

B. Inspection of products is required prior to shipment, unless specifically waived in writing by Engineer.

C. Notify Engineer 1 week prior to estimated date of inspection.

D. Repairs authorized by Engineer to be re-inspected before final acceptance, unless specifically waived.

**PART 3 EXECUTION**

3.01 PREPARATION

A. Verify dimensions and conditions in field.

B. Layout routing in straight lines parallel to building lines, unless otherwise indicated.

C. Avoid diagonal runs wherever possible.

D. Coordinate support locations with layout and joints.

3.02 GENERAL INSTALLATION

A. General: Refer to Area Classification Table in General Section of Drawings for installation material requirements.

B. Miscellaneous:

1. Slope to drain. Provide drains at low points.
2. Install ductwork in accordance with SMACNA Construction Standards, NFPA 90A, and NFPA 90B.
3. Install ductwork in accordance with manufacturer’s recommendations using manufacturer’s recommended gaskets and accessories.
4. Align ductwork accurately at connections, within 1/8-inch misalignment tolerance and with internal surfaces smooth.
5. Install and torque flange and clamp bolts to manufacturer’s recommendations.
6. Interface Between Ductwork and Equipment: Install necessary transitions between ductwork and equipment cabinet connections in accordance with SMACNA guidelines.


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C. Ductwork Location:

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

D. Penetrations:

1. Provide duct sleeves or prepared openings for duct mains, duct branches, and ducts passing through roofs, walls and ceilings.
2. Clearances: Allow 1-inch clearance between duct and sleeve.
3. Closure Collars:
   a. Minimum 4 inches wide on each side of walls or floors where sleeves or prepared openings are installed.
   b. Fit collars snugly around ducts.
   c. Same gauge and material as duct.
   d. Grind edges of collar smooth.
   e. Use fasteners with maximum 6-inch centers on collars.
4. Packing: Mineral fiber in spaces between sleeve or opening and duct or duct insulation.

E. Coordination with Other Trades:

1. Coordinate duct installation with installation of accessories, dampers, coil frames, equipment, controls, and other associated work of ductwork system.
2. Configure, position, and install ductwork to permit light fixture installation as indicated on the Drawings.
3. Coordinate ductwork layout with suspended ceiling, lighting and sprinkler head layouts and similar finished work.
4. Electrical Equipment Spaces: Do not run ductwork through transformer vaults and other electrical equipment spaces and enclosures.
5. Do not run hazardous exhaust through fire or smoke rated penetrations.


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## 3.03 DUCTWORK INSTALLATION

A. Inspection:

1. Examine areas and conditions under which ductwork is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.
2. Prior to assembling, examine components to determine if any have been damaged.
3. Repair of Scratches: Contact coating manufacturer for repair instructions. Unless otherwise recommended by manufacturer, coat all scratches, chips, and other damage to coating with a field-applied coating patch to cover an area 2 inches on each side of damaged area. Clean and prepare affected area as described in manufacturer's instructions. Spark test repairs prior to installation.
4. Holes and Dents: Replace components having holes or dents.

B. Provide flanges at each ducting connection to equipment to facilitate installation and removal.

C. Install duct so that no load or movement in excess of that stipulated by equipment manufacturer will be imposed upon equipment connection; install to allow for contraction and expansion without stressing pipe, joints, or connected equipment.

D. Installation:

1. Assemble and install ductwork using extreme care not to scratch surface of coatings and in accordance with manufacturer's instructions and recognized industry practices which will achieve airtight and liquid tight systems.
2. Do not penetrate coatings for any reason. Do not use fastening devices, such as Tek screws and rivets on any part of a coated ductwork application. Predetermine test holes for monitoring and measurement before fabrication and install before coating. Coordinate with testing and balance contractor for required test port locations.
3. Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal space between construction openings and ductwork with sheet metal flanges of same material and gauge as duct. Overlap opening on all sides by at least 1-1/2 inches.
4. Provide drains with corrosion resistant drain plugs on SMACNA System Class 5 duct systems and other systems where water or other liquids could accumulate.
5. Provide test ports at all branches suitable for system balancing.



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E. Flanged Joints:

1. Install perpendicular to duct centerline.
2. Bolt Holes: Straddle vertical centerlines aligned with connecting equipment flanges or as shown.
3. Use torque-limiting wrenches to ensure uniform bearing and proper bolt tightness.
4. Raised-Face Flanges: Use flat-face flange when joining with flat-faced ductile or cast-iron flange.
5. Verify compatibility of mating flange to adapter flange gasket prior to selecting adapter flanging.
6. Flange fillers are to be avoided, but if necessary, may be used to make up for small angles up to 6 degrees and for filling gaps up to 2 inches between flanges. Stacked flange fillers shall not be used.
7. Threaded flanged joints shall be shop-fabricated and delivered to Site with flanges in-place and properly faced.
8. Manufacturer: Same as duct manufacturer for factory fabricated duct.

## 3.04 FIELD WELDING

A. Perform in accordance with SMACNA Industrial Standards. Provide full penetration welds on all seams and joints.

B. Weld Identification: Keep paper record of which welder welded each joint.

C. All welds shall conform to these standards:

1. SMACNA Managers Guide to Welding, 2nd Edition.
2. SMACNA RIDCS for pressure and system classification indicated.
3. AWS D9.1.

D. Surfaces:

1. Clean and free of paint, oil, rust, scale, slag, or other material detrimental to welding.
2. Clean stainless steel joints with stainless steel wire brushes or stainless steel wool prior to welding.
3. Do not use carbon steel cleaning tools on stainless or aluminum welds.
4. Thoroughly clean each layer of deposited weld metal, including final pass, prior to deposition of each additional layer of weld metal with a power-driven wire brush.


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E. Alignment and Spacing:

1. Align ends to be joined within existing commercial tolerances on diameters, wall thicknesses, and out-of-roundness.
2. Root Opening of Joint: As stated in qualified welding procedure.
3. Minimum Spacing of Circumferential Butt Welds: 1 inch.

F. Climatic Conditions:

1. Do not perform welding if there is impingement of any rain, snow, sleet, or wind exceeding 5 mph on weld area, or if ambient temperature is below 32 degrees F.
2. Stainless Steel and Alloy Piping: If ambient is less than 32 degrees F, local preheating to a temperature warm to hand is required.

G. Tack Welds: Performed by qualified welder using same procedure as for completed weld, made with electrode similar or equivalent to electrode to be used for first weld pass, and not defective. Remove those not meeting requirements prior to commencing welding procedures.

H. Surface Defects: Chip or grind out those affecting soundness of weld.

I. Weld Quality: Meet requirements of governing welding codes.

## 3.05 DUCTWORK HANGERS AND SUPPORTS

A. Supports: As specified in Section 40 05 15, Piping Support Systems. All supports shall have corrosion-resistance equivalent to that of duct supported.

B. Install ductwork with support systems in accordance with SMACNA Industrial Manuals and manufacturer’s recommendations. Provide supports designed to handle accumulations of liquid and particulate where indicated by system classification or as noted on the Drawings.

C. Penetrating fasteners of any type, such as Tek screws and rivets, are not permitted for hanging ductwork.

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

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

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

G. Support vertical ducts at maximum interval of 15 feet and at each floor.


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

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

3.06 EXPANSION JOINTS/FLEXIBLE CONNECTIONS

A. Flexible Collars and Connections:

1. Provide at inlet and outlet of each fan.
2. Provide at each end of a road crossing.
3. Provide as necessary to accommodate thermal expansion.
4. Provide as indicated on the Drawings.

B. Install such that flexible molded boot is not concave or otherwise twisted or deformed during normal operating conditions.

3.07 DAMPERS

A. General:

1. Inspection:
   a. Inspect areas to receive dampers.
   b. Notify Engineer of conditions that would adversely affect installation or subsequent utilization of dampers.
   c. Do not proceed with installation until unsatisfactory conditions are corrected.
2. Install dampers at locations indicated on the Drawings and in accordance with manufacturer’s installation instructions.
3. Install with damper shaft in horizontal position.
4. Install square and level.
5. Handle damper using sleeve or frame. Do not lift damper using blades or jack-shaft.
6. Confirm that damper blades and hardware operate freely without obstruction.
7. Damper blades and hardware that bind within frame or obstructed by adjacent construction will not be acceptable.
8. Provide gasketed damper frames to eliminate leakage between duct and damper frames.
9. Suitable for installation in mounting arrangement shown.
10. Do not compress or stretch damper frame into duct or opening.


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B. Manual Dampers:

1. Provide balancing dampers for grilles and diffusers as indicated on the Drawings in branch duct as near main as possible.
2. Add or remove balancing dampers as requested by air balancing firm for necessary control of air.

3.08 DUCT SEALING

A. If no specific duct sealing requirements are specified, seal in accordance with SMACNA Construction Standards.

B. Provide additional duct sealing as required to comply with Article Ductwork Leakage Testing.

C. Seal all audible leaks.

3.09 BALANCING OF AIR SYSTEMS

A. Perform air balancing in accordance with requirements of Section 23 05 93, Testing, Adjusting, and Balancing for HVAC unless otherwise stated.

B. H090 DEW1 OFC01 System: Manual dampers will be used to isolate each individual centrifuge, and to balance odorous air removal vents such that each centrifuge and each of the individual vents on and around each centrifuge are evenly exchanging flow.

1. H090 DEW1 OFC01 System Balancing Narrative:
   a. H090 DEW1 OFC01 is designed to remove 1440 ACFM of odorous air from the entire system at 4 inches of water column.
      1) Note that the motor installed can provide higher operating points if expansion of the odor control system is desired.
   b. System is designed for two duty centrifuges, but leaving the standby centrifuge isolation damper open will not harm equipment.
   c. Each individual centrifuge odor control system has three vents at the following points:
      1) Centrate chute.
      2) Solids discharge chute.
      3) Conveyor location (close proximity the solids discharge chute vent).
   d. Each system shall be balanced with dampers such that each vent location is removing approximately 240 ACFM, regardless of the individual vent distance from H090 DEW1 OFC01.
   e. The three isolation dampers shall be used to stop odorous air removal at the standby centrifuge system. It shall also be used to


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ensure the individual centrifuge systems are receiving approximately equal air removal regardless of the distance from H090 DEW1 OFC01.

3.10 PROTECTION OF INSTALLED WORK

A. Cover open ends of installed ductwork systems to prevent dust, foreign objects, and water from entering ductwork.

B. Do not use ductwork systems for air conveyance until adequate air filtration devices are installed in air handling equipment, to prevent ingress of construction dust.

3.11 FIELD TESTING

A. Field test ductwork after installation and before concealment or burying, with air test to 90 percent of maximum working pressure for a period of 4 hours. Correct leaks and retest until no further leaks appear.

3.12 MANUFACTURER'S SERVICES

A. Manufacturer's Representative:

1. Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:
   a. 1 person-day for installation assistance, including pre-installation training of Contractor personnel in joint assembly and inspection.
   b. 1 person-day for field testing and completion of Manufacturer's Certificate of Proper Installation.

B. See Section 01 43 33, Manufacturers' Field Services.

3.13 CLEANING

A. Clean ductwork of rust, dust, and debris, both internally and externally, before placing in operation.

B. Confirm that dampers are smooth, clean, and free of dirt when installed.

3.14 SUPPLEMENT

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

1. Odor Control Ductwork Schedule.

**END OF SECTION**


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**Odor Control Ductwork Schedule**

| System | Service | Location | Specification | Pressure Class (in W.G.) | Materials of Construction | Seal Class | Remarks |
|---|---|---|---|---|---|---|---|
| H090-DEW1-OFC01 | Fan Discharge | Outdoor | 23 31 13.05 | +4 | Aluminum | A | Full penetration welds |
| | Fan Suction | Indoor | 40 27 00.09 | -4 | FPVC* | A | |
| | | Outdoor | 23 31 13.05 | -4 | Aluminum | A | |
| H095-COM2-FAN01 thru FAN10 | Active Compost Fans | Buried | 40 27 00.14 | -10/+10 | HDPE | A | Debeaded welds |
| | | Exposed | 23 31 13.05 | -10/+10 | Aluminum | A | Full penetration welds |
| H095-COM2-FAN11 and FAN12 | Biofilter Fans | Buried | 40 27 00.14 | -12/+12 | HDPE | A | Debeaded welds |
| | | Exposed | 23 31 13.05 | -12/+12 | Aluminum | A | Full penetration welds |
| H095-COM3-FAN01 thru FAN04 | Curing Fans | Buried | 40 27 00.14 | +10 | HDPE | A | Debeaded welds |
| | | Exposed | 23 31 13.05 | +10 | Aluminum | A | Full penetration welds |

*FPVC = fire resistant polyvinyl chloride ducting


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# SECTION 23 34 00
# HVAC FANS

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. Air Movement and Control Association International (AMCA):
   a. 99, Standards Handbook.
   b. 201, Fans and Systems.
   c. 203, Field Performance Measurement of Fan Systems.
   d. 204, Balance Quality and Vibration Levels for Fans.
   e. 210, Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.
   f. 300, Reverberant Room Method for Sound Testing of Fans.
   g. 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
2. American Bearing Manufacturers Association (ABMA): 9, Load Ratings and Fatigue Life for Ball Bearings.
3. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
4. ASTM International (ASTM):
   a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
   b. D2247, Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity.
   c. D2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
   d. D3363, Standard Test Method for Film Hardness by Pencil Test.
   e. D4167, Standard Specification for Fiber-Reinforced Plastic Fans and Blowers.
   f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
5. National Electrical Manufacturers Association (NEMA).
6. National Fire Protection Association (NFPA): 45, Standard on Fire Protection for Laboratories Using Chemicals.
7. Occupational Safety and Health Act (OSHA).
8. Society for Protective Coatings (SSPC):
   a. SP 3, Power Tool Cleaning.
   b. SP 5, White Metal Blast Cleaning.


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c. SP 6, Commercial Blast Cleaning.
d. SP 10, Near-White Blast Cleaning.

9. UL:
   a. 507, Safety Standard for Electric Fans.
   b. 705, Power Ventilators, covering roof, wall-mounted, and duct fans used in commercial, industrial and residential settings.
   c. 900, Air filters units.

1.02 DEFINITIONS

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

1. AC: Alternating Current.
2. CISD: Chemical Industry, Severe-Duty.
3. dB: Decibel.
4. DWDI: Double Width, Double Inlet.
5. ECM: Electronically Commuted Motor.
6. FRP: Fiberglass Reinforced Plastic.
7. hp: Horsepower.
8. ODP: Open Drip Proof.
9. SWSI: Single Width, Single Inlet.
10. TEFC: Totally Enclosed, Fan Cooled.
11. UV: Ultra Violet
12. XP: Explosion Proof.

1.03 SUBMITTALS

A. Action Submittals:

1. Provide following for specified products:
   a. Identification as referenced in Contract Documents.
   b. Manufacturer’s name and model number.
   c. Descriptive specifications, literature, and drawings.
   d. Dimensions and weights.
   e. Fan sound power level data (reference 10 to power minus 12 watts) at design operating point.
   f. Fan Curves:
      1) Performance Curves Indicating:
         a) Relationship of flow rate to static pressure for various fan speeds.
         b) Brake horsepower curves.
         c) Acceptable selection range (surge curves, maximum revolutions per minute).


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d) Static pressure, capacity, horsepower demand and overall efficiency required at duty point, including drive losses.

2) For variable air volume applications, indicate operating points at 100, 80, 60 and 40 percent of design capacity on fan curves including data to indicate effect of capacity control devices such as inlet vanes on flow, pressure, and brake horsepower.

g. Capacities and ratings.
h. Construction materials.
i. Fan type, size, class, drive arrangement, discharge, rotation, and bearings.
j. Wheel type, diameter, maximum revolutions per minute for fan class, operating revolutions per minute, and tip speed.
k. Motor data, including service factor and operating horsepower, as specified in Section 26 20 00, Low-Voltage AC Induction Motors.
l. Fan shaft first critical speed.
m. Belt service factor.
n. Drive assembly horsepower rating.
o. Sheave horsepower rating.
p. Power and control wiring diagrams, including terminals and numbers.
q. Factory run test and vibration test reports.
r. Vibration isolation.
s. Factory finish system.
t. Color selection charts where applicable.
u. Corrosion protection coating product data.

2. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.
3. “Or Equal” Equipment:
   a. Where submitted equipment results in change to fan inlet or outlet ductwork configuration shown on the Drawings, submit system effect factor calculations indicating increased static pressure requirements as described in AMCA 201.
   b. Where submitted equipment results in change to ductwork and equipment configuration shown on the Drawings, submit detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement to equipment furnished.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.


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2. Recommended procedures for protection and handling of products prior to installation.
3. Manufacturer's installation instructions.
4. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for the following:
   a. Motors specified to be premium efficient type.
5. Test reports.
6. Operation and maintenance data in conformance with Section 01 78 23, Operation and Maintenance Data. Include as-built version of equipment schedules.

1.04 QUALITY ASSURANCE

A. Performance Ratings: Tested in accordance with AMCA 210.

B. Sound Ratings: Tested in accordance with AMCA 300.

C. Fabrication: In accordance with AMCA 99.

1.05 EXTRA MATERIALS

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

| Item | Quantity |
|---|---|
| Vee Belts | One complete set per unit |
| Special tools required to maintain or dismantle | One complete set for each different size unit |

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

**PART 2 PRODUCTS**

2.01 EQUIPMENT SCHEDULES

A. Some specific equipment requirements are listed in Equipment Schedule. Refer to the Drawings.



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2.02 GENERAL

A. Spark Resistant Construction: Fans required to be spark resistant shall comply with requirements of AMCA 99-0401.

B. Operating Limits: Fans designated to meet a specified fan class shall comply with requirements of AMCA 99-2408.

C. Acoustical Levels: Equipment selections shall produce sound power levels in each octave band no greater than shown in Equipment Schedule.

D. Fan Drives:

1. Drive assembly shall be sized for a minimum 140 percent of fan motor horsepower rating.
2. Furnish multiple drive belts where motor horsepower is 2 hp or larger.
3. Sheaves:
    a. Capable of providing 150 percent of motor horsepower.
    b. Unless otherwise noted, furnish belt-driven fans with cast iron or flanged steel sheaves.
4. Drive Adjustment:
    a. When fixed-pitch sheaves are furnished, accomplish system air balancing by either trial of different fixed-pitch sheaves or use of temporary adjustable-pitch sheaves.
    b. Provide trial and final sheaves, as well as drive belts, as required.
5. Fan Shafts: First critical speed of at least 125 percent of fan maximum operating speed.
6. Provide speed test openings at shaft locations.
7. Belts: Oil and heat resistant, nonstatic type.
8. Motors:
    a. Motors 20 hp or Smaller:
        1) Variable pitch V-belt sheaves allowing at least 20 percent speed variation.
        2) Final operating point shall be at approximate sheave midpoint.
    b. Motors Larger than 20 hp: Fixed-pitch sheaves.
    c. Furnish motors for V-belt drives with adjustable rails or bases.
9. Weather Cover: For outdoor applications, factory fabricated drive assembly of same material as fan housing, unless specified otherwise.
10. Belt and Shaft Guards:
    a. Easily removable and to enclose entire drive assembly, meeting federal, OSHA, and State of Oklahoma requirements.
    b. Guard faces of expanded metal having minimum 60 percent free area for ventilation.
    c. Bright yellow finish.


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E. Finishes:

1. Carbon Steel Parts: Factory finish as follows, unless indicated otherwise.
   a. Parts cleaned and chemically pretreated with phosphatizing process.
   b. Alkyd enamel primer.
   c. Air dry enamel topcoat.
2. Aluminum Parts: Finished smooth and left unpainted, unless stated otherwise.
3. Stainless Steel Parts: Finished smooth and left unpainted.

2.03 CABINET FAN

A. General:

1. Factory-assembled, ceiling, wall or inline mounted, centrifugal cabinet fan; including housing, fan wheel, drive assembly, motor and accessories.
2. Bearing AMCA Certified Ratings Seal for sound and air performance.

B. Housing:

1. Material: Minimum 20-gauge galvanized steel.
2. Construction:
   a. Minimum 14-gauge blower and motor support frame.
   b. Lined with minimum 1/2-inch acoustical insulation.
   c. Outlet duct collar with integral reinforced aluminum backdraft damper, with nylon bushings.
   d. Motor mounted on resilient vibration isolators.
   e. Motor and blower removable from unit without cabinet disassembly.
   f. Removable cabinet access panels.
   g. Air Inlet: Field convertible for bottom or end air inlet configuration.
   h. Predrilled universal mounting brackets, adjustable.

C. Wheel: Centrifugal forward curved type, galvanized steel or plastic construction.

D. Shaft, Bearings, Drive:

1. Shafts: Turned, ground and polished carbon steel.
2. Bearings: Grease lubricated, precision antifriction ball, sealed type.


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3. Drives:
    a. In accordance with Paragraph Fan Drives.
    b. Factory set to specified fan revolutions per minute.
    c. Type: Direct.

E. Electrical:

1. Integral wiring box.
2. Factory-installed disconnect receptacle.

F. Accessories:

1. Provide as follows:
    a. Ceiling Grille: Factory fabricated, steel construction, white baked enamel finish.
    b. Speed Controller:
        1) Integral dial type combination ON/OFF switch and SPEED selector.
2. Wall Cap:
    a. Aluminum construction, powder coated finish, color as scheduled on Exterior Finish Schedule as shown on the Drawings.
    b. backdraft damper.
    c. Bird screen.
    d. Round duct connection.
    e. Greenheck model WC series.

G. Manufacturers and Products:

1. Loren Cook; Gemini Series.
2. Greenheck; SP-AP Series.
3. ACME; Model VQ Series.
4. Twin City Fan; T Series.

## 2.04 DIRECT DRIVE ROOF UPBLAST PROPELLER EXHAUST FAN

A. General Description:

1. Discharge air directly away from the mounting surface.
2. Roof mounted application.
3. Fan shall bear a permanently affixed manufacturer’s engraved metal nameplate containing the model number and individual serial number.

B. Propeller:

1. Constructed of aluminum.
2. Securely attached to fan shaft.


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3. Statically and dynamically balanced in accordance to AMCA Standard 204-05.
4. The propeller and fan inlet will be matched and shall have a precise running tolerance for maximum performance and operating efficiency.

C. Motor:

1. Electrically Commutated Motor:
   a. Motor Enclosures: Totally enclosed fan cooled.
   b. Electronic commutation type motor (ECM) specifically designed for fan applications. AC induction type motors are not acceptable. Examples of unacceptable motors are shaded pole, permanent split capacitor (PSC), split phase, capacitor start and three-phase induction type motors.
   c. Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase.
   d. Internal motor circuitry to convert AC power supplied to the fan to DC power to operate the motor or integrated variable frequency drive.
   e. Motor shall be speed controllable down to 20 percent of full speed (80 percent turndown). Speed shall be controlled by either a potentiometer dial mounted at the motor.
   f. Motors can achieve up to 95 percent efficiency (model and horsepower dependent).

D. Housing:

1. Constructed of heavy gauge aluminum.
2. Rigid internal support structure.
3. Leakproof.
4. Constructed with windband.

E. Drive Frame:

1. Drive frame assemblies shall be galvanized steel.
2. Drive frame shall formed channels and fan panels shall have a deep formed inlet venture.

F. Windband:

1. Constructed of heavy auge galvanized steel with reinforced and bolted seams.
2. Removable windband to gain access to the fan through dampers.
3. Direct exhaust air away from mounting surface.


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G. Disconnect Switches:

1. NEMA Rated: 4X.
2. Positive electrical shut-off.
3. Wired from fan motor to junction box.

H. Butterfly Dampers:

1. Material: Aluminum.
2. Damper type: Gravity.
3. Damper Lifter: Not required.

I. Curb Caps: Includes prepunched mounting holes to ensure correct attachment to roof.

J. Optional Accessories:

1. Roof Curbs
   a. Type: GPFP.
   b. Mounted onto roof with fan.
   c. Material: Aluminum.
   d. Insulation: Not Required.
   e. Coating Type: Hi-Pro polyester.
2. Outlet Screen.
   a. Constructed of heavy gauge steel mesh.
3. Wiring Pigtail:
   a. Direct Hook-up to the power supply.
   b. Nine foot wiring extension.

K. Manufacturer and Product: Greenheck, RDU model, or equal.

2.05 ROOF FAN, CENTRIFUGAL UPBLAST

A. General:

1. Factory-assembled centrifugal upblast roof fan; including housing, fan wheel, drive assembly, motor and accessories.
2. Bearing AMCA Certified Ratings Seal for sound and air performance.

B. Housing:

1. Construction: Spun-formed aluminum, minimum 16-gauge marine alloy.
2. Windband: Finish with rolled bead.
3. Top Cap: Motor access via quick release latches.
4. Motor completely sealed from exhaust air stream.


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5. Motor cooling via air breather tubes.
6. Integral conduit chase for wiring.
7. Drain trough at lowest point of housing.
8. Fan Inlet:
    a. Full inlet cone of aluminum construction.
    b. Match inlet shroud.

C. Wheel:

1. Aluminum construction, backward inclined centrifugal, nonoverloading type.
2. Machined, cast aluminum hub.
3. Matched to deep spun inlet venturi.

D. Shaft, Bearings, Drive:

1. Shaft:
    a. Turned, ground, and polished carbon steel.
    b. Keyed for sheave installation.
    c. Zinc-phosphate coated and oil emulsion-dipped.
2. Bearings:
    a. Grease lubricated, precision antifriction ball, self-aligning, pillow block style.
    b. Selected for average life (ABMA 9 $L_{50}$) of not less than 200,000 hours operation at maximum cataloged operating speed.
    c. Terminate with zerk fittings.
3. Drives:
    a. In accordance with Paragraph Fan Drives.
    b. Factory set to specified fan revolutions per minute.
    c. Type: Belt or direct, as indicated in Equipment Schedule.

E. Accessories:

1. Provide as follows:
    a. Bird Screens: Aluminum construction.
    b. Roof Curb:
        1) Factory fabricated, aluminum construction.
        2) Sloped to match roof pitch, and to provide level top.
        3) Height Above Finished Roof: 12 inches.
        4) Mitered continuous welded corner seams.
        5) Pressure-treated wood nailer.
        6) Insulation: Minimum 1-1/2 inches thick, 3 pounds per cubic foot density, rigid mineral fiberboard insulation with metal liner.


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c. Disconnect: Factory installed, nonfused, NEMA Type as scheduled.
d. Bearing Lubrication Lines:
1) Extended to outside of fan housing.
2) Type 316 stainless steel construction.
3) Terminate with zerk fittings.
e. Spark Resistant Construction Classification: AMCA 99-0401 Type B.

2. Pressure Controller as indicated on schedules.
a. Greenheck; Constant Pressure Controller with Integral Transducer.
b. Pressure Setpoint: 0.1 in-wg.
c. 24V dc control voltage.
d. 2-line, backlit Display.
e. 0V dc to 10V dc output to vari-green motor.
f. Include factory fan mounted transformer.

F. Manufacturers and Products:

1. Aerovent: Model ATB.
2. Cook; Model ACRUD (Direct Drive); ACRUB (Belt Drive).
3. Greenheck; Model CUE (Direct Drive); CUBE (Belt Drive).
4. ACME, Model PDU (Direct Drive); PNU (Belt Drive).
5. Twin City Fan; BCRU.

2.06 CORROSION PROTECTION COATING

A. General:

1. Factory-applied corrosion protection coating for application to fan components and accessories, where required by this section.
2. Quality Control:
a. Verify dry film thickness before final baking.
b. Finished coating system shall be free from voids, checks, cracks, and blisters.
3. Surface Cleaning:
a. Clean parts to be coated as follows:
1) Immerse parts in heated cleaning solution to remove lubricants, machining oils, and residual factory contamination.
2) Follow with immersion in potable water bath to neutralize and remove cleaning solution.
3) Chemical Pretreatment: Immerse parts in heated chemical solution, iron phosphate for steel, clear/yellow chromate for aluminum.


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B. Baked Epoxy:

1. Material: Epoxy.
2. Surface Preparation: Sandblast surface to SSPC SP 10.
3. Application: Electrostatic spray.
4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
5. Finished Thickness: 2.5-mil to 3.5-mil dry film thickness.
6. Performance:
   a. Coating shall meet or exceed following criteria:
      1) Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
      2) Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
      3) Impact Resistance: 100 inch pounds, ASTM D2794 test method.
      4) Pencil Hardness: 2H, ASTM D3363 test method.
      5) Service Temperature: Maximum 230 degrees F, continuous.

## 2.07 MOTORS

A. General:

1. Fan motors shall comply with provisions of Section 26 20 00, Low-Voltage AC Induction Motors.
2. Provide integral self-resetting overload protection on single-phase motors.
3. Motors for fans specified for use with variable frequency drives shall be inverter duty type.
4. Motors shall not operate into service factor in any case.

B. Motor requirements shall be as follows, unless designated otherwise on Equipment Schedule:

1. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
2. Winding Thermal Protection: None.
3. Space Heater: No.
4. Number of Speeds: Single.
5. Number of Windings: One.
6. Motor Efficiency: Premium efficient.
7. Shaft Type: Solid, carbon steel.
8. Mounting: As required for fan arrangement.
9. Service Factor: 1.15.


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## 2.08 ACCESSORIES

A. Equipment Identification Plates: Furnish 16-gauge Type 304 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch high engraved block type black enamel filled equipment identification number and letters indicated in this specification and as shown on the Drawings.

B. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

## 2.09 SOURCE QUALITY CONTROL

A. General:

1. Fan shall operate at single stable point as indicated by fan curve. Fans having two potential operating points are not acceptable.
2. Fan and motor combination shall be capable of delivering 110 percent of scheduled air quantity and static pressure. Motor shall not operate into motor service factor in any listed case.
3. Consider drive efficiency in motor selection according to manufacturer’s published recommendation or according to AMCA 203, Appendix L.

B. Testing Provisions:

1. Provide tachometer access holes large enough to accept standard tachometer drive shaft.
2. Center punch fan shaft to accommodate tachometer readings.

C. Acoustical Levels:

1. Perform noise tests in accordance with AMCA 300 and AMCA 301.
2. Fan sound power levels (dB, Reference $10^{-12}$ Watts) shall be no greater than scheduled values.

D. Balancing:

1. Unless noted otherwise, each fan wheel shall be statically and dynamically balanced to ASA S2.19 Grade G6.3.
2. Fans controlled by variable frequency drives shall be dynamically balanced at speeds 25 percent, 50 percent, 75 percent, and 100 percent of design revolutions per minute.


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E. Vibration Test:

1. Each fan furnished with 5-horsepower or larger motor shall have factory run vibration test, including vibration signatures taken on each bearing in horizontal, vertical, and axial direction.
2. Vibration reading as measured at scheduled rotational speed shall not exceed the following values when fan is rigidly mounted:
   a. Belt Drive (except Vane Axial): 0.15 inch per second peak velocity.
   b. Belt Drive Vane Axial: 0.08 inch per second peak velocity.
   c. Direct Drive: 0.08 inch per second peak velocity.
3. Written records of run test and vibration test shall be made available upon request.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. Install fans level and plumb.

B. Secure roof-mounted fans to roof curbs with Type 316 stainless steel hardware.

C. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

D. Scroll Drains: Pipe drain connection through running trap to floor drain.

E. Labeling:

1. Label fans in accordance with Article Accessories.
2. Mark exhaust fans serving fume hoods with arrows to indicate proper direction of rotation, in accordance with NFPA 45.

F. Service Access: Locate units to provide access spaces required for motor, drive, bearing servicing, and fan shaft removal.

G. Equipment Support and Restraints:

1. Refer to Section 23 05 48, Vibration Isolation and Seismic Control.
2. Install floor-mounted units on concrete bases designed to withstand, without damage to equipment, the seismic force required by code.
3. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.
4. Seismic Restraint Snubbers: Install with sufficient clearance so unit isolators are not restricted for proper free isolation, but do limit movement in all directions.


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H. Connections:

1. Refer to Section 23 31 13, Metal Ducts and Accessories.
2. Isolate duct connections to fans.
3. Install ductwork adjacent to fans to allow proper service and maintenance.

3.02 FIELD QUALITY CONTROL

A. Functional Tests:

1. Verify blocking and bracing used during shipping are removed.
2. Verify fan is secure on mountings and supporting devices, and connections to ducts and electrical components are complete.
3. Verify proper thermal-overload protection is installed in motors, starters, and disconnect switches.
4. Verify cleaning and adjusting are complete.
5. Disconnect fan drive from motor; verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation.
6. Reconnect fan drive system; align and adjust belts and install belt guards.
7. Verify lubrication for bearings and other moving parts.
8. Verify manual and automatic volume control and fire and smoke dampers in connected ductwork are in fully open position.

B. Performance Tests:

1. Starting Procedures:
   a. Energize motor and adjust fan to indicated revolutions per minute.
   b. Measure and record motor voltage and amperage.
2. Operational Test:
   a. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   b. Repair or replace malfunctioning units; retest as specified after repairs or replacement is made.
   c. Test and adjust control safeties.
   d. Replace damaged and malfunctioning controls and equipment.

3.03 MANUFACTURER’S SERVICES

A. Refer Section 01 43 33, Manufacturers’ Field Services, and Section 01 91 14, Equipment Testing and Facility Startup.


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## 3.04 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

D. Balancing:

1. Perform air system balancing as specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.
2. Replace fan and motor sheaves as required to achieve design airflow.

E. Vibration Testing:

1. Perform field testing on rotating equipment, where specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC, to determine actual operating vibration.
2. If vibration limits described therein are exceeded, rebalance equipment in-place until design tolerances are met.
    a. Vibration readings as measured at actual rotational speed shall not exceed the following values:
        1) Belt Drive, Flexibility Mounted: 0.25 inch per second peak velocity.
        2) Belt Drive, Rigidly Mounted: 0.16 inch per second peak velocity.

## 3.05 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

B. On completion of installation, internally clean fans according to manufacturers' written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

**END OF SECTION**


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# SECTION 23 34 05
# ODOR CONTROL FANS

## EQUIPMENT AND COMPONENT NUMBER(S)

Odor Control Fan(s):
H090-DEW1-OFC01: Odor Control Fan No. 1.
H095-COM2-FAN01 through FAN10: Compost Fan No. 1 through No. 10.
H095-COM2-FAN11 through FAN12: Biofiler Fan 1 and Biofilter Fan 2.
H095-COM3-FAN01 through FAN04: Curing Fan No. 1 through No. 4.

## PART 1 GENERAL

1.01 GENERAL

A. Like items of equipment provided hereunder shall be the end products of one manufacturer to achieve standardization for operation, maintenance, spare parts, and manufacturers' services.

B. AC Induction Motor requirements: Conform to requirements of Section 26 20 00, Low-Voltage AC Induction Motors.

C. Adjustable Frequency Drive requirements: Conform to requirements of Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.

1. Submit letter verifying compatibility of AFDs with the motor and coordination of AFD sizing requirements.

D. Air flow balancing requirements: Conform to requirements of Section 23 05 93 Testing, Adjusting and Balancing for HVAC.

E. Inlet Vane Dampers and Backdraft Dampers: Conform to requirements of Section 23 31 13.05, Metallic Process Ductwork.

1.02 REFERENCES

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

1. Acoustical Society of America (ASA): S2.19, Mechanical Vibration—Balance Quality Requirements of Rigid Rotors—Part 1, Determination of Permissible Residual Unbalance.
2. Air Movement and Control Association International (AMCA):
   a. 99, Standards Handbook.
   b. 99-0401 Classifications of Spark Resistant Construction.
   c. 201, Fans and Systems.
   d. 203, Field Performance Measurement of Fan Systems.


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e. 210, Laboratory Methods of Testing Fans for Rating.
f. 300, Reverberant Room Method for Sound Testing of Fans.
g. 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
h. 99-2408, Operating Limits for Centrifugal Fans.

3. American Bearing Manufacturers Association (ABMA): 9, Load Ratings and Fatigue Life for Ball Bearings.
4. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): HVAC Applications Handbook.
5. ASTM International (ASTM):
   a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
   b. D2247, Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity.
   c. D2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
   d. D3363, Standard Test Method for Film Hardness by Pencil Test.
   e. D4167, Standard Specification for Fiber-Reinforced Plastic Fans and Blowers.
   f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
6. National Electrical Manufacturers Association (NEMA).
7. Occupational Safety and Health Act (OSHA).
8. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): Seismic Restraint Manual: Guidelines for Mechanical Systems.
9. Society for Protective Coatings (SSPC):
   a. SP 3, Power Tool Cleaning.
   b. SP 5, White Metal Blast Cleaning.
   c. SP 6, Commercial Blast Cleaning.
   d. SP 10, Near-White Blast Cleaning.
10. UL: 507, Electric Fans.
11. Vibration Isolation and Seismic Control Manufacturers Association (VISCMA).

1.03 DEFINITIONS

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

1. AC: Alternating Current.
2. CISD: Chemical Industry, Severe-Duty.
3. dB: Decibel.
4. FRP: Fiberglass Reinforced Plastic.
5. hp: Horsepower.
6. ICCES: International Code Council Evaluation Services


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7. SWSI: Single Width, Single Inlet.
8. TEFC: Totally Enclosed, Fan Cooled.
9. UV: Ultraviolet.
10. XP: Explosion Proof.

1.04 SUBMITTALS

A. Action Submittals:

1. Provide for all products specified, as follows:
    a. Identification as referenced in Contract Documents.
    b. Manufacturer’s name and model number.
    c. Descriptive specifications, literature, and drawings.
    d. Dimensions and weights.
    e. Fan sound power level data (reference 10 to power minus 12 Watts) at design operating point.
    f. Fan Curves:
        1) Performance curves at design point indicating:
            a) Curve showing relationship of flow rate to static pressure.
            b) Brake horsepower curves.
            c) Acceptable selection range (surge curves, maximum revolutions per minute).
            d) Static pressure, capacity, horsepower demand and overall efficiency required at the duty point, including any estimated drive losses.
            e) Fan wheel revolutions per minute and tip speed.
            f) For multiple fans operated in parallel, provide combined fan curves for number of fans operated simultaneously.
    g. Construction materials, including statement of resins and reinforcing proposed for use.
    h. Fan type, wheel type, wheel diameter, wheel maximum safe speed, size, class, drive arrangement, discharge, rotation, and bearing type.
    i. Motor submittals in conformance with Section 26 20 00, Low-Voltage AC Induction Motors.
    j. Vibration isolation.
    k. Acoustic attenuation treatment product information with noise attenuation calculations.
    l. Factory finish system.
    m. Color selection charts where applicable.
    n. Corrosion protection coating product data.


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o. Fan shaft first critical speed.
p. Belt service factor.
q. Drive assembly horsepower rating.
r. Sheave horsepower rating.

2. Equipment anchorage and support drawings or cut sheets indicating size, material, spacing, embedment and edge distances of anchors and other relevant information. The Drawings should reflect the results of the calculations submitted below.
3. "Or Engineered approved equal" Equipment:
   a. Where submitted equipment results in change to fan inlet or outlet ductwork configuration shown on the Drawings, submit system effect factor calculations indicating increased static pressure requirements as described in AMCA 201.
   b. Where submitted equipment results in change to ductwork and equipment configuration shown on the Drawings, submit detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement to equipment furnished.

B. Informational Submittals:

1. Recommended procedures for protection and handling of products prior to installation.
2. Manufacturer's installation instructions.
3. Manufacturer's Certificate of Compliance in accordance with Section 01 43 33, Manufacturers' Field Services, for the following:
   a. Motors specified to be premium efficient type.
   b. FRP fans.
4. Factory Test reports: Factory run test, dynamic balancing, performance test, sound test.
5. Operation and maintenance data in conformance with Section 01 78 23, Operation and Maintenance Data. Include as-built version of equipment drawings and schedules.
6. Support and anchorage calculations stamped by an Engineer licensed in the State of Oklahoma. Anchorage, bracing and support design criteria and calculations shall conform to the manufacturer's requirements as well as design criteria indicated on the Structural General Notes on the Drawings and any other referenced standards. Anchor calculations shall indicate edge distance, embedment, concrete thickness and strength, and other conditions assumed in the design calculations. Verify field conditions prior to installation of the anchors and bracing.


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1.05 QUALITY ASSURANCE

A. Performance Ratings: Fan performance in accordance with AMCA 210.

B. Sound Ratings: Rated in accordance with AMCA 300.

C. Fabrication: In accordance with AMCA 99.

1.06 EXTRA MATERIALS

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

| Item | Quantity |
|---|---|
| Fan/motor shaft coupling | One per fan size |
| Fan shaft seal | One per fan size |
| V-belts | One set per fan |
| Special tools required to maintain or dismantle | One complete set |

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

**PART 2 PRODUCTS**

2.01 EQUIPMENT SCHEDULES

A. Some specific equipment requirements are listed in Supplement following this section.

2.02 SPARK RESISTANT CONSTRUCTION

A. Fans required to be of spark resistant construction shall comply with requirements of AMCA 99-0401 Classifications of Spark Resistant Construction.

2.03 PERFORMANCE REQUIREMENTS

A. Fan shall operate at single stable point as indicated by fan curve. Fans having two potential operating points on a single rpm curve are not acceptable. Duty point shall be at least 10 percent below the crest of the fan curve.

B. Fan shall operate at a speed not greater than 90 percent of the maximum safe speed at selected design point.


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C. Fan and motor combination shall be capable of operating at 105 percent of Supplier's selected speed at design point. Motor shall not operate into motor service factor over the published range of flow at this higher speed.

D. Where inlet box is used, provide fan curves inclusive of inlet box losses.

E. Where inlet vane dampers are used, provide fan curves inclusive of inlet vane damper losses.

2.04 NAMEPLATES

A. Units shall include factory installed permanently attached nameplate displaying unit model and serial number.

2.05 OPERATING LIMITS

A. Fans designated to meet a specified fan class shall comply with requirements of AMCA 99-2408.

2.06 ACOUSTICAL LEVELS

A. Equipment selections shall produce sound power levels in each octave band no greater than shown in Fan Schedule for both initial and future operating conditions.

B. Fans that exceed scheduled sound power levels shall be provided with acoustical jacketing or other acoustical attenuation treatment as specified herein such that the overall A-Scale weighted sound pressure level of the installed equipment shall be no greater than 72 dBA at a distance of 5 feet from the equipment while operating at design conditions with Q=2.

2.07 FINISHES

A. Carbon Steel Parts (including vibration isolation, unitary base, and seismic control devices): Factory finished in accordance with Article Corrosion Protection Coating.

B. Aluminum Parts: Finished smooth and left unpainted, unless stated otherwise.

C. Stainless Steel Parts: Finished smooth and left unpainted.

D. Fiberglass Parts: Finished in accordance with Paragraph Fiberglass Material.



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## 2.08 UTILITY BLOWER, CENTRIFUGAL SWSI, COMPOST/CURING FANS

A. General:

1. Factory-assembled utility blower; including housing, fan wheel, drive assembly, motor, and accessories.
2. Spark Resistant Construction:
   a. Carbon fiber veil impregnated in housing and wheel fiberglass resin corrosion barrier.
   b. Static grounding.
   c. Classification: AMCA 99-0401 Classifications of Spark Resistant Construction Type B.
3. Suitable to convey air at temperatures up to 250 degrees F.
4. Airstream Hardware: Type 316 stainless steel.
5. Base/Pedestal Hardware: Type 316 stainless steel.

B. Housing:

1. Material: Aluminum.
2. Construction:
   a. Curved scroll configuration.
   b. Integral flanges to ensure housing concentricity and housing strength.
   c. Flanged Outlet: Heavy fiberglass construction, factory drilled and flanged.
   d. Flanged Inlet: Heavy fiberglass construction, factory drilled and flanged.
   e. Drain Connection: Minimum 1-inch NPT size and located at lowest point of fan housing.
   f. Inlet:
      1) Die-formed bell mouth of construction.
      2) Bolted to housing to permit wheel removal.
   g. Shaft Seal: Viton or Teflon labyrinth construction, located at shaft penetration of housing.
   h. Housing Access Doors: Bolted and gasketed.
3. Base/Pedestal: All-welded heavy gauge Type 316 stainless steel.

C. Unitary Subbase:

1. Structural metal subbase, same material as fan base/pedestal.
2. Bolted to bottom of fan base/pedestal.
3. Drilled for field installation of vibration isolators.


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D. Wheel:

1. Material: Aluminum.
2. Centrifugal, one-piece, nonoverloading, radial blade type.
3. Attached to fan shaft with split taper lock bushing.

E. Shaft, Bearings, Drive:

1. Shafts:
   a. Turned, ground and polished Type 316 or Type 304 stainless steel.
   b. Ends drilled and tapped for wheel installation.
   c. Keyed for sheave installation.
   d. Airstream portion fully stainless steel sleeve bonded to fan wheel. Where shaft seal does not allow for encapsulation (such as, lip type) shaft to be Type 316 stainless steel.
   e. Fan Shafts: First critical speed of at least 125 percent of fan maximum operating speed.
   f. Tach hole on shaft for rpm measurement.
2. Bearings:
   a. Grease lubricated, precision antifriction ball, self-aligning type.
   b. Mounted in cast iron pillow block housing.
   c. Selected for average life (ABMA 9 $L_{50}$) of not less than 200,000 hours operation at maximum cataloged operating speed.
3. Drives:
   a. Fan drive shall be direct drive or belt drive type with arrangement as shown on Fan Schedule.
   b. Entire drive assembly shall be sized for a minimum 150 percent of fan motor horsepower rating.
   c. Belts: Oil and heat resistant, nonstatic type.

F. Safety Guards:

1. Belt, Shaft, and Bearing Guard: Carbon steel sheet metal for complete coverage of shaft and bearings.
2. Easily removable and meeting federal OSHA, and State safety requirements.
3. Guard faces of expanded metal having minimum 60 percent free area for ventilation.
4. Bright yellow finish.


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G. Accessories:

1. Equipment Identification Plates: Furnish 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component in a readily visible location. Plate shall bear 3/8-inch high engraved block type black enamel filled equipment tag indicated in this specification.
2. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 70 pounds.
3. Rubber-in-Shear Vibration Isolation:
   a. Rubber in shear type, RIS, Neoprene.
   b. Deflection: 0.25 inch to 0.5 inch.
4. Corrosion Protection Coating:
   a. Provide factory-applied corrosion protection coating on these fan components:
      1) Wheel.
      2) Housing.
      3) Accessories.
      4) Interior surfaces in contact with airstream.
5. Acoustic Jacket:
   a. Custom formed, sectioned, removable cover designed to limit sound power level emissions from fan scroll.
   b. Suitable for outdoor installation.
   c. Jacketing shall be designed as not limit access to fan shaft, bearings, or other fan appurtenances.
   d. Minimum Acoustic Jacket Thickness: 3 inches.
   e. Performance: Sound pressure level of the installed fan as measured at a distance of 3 feet from the fan shall not exceed the A-Scale weighted value as specified in Article Acoustical Levels.
   f. Manufacturer and Product:
      1) Advance Thermal Corp.; Model ACOUSTIRAP.
      2) Or Engineered approved equal.

H. Manufacturers:

1. Twin City Fan.
2. New York Blower.
3. Aerovent.
4. Hartzell.


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## 2.09 UTILITY BLOWER, CENTRIFUGAL SWSI, BIOFILTER FANS

A. General:

1. Factory-assembled utility blower; including housing, fan wheel, drive assembly, motor, and accessories.
2. Fiberglass Construction: In accordance with ASTM D4167.
3. Spark Resistant Construction:
   a. Carbon fiber veil impregnated in housing and wheel fiberglass resin corrosion barrier.
   b. Static grounding.
   c. Classification: AMCA 99-0401 Classifications of Spark Resistant Construction Type B.
4. Suitable to convey air at temperatures up to 250 degrees F.
5. Airstream Hardware: Type 316 stainless steel.
6. Base/Pedestal Hardware: Type 316 stainless steel.

B. Housing:

1. Material: Aluminum.
2. Construction:
   a. Curved scroll configuration.
   b. Integral flanges to ensure housing concentricity and housing strength.
   c. Flanged Outlet: Heavy construction, factory drilled and flanged.
   d. Flanged Inlet: Heavy construction, factory drilled and flanged.
   e. Drain Connection: Minimum 1-inch NPT size and located at lowest point of fan housing.
   f. Inlet:
      1) Die-formed bell mouth of construction.
      2) Bolted to housing to permit wheel removal.
   g. Shaft Seal: Viton or Teflon labyrinth construction, located at shaft penetration of housing.
   h. Housing Access Doors: Bolted and gasketed.
3. Base/Pedestal: All-welded heavy gauge Type 316 stainless steel.

C. Unitary Subbase:

1. Structural metal subbase, same material as fan base/pedestal.
2. Bolted to bottom of fan base/pedestal.
3. Drilled for field installation of vibration isolators.



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D. Wheel:

1. Material: Aluminum.
2. Centrifugal, one-piece, nonoverloading, blade type as scheduled.
3. Wheel hub permanently bonded to shaft and completely encapsulated in fiberglass.

E. Shaft, Bearings, Drive:

1. Shafts:
   a. Turned, ground and polished Type 316 or Type 304 stainless steel.
   b. Ends drilled and tapped for wheel installation.
   c. Keyed for sheave installation.
   d. Airstream portion fully encapsulated with FRP or stainless steel sleeve bonded to fan wheel. Where shaft seal does not allow for encapsulation (such as, lip type) shaft to be Type 316 stainless steel.
   e. Fan Shafts: First critical speed of at least 125 percent of fan maximum operating speed.
   f. Tach hole on shaft for rpm measurement.
2. Bearings:
   a. Grease lubricated, precision antifriction ball, self-aligning type.
   b. Mounted in cast iron pillow block housing.
   c. Selected for average life (ABMA 9 L50) of not less than 200,000 hours operation at maximum cataloged operating speed.
3. Drives:
   a. Fan drive shall be direct drive or belt drive type with arrangement as shown on Fan Schedule.
   b. Entire drive assembly shall be sized for a minimum 150 percent of fan motor horsepower rating.
   c. Belts: Oil and heat resistant, nonstatic type.

F. Safety Guards:

1. Belt, Shaft, and Bearing Guard: Carbon steel sheet metal for complete coverage of shaft and bearings.
2. Easily removable and meeting federal OSHA, and State safety requirements.
3. Guard faces of expanded metal having minimum 60 percent free area for ventilation.
4. Bright yellow finish.


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G. Accessories:

1. Equipment Identification Plates: Furnish 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component in a readily visible location. Plate shall bear 3/8-inch high engraved block type black enamel filled equipment tag indicated in this specification.
2. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 70 pounds.
3. Rubber-in-Shear Vibration Isolation:
   a. Rubber in shear type, RIS, Neoprene.
   b. Deflection: 0.25 inch to 0.5 inch.
4. Fan Inlet Box: Where shown on the Drawings, constructed from same resin as fan housing, rectangular inlet, round outlet matching fan inlet flange, low point drain, and supported so fan and inlet box are supported as one assembly.
5. Corrosion Protection Coating:
   a. Provide factory-applied corrosion protection coating on these fan components:
      1) Wheel.
      2) Housing.
      3) Accessories.
      4) Interior surfaces in contact with airstream.
6. Acoustic Jacket:
   a. Custom formed, sectioned, removable cover designed to limit sound power level emissions from fan scroll.
   b. Suitable for outdoor installation.
   c. Jacketing shall be designed as not limit access to fan shaft, bearings, or other fan appurtenances.
   d. Minimum Acoustic Jacket Thickness: 3 inches.
   e. Performance: Sound pressure level of the installed fan as measured at a distance of 3 feet from the fan shall not exceed the A-Scale weighted value as specified in Article Acoustical Levels.
   f. Manufacturer and Product:
      1) Advance Thermal Corp.; Model ACOUSTIRAP.
      2) Or Engineered approved equal.

H. Manufacturers and Products:

1. Twin City Fan.
2. New York Blower.
3. Aerovent.
4. Hartzell.


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## 2.10 CORROSION PROTECTION COATING

A. General:

1. Provide factory-applied corrosion protection coating on fan steel components.
2. Coating system shall be baked epoxy.
3. Color shall be factory standard unless otherwise noted.
4. Quality Control:
   a. Verify dry film thickness before final baking.
   b. Finished coating system shall be free from voids, checks, cracks, and blisters.
5. Surface Cleaning:
   a. Clean parts to be coated as follows:
      1) Immerse parts in heated cleaning solution to remove lubricants, machining oils, and residual factory contamination.
      2) Follow with immersion in potable water bath to neutralize and remove cleaning solution.
      3) Chemical Pretreatment: Immerse parts in heated chemical solution, iron phosphate for steel, clear/yellow chromate for aluminum.

B. Baked Epoxy:

1. Material: Epoxy.
2. Surface Preparation: Sandblast surface to SSPC-SP 10.
3. Application: Electrostatic spray.
4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
5. Finished Thickness: 2.5-mil to 3.5-mil dry film thickness.
6. Performance:
   a. Coating shall meet or exceed following criteria:
      1) Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
      2) Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
      3) Impact Resistance: 100-inch pounds, ASTM D2794 test method.
      4) Pencil Hardness: 2H, ASTM D3363 test method.
      5) Service Temperature: Maximum 230 degrees F, continuous.


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## 2.11 MOTORS

A. Fan motors shall comply with all provisions of Section 26 20 00, Low-Voltage AC Induction Motors.

1. Winding Thermal Protection; Thermostats: Required.
2. Motor Space Heaters: Not required.

B. Motors for fans specified for use with adjustable frequency drives shall be inverter duty type. Coordinate fan and motor requirements with adjustable frequency drive manufacturer in accordance with Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.

C. Motors shall not operate into service factor in any case.

D. Motors shall be suitable for operation within a Class 1, Division 2, Group D classified area.

## 2.12 SOURCE QUALITY CONTROL

A. General:

1. Factory run test and wheel dynamic balance for each fan.
2. Factory Test: Performance test and sound test.

B. Acoustical Levels:

1. Perform factory noise tests in accordance with AMCA 300 and AMCA 301 for each Biofilter fan size.
2. Fan sound power levels (dB, Reference 10-12 Watts) shall be no greater than scheduled values.

C. Balancing:

1. Unless noted otherwise, each fan wheel shall be statically and dynamically balanced to ASA S2.19 Grade G6.3.

D. Vibration Test:

1. Furnish factory run vibration test for fans with a 5-hp or larger motor, including vibration signatures taken on each bearing in horizontal, vertical, and axial direction.
2. Vibration reading as measured at scheduled rotational speed shall not exceed the following values when fan is rigidly mounted (filter in):
   a. Belt Drive: 0.15 inch per second peak velocity.
   b. Direct Drive: 0.10 inch per second peak velocity.



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3. Provide written records of run test and vibration test as part of Informational Submittals.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. Install fans level and plumb.

B. Scroll Drains: Pipe drain connection through P-trap to drain location as indicated on the Drawings.

C. Labeling: Label fans in accordance with Paragraph Accessories.

D. Service Access: Locate units to provide access spaces required for motor, bearing servicing, and fan wheel/shaft removal.

E. Equipment Support and Restraints:

1. Secure vibration controls to concrete bases using anchor bolts cast in concrete base.
2. Seismic Restraint Snubbers: Install with sufficient clearance so unit isolators are not restricted for proper free isolation but do limit movement in all directions.

F. Connections:

1. Refer to Section 23 31 13.05, Metallic Process Ductwork.
2. Isolate duct connections to fans with flexible connections.
3. Install ductwork adjacent to fans to allow proper service and maintenance.
4. Connect fan housing grounding connection to suitable ground.

### 3.02 FIELD QUALITY CONTROL

A. Functional Tests:

1. Verify blocking and bracing used during shipping are removed.
2. Verify fan is secure on mountings and supporting devices, and connections to ducts and electrical components are complete.
3. Verify proper thermal-overload protection is installed for motors, starters, and disconnect switches.
4. Verify that cleaning and adjusting are complete.
5. Disconnect fan shaft from motor; verify proper motor rotation direction and verify fan wheel free rotation and smooth bearing operation.


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6. Reconnect fan shaft coupling system; align shafts and install safety guards.
7. Verify lubrication for bearings and other moving parts.
8. Verify fan isolation dampers in connected ductwork are in fully open position.

B. Performance Tests:

1. Starting Procedures:
   a. Energize motor and adjust fan to indicated revolutions per minute.
   b. Measure and record motor voltage and amperage.
2. Operational Test:
   a. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   b. Repair or replace malfunctioning units; retest as specified after repairs or replacement is made.
   c. Test and adjust control safeties.
   d. Replace damaged and malfunctioning controls and equipment.
3. Perform air system balancing as specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.
4. Test each fan to verify design air flow rates as specified.
5. Adjust fan speed as required to achieve design airflow.
6. Document the fan operating speed and static pressure at each fan inlet and discharge at the design flow rate. Collect data at three additional conditions to provide the data required for calculation of air flow rate as required by Section 40 90 00, Instrumentation and Control for Process Systems, Supplement Loop Specifications.

C. Vibration Tests:

1. Test each Biofilter fan for vibration after the completion of function tests, performance tests, and system balancing.
2. Dynamically balance wheels to Balance Quality Grade G6.3 per ANSI S2.19.
3. Test each assembled fan as installed at the rated fan rpm.
4. Take vibration signatures on each fan bearing in the horizontal, vertical, and axial directions.
5. The maximum allowable fan vibration level shall be as follows (all values are filter in):
   a. Belt Drive, Flexibly Mounted: 0.35 inch per second peak velocity.
   b. Belt Drive, Rigidly Mounted: 0.25 inch per second peak velocity.
   c. Direct Drive, Flexibly Mounted: 0.30 inch per second peak velocity.
   d. Direct Drive, Rigidly Mounted: 0.20 inch per second peak velocity.


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6. Field-balance fans exceeding the maximum allowable vibration level until acceptable vibration levels are attained.
7. Replace fans that cannot be field balanced to within acceptable vibrational levels.

3.03 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of the Owner's personnel for specified component, subsystem, equipment, or system.

B. Manufacturer's Representative:

1. Present at Site or classroom designated by the Owner, for minimum person-days listed below, travel time excluded:
   a. 1 person-day for installation assistance and inspection.
   b. 1 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.

3.04 ADJUSTING

A. Lubricate bearings.

B. Balancing: Perform air system balancing as specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

3.05 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

B. On completion of installation, internally clean fans according to manufacturers' written instructions. Remove foreign material and construction debris.

3.06 SUPPLEMENT

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

1. Odor Control Fan Schedule.

**END OF SECTION**


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**Odor Control Fan Schedule**

| Tag No. | Location | Type | Operating SCFM @ SP in W.G. | Drive Type | Wheel Type | Motor | Manufacturer | Model No. |
|---|---|---|---|---|---|---|---|---|
| H090-DEW1-OFC01 | Dewatering Building | Radial Fume Exhauster | 1,440 @ 4 | Belt | Radial (Open Frontplate) | 5 HP[1], 460V, 3 PH | New York Blower | 500 |
| H095-COM2-FAN01 thru FAN10 | Composting Facility | Arrangement 4 | 2,350 @ 10 | Direct | Radial | 7.5 HP[2], 460V, 3 PH | Twin City Fan | TBNA |
| H095-COM2-FAN11 and FAN12 | Biofilter Facility | Arrangement 9 | 25,000 @ 12 | Belt | Radial | 75 HP[2], 460V, 3PH | Twin City Fan | BC-SW |
| H095-COM3-FAN01 thru FAN04 | Composting Facility | Arrangement 4 | 2,350 @ 10 | Direct | Radial | 7.5 HP[2], 460V, 3 PH | Twin City Fan | TBNA |

Notes:

1. Motor is oversized for the operating point to account for future odor control additions and higher.
2. Motor speed shall be sized such that 1,800 RPMs achieved to ensure noise control is met.


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# SECTION 23 37 00
# AIR OUTLETS AND INLETS

## PART 1 GENERAL

1.01 REFERENCES

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

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 880, Air Terminals.
2. ASTM International (ASTM): C636/C636M, Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels.
3. UL.

1.02 DEFINITIONS

A. NC: Noise Criteria; background sound rating method for indoor sound.

B. VAV: Variable air volume.

C. WC: Water column.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Manufacturer’s data and descriptive literature for products specified.
   b. Furnish the following information for each type of diffuser, register, and grille furnished.
      1) NC sound data.
      2) Static pressure loss data.
      3) Throw data.
2. Samples: Finish color samples.
3. Informational Submittals: List of recommended spare parts for products specified.


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## PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Refer to schedule on the Drawings.

2.02 CEILING DIFFUSERS

A. Premium Louvered Face Diffusers (SD-1):

1. Construction: Refer to Equipment Schedule.
2. Removable core section of louvers.
3. Continuous sponge rubber gasket at face flange.
4. Performance:
    5. As follows:
        a. Distribution Pattern: Four-way.
        b. Maximum Pressure Drop: 0.05 inches WC.
        c. Sound: Maximum NC 30.
6. Manufacturers and Products:
    a. Krueger; Model 5SHR (aluminum).
    b. Carnes; Type SE (aluminum).
    c. Titus; Model TDCA-AA (aluminum).

2.03 SUPPLY GRILLES AND REGISTERS

A. High Capacity Supply Grilles and Registers (SG-1):

1. Construction:
    a. As follows:
        1) Square aluminum egg crate construction.
        2) Baked white enamel finished frame.
        3) Extruded 1-1/4-inch flat frame with concealed fasteners.
        4) Fixed louver grid with 1/2-inch by 1/2-inch by 1/2-inch louver spacing.
        5) Manufacturers and Products:
            a) Titus; Model 272RL.
            b) Krueger; Model EGC5.
            c) Carnes; Type RAPAF.

2.04 RETURN, EXHAUST AND TRANSFER GRILLES AND REGISTERS

A. Exhaust Grilles (EG-1):

1. Construction: Refer to Equipment Schedule.
2. Fixed horizontal louvers set at 35 degrees to 45 degrees.
3. 1-inch minimum flat, rectangular frame.



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4. Manufacturers and Products:
   a. Krueger; S80/S580H Series.
   b. Carnes; Type RAAAH.
   c. Titus; 350 Series.

B. Perforated Ceiling Return, Exhaust and Transfer Grilles and Registers (RD-1):

1. Construction: Refer to Equipment Schedule.
   a. RR and ER Register Accessories:
      1) Gang-operated opposed-blade volume control damper.
      2) Material to match grille.
2. Removable perforated faceplate.
3. Size to fit into standard lay-in tee-bar ceiling.
4. Round neck.
5. Manufacturers and Products:
   a. Titus; Model PAR (steel) or PAR-AA (aluminum).
   b. Krueger; Model 6500 Series.
   c. Carnes; Type SPRB (steel) or SLRB (aluminum).

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. Refer to architectural reflected ceiling plans for coordination of locations of ceiling-mounted air outlets and inlets with ceiling grids and lighting. Where locations of devices shown on mechanical drawings do not agree with locations that are shown on architectural reflected ceiling plans, reflected ceiling plans shall take precedence. If air outlets or inlets are shown on mechanical drawings, but are not shown on architectural reflected ceiling plans, devices shall be located as near as possible to locations shown on mechanical drawings when coordinating with ceiling.

B. Install diffusers, grilles, and registers tight on their respective mounting surfaces, level, plumb, and true with room dimensions.

C. Provide appropriate frame to adapt to mounting surface. Provide a 24-inch by 24-inch lay-in ceiling module for diffusers, registers, and grilles in lay-in ceilings.

D. Support air inlets and outlets where installed in metal suspension systems for acoustical tile and lay-in panel ceilings as specified in ASTM C636/C636M.

**END OF SECTION**


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# SECTION 23 81 00
# UNITARY AIR-CONDITIONING EQUIPMENT

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 210/240, Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
2. Air Moving and Conditioning Association (AMCA): Bulletin 300, Setup No. 1.
3. American Gas Association (AGA).
4. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
   a. 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
   b. 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
5. American Society of Mechanical Engineers (ASME): BPVC Section IX, Welding and Brazing Qualifications.
6. ASTM International (ASTM):
   a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
   b. D2370, Standard Test Method for Tensile Properties of Organic Coatings.
   c. D4060, Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser.
   d. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
   e. G154, Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials.
7. Canadian Standards Association (CSA).
8. ETL Testing Laboratories (ETL).
9. International Organization for Standardization (ISO):
   a. 9001, Quality Management Systems - Requirements.
   b. 13256-1, Water-Source Heat Pumps—Testing and Rating for Performance—Part 1: Water-to-Air and Brine-to-Air Heat Pumps.
10. National Electrical Manufacturers Association (NEMA).


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11. National Fire Protection Association (NFPA): 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
12. UL: 94, Safety Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.02 DEFINITIONS

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

1. AC: Air Conditioning.
2. COP: Coefficient of Performance.
3. DX: Direct Expansion.
4. EER: Energy Efficiency Ratio.
5. HP: Heat Pump.
6. IR: Infra Red.
7. LED: Light Emitting Diode.
8. PSC: Permanent Split Capacitor.
9. PTAC: Packaged Terminal Air Conditioner.
10. SPST: Single Pole, Single Throw.
11. TXV: Thermostatic Expansion Valve.
12. UV: Ultraviolet.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Anchorage and bracing drawings and data sheets, as required by Section 01 88 15, Anchorage and Bracing.
   b. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature which shall include make, model, dimensions, weight of equipment, and electrical schematics for all products specified.
   c. Manufacturer’s standard finish color selection for enclosure finishes.
   d. Complete performance data that will indicate full compliance with specification:
      1) Include fan sound power level data (ref. 10 to 12 watts) at design operating point, based on AMCA Bulletin 300, Setup No. 1.
      2) Include heating and cooling performance data at design operating conditions.
   e. Air Pressurization Unit: Documentation that media filter modules are UL rated Class 1.
   f. Factory dip-applied protective coating product data.


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B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's documentation that media filter modules rated UL Class 1.
3. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for heat pumps, air-conditioning units, and motors.
4. Detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement or details shown to equipment furnished.
5. Sample copy of guarantee.
6. Test reports.
7. Operation and Maintenance Data in conformance with Section 01 78 23, Operation and Maintenance Data.
    a. Include wiring and control diagrams for equipment.
    b. Include as-built version of equipment schedules.

1.04 QUALITY ASSURANCE

A. Heating and Cooling Equipment: Minimum operating efficiencies, defined as COP and EER, as specified in ASHRAE 90.1.

B. Unit shall be rated (when matched with appropriate outdoor unit) per AHRI 210/240.

C. Units shall be certified by UL and CSA, and shall be UL or ETL listed and labeled.

D. Cooling performance rated in accordance with AHRI testing procedures.

E. Air Pressurization Unit Manufacturer Qualifications:

1. Manufacturer shall have a minimum of 10 years' experience in design, fabrication and testing of systems that are 99.95 percent efficient in removal of these gases.
2. Manufacturer shall be a single source provider of equipment, media, and testing services, and certified to ISO 9001 standards or adhere to quality standards equal to ISO 9001.
3. Welding procedure qualifications and welder performance qualifications shall conform to the requirements of ASME BPVC Section IX. Welder's performance qualification records shall be made available to Engineer upon request.


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1.05 DELIVERY, STORAGE, AND HANDLING

A. Storage: Products shall be carefully stored in a manner that will prevent damage and in an area that is protected from the elements.

B. Protection of Equipment:

1. Box, crate, or otherwise protect from damage and moisture during shipment, handling, and storage.
2. Protect from exposure to corrosive fumes and keep thoroughly dry at all times.
3. Store motors, drives, electrical equipment, and other equipment with antifriction or sleeve bearings in weathertight and heated storage facilities prior to installation.
4. For extended storage periods, plastic equipment wrappers shall not be used to prevent accumulation of condensate in gears and bearings.

1.06 SPECIAL GUARANTEE

A. Refrigerant Compressors: Furnish manufacturer’s extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of Owner, removal and replacement of compressors specified in this specification found defective during a period of 5 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in the General Conditions.

**PART 2 PRODUCTS**

2.01 GENERAL

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

B. Multiple Compressor Units:

1. Provide completely independent refrigeration circuits and controls.
2. Indoor unit air coils shall have intermingled circuits, unless specified otherwise.

2.02 EQUIPMENT SCHEDULES

A. Refer to the Drawings.


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## 2.03 SPLIT SYSTEM IN-CEILING CASSETTE AC UNIT, DUCTLESS

A. General:

1. Split system, indoor, DX, ductless, fan coil AC unit, complete with DX coil, fan, fan motor, piping connectors, electrical controls, condensate pump, and hanging brackets.
2. Suitable for use with air conditioner or heat pump outdoor unit.
3. Indoor unit shall be of the same manufacturer as the associated outdoor unit.

B. Unit Cabinet:

1. Constructed of zinc-coated steel.
2. Fully insulated.
3. Discharge and inlet grilles, high-impact polystyrene.
4. Adjacent room cooling to be provided by a simple knockout in cabinet side panel.

C. Evaporator Fan:

1. Centrifugal, direct-drive blower type with air intake in center of unit and discharge on perimeter.
2. Air louvers shall be adjustable for 2-, 3-, or 4-way discharge.
3. Motors:
   a. Totally enclosed and permanently lubricated with inherent protection.
   b. Three-speed.

D. DX Evaporator Coil:

1. Copper tube with aluminum fins and galvanized steel tube sheets.
2. Fins bonded to tubes by mechanical expansion.
3. Condensate Drip Pan: Locate under coil with drain connection for hose attachment to remove condensate.

E. Internal Condensate Pump:

1. To remove condensate from drain pan when gravity drainage cannot be used.
2. Lift capability of condensate pump shall be 18 inches.

F. Electric Heater: Units shall be equipped with factory-mounted electric heaters. Minimum protection shall include overcurrent and high temperature protection.


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G. Controls:

1. Refrigerant Metering:
   a. Factory installed refrigerant metering device.
   b. Heat Pump Applications: Reverse flow bypass refrigerant metering device with internal check valves.
2. 24-volt wall-mounted thermostat with three fan speed selections and auto/manual switch.
3. Automatic restart after power failure at same operating conditions as at failure.
4. Float control in condensate sump to shut unit down in case of pump malfunction.
5. Evaporator coil freeze protection.

H. Air Filters: Filter tracks and cleanable filters, accessible from below with 1/4-turn fastener.

I. Accessories: Provide as scheduled in Equipment Schedule.

1. Electronic Programmable Thermostat:
   a. Commercial grade, 7-day, four-event scheduling.
   b. Integral subbase, three-speed fan control, heating/cooling switchover capability, air sweep auto changeover.
   c. Shall not require battery to retain memory.

J. Manufacturers and Products:

1. Carrier; 40QK Series.
2. Enviromaster International; Model CAH.
3. Mitsubishi; Mr. Slim.
4. “Or-equal.”

## 2.04 SPLIT SYSTEM AC OUTDOOR UNITS

A. General:

1. Factory assembled, single piece, air-cooled air conditioner outdoor unit.
2. Contained within the unit enclosure shall be factory wiring, piping, controls, compressor, and holding charge of R-32 refrigerant.
3. Outdoor unit shall be same manufacturer as associated indoor unit.

B. Unit Cabinet:

1. Constructed of galvanized steel, phosphatized and coated with a baked enamel finish.
2. Removable access panels for access to internal components.


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3. Outdoor Compartment: Isolated, with acoustic lining to ensure quiet operation.
4. Knockouts for unit electrical power.

C. Condenser Fans:

1. Direct-drive propeller type shall discharge air vertically and shall blow air through outdoor coil.
2. Motors:
   a. Totally enclosed, with Class B insulation and permanently lubricated bearings.
   b. Thermal overload protection.
3. Shaft of galvanized or stainless steel construction.
4. Fan blades shall be corrosion-resistant and be statically and dynamically balanced.
5. Equip openings with PVC-coated protection grille over fan and coil.

D. Compressor:

1. Fully hermetic reciprocating or scroll type.
2. Equipped with oil system, operating oil charge, and motor.
3. Internal overloads shall protect compressor from overtemperature and overcurrent.
4. Motor: NEMA rated, Class F, suitable for operation in a refrigerant atmosphere.
5. Scroll compressors shall have high discharge gas temperature protection.
6. Reciprocating compressors shall be equipped with crankcase heaters to minimize liquid refrigerant accumulation in compressor during shutdown and to prevent refrigerant dilution of oil.
7. Installed on rubber vibration isolators and shall have internal spring isolation.

E. Condenser Coil:

1. Constructed of aluminum fins mechanically bonded to internally enhanced seamless copper tubes that are cleaned, dehydrated, and sealed.
2. Coat entire coil with anticorrosion protective coating, in accordance with Article Factory Dip-Applied Protective Coating

F. Refrigeration Components:

1. Brass external liquid line service valve with service gauge port connections.
2. Suction line service valve with service gauge connection port.


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3. Service gauge port connections on compressor suction and discharge lines with Schrader-type fittings with brass caps.
4. Suction Line: Accumulator.
5. Pressure relief.

G. Controls:

1. Factory selected, assembled, and tested.
2. Refrigerant Metering:
   a. Reversing valve for heat pump units.
   b. Heating mode metering device for heat pump units.
3. Automatic restart on power failure.
4. Three-pole contactors.
5. Time delay control sequence shall be provided standard through control board on indoor units.
6. High pressure and liquid line low pressure switches.
7. Automatic outdoor fan motor protection.
8. Start capacitor and relay (single-phase units without scroll compressors).
9. Defrost board to provide defrost control.
10. Safeties:
    a. Time delay restart to prevent compressor reverse rotation on single-phase scroll compressors.
    b. Safety lockout if an outdoor unit safety is open.
    c. High condensing temperature protection.
    d. System diagnostics.
    e. Compressor motor current and temperature overload protection.
    f. High pressure relief.
    g. Outdoor fan failure protection.

H. Accessories: Provide as scheduled in Equipment Schedule.

1. Low-Ambient Cooling Kit:
   a. Solid state condenser fan motor fully modulating speed controller; responds to saturated condensing pressure/temperature of unit.
   b. Maintains a saturated condensing temperature of 100 degrees F plus or minus 10 degrees F with outdoor temperatures down to minus 20 degrees F.
   c. Includes winter start control package, to bypass low-pressure switch temporarily to allow compressor start during low load conditions.
   d. Includes ball bearing condenser fan motor.
2. Compressor Cycle Delay: Compressor prevented from restarting for a minimum of 5 minutes after shutdown.


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3. Hot Gas Bypass: Cooling capacity modulation with hot-gas solenoid valve and bypass piping on both compressors.
4. Filter Drier: Liquid-line mounted, bi-flow type for heat pumps.
5. Liquid Solenoid Valve: Electric operated shutoff valve, bi-flow for heat pumps, interlocked with compressor operation.

I. Manufacturers:

1. Carrier.
2. Trane.
3. Rheem.
4. Lennox International.
5. Addison.
6. Mitsubishi.
7. “Or-equal.”

## 2.05 PACKAGED ROOFTOP AC UNITS

A. General:

1. Factory assembled, packaged rooftop air-cooled air-conditioning unit.
2. Contained within unit enclosure shall be factory wiring, piping, controls, compressor, holding charge of R-454B refrigerant.
3. Unit Configuration: Packaged, roof-mount type.

B. Unit Cabinet:

1. Unit construction will be double wall with G90 galvanized steel on both sides and a thermal break. Double wall construction with a thermal break prevents moisture accumulation on the insulation, provides a cleanable interior, reduces heat transfer through the panel, and prevents exterior condensation on the panel.
2. Removable access panels with access to internal components.
3. Outdoor Compartment: Isolated with minimum 1/2-inch thick acoustic lining to ensure quiet operation.
4. Knockouts for unit electrical power and condensate piping connections.
5. Supported on steel full-length mounting rails. Indoor compartment interior insulation will have a minimum thermal resistance R-value of 16. Foam insulation will have a minimum density of 2 pounds/cubic foot and will be tested in accordance with ASTM D-1929-11 for a minimum flash ignition temperature of 610 degrees F.
6. Duct flanges for connection of supply and return ductwork.
7. Weatherproof indoor section.


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C. Evaporator Fan:

1. Double-inlet, double-width, forward-curved fan.
2. Direct-drive or belt-drive as standard with unit.
3. Motor:
   a. Totally enclosed and permanently lubricated, with integral overload protection.
   b. Three speed.

D. DX Evaporator Coil:

1. Coil: Constructed of aluminum fins mechanically bonded to internally enhanced seamless copper tubes, with galvanized steel tube sheets.
2. Condensate Drain Pan: Plastic, insulated, with primary and secondary drain fittings.

E. Condenser Fan:

1. Direct-drive propeller type.
2. Motors:
   a. Totally enclosed, single-phase motors with Class B insulation and permanently lubricated sleeve bearings.
   b. Protected by internal thermal overload protection.
3. Shaft: Inherent corrosion resistance.
4. Fan Blades: Corrosion-resistant and statically and dynamically balanced.
5. Equip openings with PVC-coated protection grille over fan and coil.

F. Compressor:

1. Fully hermetic reciprocating or scroll type.
2. Equipped with oil system, operating oil charge, and motor.
3. Internal overloads shall protect compressor from over-temperature and over-current.
4. Motor: NEMA rated, Class F, suitable for operation in a refrigerant atmosphere.
5. Reciprocating compressors shall be equipped with crankcase heaters to minimize liquid refrigerant accumulation in compressor during shutdown and to prevent refrigerant dilution of oil.
6. Scroll compressors shall have high discharge gas temperature protection, if required.
7. Compressor assembly shall be installed on rubber vibration isolators and have internal spring isolation.


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G. Condenser Coil:

1. Constructed of aluminum fins mechanically bonded to internally enhanced seamless copper tubes, with galvanized steel tube sheets.
2. Coat entire coil with anti-corrosion protective coating, in accordance with Article Factory Dip-Applied Protective Coating.

H. Refrigeration Components:

1. Brass external liquid line service valve with service gauge port connections.
2. Suction line service valve with service gauge connection port.
3. Service gauge port connections on compressor suction and discharge lines with Schrader-type fittings with brass caps.
4. Accumulator.
5. Filter drier, bi-flow type for heat pump units.
6. Pressure relief.
7. Reversing valve, for heat pump units.
8. Heating mode metering device, for heat pump units.

I. Electric Heating Coil as follows:

1. Heavy-duty nickel-chromium elements.
2. Individual line-break HIGH limit control for each stage.
3. HIGH limit control operating through heating element contactors equipped with automatic reset.
4. Internally factory-wired to provide single-point power connection with unit.
5. UL listed.
6. Electric heater will have full modulation capacity controlled by an SCR (Silicon Controlled Rectifier). A 0-10 Vdc heating control signal will be factory provided to control the amount of heating.

J. Controls:

1. Unit controller will be capable of controlling all features and options of the unit. Controller will be factory installed in the unit controls compartment and factory tested. Controller will be capable of stand alone operation with unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling available without dependence on a building management system.
2. Factory selected, assembled, and tested.
3. Refrigerant Metering:
    a. Factory installed refrigerant metering device.
    b. Heat Pump Applications: Reverse flow bypass TXV refrigerant metering device with internal check valves.


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4. Time delay restart to prevent compressor reverse rotation on single-phase scroll compressors.
5. Automatic restart on power failure.
6. Three-pole contactors.
7. Safety lockout if outdoor unit safety is open.
8. Time delay control sequence shall be provided standard through control board.
9. High pressure and liquid line low pressure switches.
10. Automatic outdoor fan motor protection.
11. Start capacitor and relay (single-phase units without scroll compressors).
12. Automatic demand-type defrost start and termination.
13. Safeties:
    a. High condensing temperature protection.
    b. System diagnostics.
    c. Compressor motor current and temperature overload protection.
    d. High pressure relief.
    e. Outdoor fan failure protection.
14. H095 COM1 ACU 01: Air-source heat pump will include an optimized start defrost cycle to prevent frost accumulation on the outdoor coil during heat pump heating operation and to minimized defrost cycle energy usage. If the temperature of the outdoor heat exchanger and/or the suction line is less than a predetermined value, a deferred defrost cycle is initiated wherein the defrost cycle starts after a variable, continuously optimizing, time interval has elapsed. The defrost cycle is terminated when the relative temperatures of the outdoor heat exchanger and/or the suction line indicate that sufficient frost is melted from the heat exchanger to insure adequate time between successive defrost cycles for optimizing the efficiency and reliability of the system, or after a predetermined time interval has elapsed, whichever condition occurs first. During defrost cycle all compressors will energize, reversing valves will de-energize, and auxiliary heat will energize.

K. Outside Air/Economizer:

1. H095 COM1 ACU 01: Unit will include 0 percent to 100 percent economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades will be gear driven and designed to have no more than 20 cfm of leakage per sq ft. at 4-inch w.g. air pressure differential across the damper. Low leakage dampers will be Class 2 AMCA certified, in accordance with AMCA Standard 511. Unit will include outside air opening bird screen and outside air hood. Unit, except for horizontal


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series, will also include barometric relief dampers and enthalpy controller.

a. H095 COM1 ACU 01: Economizer will be furnished with a California Energy Commission Certified Title 24 Fault Detection and Diagnostic package. Economizer assembly will carry a 5 year parts warranty from the date of original equipment shipment from the factory.

2. H040 WAS1 AC U01, H090 DEW1 ACU 01, H090 DEW2 ACU 01: Unit will include 100 percent motor operated outside air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge and end seals. Damper blades will be gear driven and designed to have no more than 20 cfm of leakage per square feet at 4-inch w.g. air pressure differential across the damper. Low leakage dampers will be Class 2 AMCA certified, in accordance with AMCA Standard 511. Damper assembly will be controlled by spring return, two-position actuator. Unit will include outside air opening bird screen and outside air hood.

L. Air Filters:

1. Rack mounted.
2. Unit will include 2-inch thick, pleated panel filters with an ASHRAE MERV rating of 8, upstream of the cooling coil or last coil if cooling coil is not equipped.
3. Rated at 30 percent efficiency and 90 percent average arrestance in accordance with ASHRAE 52.2.
4. Manufacturer and Product: Farr; 30/30.

M. Accessories: Provide as scheduled in Equipment Schedule.

1. Compressor Cycle Delay: Compressor prevented from restarting for a minimum of 5 minutes after shutdown.
2. Hot-Gas Reheat:
   a. Solenoid valve and controls shall allow redirection of refrigerant hot gas to reheat coil located in associated indoor unit.
   b. Reheat coil located in indoor section, same construction as evaporator coil.
3. Compressor Start Assist: Capacitor/relay type.
4. Evaporator Coil Freeze Thermostat: SPST temperature activated switch, shuts down unit upon evaporator freeze up.
5. Filter Drier: Liquid line mounted, bi-flow type for heat pumps.
6. Liquid Solenoid Valve: Electric operated shutoff valve, bi-flow for heat pumps, interlocked with compressor operation.


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7. Plenum Curb for Side Discharge and Roof Curb: Factory provided, 12 inches high, welded galvanized steel construction, with insulation, and wooden nailer strip.
8. Manufacturer provides necessary instruments to ensure the unit operates according to its sequence of operations.

N. Manufacturers:

1. Aaon.
2. Carrier.
3. Trane.
4. Rheem.
5. Lennox International.
6. Addison.
7. York Air Conditioning.

## 2.06 HARSH ENVIRONMENT CORROSION PROTECTION SYSTEM

A. General:

1. Corrosion protection system below shall be provided for equipment where indicated in this specification.
2. Exterior and interior surfaces of unit cabinet/casing shall be coated with anticorrosion protection coating as described below.
3. Protective coating to be applied to unit after factory assembly of equipment.

B. Coating Material: Use one of the following materials.

1. Epoxy modified phenolic. Straight phenolic materials are not acceptable.
2. Epoxy or epoxy urethane.
3. Complex chain linked polyelastomer material.

C. Cabinet Coating Process:

1. Unit Disassembly:
   a. Disassemble unit.
   b. Remove condenser fan motor.
   c. Mask or pull back exterior wires.
2. Cabinet Cleaning:
   a. Clean surfaces by residue-free solvent wipe down or steam cleaner/pressure washer with soap to remove lubricants, machining oils, and residual factory contamination. Do not soak or damage unit insulation.
   b. Rinse with clean potable water to remove cleaning solution.


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3. Coating Application:
    a. Etch bare interior and exterior surfaces including: compressor/condenser section, base rails, and underside of unit. Rinse etched surfaces to remove etching solution and residue.
    b. Previously painted surfaces to be scuff sanded with 220-grit to 320-grit abrasive to remove gloss on original coating. Sanded surfaces to be cleaned with residue-free solvent wipe down.
    c. Clean surfaces and allowed to dry.
    d. Base Coat: When cabinet is dry, apply primer to interior and exterior surfaces. Allow to dry minimum of 12 hours.
    e. Top Coat: When primer is dry, apply final protective coating to interior and exterior surfaces. Apply two coats for optimum protection.
    f. Allow coating to dry completely before reassembling unit.
4. Quality Control: Free from voids, checks, cracks, and blisters.

D. Performance: Cabinet finish shall meet or exceed the following criteria.

1. Salt Spray Test: In accordance with ASTM B117, minimum 3,000-hour duration, with no corrosion or degradation.
2. Exposure to UV Light: UV inhibited life of minimum 10 years when exposed to sun.

E. Manufacturers and Products:

1. Aero-Marine Engineering Inc.; Technicoat 10-1.
2. AST ElectroFin Inc; Electrofin.
3. Blygold; Refamac.

F. Application of coating shall be done by companies certified by the product manufacturer.

1. Aero-Marine Engineering Inc.
2. MJC Inc.
3. AST ElectroFin Inc.

G. Refrigerant Coils: Condenser and evaporator coil(s) shall be coated with a corrosion protection coating in accordance with Article Factory Dip-Applied Protective Coating.

H. Fasteners: Replace factory fasteners with stainless steel components.


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## 2.07 UNITARY EQUIPMENT CONTROLS

A. Electric Thermostat:

1. Two-position electric type.
2. Temperature Scale: Furnish 50 degrees F to 90 degrees F scale.
3. Adjustments external to units.
4. Adjustable sensitivity.
5. Nonlocking cover.
6. Insulating back, where exterior mounting is indicated.

B. Electronic Multistage AC Unit Controller:

1. Heating and Cooling Stages:
   a. Four-stage cooling and four-stage heating electronic control.
   b. Staging delay between each cycle.
   c. Visual indication of activation of each stage.
2. Integrated thermostat.
3. Temperature Scale: Manually adjustable, 55 degrees F to 90 degrees F scale.
4. Duty Cycle:
   a. Automatic duty cycling of equipment.
   b. Manual adjustment for 1-day to 24-day cycle time.
   c. Manual cycle advance.
   d. Visual indication of lead unit.
5. Enclosure:
   a. Single wall-mounted enclosure with operator interface on outside of panel door.
   b. NEMA Type 1 enclosure.
6. Operator interface to consist of temperature adjustment, LCD room temperature display, and visual indication of lead unit and each cooling and heating stage activation.
7. Adjustments external to controller.
8. Adjustable “dead band” between heating and cooling to be between 4 degrees F and 20 degrees F.
9. Power loss memory for restoration of sequence of operation in event of power loss.
10. Refer to Section 23 09 00, Instrumentation and Control Devices for HVAC, for additional controller operation options.
11. Manufacturer and Product: Bard; TEC40.

C. Direct Digital Control: Stand-alone control module compatible with temperature control system.


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## 2.08 FACTORY DIP-APPLIED PROTECTIVE COATING

A. General:

1. Factory dip-applied protective coating for application to plate fin and tube coils.
2. Coil factory assembled and tested before coating application.
3. Coating suitable for coils with maximum 30 fins per inch fin density. Bridging of product across coil fins is unacceptable.
4. After application and proper curing, product shall endure bending of coil assembly in standard manufacturing process without cracking.
5. Apply coating to coil before final factory assembly of equipment. Coating process that requires disassembly of equipment for removal of coil to be coated is not acceptable. If protective coating is applied to coil after factory assembly of equipment, cost for shipping unit to coating factory, disassembly, coating process, reassembly, and delivery to Site shall be borne by Contractor.

B. Coating Material:

1. Use one of the following materials:
   a. Epoxy Modified Phenolic. Straight phenolic materials are not acceptable.
   b. Epoxy or epoxy urethane.
   c. Polyelastomer: Complex chain linked polyelastomer material.

C. Coating Process:

1. Coil Inspection and Sealing:
   a. Inspect coil for open tubes, headers, capillary tubes; repair as necessary.
   b. Fill with dry nitrogen, cap and seal, to prevent contamination of internal coil surfaces with cleaning or coating solutions.
2. Coil Cleaning:
   a. Immerse coil in heated alkaline cleaning solution to remove lubricants, machining oils, and residual factory contamination.
   b. Followed with immersion in potable water bath to neutralize and remove cleaning solution.
3. Coating Application:
   a. Immerse coil assembly in coating bath, including headers, casing, and heat exchange surfaces.
   b. Completed remove coil from equipment during coating application.
   c. Spray-on coatings are not acceptable.


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4. Curing: Oven baked at metal temperature not to exceed 400 degrees F.
5. Quality Control: Free from voids, checks, cracks and blisters.

D. Performance:

1. Coil finish shall meet or exceed the following criteria:
   a. Salt Spray Test: In accordance with ASTM B117, minimum 3,000-hour duration, with no fin corrosion or degradation.
   b. Thermal Efficiency: Loss no greater than 1 percent after coating application.
   c. Exposure to UV Light: UV inhibited life of minimum 10 years when exposed to sun in the State of Florida.

E. Manufacturers and Products:

1. Aero-Marine Engineering Inc.; Technicoat 10-1.
2. AST ElectroFin Inc; ElectroFin.

2.09 ELECTRICAL

A. General:

1. Units shall include high and low voltage terminal block connections.
2. Control voltage to indoor unit fan shall be 24 volts.
3. Motor Starters/Contactors: Factory installed with unitary equipment, unless otherwise noted.
4. Disconnects: Factory installed nonfused disconnects or circuit breakers on each unit, unless otherwise noted.

B. Motors:

1. Refer to Section 26 20 00, Low-Voltage AC Induction Motors, for general requirements.
2. Unless otherwise stated, electric motors shall comply with the following:
   a. Voltage, Phase, Horsepower, Synchronous Speed: Refer to Equipment Schedule for motor driven equipment.
   b. Enclosure: ODP, unless specified otherwise.
   c. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
   d. Winding Thermal Protection: Manufacturer’s standard.
   e. Space Heater: Manufacturer’s standard.
   f. Multispeed Motors, Synchronous Speed, Number of Windings: Manufacturer’s standard.
   g. Efficiency: Minimum efficiency per Section 26 20 00, Low-Voltage AC Induction Motors.


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2.10 ACCESSORIES

A. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 100 pounds.

B. Equipment Identification Plates: Furnish 16-gauge Type 304 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch-high engraved block type black enamel filled equipment identification number and letters indicated in this Specification.

C. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, 1/2-inch minimum diameter, and as specified in Section 05 50 00, Metal Fabrications. Quantity as recommended by manufacturer.

2.11 SOURCE QUALITY CONTROL

A. Factory Tests:

1. Direct expansion coils leak tested underwater with 200-psig air. Pressure tested to 450 psig.
2. Electric heating coils tested with 2,000-volt dielectric test.

**PART 3 EXECUTION**

3.01 INSTALLATION

A. General:

1. Install equipment in accordance with manufacturer’s recommendations, and these Specifications.
2. Set and install equipment so equipment is level and properly supported.
3. Ensure piping connections to equipment do not cause strain on equipment.
4. Ensure vibration isolation has been installed per manufacturer’s instructions and isolation devices are performing satisfactorily.
5. Install safety devices as recommended by manufacturer and required by code.

B. Seal outside air intake watertight to roof curb.

C. Isolate sheet metal duct connections from portions of unit not internally spring-isolated from fans, or other vibrating or rotating equipment.

D. Inspect internal casing insulation, seal exposed edges, and butt joints with mastic to ensure insulation will not be loosened during operation.


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E. Filters:

1. Install set of filters in each unit before operating and leave in place during startup and testing to keep equipment and ductwork clean.
2. Do not operate units until filters are installed. If operated without filters, completely clean ductwork, coils, and interior of units.

F. Lubricate unsealed bearings prior to startup.

3.02 FIELD QUALITY CONTROL

A. Initial equipment testing and startup shall be made by authorized representative of unit manufacturer.

B. Air-cooled outdoor unit shall not be started without complete prestart checkout of entire refrigerant piping system and charging of system with refrigerant as recommended by equipment manufacturer.

C. Field Testing: Manufacturer shall provide factory-trained representative employed by equipment manufacturer to perform the following services. Supervision only, of Contractor personnel, will not be acceptable.

1. Leak test.
2. Refrigerant pressure test.
3. Evacuate (if required).
4. Dehydrate (if required).
5. Charge condensing unit with refrigerant and oil (if required).

3.03 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for the following:

1. Inspect installation including external interlock, power connections; supervise initial operation, calibration of operating and safety controls and supervise electrical testing including insulation resistance of motors and voltage balance between phases during starting and running.
2. Test Report:
   a. Submit test reports unit is in safe and proper operating condition.
   b. Contain pressure and control settings, meg readings, voltage readings per phase during START and RUN, suction temperature and pressure, liquid temperature and pressure.
   c. List minor discrepancies to be corrected which do not affect safe and reliable operation.
   d. One copy of report shall be left in unit control panel.


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3. One copy of bound installation operation and maintenance service, and parts brochures, including applicable serial numbers, full unit description, parts ordering sources, shall be placed in unit control panel at time of starting.
4. Training of Owner's personnel for specified equipment.

3.04 ADJUSTING AND CLEANING

A. Air System Balancing: As specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

B. Install set of filters at time of final cleaning as defined in Section 01 77 00, Closeout Procedures.

**END OF SECTION**


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# SECTION 26 05 02
# BASIC ELECTRICAL REQUIREMENTS

## PART 1 GENERAL

### 1.01 RELATED SECTIONS

A. Requirements specified within this section apply to Division 26, Electrical. Work specified herein shall be performed as if specified in the individual sections.

### 1.02 REFERENCES

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

1. National Electrical Contractors Association (NECA): National Electrical Installation Standards.
2. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. Z535.4, Product Safety Signs and Labels.
3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).

### 1.03 DESIGN REQUIREMENTS

A. Provide anchorage and bracing design drawings, calculations, and related information where required under Section 01 88 15, Anchorage and Bracing.

B. Provide seismic certification per requirements of Section 01 45 33, Special Inspection, Observation, and Testing, where required in that section for electrical equipment listed.

### 1.04 ELECTRIC AND TELEPHONE SERVICE DIVISION OF RESPONSIBILITY

A. Existing incoming underground electrical service facilities provided by the serving utility as part of its normal obligation to customers is work provided outside this Contract. Schedule and coordinate work of serving utility as required to provide electric service to the Work.

B. Incoming telephone service facilities provided by the serving utilities as part of their normal obligation to customers is work provided outside this Contract. Under this Contract, provide customer required service provisions and electrical work.


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## 1.05 SUBMITTALS

A. Action Submittals:

1. Provide manufacturers' data for the following:
   a. Electrical service components.
   b. Telephone service components.
   c. Nameplates, signs, and labels.
2. Anchorage and bracing drawings and catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads in Section 01 61 00, Common Product Requirements.

B. Informational Submittals: Anchorage and bracing calculations, as required by Section 01 88 15, Anchorage and Bracing, for loads in Section 01 61 00, Common Product Requirements.

## 1.06 DESIGN REQUIREMENTS

A. Provide comprehensive short circuit, protective device coordination and arc flash studies per Section 26 05 70, Electrical Systems Analysis. Initial complete short circuit, protective device coordination and arc flash studies shall be submitted, reviewed, and approved before major electrical equipment Shop Drawings will be reviewed.

B. Provide lightning protection design and construction for abovegrade structures per Section 26 41 00, Facility Lightning Protection.

C. Provide fire alarm system design and installation per Section 28 31 00, Fire Detection and Alarm.

## 1.07 SCOPE OF WORK

A. Provide, install, and test one padmounted sectionalizing switches, one padmounted stepdown transformer, three low voltage motor control centers.

B. Furnish, install, and test low voltage site power distribution system as specified and/or shown.

C. Furnish and install the low voltage and control duct bank systems as shown.

D. Furnish, install, terminate, and test all interconnecting power, control, and instrumentation wiring as shown on the One-Line Diagrams, riser diagrams and P&ID Drawings.


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E. Furnish and install all conduit, wiring, and field connections for all motors, motor controllers, control devices, control panels, and electrical equipment furnished under other divisions of these Specifications.

F. Furnish and install equipment grounding conductors sized per Table 250-122 of the NEC unless otherwise shown on the Drawings, in all conduits throughout the entire plant.

G. Furnish and install raceways for the fiber optic cable system as required to implement fiber optic data links shown on the P&ID Drawings. Install an inner duct/outer duct system as shown and specified. Install fiber optic cable furnished by PICS subcontractor. Termination and testing by PICS subcontractor. Provide accurate estimate of fiber optic cable lengths to the PICS subcontractor.

H. Furnish and install a complete raceway system for data highway cables and specialty cables systems. Install manufacturer-supplied data highway cables and other specialty cable systems in accordance with the system manufactures' installation instructions. Review the raceway layout, prior to installation, with the PICS subcontractor and cable manufacture to ensure raceway compatibility with the systems and materials being furnished. Where redundant cables are furnished, install cables in separate raceways.

I. Provide support to the PICS subcontractor for installation, wiring, and termination of all control panels, field instruments, lightning, and surge protection equipment at process instrumentation transmitters, and computer equipment. Install vendor furnished cables specified under other Divisions of these Specifications.

J. Furnish and install conduit, wiring, and terminations for adjustable frequency drives, harmonic filters, and transformers furnished under other Divisions of these Specifications.

K. Furnish and install power wiring for all heating, ventilation, and air conditioning (HVAC) equipment furnished under other divisions of these specifications, including power wiring for 120-volt unit heaters, thermostats, fan motors, dampers and other HVAC inline unit wiring shown on the Drawings.

L. Furnish, install, and wire all site and facility lighting as shown on the Drawings.

M. Conduct and participate in all electrical and PICS subcontractor's testing. Specifically all operational readiness tests and functional acceptance tests shall be jointly conducted by the PICS subcontractor and the Electrical subcontractor.


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N. Furnish and install all telephone/data outlet raceway systems as shown and required for satisfactory operation.

O. Sequence work to meet the Contractor's overall schedule and construction sequence.

P. Prepare and furnish electrical and instrumentation conduit layout Shop Drawings for yard electrical, within and under all roads, buildings and structures to the Engineer for approval prior to commencing work. Layouts shall include but not be limited to equipment, pull boxes, manholes, handholes, conduit routing, dimensioning, methods and location of supports, reinforcing, encasement, materials, conduit sizing, equipment access, potential conflicts, building and yard lighting, and all other pertinent technical specifications for all electrical and instrumentation conduits and equipment to be furnished.

Q. The Work shall include complete testing of all equipment and wiring at the completion of Work and making any necessary corrections or adjustments necessary for the proper functioning of the system and equipment. All workmanship shall be of the highest quality; substandard work will be rejected.

R. Contractor shall provide their own temporary power for miscellaneous power (drills, pumps, etc.). Any temporary added shall be removed at Job completion.

S. Complete coordination with other Contractors. Contractor shall coordinate with all other Contractor's equipment submittals and obtain all relevant submittals.

T. Each bidder or their authorized representatives shall, before preparing their proposal, visit all areas of the site, in which Work under this Division is to be performed. The submission of the proposal by this bidder shall be considered evidence that their representative has visited the Site, and noted the locations and conditions under which the Work will be performed and that he/she takes full responsibility for a complete knowledge of all factors governing his/her work.

## 1.08 QUALITY ASSURANCE

A. Provide the Work in accordance with NFPA 70. Where required by Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ, in order to provide a basis for approval under the NEC.


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B. Materials and equipment manufactured within the scope of standards published by UL shall conform to those standards and shall have an applied UL listing mark or label.

C. Provide materials and equipment acceptable to AHJ for Class, Division, and Group of hazardous area indicated.

1.09 ENVIRONMENTAL CONDITIONS

A. The following areas are classified hazardous, Class I, Division 1, Group D, because of the potential for accumulation of hazardous concentrations of combustible gases, and for exposure to corrosive environment. Use materials and methods required for such areas.

1. Scum-pumping area within pit.

B. The following areas are classified hazardous, Class I, Division 2, Group D, because of the potential for accumulation of hazardous concentrations of combustible gases, and for exposure to corrosive environment. Use materials and methods required for such areas.

1. Within 10 feet of the scum pit.
    a. Abovegrade and open to the atmosphere.
2. Sludge Storage Holding Tank:
    a. Interior of the tank from the minimum operating sludge surface to the top of the tank wall.
    b. 18 inches above the top of the tank.
    c. 18 inches beyond the exterior wall.
    d. 18 inches above grade extending 10-inch to 0-inch horizontally from the exterior tank walls.

C. The following areas are classified nonhazardous, wet, and corrosive. Use materials and methods required for such areas.

1. Dewatering Building: When continuously ventilated at six air exchanges per hour.
2. Waste Activated Sludge Pumping Station – Dry Well: When continuously ventilated at six air exchanges per hour.
3. Sludge Pumping Station – Dry Well: When continuously ventilated at six air exchanges per hour.
4. Compost Piles: When not enclosed.


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D. The following areas are classified as indoor and dry:

1. Admin Compost Building.
2. Electrical Rooms.
3. Areas not covered above.

E. Areas Not Covered Above: Consult with AHJ and NFPA 820.

## PART 2 PRODUCTS

### 2.01 GENERAL

A. Where two or more units of the same class of material or equipment are required, provide products of a single manufacturer. Component parts of materials or equipment need not be products of the same manufacturer.

B. Material and equipment installed in heated and ventilated areas shall be capable of continuous operation at their specified ratings within an ambient temperature range of 40 degrees F to 104 degrees F.

C. Materials and equipment installed outdoors shall be capable of continuous operation at their specified rating within the ambient temperature range stated in Section 01 61 00, Common Product Requirements.

D. Equip panels installed outdoors in direct sun with sun shields.

### 2.02 EQUIPMENT FINISH

A. Interior: Manufacturer’s standard finish color, except where specific color is indicated. If manufacturer has no standard color, finish equipment in accordance with ANSI No. 61, light gray color.

### 2.03 NAMEPLATES

A. Material: Laminated plastic.

B. Attachment Screws: Stainless steel.

C. Color: Black, engraved to a white core.

D. Letter Height:

1. Pushbuttons/Selector Switches: 1/8-inch.
2. Other Electrical Equipment: 1/4-inch.


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2.04 SIGNS AND LABELS

A. Sign size, lettering, and color shall be in accordance with NEMA Z535.4.

B. Warning labels for arc flash hazards shall be provided per NEC code.

C. Based on the results of arc-flash calculations performed as specified in Section 26 05 70, Electrical Systems Analysis, provide appropriate warning labels on all electrical equipment.

**PART 3 EXECUTION**

3.01 GENERAL

A. Electrical Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned. Contractor shall be responsible for actual location of equipment and devices and for proper routing and support of raceways, subject to approval of Engineer. Coordinate the conduit installation with other trades and the actual supplied equipment. Obtain information relevant to the placement of electrical work and in case of any interference with other work, processed as directed by the Engineer and furnished all labor and materials necessary to complete the Work in an approved manner.

B. Check approximate locations of light luminaires, switches, receptacles, disconnect switches, equipment, and other electrical system components shown on the Drawings for conflicts with openings, structural members, and components of other systems and equipment having fixed locations. In the event of conflicts, notify Engineer in writing. Any adjustments required in the field shall be provided at no additional cost to the Owner.

C. Install Work in accordance with NECA Standard of Installation, unless otherwise specified.

D. Keep openings in boxes and equipment closed during construction.

E. Lay out work carefully in advance. Do not cut or notch any structural member or building surface without specific approval of Engineer. Carefully perform cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, paving, or other surfaces required for the installation, support, or anchorage of conduit, raceways, or other electrical materials and equipment. Following such work, restore surfaces to original condition.

F. Unless otherwise approved by the Engineer, conduit shown exposed shall be installed exposed; conduit shown concealed shall be installed concealed.


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G. Circuit layouts are not intended to show the number of fittings, or other installation details. Furnish all labor and materials necessary to install and place in satisfactory operation all power, lighting, and other electrical systems shown. Additional circuits shall be installed wherever needed to conform to the specific requirements of the approved equipment at no additional cost to the Owner.

H. Redesign of electrical or mechanical work, which is required due to the Contractor's use of an alternate item, arrangement or equipment and/or layout other than specified herein, shall be done by the Contractor at Contractor's own expense. Redesign and detailed plans shall be submitted to the Engineer for approval. No additional compensation will be provided for changes in the work, either the Contractor's own or others, caused by such redesign.

I. Surface mounted panel boxes, junction boxes, conduit, etc., shall be supported with 1/2-inch spacers to provide a clearance between wall and equipment.

J. All floor mounted electrical equipment shall be placed on 4-inch thick (3/4-inch, 45-degree chamfer at all exposed edges) concrete pads, provide reinforcement, anchors, etc.

K. The Contractor shall coordinate with the work of the different trades so that interferences between conduits, piping, equipment, architectural and structural work will be avoided. All necessary offsets shall be furnished so as to take up a minimum space and all such offsets, fittings, etc., required to accomplish this shall be furnished and installed by the Contractor without additional expense to the Owner. In case interference develops, the Engineer is to decide which equipment, piping, etc., must be relocated, regardless of which was installed first.

L. Raceways and conductors for lighting, switches, receptacles, and other miscellaneous low voltage power and signal system as specified are not shown on the Drawings. Raceways and conductors shall be provided as required for a complete and operating system. Homeruns, as shown on the Drawings, are to assist the Contractor in identifying raceways to be run exposed and raceways to be run concealed. Raceways shall be installed concealed in all finished spaces and may be installed exposed or concealed in all process spaces. Raceways installed exposed shall be near the ceiling or along walls of the areas through which they pass and shall be routed to avoid conflicts with HVAC ducts, cranes hoists, monorails, equipment hatches, doors, windows, etc. Raceways installed concealed shall be run in the center of concrete floor slabs, above suspended ceilings, or in partitions as required.


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M. Investigate each space in the structure through which equipment must pass to reach its final location. Coordinate shipping splits with the manufacturer to permit safe handling and passage through restricted areas in the structure.

N. The equipment shall be kept upright at all times during storage and handling. When equipment must be tilted for passage through restricted areas, brace the equipment to ensure that the tilting does not impair the functional integrity of the equipment.

3.02 ANCHORING, BRACING, AND MOUNTING

A. Equipment anchoring and mounting shall be in accordance with manufacturer's requirements for Project design criteria provided in Section 01 61 00, Common Product Requirements, to meet the requirements of Section 01 88 15, Anchorage and Bracing.

3.03 COMBINING CIRCUITS INTO COMMON RACEWAY

A. Homerun circuits shown on the Drawings indicate functional wiring requirements for power and control circuits. Circuits may be combined into common raceways in accordance with the following requirements:

1. Analog control circuits from devices in same general area to same destination.
    a. No power or AC discrete control circuits shall be combined in same conduit with analog circuits.
    b. No Class 2 or Class 3 circuits including, but not limited to, HVAC control circuits, fire alarm circuits, paging system circuits shall be combined with power or Class 1 circuits.
    c. Analog circuits shall be continuous from source to destination. Do not add TJB, splice, or combine into a multi-pair cable without authorization of Engineer.
    d. Raceways shall be sized per General Circuit and Raceway Schedule and shall not exceed 40 percent fill.
    e. Changes shall be documented on the Record Drawings.
2. Discrete control circuits from devices in the same general area to the same destination.
    a. No power or analog control circuits shall be combined in same conduit with discrete circuits.
    b. No Class 2 or Class 3 circuits including, but not limited to, HVAC control circuits, fire alarm circuits, and paging system circuits shall be combined with power or Class 1 circuits.
    c. Raceways shall be sized per the General Circuit and Raceway Schedule and shall not exceed 40 percent fill.
    d. Changes shall be documented on the Record Drawings.


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3. Power circuits from loads in same general area to same source location (such as: panelboard, switchboard, low voltage motor control center).
   a. Lighting Circuits: Combine no more than three circuits, with separate neutrals, to a single raceway. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.
   b. Receptacle Circuits, 120-Volt Only: Combine no more than three circuits, with separate neutrals, to a single raceway. Provide a separate neutral conductor for each circuit. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.
   c. All Other Power Circuits: Do not combine power circuits without authorization of Engineer.

## 3.04 NAMEPLATES, SIGNS, AND LABELS

A. Arc Flash Protection Warning Signs: Field mark switchgear, motor control centers, panelboards, etc. to warn qualified persons of potential arc-flash hazards. Locate marking so to be clearly visible to persons before working on energized equipment. Refer to Section 26 05 70, Electrical Systems Analysis, for additional requirements.

B. Multiple Power Supply Sign: Install permanent plaque or directory at each service disconnect location denoting other services, feeders, and branch circuits supplying a building, and the area served by each.

C. Equipment Nameplates:

1. Provide a nameplate to label electrical equipment including switchgear, switchboards, motor control centers, panelboards, motor starters, AFDs, transformers, terminal junction boxes, disconnect switches, switches and control stations.
2. Motor control center, dry-type transformer, and terminal junction box nameplates shall include equipment designation, and equipment tag number.
3. Disconnect switch, starter, AFDs, and control station nameplates shall include equipment designation, equipment tag number and power source of equipment powered or controlled by that device.
4. Switchboard and panelboard nameplates shall include equipment designation, equipment tag number, service voltage, phases, and power source.

D. Procedural Signs: Provide procedural signs for Kirk-Key interlocks and main-tie-main operation sequences and location of keys.


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E. Procedural Signs for all mechanical key interlocks, including a laminated sign for each equipment

F. Each Motor Control Center modified shall have an updated laminated single line diagram posted on the side of the gear.

3.05 LOAD BALANCE

A. Drawings and Specifications indicate circuiting to electrical loads and distribution equipment.

B. Balance electrical load between phases as nearly as possible on switchboards, panelboards, motor control centers, and other equipment where balancing is required.

C. When loads must be reconnected to different circuits to balance phase loads, maintain accurate record of changes made, and provide circuit directory that lists final circuit arrangement.

3.06 SLEEVES AND FORMS FOR OPENINGS

A. Provide and place all sleeves for conduits penetrating floors, walls, partitions, etc. Locate all necessary slots for electrical work and form before concrete is poured.

B. Exact locations are required for stubbing-up and terminating concealed conduit. Obtain Shop Drawings and templates from equipment vendors or other subcontractors and locate the concealed conduits before the floor slab is poured.

C. Where setting Drawings are not available in time to avoid delay in scheduled floor slab pours, the Engineer may allow the installation of such conduits to be exposed. Request for this deviation must be submitted in writing. No additional compensation for such change will be allowed.

D. Seal all openings, sleeves, penetrations and slots as specified in Section 26 05 33, Raceway and Boxes.

3.07 CLEANING AND TOUCHUP PAINTING

A. Cleaning: Throughout the Work, clean interior and exterior of devices and equipment by removing debris and vacuuming.


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B. Touchup Paint:

1. Touchup scratches, scrapes and chips on exterior and interior surfaces of devices and equipment with finish matching type, color, and consistency and type of surface of original finish.
2. If extensive damage is done to equipment paint surfaces, refinish entire equipment in a manner that provides a finish equal to or better than factory finish, that meets requirements of specification, and is acceptable to Engineer.

## 3.08 PROTECTION FOLLOWING INSTALLATION

A. Protect materials and equipment from corrosion, physical damage, and effects of moisture on insulation and contact surfaces.

B. When equipment intended for indoor installation is installed at Contractor's convenience in areas where subject to dampness, moisture, dirt or other adverse atmosphere until completion of construction, ensure adequate protection from these atmospheres is provided and acceptable to Engineer.

## 3.09 CHECKOUT AND STARTUP

A. Voltage Field Test:

1. Check voltage at point of termination of power company supply system to project when installation is essentially complete and is in operation.
2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
3. Record supply voltage (all three phases simultaneously on same graph) for 24 hours during normal working day.
   a. Submit Voltage Field Test Report within 5 days of test.
4. Unbalance Corrections:
   a. Make written request to power company to correct condition if balance (as defined by NEMA) exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded condition more than plus or minus 4 percent of nominal.
   b. Obtain a written certification from a responsible power company official that the voltage variations and unbalance are within their normal standards if corrections are not made.



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B. Equipment Line Current Tests:

1. Check line current in each phase for each piece of equipment.
2. Make line current check after power company has made final adjustments to supply voltage magnitude or balance.
3. If any phase current for any piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken.

**END OF SECTION**


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# SECTION 26 05 04
# BASIC ELECTRICAL MATERIALS AND METHODS

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. ASTM International (ASTM):
   a. A1011/A1011M, Standard Specification for Steel, Sheet, and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low Alloy and High-Strength Low Alloy Formability.
   b. E814, Method of Fire Tests of Through-Penetration Fire Stops.
2. Canadian Standards Association (CSA).
3. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 18, Standard for Shunt Power Capacitors.
4. International Society of Automation (ISA): RP12.06.01, Wiring Practices for Hazardous (Classified) Locations Instrumentation–Part 1: Intrinsic Safety.
5. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. C12.1, Code for Electricity Metering.
   c. C12.6, Phase-Shifting Devices Used in Metering, Marking and Arrangement of Terminals.
   d. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts.
   e. ICS 5, Industrial Control and Systems: Control Circuit and Pilot Devices.
   f. KS 1, Enclosed and Miscellaneous Distribution Switches (600 Volts Maximum).
6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
7. UL:
   a. 98, Standard for Enclosed and Dead-Front Switches.
   b. 248, Standard for Low Voltage Fuses.
   c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   d. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   e. 508, Standard for Industrial Control Equipment.
   f. 810, Standard for Capacitors.
   g. 943, Standard for Ground-Fault Circuit-Interrupters.


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h. 1059, Standard for Terminal Blocks.
i. 1479, Fire Tests of Through-Penetration Fire Stops.

1.02 SUBMITTALS

A. Action Submittals:

1. Provide manufacturers' data for the following:
   a. Control devices.
   b. Control relays.
   c. Circuit breakers.
   d. Fused switches.
   e. Nonfused switches.
   f. Timers.
   g. Fuses.
   h. Magnetic contactors.
   i. Intrinsic safety barriers.
   j. Firestopping.
   k. Enclosures: Include enclosure data for products having enclosures.
2. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals: Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.

1.03 EXTRA MATERIALS

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

1. Fuses, 0-Volt to 600 Volts: Six of each type and each current rating installed.

1.04 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

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


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## PART 2 PRODUCTS

2.01 MOLDED CASE CIRCUIT BREAKER THERMAL MAGNETIC, LOW VOLTAGE

A. General:

1. Type: Molded case.
2. Trip Ratings: 15 amps to 800 amps.
3. Voltage Ratings: 120V ac, 240V ac, 277V ac, 480V ac, and 600V ac.
4. Suitable for mounting and operating in any position.
5. UL 489.

B. Operating Mechanism:

1. Overcenter, trip-free, toggle type handle.
2. Quick-make, quick-break action.
3. Locking provisions for padlocking breaker in OPEN position.
4. ON/OFF and TRIPPED indicating positions of operating handle.
5. Operating handle to assume a CENTER position when tripped.

C. Trip Mechanism:

1. Individual permanent thermal and magnetic trip elements in each pole.
2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
3. Two and three pole, common trip.
4. Automatically opens all poles when overcurrent occurs on one pole.
5. Test button on cover.
6. Calibrated for 40 degrees C ambient, unless shown otherwise.
7. Do not provide single-pole circuit breakers with handle ties where multi-pole circuit breakers are shown.

D. Short Circuit Interrupting Ratings:

1. Not less than the following RMS symmetrical currents for the indicated ratings:
   a. Less than 250V ac: 10,000 amps unless otherwise shown on the Drawings.
   b. 250V ac to 600V ac: 65,000 amps unless otherwise shown on the Drawings.
2. Series Connected Ratings: Do not apply series connected short circuit ratings.


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E. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker as specified above with ground fault sensor and rated to trip on 5-mA ground fault within 0.025-second (UL 943, Class A sensitivity, for protection of personnel).

1. Ground fault sensor shall be rated same as circuit breaker.
2. Push-to-test button.

F. Magnetic Only Type Breakers: Where shown; instantaneous trip adjustment which simultaneously sets magnetic trip level of each individual pole continuously through a 3X to 10X trip range.

G. Accessories: Shunt trip, auxiliary switches, handle lock ON devices, mechanical interlocks, key interlocks, unit mounting bases, double lugs as shown or otherwise required. Shunt trip operators shall be continuous duty rated or have coil-clearing contacts.

H. Connections:

1. Supply (line side) at either end.
2. Mechanical wire lugs, except crimp compression lugs where shown.
3. Lugs removable/replaceable for breaker frames greater than 100 amperes.
4. Suitable for 75 degrees C rated conductors without derating breaker or conductor ampacity.

I. Enclosures for Independent Mounting:

1. See Article Enclosures.
2. Service Entrance Use: Breakers in required enclosure and required accessories shall be UL 489 listed.
3. Interlock: Enclosure and switch shall interlock to prevent opening cover with switch in the ON position. Provide bypass feature for use by qualified personnel.

2.02 FUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

A. UL 98 listed for use and location of installation.

B. NEMA KS 1.

C. Short Circuit Rating: 200,000 amps rms symmetrical with Class R, Class J, or Class L fuses installed.

D. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.


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E. Connections:

1. Mechanical lugs, except crimp compression lugs where shown.
2. Lugs removable/replaceable.
3. Suitable for 75 degrees C rated conductors at NEC 75 degrees C ampacity.

F. Fuse Provisions:

1. 30-amp to 600-amp rated shall incorporate rejection feature to reject all fuses except Class R.
2. 601-amp rated and greater shall accept Class L fuses, unless otherwise shown.

G. Enclosures: See Article Enclosures.

H. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.03 NONFUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

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. Lugs: Suitable for use with 75 degrees C wire at NEC 75 degrees C ampacity.

D. Enclosures: See Article Enclosures.

E. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.04 FUSE, 250-VOLT AND 600-VOLT

A. Power Distribution, General:

1. Current-limiting, with 200,000 ampere rms interrupting rating.
2. Provide to fit mountings specified with switches.
3. UL 248.

B. Power Distribution, Ampere Ratings 1-Amp to 600 Amps:

1. Class: RK-1.
2. Type: Dual element, with time delay.


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3. Manufacturers and Products:
    a. Bussmann; Types LPS-RK (600 volts) and LPN-RK (250 volts).
    b. Littelfuse; Types LLS-RK (600 volts) and LLN-RK (250 volts).

C. Power Distribution, Ampere Ratings 601 Amps to 6,000 Amps:

1. Class: L.
2. Double O-rings and silver links.
3. Manufacturers and Products:
    a. Bussmann; Type KRP-C.
    b. Littelfuse, Inc.; Type KLPC.

D. Cable Limiters:

1. 600V or less; crimp to copper cable, bolt to bus or terminal pad.
2. Manufacturer and Product: Bussmann; K Series.

E. Ferrule:

1. 600V or less, rated for applied voltage, small dimension.
2. Ampere Ratings: 1/10-amp to 30 amps.
3. Dual-element time-delay, time-delay, or nontime-delay as required.
4. Provide with blocks or holders as indicated and suitable for location and use.
5. Manufacturers:
    a. Bussmann.
    b. Littlefuse, Inc.

## 2.05 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.

B. Selector Switch Operating Lever: Standard.

C. Indicating Light: Push-to-test, LED.

D. Pushbutton Color:

1. ON or START: Red.
2. OFF or STOP: Black.

E. Pushbutton and selector switch lockable in OFF position where indicated.


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F. Legend Plate:

1. Material: Aluminum.
2. Engraving: Enamel filled in high contrasting color.
3. Text Arrangement: 11-character/spaces on one line, 14-character/spaces on each of two lines, as required, indicating specific function.
4. Letter Height: 7/64-inch.

G. Manufacturers and Products:

1. Heavy-Duty, Oil-Tight Type:
   a. General Electric Co.; Type CR 104P.
   b. Square D Co.; Type T.
   c. Eaton/Cutler-Hammer; Type 10250T.
2. Heavy-Duty, Watertight, and Corrosion-Resistant Type:
   a. Square D Co.; Type SK.
   b. General Electric Co.; Type CR 104P.
   c. Eaton/Cutler-Hammer; Type E34.
   d. Crouse-Hinds; Type NCS.

## 2.06 TERMINAL BLOCK, 600 VOLTS

A. UL 486E and UL 1059.

B. Size components to allow insertion of necessary wire sizes.

C. Capable of termination of control circuits entering or leaving equipment, panels, or boxes.

D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between compression screw and yoke.

E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.

F. Yoke shall guide all strands of wire into terminal.

G. Current bar shall ensure vibration-proof connection.

H. Terminals:

1. Capable of wire connections without special preparation other than stripping.
2. Capable of jumper installation with no loss of terminal or rail space.
3. Individual, rail mounted.

I. Marking system, allowing use of preprinted or field-marked tags.


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J. Manufacturers:

1. Weidmuller, Inc.
2. Ideal.
3. Electrovert USA Corp.

2.07 MAGNETIC CONTROL RELAY

A. Industrial control with field convertible contacts rated 10 amps continuous, 7,200VA make, 720VA break.

B. NEMA ICS 2, Designation: A600 (600 volts).

C. Time Delay Relay Attachment:

1. Pneumatic type, timer adjustable from 0.2-second to 60 seconds (minimum).
2. Field convertible from ON delay to OFF delay and vice versa.

D. Latching Attachment: Mechanical latch, having unlatching coil and coil clearing contacts.

E. Manufacturers and Products:

1. Eaton/Cutler-Hammer; D26 Type M.
2. ABB/General Electric Co.; Type CR120B.
3. Schneider Electric/Square D; Type X.

2.08 TIME DELAY RELAY

A. Industrial relay with contacts rated 5 amps continuous, 3,600VA make, 360VA break.

B. NEMA ICS 2 Designation: B150 (150 volts).

C. Solid-state electronic, field convertible ON/OFF delay.

D. One normally open and one normally closed contact (minimum).

E. Repeat accuracy plus or minus 2 percent.

F. Timer adjustment from 1-second to 60 seconds, unless otherwise indicated on the Drawings.


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G. Manufacturers and Products:

1. Schneider Electric/Square D Co.; Type XO.
2. Eaton/Cutler-Hammer; Type D26MR.
3. ABB/General Electric Co.; Type CR120.

2.09 RESET TIMER

A. Drive: Synchronous motor, solenoid-operated clutch.

B. Mounting: Semiflush panel.

C. Contacts: 10 amps, 120 volts.

D. Manufacturers and Products:

1. Eagle Signal Controls; Bulletin 125.
2. Automatic Timing and Controls; Bulletin 305.

2.10 ELAPSED TIME METER

A. Drive: Synchronous motor.

B. Range: 0-hour to 99,999.9 hours, nonreset type.

C. Mounting: Semiflush panel.

D. Manufacturers and Products:

1. General Electric Co.; Type 240, 2-1/2-inch Big Look.
2. Eagle Signal Controls; Bulletin 705.

2.11 PHASE MONITOR RELAY

A. Features:

1. Voltage and phase monitor relay shall drop out on low voltage, voltage unbalance, loss of phase, or phase reversal.
2. Contacts: Single-pole, double-throw, 10 amperes, 120/240V ac. Where additional contacts are shown or required, provide magnetic control relays.
3. Adjustable trip and time delay settings.
4. Transient Protection: 1,000V ac.
5. Mounting: Multipin plug-in socket base.

B. Manufacturer and Product: Automatic Timing and Controls; SLD Series.


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## 2.12 MAGNETIC LIGHTING CONTACTOR

A. Comply with NEMA ICS 2; provide UL 508 listing.

B. Electrically operated by dual-acting, single coil mechanism.

C. Inherently interlocked and mechanically held in both OPEN and CLOSED position.

D. Main Contacts:

1. Double-break, continuous-duty, rated 20 amperes, unless otherwise shown, 600 volts, withstand rating of 22,000 amps rms symmetrical at 250 volts; 65,000 amps rms symmetrical at 480 volts.
2. Marked for electric discharge lamps, tungsten, and general purpose loads.
3. Position not dependent on gravity, hooks, latches, or semipermanent magnets.
4. Capable of operating in any position.
5. Visual indication for each contact.

E. Auxiliary contact relay for two-wire control.

F. Provision for remote pilot lamp with use of auxiliary contacts.

G. Clamp type, self-rising terminal plates for solderless connections.

H. Enclosures: See Article Enclosures.

I. Manufacturers and Products:

1. ASCO.
2. Eaton/Cutler-Hammer; Class A202.
3. Square D; Class 8903, Type LL (mechanically held).

## 2.13 SUPPORT AND FRAMING CHANNELS

A. Carbon Steel Framing Channel:

1. Material: Rolled, mild strip steel, 12-gauge minimum, ASTM A1011/A1011M, Grade 33.
2. Finish: Hot-dip galvanized after fabrication.

B. Paint Coated Framing Channel: Carbon steel framing channel with electro-deposited rust inhibiting acrylic or epoxy paint.


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C. PVC-Coated Framing Channel: Carbon steel framing channel with 40-mil polyvinyl chloride coating.

D. Stainless Steel Framing Channel: Rolled, Type 316 stainless steel, 12-gauge minimum.

E. Extruded Aluminum Framing Channel:

1. Material: Extruded from Type 6063-T6 aluminum alloy.
2. Fittings fabricated from Alloy 5052-H32.

F. Nonmetallic Framing Channel:

1. Material: Fire retardant, fiber reinforced vinyl ester resin.
2. Channel fitting of same material as channel.
3. Nuts and bolts of long glass fiber reinforced polyurethane.

G. Manufacturers:

1. B-Line Systems, Inc.
2. Unistrut Corp.
3. Aickinstrut.

## 2.14 INTRINSIC SAFETY BARRIER

A. Provides a safe energy level for exposed wiring in a Class I, Division 1 or Division 2 hazardous area when circuit is connected to power source in nonhazardous area.

B. Rating: Power source shall be rated 24V dc, nominal, with not more than 250 volts available under fault conditions.

C. Contact Rating: 5 amps, 250V ac.

D. Mounting: Rail or surface.

E. Manufacturers and Products:

1. MTL, Inc.; Series 2000 or Series 3000.
2. R. Stahl, Inc.

## 2.15 SWITCHBOARD MATTING

A. Provide matting having a breakdown of 20 kV minimum.

B. Manufacturer: U.S. Mat and Rubber Company.


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## 2.16 FIRESTOPS

A. General:

1. Provide UL 1479 classified hourly fire rating equal to, or greater than, the assembly penetrated.
2. Prevent the passage of cold smoke, toxic fumes, and water before and after exposure to flame.
3. Sealants and accessories shall have fire-resistance ratings as established by testing identical assemblies in accordance with ASTM E814, by UL, or other testing and inspection agency acceptable to authorities having jurisdiction.

## 2.17 ENCLOSURES

A. Finish: Sheet metal structural and enclosure parts shall be completely painted using an electrodeposition process so interior and exterior surfaces as well as bolted structural joints have a complete finish coat on and between them.

B. Color: Manufacturer's standard color (gray) baked-on enamel, unless otherwise shown.

C. Barriers: Provide metal barriers within enclosures to separate wiring of different systems and voltage.

D. Enclosure Selections:

1. Except as shown otherwise, provide electrical enclosures according to the following table:

| **Enclosures** | | | |
|---|---|---|---|
| **Location** | **Finish** | **Environment** | **NEMA 250 Type** |
| Indoor | Finished | Dry | 1 |
| Indoor | Unfinished | Dry | 1 |
| Indoor and Outdoor | Any | Wet and Corrosive | 4X 316 Stainless Steel |
| Indoor and Outdoor | Any | Hazardous Gas | 7 |
| Indoor and Outdoor | Any | Hazardous Dust | 9 |



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## PART 3 EXECUTION

3.01 GENERAL

A. Install equipment in accordance with manufacturer's recommendations.

3.02 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Install heavy-duty, oil-tight type in nonhazardous, indoor, dry locations, including motor control centers, control panels, and individual stations, unless otherwise shown.

B. Install heavy-duty, watertight and corrosion-resistant type in nonhazardous, outdoor, or normally wet areas, unless otherwise shown.

3.03 SUPPORT AND FRAMING CHANNEL

A. Install where required for mounting and supporting electrical equipment, raceway, and cable tray systems.

B. Channel Type:

1. Interior, Wet or Dry (Noncorrosive) Locations:
   a. Aluminum Raceway: Extruded aluminum or carbon steel with neoprene material isolators.
   b. PVC-Coated Conduit: PVC coated.
   c. Steel Raceway and Other Systems Not Covered: Carbon steel or paint coated.
2. Interior, Corrosive (Wet or Dry) Locations:
   a. Aluminum Raceway: Extruded aluminum.
   b. PVC Conduit: Type 316 stainless steel or nonmetallic.
   c. PVC-Coated Steel Conduit and Other Systems Not Covered: Type 316 stainless steel, nonmetallic, or PVC-coated steel.
3. Outdoor, Noncorrosive Locations:
   a. Steel Raceway: Carbon steel or paint coated framing channel, except where mounted on aluminum handrail, then use aluminum framing channel.
   b. Aluminum Raceway and Other Systems Not Covered: Aluminum framing channel or carbon steel with neoprene material isolators.
4. Outdoor Corrosive Locations:
   a. PVC Conduit: Type 316 stainless steel or nonmetallic.
   b. Aluminum Raceway: Aluminum or carbon steel with neoprene material isolators.
   c. PVC-Coated Steel Conduit and Other Systems Not Covered: Type 316 stainless steel, nonmetallic, or PVC-coated steel.


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5. Aluminum Railings: Devices mounted on aluminum railing shall use aluminum framing channel.

C. Paint cut ends prior to installation with the following:

1. Carbon Steel Channel: Zinc-rich primer.
2. Painted Channel: Rust-inhibiting epoxy or acrylic paint.
3. Nonmetallic Channel: Epoxy resin sealer.
4. PVC-Coated Channel: PVC patch.

3.04 INTRINSIC SAFETY BARRIERS

A. Install in compliance with ISA RP12.06.01.

B. Arrange conductors such that wiring from hazardous areas cannot short to wiring from nonhazardous area.

C. Stencil “INTRINSICALLY SAFE CIRCUIT” on all boxes enclosing barriers.

3.05 SWITCHBOARD MATTING

A. Install 36-inch width at switchgear, switchboard, motor control centers, and panelboards.

B. Matting shall run full length of all sides of equipment that have operator controls or afford access to devices.

3.06 FIRESTOPS

A. Install in strict conformance with manufacturer’s instructions. Comply with installation requirements established by testing and inspecting agency.

B. Sealant: Install sealant including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide firestops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs.

**END OF SECTION**



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# SECTION 26 05 05
# CONDUCTORS

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. Association of Edison Illuminating Companies (AEIC): CS 8, Specification for Extruded Dielectric Shielded Power Cables Rated 5 kV through 46 kV.
2. ASTM International (ASTM):
   a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   b. B3, Standard Specification for Soft or Annealed Copper Wire.
   c. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   d. B496, Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors.
3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV Through 500 kV.
   b. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
   c. 404, Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500000 V.
4. Insulated Cable Engineer's Association, Inc. (ICEA):
   a. S-58-679, Standard for Control Cable Conductor Identification.
   b. S-73-532, Standard for Control Thermocouple Extensions and Instrumentation Cables.
   c. T-29-520, Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input of 210,000 Btu/hour.
5. National Electrical Manufacturers' Association (NEMA):
   a. CC 1, Electric Power Connectors for Substations.
   b. WC 57, Standard for Control, Thermocouple Extension, and Instrumentation Cables.
   c. WC 70, Standard for Power Cables Rated 2,000 Volts or Less for the Distribution of Electrical Energy.
   d. WC 71, Standard for Nonshielded Cables Rated from 2,001 Volts to 5,000 Volts for Use in the Distribution of Electric Energy.


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e. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.

6. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
7. Telecommunications Industry Association (TIA): TIA-568-C, Commercial Building Telecommunications Cabling Standard.
8. UL:
   a. 13, Standard for Safety for Power-Limited Circuit Cables.
   b. 44, Standard for Safety for Thermoset-Insulated Wires and Cables.
   c. 62, Standard for Safety for Flexible Cord and Cables.
   d. 486A-486B, Standard for Safety for Wire Connectors.
   e. 486C, Standard for Safety for Splicing Wire Connectors.
   f. 510, Standard for Safety for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
   g. 854, Standard for Safety for Service-Entrance Cables.
   h. 1072, Standard for Safety for Medium-Voltage Power Cables.
   i. 1277, Standard for Safety for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
   j. 1569, Standard for Safety for Metal-Clad Cables.
   k. 1581, Standard for Safety for Reference Standard for Electrical Wires, Cables, and Flexible Cords.

## 1.02 SUBMITTALS

A. Action Submittals:

1. Product Data:
   a. Wire and cable.
   b. Wire and cable accessories.
   c. Cable fault detection system.
2. Cable Pulling Calculations:
   a. Ensure submitted and reviewed before cable installation.
   b. Provide for the following cable installations:
      1) Medium voltage cable runs that cannot be hand pulled.
      2) Multiconductor 600-volt cable sizes larger than 2 AWG that cannot be hand pulled.
      3) Feeder circuits; single conductors #4/0 and larger.

B. Informational Submittals:

1. Journeyman lineman or electrician splicing credentials.
2. Factory Test Report for conductors 600 volts and below.


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3. Factory Test Report per AEIC CS 8, including AEIC qualification report for conductors above 600 volts.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

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

B. Terminations and Splices for Conductors above 600 Volts: Work shall be done by journeyman lineman with splicing credentials or electrician certified to use materials approved for cable splices and terminations.

**PART 2 PRODUCTS**

2.01 CONDUCTORS 600 VOLTS AND BELOW

A. Conform to applicable requirements of NEMA WC 70.

B. Conductor Type:

1. All Circuits: Stranded copper.

C. Insulation: Type XHHW-2.

D. Direct Burial and Aerial Conductors and Cables:

1. Type USE/RHH/RHW insulation, UL 854 listed, or Type RHW-2/USE-2.
2. Conform to physical and minimum thickness requirements of NEMA WC 70.

E. Flexible Cords and Cables:

1. Type SOW-A/50 with ethylene propylene rubber insulation in accordance with UL 62.
2. Conform to physical and minimum thickness requirements of NEMA WC 70.


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## 2.02 CONDUCTORS ABOVE 600 VOLTS

A. EPR Insulated Cable:

1. Extrusion: Single-pass, triple-tandem, of conductor screen, insulation, and insulation screen.
2. Type: 15 kV, shielded, UL 1072, Type MV-105.
3. Conductors: Aluminum, concentric lay Class B round stranded in accordance with ASTM B3, ASTM B8, and ASTM B496.
4. Strand Fill: Waterproof strand compound enclosing conductors.
5. Conductor Screen: Extruded, semiconducting ethylene-propylene rubber in accordance with NEMA WC 71 and AEIC CS 8.
6. Insulation: 133 percent insulation level, ethylene-propylene rubber (EPR) containing no polyethylene, in accordance with NEMA WC 71, and AEIC CS 8.
7. Insulation Thickness: 220-mil, 15 kV, nominal.
8. Insulation Screen: Thermosetting, semiconducting ethylene-propylene rubber (EPR), extruded directly over insulation in accordance with NEMA WC 74 and AEIC CS 8.
9. Metallic Shield: Uncoated, 5-mil, copper shielding tape, helically applied with 17-1/2 percent minimum overlap.
10. Jacket: Extruded chlorinated polyethylene (CPE) compound applied in accordance with NEMA WC 71 or NEMA WC 74.
11. Operating Temperature: 105 degrees C continuous normal operations, 130 degrees C emergency operating conditions, and 250 degrees C short-circuit conditions.
12. Manufacturers:
    a. Okonite Co.
    b. General Cable.
    c. Southwire Co.

## 2.03 600-VOLT RATED CABLE

A. General:

1. Type TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 70,000 Btu per hour, and NFPA 70, Article 340, or UL 13 meeting requirements of NFPA 70, Article 725.
2. Permanently and legibly marked with manufacturer’s name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
3. Suitable for installation in open air, in cable trays, or conduit.
4. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
5. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.


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B. Type 1, Multiconductor Control Cable:

1. Conductors:
   a. 14 AWG, seven-strand copper.
   b. Insulation: 15-mil PVC with 4-mil nylon.
   c. UL 1581 listed as Type THHN/THWN rated VW-1.
   d. Conductor group bound with spiral wrap of barrier tape.
   e. Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.
2. Cable: Passes the ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
3. Cable Sizes:

| No. of Conductors | Max. Outside Diameter (Inches) | Jacket Thickness (Mils) |
|---|---|---|
| 3 | 0.41 | 45 |
| 5 | 0.48 | 45 |
| 7 | 0.52 | 45 |
| 12 | 0.72 | 60 |
| 19 | 0.83 | 60 |
| 25 | 1.00 | 60 |
| 37 | 1.15 | 80 |

4. Manufacturers:
   a. Okonite Co.
   b. Southwire.

C. Type 2, Multiconductor Power Cable:

1. General:
   a. Meet or exceed UL 1581 for cable tray use.
   b. Meet or exceed UL 1277 for direct burial and sunlight-resistance.
   c. Overall Jacket: PVC.
2. Conductors:
   a. Class B stranded, coated copper.
   b. Insulation: Chemically cross-linked ethylene-propylene or cross-linked polyethylene.
   c. UL rated VW-1 or listed Type XHHW-2.
   d. Color Code:
      1) Conductors, size 8 AWG and smaller, colored conductors, ICEA S-58-679, Method 1, Table 1.
      2) Conductors, size 6 AWG and larger, ICEA S-73-532, Method 4.


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3. Cable shall pass ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
4. Cable Sizes:

| Conductor Size | Minimum Ground Wire Size | No. of Current Carrying Conductors | Max. Outside Diameter (Inches) | Nominal Jacket Thickness (Mils) |
|---|---|---|---|---|
| 12 | 12 | 2<br>3<br>4 | 0.42<br>0.45<br>0.49 | 45 |
| 10 | 10 | 2<br>3<br>4 | 0.54<br>0.58<br>0.63 | 60 |
| 8 | 10 | 3<br>4 | 0.66<br>0.75 | 60 |
| 6 | 8 | 3<br>4 | 0.74<br>0.88 | 60 |
| 4 | 6 | 3<br>4 | 0.88<br>1.04 | 60<br>80 |
| 2 | 6 | 3<br>4 | 1.01<br>1.16 | 80 |
| 1 | 6 | 3<br>4 | 1.10<br>1.25 | 80 |
| 1/0 | 6 | 3<br>4 | 1.22<br>1.35 | 80 |
| 2/0 | 4 | 3<br>4 | 1.32<br>1.53 | 80 |
| 3/0 | 4 | 3<br>4 | 1.40<br>1.60 | 80 |
| 4/0 | 4 | 3<br>4 | 1.56<br>1.78 | 80<br>110 |

5. Manufacturers:
   a. Okonite Co.
   b. Southwire.


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D. Type 3, 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal thickness.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
3. Dimension: 0.31-inch nominal OD.
4. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
    b. 20 AWG, seven-strand tinned copper drain wire.
    c. Insulation: 15-mil nominal PVC.
    d. Jacket: 4-mil nominal nylon.
    e. Color Code: Pair conductors, black and red.
5. Manufacturers:
    a. Okonite Co.
    b. Alpha Wire Corp.
    c. Belden.

E. Type 4, 16 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
3. Dimension: 0.32-inch nominal OD.
4. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
    b. 20 AWG, seven-strand, tinned copper drain wire.
    c. Insulation: 15-mil nominal PVC.
    d. Jacket: 4-mil nylon.
    e. Color Code: Triad conductors black, red, and blue.
5. Manufacturers:
    a. Okonite Co.
    b. Alpha Wire Corp.
    c. Belden.


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F. Type 5, 18 AWG, Multitwisted Shielded Pairs, with a Common Overall Shield, Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable, meeting NEMA WC 57 requirements.

1. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
   b. Tinned copper drain wires.
   c. Pair drain wire size AWG 20, group drain wire size AWG 18.
   d. Insulation: 15-mil PVC.
   e. Jacket: 4-mil nylon.
   f. Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.
   g. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer.
2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.
3. Cable Sizes:

| Number of Pairs | Maximum Outside Diameter (Inches) | Nominal Jacket Thickness (Mils) |
|---|---|---|
| 4 | 0.50 | 45 |
| 8 | 0.68 | 60 |
| 12 | 0.82 | 60 |
| 16 | 0.95 | 80 |
| 24 | 1.16 | 80 |
| 36 | 1.33 | 80 |
| 50 | 1.56 | 80 |

4. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Belden.

G. Type 6, 18 AWG, Multitwisted Pairs with Common Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable meeting NEMA WC 57.

1. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
   b. Tinned copper drain wire size AWG 18.


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c. Insulation: 15-mil nominal PVC.
d. Jacket: 4-mil nylon.
e. Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.

2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.

| Cable Sizes: Number of Pairs | Maximum Outside Diameter (Inches) | Nominal Jacket Thickness (Mils) |
|---|---|---|
| 4 | 0.48 | 45 |
| 8 | 0.63 | 60 |
| 12 | 0.75 | 60 |
| 16 | 0.83 | 60 |
| 24 | 1.10 | 80 |
| 36 | 1.21 | 80 |
| 50 | 1.50 | 80 |

3. Manufacturers:
a. Okonite Co.
b. Alpha Wire Corp.
c. Belden.

H. Type 7, Multiconductor Metal-Clad (UL Type MC) Power Cable:

1. Meeting requirements of UL 44 and UL 1569.
2. Conductors:
a. Class B stranded, coated copper.
b. Insulation: 600-volt cross-linked polyethylene, UL Type XHHW or EPR.
c. Grounding Conductors: Bare, stranded copper.
3. Sheath:
a. UL listed Type MC.
b. Continuous welded, corrugated aluminum sheath.
c. Suitable for use as grounding conductor.
4. Outer Jacket: PVC per UL 1569.
5. Cable shall pass ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.


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6. Cable Sizes:

| Conductor Size | Minimum Ground Wire Size (AWG) | No. of Insulated Conductors | Max. Outside Diameter (Inches) | Jacket Thickness (Mils) |
|---|---|---|---|---|
| 12 AWG | 12 or 3x16 | 3<br>4 | 0.79<br>0.85 | 50 |
| 10 AWG | 10 or 3x14 | 3<br>4 | 0.82<br>0.90 | 50 |
| 8 AWG | 10 or 3x14 | 3<br>4 | 0.85<br>1.00 | 50 |
| 6 AWG | 8 or 3x12 | 3<br>4 | 0.99<br>1.10 | 50 |
| 4 AWG | 8 or 3x12 | 3<br>4 | 1.08<br>1.20 | 50 |
| 2 AWG | 6 or 3x10 | 3<br>4 | 1.24<br>1.45 | 50 |
| 1 AWG | 6 or 3x10 | 3<br>4 | 1.40<br>1.55 | 50 |
| 1/0 KCM | 6 or 3x10 | 3<br>4 | 1.52<br>1.60 | 50 |
| 2/0 AWG | 4 or 3x8 | 3<br>4 | 1.67<br>1.75 | 50 |
| 4/0 AWG | 4 or 3x8 | 3<br>4 | 1.93<br>2.10 | 60 |
| 250 KCM | 4 or 3x8 | 3<br>4 | 2.11<br>2.20 | 60 |
| 350 KCM | 3 or 3x8 | 3<br>4 | 2.39<br>2.50 | 60 |
| 500 KCM | 2 or 3x8 | 3<br>4 | 2.80<br>2.90 | 75 |

7. Manufacturers and Products:
   a. Okonite Co.; Type CLX.
   b. Southwire Type MC.
   c. General Cable, CCW Armored Power.


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I. Type 8, Multiconductor Adjustable Frequency Drive Power Cable:

1. Conductors:
   a. Class B, stranded coated copper.
   b. Insulation: 600-volt cross-linked polyethylene, UL Type XHHW-2.
   c. Grounding Conductors: Insulated stranded copper.
2. Sheath:
   a. UL 1277 Type TC, 90 degrees C.
   b. Continuous shield, A1/polyester foil, drain wires, overall copper braid.
3. Outer Jacket: Polyvinyl chloride (PVC) per UL 1569.
4. Cable Sizes:

| Conductor Size | Minimum Ground Wire Size (AWG) | No. of Insulated Conductors | Max. Outside Diameter (Inches) | Minimum Jacket Thickness (Mils) |
|---|---|---|---|---|
| 12 AWG | 12 | 4 | 0.655 | 50 |
| 10 AWG | 10 | 4 | 0.769 | 50 |
| 8 AWG | 8 | 4 | 0.940 | 50 |
| 6 AWG | 6 | 4 | 1.038 | 50 |
| 4 AWG | 4 | 4 | 1.180 | 50 |
| 2 AWG | 2 | 4 | 1.351 | 50 |

5. Manufacturers and Products:
   a. Alpha Wire; Series V.
   b. Belden; Series 29500.
   c. LAPP USA; OLFLEX VFD Slim.

J. Type 9, Multiconductor Metal-Clad (UL Type MC) Power Cable for Adjustable Frequency Drive Applications:

1. Meeting requirements of UL 44 and UL 1569.
2. Conductors:
   a. Class B, stranded coated copper.
   b. Insulation: 600-volt cross-linked polyethylene, UL Type XHHW or EPR.
   c. Grounding Conductors: Bare, stranded copper. Provide three symmetrical grounding conductors.
3. Sheath:
   a. UL listed Type MC.
   b. Continuous welded, corrugated aluminum sheath.
   c. Suitable for use as grounding conductor.


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4. Outer Jacket: PVC per UL 1569.
5. Cable shall pass ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
6. Cable Sizes:

| Conductor Size | Minimum Ground Wire Size (AWG) | No. of Insulated Conductors | Max. Outside Diameter (Inches) | Jacket Thickness (Mils) |
|---|---|---|---|---|
| 12 AWG | 3x16 | 3<br>4 | 0.79<br>0.85 | 50 |
| 10 AWG | 3x14 | 3<br>4 | 0.82<br>0.90 | 50 |
| 8 AWG | 3x14 | 3<br>4 | 0.85<br>1.00 | 50 |
| 6 AWG | 3x12 | 3<br>4 | 0.99<br>1.10 | 50 |
| 4 AWG | 3x12 | 3<br>4 | 1.08<br>1.20 | 50 |
| 2 AWG | 3x10 | 3<br>4 | 1.24<br>1.45 | 50 |
| 1 AWG | 3x10 | 3<br>4 | 1.40<br>1.55 | 50 |
| 1/0 KCM | 3x10 | 3<br>4 | 1.52<br>1.60 | 50 |
| 2/0 AWG | 3x8 | 3<br>4 | 1.67<br>1.75 | 50 |
| 4/0 AWG | 3x8 | 3<br>4 | 1.93<br>2.10 | 60 |
| 250 KCM | 3x8 | 3<br>4 | 2.11<br>2.20 | 60 |
| 350 KCM | 3x8 | 3<br>4 | 2.39<br>2.50 | 60 |
| 500 KCM | 3x8 | 3<br>4 | 2.80<br>2.90 | 75 |

7. Manufacturer and Product: Okonite Co.; Type CLX MC-HL.


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2.04 SPECIAL CABLES

A. Type 30, Unshielded Twisted Pair (UTP) Telephone and Data Cable, 300V:

1. Category 6 UTP, UL listed, and third party verified to comply with TIA/EIA 568-C Category 6 requirements.
2. Suitable for high speed network applications including gigabit ethernet and video. Cable shall be interoperable with other standards compliant products and shall be backward compatible with Category 5 and Category 5e.
3. Provide four each individually twisted pair, 23 AWG conductors, with FEP insulation and blue PVC jacket.
4. NFPA 70 Plenum (CMP) rated; comply with flammability plenum requirements of NFPA 70 and NFPA 262.
5. Cable shall withstand a bend radius of 1-inch minimum at a temperature of minus 20 degrees C maximum without jacket or insulation cracking.
6. Manufacturer and Product: Belden; 7852A.

2.05 GROUNDING CONDUCTORS

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

B. Direct Buried: Bare stranded copper.

2.06 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

A. Tape:

1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33+, rated for 90 degrees C minimum, meeting requirements of UL 510.
2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.
3. Arc and Fireproofing:
   a. 30-mil, elastomer.
   b. Manufacturers and Products:
      1) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.
      2) Plymouth; 53 Plyarc, with 77 Plyglas glass cloth tapebinder.

B. Identification Devices:

1. Sleeve:
   a. Permanent, PVC, yellow or white, with legible machine-printed black markings.


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b. Manufacturers and Products:
   1) Raychem; Type D-SCE or Type ZH-SCE.
   2) Brady, Type 3PS.

2. Heat Bond Marker:
   a. Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive.
   b. Self-laminating protective shield over text.
   c. Machine printed black text.
   d. Manufacturer and Product: 3M Co.; Type SCS-HB.
3. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.
4. Tie-On Cable Marker Tags:
   a. Chemical-resistant white tag.
   b. Size: 1/2-inch by 2 inches.
   c. Manufacturer and Product: Raychem; Type CM-SCE.
5. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum.

C. Connectors and Terminations:

1. Nylon, Self-Insulated Crimp Connectors:
   a. Manufacturers and Products:
      1) Thomas & Betts; Sta-Kon.
      2) Burndy; Insulug.
      3) ILSCO.
2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
   a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
   b. Seamless.
   c. Manufacturers and Products:
      1) Thomas & Betts; Sta-Kon.
      2) Burndy; Insulink.
      3) ILSCO; ILSCONS.
3. Self-Insulated, Freespring Wire Connector (Wire Nuts):
   a. UL 486C.
   b. Plated steel, square wire springs.
   c. Manufacturers and Products:
      1) Thomas & Betts.
      2) Ideal; Twister.
4. Self-Insulated, Set Screw Wire Connector:
   a. Two piece compression type with set screw in brass barrel.
   b. Insulated by insulator cap screwed over brass barrel.


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c. Manufacturers:
   1) 3M Co.
   2) Thomas & Betts.
   3) Marrette.

D. Cable Lugs:

1. In accordance with NEMA CC 1.
2. Rated 600 volts of same material as conductor metal.
3. Uninsulated Crimp Connectors and Terminators:
   a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
   b. Manufacturers and Products:
      1) Thomas & Betts; Color-Keyed.
      2) Burndy; Hydent.
      3) ILSCO.
4. Uninsulated, Bolted, Two-Way Connectors and Terminators:
   a. Manufacturers and Products:
      1) Thomas & Betts; Locktite.
      2) Burndy; Quiklug.
      3) ILSCO.

E. Cable Ties:

1. Nylon, adjustable, self-locking, and reusable.
2. Manufacturer and Product: Thomas & Betts; TY-RAP.

F. Heat Shrinkable Insulation:

1. Thermally stabilized cross-linked polyolefin.
2. Single wall for insulation and strain relief.
3. Dual Wall, adhesive sealant lined, for sealing and corrosion resistance.
4. Manufacturers and Products:
   a. Thomas & Betts; SHRINK-KON.
   b. Raychem; RNF-100 and ES-2000.

## 2.07 ACCESSORIES FOR CONDUCTORS ABOVE 600 VOLTS

A. Molded Splice Kits:

1. Components necessary to provide insulation, metallic shielding and grounding systems, and overall jacket.
2. Capable of making splices with a current rating equal to, or greater than cable ampacity, conforming to IEEE 404.


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3. Class 15 kV, with compression connector, EPDM molded semiconductive insert, peroxide-cured EPDM insulation, and EPDM molded semiconductive outer shield.
4. Premolded splice shall be rejacketed with a heat shrinkable adhesive-lined sleeve to provide a waterproof seal.
5. Manufacturers:
   a. Elastimold.
   b. Cooper Industries.

B. Heat Shrinkable Splice Kits:

1. Components necessary to provide insulation, metallic shielding and grounding systems, and overall jacket.
2. Capable of making splices with a current rating equal to, or greater than, cable ampacity, conforming to IEEE 404.
3. Class 15 kV, with compression connector, splice insulating and conducting sleeves, stress-relief materials, shielding braid and mesh, and abrasion-resistant heat shrinkable adhesive-lined rejacketing sleeve to provide a waterproof seal.
4. Manufacturers:
   a. Raychem.
   b. 3M Co.

C. Termination Kits:

1. Capable of terminating 15 kV, single-conductor, polymeric-insulated shielded cables plus a shield ground clamp.
2. Capable of producing a termination with a current rating equal to, or greater than, cable ampacity meeting Class 1 requirements of IEEE 48.
3. Capable of accommodating cable shielding or construction without need for special adapters or accessories.
4. Manufacturers:
   a. Raychem.
   b. 3M Co.

D. Bus Connection Insulation:

1. Heat shrinkable tubing, tape, and sheets of flexible cross-linked polymeric material formulated for high dielectric strength.
2. Tape and sheet products to have coating to prevent adhesion to metal surfaces.
3. Insulating materials to be removable and reusable.
4. Manufacturer: Raychem.


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E. Elbow Connector Systems:

1. Molded, peroxide-cured, EPDM-insulated, Class 15 kV, 95 kV BIL, 200A, 10,000A rms load-break elbows as shown, having copper current-carrying parts in accordance with IEEE 386.
2. Protective Caps: Class 15 kV, 95 kV BIL, 200 amperes, with molded EPDM insulated body.
3. Insulated Standoff Bushings: Class 15 kV, 95 kV BIL, 200 amperes, complete with EPDM rubber body, stainless steel eyebolt with brass pressure foot, and stainless steel base bracket.
4. Bushing Inserts: Class 15 kV, 95 kV BIL, 200A, nonload-break with EPDM rubber body and all-copper, current-carrying parts.
5. Manufacturers:
   a. Cooper Industries.
   b. Elastimold.

F. Cable Lugs:

1. In accordance with NEMA CC1.
2. Rated 15 kV of same material as conductor metal.
3. Manufacturers and Products, Uninsulated Compression Connectors and Terminators:
   a. Burndy; Hydent.
   b. Thomas & Betts; Color-Keyed.
   c. ILSCO.
4. Manufacturers and Products, Uninsulated, Bolted, Two-Way Connectors and Terminators:
   a. Thomas & Betts; Locktite.
   b. ILSCO.

## 2.08 PULLING COMPOUND

A. Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant; UL listed.

B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.

C. Approved for intended use by cable manufacturer.

D. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.


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E. Manufacturers:

1. Ideal Co.
2. Polywater, Inc.
3. Cable Grip Co.

2.09 WARNING TAPE

A. As specified in Section 26 05 33, Raceway and Boxes.

2.10 SOURCE QUALITY CONTROL

A. Conductors 600 Volts and Below: Test in accordance with UL 44 and UL 854.

B. Conductors Above 600 Volts: Test in accordance with NEMA WC 71 and AEIC CS 8 partial discharge level test for EPR insulated cable.

**PART 3 EXECUTION**

3.01 GENERAL

A. Conductor installation shall be in accordance with manufacturer's recommendations.

B. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.

C. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii.

D. Terminate conductors and cables, unless otherwise indicated.

E. Tighten screws and terminal bolts in accordance with UL 486A-486B for copper conductors.

F. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.

G. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 12 inches on center.



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H. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.

I. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrel approximately 1/4-inch smaller than raceway inside diameter.

3.02 POWER CONDUCTOR COLOR CODING

A. Conductors 600 Volts and Below:

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

| System | Conductor | Color |
|---|---|---|
| All Systems | Equipment Grounding | Green |
| 240/120 Volts, Single-Phase, Three-Wire | Grounded Neutral<br>One Hot Leg<br>Other Hot Leg | White<br>Black<br>Red |
| 208Y/120 Volts, Three-Phase, Four-Wire | Grounded Neutral<br>Phase A<br>Phase B<br>Phase C | White<br>Black<br>Red<br>Blue |
| 240/120 Volts, Three-Phase, Four-Wire, Delta, Center Tap, Ground on Single-Phase | Grounded Neutral<br>Phase A<br>High (wild) Leg<br>Phase C | White<br>Black<br>Orange<br>Blue |
| 480Y/277 Volts, Three-Phase, Four-Wire | Grounded Neutral<br>Phase A<br>Phase B<br>Phase C | White<br>Brown<br>Orange<br>Yellow |
| Note: Phase A, B, C implies direction of positive phase rotation. | | |

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


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B. Conductors Above 600 Volts:

1. Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering area 1-1/2 inches to 2 inches wide.
2. Colors:
   a. Grounded Neutral: White.
   b. Phase A: Brown.
   c. Phase B: Orange.
   d. Phase C: Yellow.

## 3.03 CIRCUIT IDENTIFICATION

A. Identify power, instrumentation, and control conductor circuits at each termination, and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.

B. Circuits:

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

C. Method:

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

## 3.04 CONDUCTORS 600 VOLTS AND BELOW

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

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


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C. Connections and Terminations:

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

D. Do not use soldered mechanical joints.

E. Splices and Terminations:

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

F. Cap spare conductors with UL listed end caps.

G. Cabinets, Panels, and Motor Control Centers:

1. Remove surplus wire, bridle and secure.
2. Where conductors pass through openings or over edges in sheet metal, remove burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.


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H. Control and Instrumentation Wiring:

1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer's instructions.
3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.
4. Where connections of cables installed under this section are to be made under Section 40 90 00, Instrumentation and Control for Process Systems, leave pigtails of adequate length for bundled connections.
5. Cable Protection:
    a. Under Infinite Access Floors: May install without bundling.
    b. All Other Areas: Install individual wires, pairs, or triads in flex conduit under floor or grouped into bundles at least 1/2-inch in diameter.
    c. Maintain integrity of shielding of instrumentation cables.
    d. Ensure grounds do not occur because of damage to jacket over shield.

I. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

## 3.05 CONDUCTORS ABOVE 600 VOLTS

A. Do not splice unless specifically indicated or approved by Engineer.

B. Make joints and terminations with splice and termination kits, in accordance with kit manufacturer's instructions.

C. Install splices or terminations as continuous operation in accessible locations under clean, dry conditions.

D. Single Conductor Cable Terminations: Provide heat shrinkable stress control and outer nontracking insulation tubings, high relative permittivity stress relief mastic for insulation shield cutback treatment, and a heat-activated sealant for environmental sealing, plus a ground braid and clamp.

E. Install terminals or connectors acceptable for type of conductor material used.

F. Provide outdoor rain skirts for outdoor switchgear terminations.

G. Provide shield termination and grounding for terminations.



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H. Provide necessary mounting hardware, covers, and connectors.

I. Where elbow connectors are specified, install in accordance with manufacturer's instructions.

J. Connections and Terminations:

1. Install uninsulated crimp connectors and terminators for power circuit conductors 4 AWG and larger.
2. Install uninsulated, bolted, two-way connectors for motor circuit conductors No. 12 and larger.
3. Insulate bus connections with heat shrinking tubing, tape, and sheets.

K. Where aluminum conductors are used, apply oxide-inhibiting compound at joints and terminations. Use compounds compatible with cable insulation and with components used for splicing and terminating.

L. Give 2 working days notice to Engineer prior to making splices or terminations.

## 3.06 CONDUCTOR ARC AND FIREPROOFING

A. Install arc and fireproofing tape on 600-volt single conductors and cables, except those rated Type TC throughout entire exposed length in manholes, handholes, vaults, cable trays, and other indicated locations.

B. Install arc and fireproofing tape on 15 kV cables throughout entire exposed length in manholes, handholes, vaults, cable trays, and other indicated locations.

C. Wrap conductors of same circuit entering from separate conduit together as single cable.

D. Follow tape manufacturer's installation instructions.

E. Secure tape at intervals of 5 feet with bands of tapebinder. Each band to consist of a minimum of two wraps directly over each other.

## 3.07 UNDERGROUND DIRECT BURIAL CABLE

A. Install in trench as specified in Section 31 23 23.15, Trench Backfill.

B. Warning Tape: Install approximately 6 inches above cable, aligned parallel to, and within 12 inches of centerline of the run.

**END OF SECTION**


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# SECTION 26 05 26
# GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. Institute of Electrical and Electronics Engineers (IEEE): C2, National Electrical Safety Code (NESC).
2. National Fire Protection Association (NFPA): 70, National Electrical Code. (NEC).
3. UL.

### 1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product data for the following:
      1) Ground rod.
      2) Grounding wells.
      3) Exothermic weld connectors.
      4) Mechanical connectors.
      5) Compression connectors.
      6) Specialty tools.

### 1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, provide material and equipment labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ to provide a basis for approval under NEC.
2. Materials and equipment manufactured within scope of standards published by UL:
   a. Confirm conformance with UL standards.
   b. Supply with an applied UL listing mark.


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## PART 2 PRODUCTS

2.01 GROUND ROD

A. Material: Copper.

B. Diameter: Minimum 3/4-inch.

C. Length: 12 feet.

2.02 GROUND CONDUCTORS

A. As specified in Section 26 05 05, Conductors.

2.03 CONNECTORS

A. Exothermic Weld Type:

1. Outdoor Weld: Suitable for exposure to elements or direct burial.
2. Indoor Weld: Use low-smoke, low-emission process.
3. Manufacturers and Product:
    a. NVent ERICO Products, Inc.; Cadweld and Cadweld Exolon.
    b. ThermOweld.

B. Compression Type:

1. Compress-deforming irreversible type; wrought copper extrusion material.
2. Single indentation for conductors 6 AWG and smaller.
3. Double indentation with extended barrel for conductors 4 AWG and larger.
4. Barrels prefilled with oxide-inhibiting and anti-seizing compound and sealed.
5. Manufacturers and Products:
    a. Burndy Corp.; Hyground Compression.
    b. Thomas and Betts Co.; EZGround Compression.
    c. NVent ILSCO.

C. Mechanical Type: Split-bolt, saddle, or cone screw type; copper alloy material.

1. Manufacturers:
    a. Burndy Corp.
    b. Thomas and Betts Co.
    c. O-Z Gedney.




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2.04 GROUNDING WELLS

A. Precast Concrete: Ground rod box complete with cast-iron riser ring and H-20 rated cast iron traffic cover marked “GROUND ROD.”

B. Polymer Concrete: Ground rod box complete with non-traffic cover marked “GROUND ROD.” ANSI/SCTE-77 Tier 22 load rating.

C. Manufacturers and Products:

1. Christy Co.; No. G5.
2. Oldcastle Infrastructure; Non-Traffic rated.

**PART 3 EXECUTION**

3.01 GENERAL

A. Provide Grounding in compliance with NFPA 70 and IEEE C2.

B. Bond electrical service neutral at service entrance equipment with grounding electrode conductor to grounding electrode system.

C. Bond each separately derived system neutral with common grounding electrode conductor to grounding electrode system.

D. Bond together all grounding electrodes that are present at each building or structure served to form one common grounding electrode system.

E. 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.

F. Shielded Power Cables: Ground shields at each splice or termination in accordance with recommendations of splice or termination manufacturer.

G. Shielded Instrumentation Cables:

1. Ground shield to ground bus at power supply for analog signal.
2. Expose shield minimum 1 inch at termination to field instrument and apply heat shrink tube.
3. Do not ground instrumentation cable shield at more than one point.


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## 3.02 WIRE CONNECTIONS

A. Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.

B. Nonmetallic Raceways and Flexible Tubing: Install equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.

C. Connect ground conductors to raceway grounding bushings.

D. Extend and connect ground conductors to ground bus in all equipment containing a ground bus.

E. Connect enclosure of equipment containing ground bus to that bus.

F. Bolt connections to equipment ground bus.

G. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.

H. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding clips mounted directly on box, or with 3/8-inch machine screws.

I. Metallic Equipment Enclosures: Use furnished ground lug; if none furnished, tap equipment housing and install solderless terminal connected to box with machine screw. For circuits greater than 20 amps use minimum 5/16-inch diameter bolt.

## 3.03 MOTOR GROUNDING

A. Extend equipment ground bus via grounding conductor installed in motor feeder raceway; connect to motor frame.

B. Nonmetallic Raceways and Flexible Tubing: Install an equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.

C. Motors Less Than 10 hp: Use furnished ground lug in motor connection box. If none furnished, provide compression, spade-type terminal connected to conduit box mounting screw.

D. Motors 10 hp and Above: Use furnished ground lug in motor connection box. If none furnished, tap motor frame or equipment housing; furnish compression, one-hole, lug type terminal connected with minimum 5/16-inch brass threaded stud with bolt and washer.




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E. Circuits 20 Amps or Above: Tap motor frame or equipment housing. Install solderless terminal with minimum 5/16-inch diameter bolt.

3.04 GROUND RODS

A. Install full length with conductor connection at upper end.

B. Install with connection point below finished grade, unless otherwise shown.

C. Space multiple ground rods by one rod length.

D. Install to 8 feet below local frost depth.

3.05 GROUNDING WELLS

A. Install for ground rods located inside buildings, asphalt and paved areas, and where shown on the Drawings.

B. Install riser ring and cover flush with surface.

C. Place 9 inches of crushed rock in bottom of each well.

3.06 CONNECTIONS

A. General:

1. Abovegrade Connections: Install exothermic weld, mechanical, or compression-type connectors; or brazing.
2. Belowgrade Connections: Install exothermic weld or compression type connectors.
3. Remove paint, dirt, or other surface coverings at connection points to allow good metal-to-metal contact.
4. Notify Engineer prior to backfilling ground connections.

B. Exothermic Weld Type:

1. Wire brush or file contact point to bare metal surface.
2. Use welding cartridges and molds in accordance with manufacturer’s recommendations.
3. Avoid using badly worn molds.
4. Mold to be completely filled with metal when making welds.
5. After completed welds have cooled, brush slag from weld area and thoroughly clean joint.


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C. Compression Type:

1. Install in accordance with connector manufacturer's recommendations.
2. Install connectors of proper size for grounding conductors and ground rods specified.
3. Install using connector manufacturer's compression tool having proper sized dies and operate per manufacturer's instructions.

D. Mechanical Type:

1. Apply homogeneous blend of colloidal copper and rust and corrosion inhibitor before making connection.
2. Install in accordance with connector manufacturer's recommendations.
3. Do not conceal mechanical connections.

## 3.07 METAL STRUCTURE GROUNDING

A. Bond metal sheathing and exposed metal vertical structural elements to grounding system.

B. Bond electrical equipment supported by metal platforms to the platforms.

C. Provide electrical contact between metal frames and railings supporting pushbutton stations, receptacles, and instrument cabinets, and raceways carrying circuits to these devices.

## 3.08 MANHOLE AND HANDHOLE GROUNDING

A. Install one ground rod inside each manhole and handhole larger than 24-inch by 24-inch inside dimensions.

B. Ground Rod Floor Protrusion: 4 inches to 6 inches above floor.

C. Make connections of grounding conductors fully visible and accessible.

D. Connect all noncurrent-carrying metal parts and any metallic raceway grounding bushings to ground rod with 6 AWG copper conductor.

## 3.09 TRANSFORMER GROUNDING

A. Bond neutrals of transformers within buildings to system ground network and to any additional indicated grounding electrodes.

B. Bond neutrals of substation transformers to substation grounding grid and system grounding network.




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C. Bond neutrals of pad-mounted transformers to four locally driven ground rods and buried ground wire encircling transformer and system ground network.

3.10 LIGHTNING PROTECTION SYSTEMS

A. Bond lightning protection system ground terminals to building or structure grounding electrode system.

3.11 SURGE PROTECTION EQUIPMENT GROUNDING

A. Connect surge arrestor ground terminals to equipment ground bus.

**END OF SECTION**


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# SECTION 26 05 33
# RACEWAY AND BOXES

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO): HB, Standard Specifications for Highway Bridges.
2. ASTM International (ASTM):
   a. A123/123M, Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products.
   b. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   c. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   d. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
   e. D149, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
3. National Electrical Contractor’s Association, Inc. (NECA): Installation standards.
4. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. C80.1, Electrical Rigid Steel Conduit (ERSC).
   c. C80.3, Steel Electrical Metallic Tubing (EMT).
   d. C80.5, Electrical Rigid Aluminum Conduit (ERAC).
   e. C80.6, Electrical Intermediate Metal Conduit (EIMC).
   f. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
   g. TC 2, Electrical Polyvinyl Chloride (PVC) Conduit.
   h. TC 3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
   i. TC 6, Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation.
   j. TC 14, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
   k. VE 1, Metallic Cable Tray Systems.


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5. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
6. Telecommunications Industry Association (TIA): 569B, Commercial Building Standard for Telecommunications Pathways and Spaces.
7. UL:
    a. 1, Standard for Safety for Flexible Metal Conduit.
    b. 5, Standard for Safety for Surface Metal Raceways and Fittings.
    c. 6, Standard for Safety for Electrical Rigid Metal Conduit – Steel.
    d. 6A, Standard for Safety for Electrical Rigid Metal Conduit – Aluminum, Red Brass and Stainless.
    e. 360, Standard for Safety for Liquid-Tight Flexible Steel Conduit.
    f. 514B, Standard for Safety for Conduit, Tubing, and Cable Fittings.
    g. 651, Standard for Safety for Schedule 40 and Schedule 80 Rigid PVC Conduit and Fittings.
    h. 651A, Standard for Safety for Type EB and A Rigid PVC Conduit and HDPE Conduit.
    i. 797, Standard for Safety for Electrical Metallic Tubing – Steel.
    j. 870, Standard for Safety for Wireways, Auxiliary Gutters, and Associated Fittings.
    k. 1242, Standard for Safety for Electrical Intermediate Metal Conduit – Steel.
    l. 1660, Standard for Safety for Liquid-Tight Flexible Nonmetallic Conduit.
    m. 1684, Standard for Safety for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
    n. 2024, Standard for Safety for Optical Fiber and Communication Cable Raceway.

## 1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer’s Literature:
    a. Rigid galvanized steel conduit.
    b. Rigid aluminum conduit.
    c. Electric Metallic Tubing.
    d. PVC Schedule 40 conduit.
    e. PVC-coated rigid galvanized steel and aluminum conduit, submittal to include copy of manufacturer’s warranty.
    f. Flexible metal, liquid-tight conduit.
    g. Conduit fittings.
    h. Surface metal raceway.
    i. Device boxes for use in hazardous areas.
    j. Junction and pull boxes used at or below grade.


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k. Large junction and pull boxes.
l. Terminal junction boxes.

2. Precast Manholes and Handholes:
   a. Dimensional drawings and descriptive literature.
   b. Traffic loading calculations.
   c. Accessory information.
3. Equipment and machinery proposed for bending metal conduit.
4. Method for bending PVC conduit less than 30 degrees.
5. Conduit Layout:
   a. Provide drawings for underground and concealed conduits including, but not limited to ductbanks, under floor slabs, concealed in floor slabs, and concealed in walls
   b. Provide plan and section showing arrangement and location of conduit and duct bank required for:
      1) Low and medium voltage feeder and branch circuits.
      2) Instrumentation and control systems.
      3) Communications systems.
      4) Empty conduit for future use.
   c. Electronic CAD; scale not greater than 1-inch equals 20 feet.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer’s certification of training for PVC-coated rigid galvanized steel conduit installer.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

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

B. PVC-Coated, Rigid Galvanized Steel Conduit Installer: Certified by conduit manufacturer as having received minimum 2 hours of training on installation procedures.


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## PART 2 PRODUCTS

2.01 CONDUIT AND TUBING

A. Rigid Galvanized Steel Conduit (RGS):

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

B. Rigid Aluminum Conduit:

1. Meet requirements of NEMA C80.5 and UL 6A.
2. Material: Type 6063, copper-free aluminum alloy.

C. Electric Metallic Tubing (EMT):

1. Meet requirements of NEMA C80.3 and UL 797.
2. Material: Hot-dip galvanized with chromated and lacquered protective layer.

D. PVC Schedule 40 Conduit:

1. Meet requirements of NEMA TC 2 and UL 651.
2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors.
3. Furnish without factory-formed bell.

E. PVC-Coated Rigid Galvanized Steel Conduit:

1. Meet requirements of NEMA RN 1 and ETL.
2. Material:
   a. Meet requirements of NEMA C80.1 and UL 6.
   b. Exterior Finish: PVC coating, 40-mil nominal thickness; bond to metal shall have tensile strength greater than PVC.
   c. Interior Finish: Urethane coating, 2-mil nominal thickness.
3. Threads: Hot-dipped galvanized and factory coated with urethane.
4. Bendable without damage to interior or exterior coating.

F. PVC-Coated Rigid Aluminum Conduit:

1. Meet requirements of NEMA RN 1.
2. Material: Type 6063, copper-free aluminum alloy.
   a. Meet requirements of NEMA C80.5 and UL 6A.
   b. Exterior Finish: PVC coating, 40-mil nominal thickness; bond to metal shall have tensile strength greater than PVC.
   c. Interior Finish: Urethane coating, 2-mil nominal thickness.


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G. Flexible Metal, Liquid-Tight Conduit:

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

H. Innerduct:

1. Resistant to spread of fire, per requirements of UL 2024.
2. Smooth HDPE.
3. Textile Manufacturer: Maxcell.

2.02 FITTINGS

A. Rigid Galvanized Steel Conduit:

1. General:
   a. Meet requirements of UL 514B.
   b. Type: Threaded, galvanized. Set screw and threadless compression fittings not permitted.
2. Bushing:
   a. Material: Malleable iron with integral insulated throat, rated for 150 degrees C.
   b. Manufacturers and Products:
      1) Appleton; Series BU-I.
      2) O-Z/Gedney; Type HB.
3. Grounding Bushing:
   a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs.
   b. Manufacturers and Products:
      1) Appleton; Series GIB.
      2) O-Z/Gedney; Type HBLG.
4. Conduit Hub:
   a. Material: Malleable iron with insulated throat with bonding screw.
   b. UL listed for use in wet locations.
   c. Manufacturers and Products:
      1) Appleton, Series HUB-B.
      2) O-Z/Gedney; Series CH.
      3) Meyers; ST Series.
5. Conduit Bodies:
   a. Sized as required by NFPA 70.
   b. Manufacturers and Products (For Normal Conditions):
      1) Appleton; Form 35 threaded unilets.
      2) Crouse-Hinds; Form 7 or Form 8 threaded condulets.
      3) Killark; Series O electrolets.
      4) Thomas & Betts; Form 7 or Form 8.


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c. Manufacturers (For Hazardous Locations):
   1) Appleton.
   2) Crouse-Hinds.
   3) Killark.

6. Couplings: As supplied by conduit manufacturer.
7. Unions:
   a. Concrete tight, hot-dip galvanized malleable iron.
   b. Manufacturers and Products:
      1) Appleton; Series SCC bolt-on coupling or Series EC three-piece union.
      2) O-Z/Gedney; Type SSP split coupling or Type 4 Series, three-piece coupling.
8. Conduit Sealing Fitting:
   a. Manufacturers and Products:
      1) Appleton; Type EYF, EYM, or Type ESU.
      2) Crouse-Hinds; Type EYS or Type EZS.
      3) Killark; Type EY or Type EYS.
9. Drain Seal:
   a. Manufacturers and Products:
      1) Appleton; Type EYD.
      2) Crouse-Hinds; Type EYD or Type EZD.
10. Drain/Breather Fitting:
   a. Manufacturers and Products:
      1) Appleton; Type ECDB.
      2) Crouse-Hinds; ECD.
11. Expansion Fitting:
   a. Manufacturers and Products:
      1) Deflection/Expansion Movement:
         a) Appleton; Type DF.
         b) Crouse-Hinds; Type XD.
      2) Expansion Movement Only:
         a) Appleton; Type XJ.
         b) Crouse-Hinds; Type XJ.
         c) Thomas & Betts; XJG-TP.
12. Cable Sealing Fitting:
   a. To form watertight nonslip cord or cable connection to conduit.
   b. For Conductors with OD of 1/2-inch or Less: Neoprene bushing at connector entry.
   c. Manufacturers and Products:
      1) Appleton; CG-S.
      2) Crouse-Hinds; CGBS.


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B. Rigid Aluminum Conduit:

1. General:
   a. Meet requirements of UL 514B.
   b. Type: Threaded, copper-free. Set screw fittings not permitted.
2. Insulated Bushing:
   a. Material: Cast aluminum, with integral insulated throat, rated for 150 degrees C.
   b. Manufacturer and Product: O-Z/Gedney; Type AB.
3. Grounding Bushing:
   a. Material: Cast aluminum with integral insulated throat, rated for 150 degrees, with solderless lugs.
   b. Manufacturer and Product: O-Z/Gedney; Type ABLG.
4. Conduit Hub:
   a. Material: Cast aluminum, with insulated throat.
   b. UL listed for use in wet locations.
   c. Manufacturers and Products:
      1) O-Z/Gedney; Type CHA.
      2) Thomas & Betts; Series 370AL.
      3) Meyers; Series SA.
5. Conduit Bodies:
   a. Manufacturers and Products (For Normal Conditions):
      1) Appleton; Form 85 threaded unilets.
      2) Crouse-Hinds; Mark 9 or Form 7-SA threaded condulets.
      3) Killark; Series O electrolets.
   b. Manufacturers (For Hazardous Locations):
      1) Appleton.
      2) Crouse-Hinds.
      3) Killark.
6. Couplings: As supplied by conduit manufacturer.
7. Conduit Sealing Fitting:
   a. Manufacturers and Products:
      1) Appleton; Type EYF-AL or Type EYM-AL.
      2) Crouse-Hinds; Type EYS-SA or Type EZS-SA.
      3) Killark; Type EY or Type EYS.
8. Drain Seal:
   a. Manufacturers and Products:
      1) Appleton; Type EYDM-A.
      2) Crouse-Hinds; Type EYD-SA or Type EZD-SA.
9. Drain/Breather Fitting:
   a. Manufacturers and Products:
      1) Appleton; Type ECDB.
      2) Crouse-Hinds; ECD.


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10. Expansion Fitting:
    a. Manufacturers and Products:
        1) Deflection/Expansion Movement: Steel City; Type DF-A.
        2) Expansion Movement Only: Steel City; Type AF-A.
11. Cable Sealing Fittings:
    a. To form watertight nonslip cord or cable connection to conduit.
    b. Bushing: Neoprene at connector entry.
    c. Manufacturer and Product: Appleton; CG-S.

C. Electric Metallic Tubing:

1. Meet requirements of UL 514B.
2. Type: Steel body and locknuts with steel or malleable iron compression nuts. Set screw and drive-on fittings not permitted.
3. Electro zinc-plated inside and out.
4. Raintight.
5. Coupling Manufacturers and Products:
    a. Appleton; Type 95T.
    b. Crouse-Hinds.
    c. Thomas & Betts.
6. Connector Manufacturers and Products:
    a. Appleton; Type ETP.
    b. Crouse-Hinds.
    c. Thomas & Betts.

D. PVC Conduit:

1. Meet requirements of NEMA TC 3.
2. Type: PVC, slip-on.

E. PVC-Coated Rigid Galvanized Steel Conduit:

1. Meet requirements of UL 514B.
2. Fittings: Rigid galvanized steel type, PVC coated by conduit manufacturer.
3. Conduit Bodies: Cast metal hot-dipped galvanized or urethane finish. Cover shall be of same material as conduit body. PVC coated by conduit manufacturer.
4. Finish: 40-mil PVC exterior, 2-mil urethane interior.
5. Overlapping pressure-sealing sleeves.
6. Conduit Hangers, Attachments, and Accessories: PVC-coated.
7. Manufacturers:
    a. Robroy Industries.
    b. Ocal.


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8. Expansion Fitting:
    a. Manufacturer and Product: Ocal; OCAL-BLUE XJG.

F. PVC-Coated Rigid Aluminum Conduit:

1. Meet requirements of UL 514B.
2. Fittings: As listed for rigid aluminum conduit.
3. Finish: 40-mil PVC exterior, 2-mil urethane interior.
4. Overlapping pressure-sealing sleeves.
5. Conduit Hangers, Attachments, and Accessories: PVC-coated.
6. Manufacturers:
    a. Robroy Industries.
    b. Ocal.

G. Flexible Metal, Liquid-Tight Conduit:

1. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C.
2. Insulated throat and sealing O-rings.
3. Manufacturers and Products:
    a. Thomas & Betts; Series 5331.
    b. O-Z/Gedney; Series 4Q.

H. Flexible Coupling, Hazardous Locations:

1. Approved for use in atmosphere involved.
2. Rating: Watertight and UL listed for use in Class I, Division 1 and 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 Type ECLK.
    b. Appleton; EXGJH or EXLK.

I. Watertight Entrance Seal Device:

1. New Construction:
    a. Material: Oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp.
    b. Manufacturer and Product: O-Z/Gedney; Type FSK or Type WSK, as required.
2. Cored-Hole Application:
    a. Material: Assembled dual pressure disks, neoprene sealing ring, and membrane clamp.
    b. Manufacturer and Product: O-Z/Gedney; Series CSM.


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## 2.03 OUTLET AND DEVICE BOXES

A. Sheet Steel: One-piece drawn type, zinc-plated or cadmium-plated.

B. Cast Aluminum:

1. Material:
   a. Box: Cast, copper-free aluminum.
   b. Cover: Gasketed, weatherproof, cast copper-free aluminum with stainless steel screws.
2. Hubs: Threaded.
3. Lugs: Cast mounting.
4. Manufacturers and Products, Nonhazardous Locations:
   a. Crouse-Hinds; Type FS-SA or Type FD-SA.
   b. Appleton; Type FS or Type FD.
   c. Killark.
5. Manufacturers and Products, Hazardous Locations:
   a. Crouse-Hinds; Type GUA-SA.
   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. Exterior Surfaces: 40-mil PVC.
   b. Interior Surfaces: 2-mil urethane.
4. Manufacturers:
   a. Robroy Industries.
   b. Ocal.

## 2.04 JUNCTION AND PULL BOXES

A. Outlet Box Used as Junction or Pull Box: As specified under Article Outlet and Device Boxes.

B. Conduit Bodies Used as Junction Boxes: As specified under Article Fittings.

C. Large Cast Metal Box, Hazardous Locations:

1. NEMA 250 Type 7 or Type 9 as required for Class, Division, and Group involved.
2. Box: Cast ferrous metal, electro-galvanize finished 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.


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5. Manufacturers and Products:
    a. Crouse-Hinds; Type EJB.
    b. Appleton; Type AJBEW.

D. Large Stainless Steel Box:

1. NEMA 250 Type 4X.
2. Box: 14-gauge, ASTM A240/A240M, Type 316 stainless steel, with white enamel painted interior mounting panel
3. Cover: Hinged with clamps.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers:
    a. Hoffman Engineering Co.
    b. Robroy Industries.
    c. Wiegman.

E. Large Steel Box:

1. NEMA 250 Type 1 gasketed or 12.
2. Box: 12-gauge or 10-gauge steel, with white enamel painted interior and gray primed exterior, over phosphated surfaces. Provide gray finish as approved by Engineer.
3. Cover: Hinged with clamps.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers:
    a. Hoffman Engineering Co.
    b. Robroy Industries.
    c. Wiegman.

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 inches by 17 inches, minimum.
5. Manufacturers and Products:
    a. Utility Vault Co.; Series 36-1017.
    b. Christy, Concrete Products, Inc.; N9.
    c. Quazite; “PG” Style.

G. Concrete Box, Traffic Areas:

1. Box: Reinforced, cast concrete with extension and bottom slab.
2. Cover: Steel checked plate; H/20 loading with screw down.
3. Cover Marking: ELECTRICAL, TELEPHONE, or as shown.


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4. Manufacturers and Products:
   a. Christy, Concrete Products, Inc.; B1017BOX.
   b. Utility Vault Co.; 3030 SB.

2.05 TELEPHONE AND DATA OUTLET

A. Provide outlet boxes and cover plates meeting requirements of TIA 569B.

2.06 TERMINAL JUNCTION BOX

A. Cover: Hinged, unless otherwise shown.

B. Interior Finish: Paint with white enamel or lacquer.

C. Terminal Blocks:

1. Separate connection point for each conductor entering or leaving box.
2. Spare Terminal Points: 25 percent, minimum.

2.07 METAL WIREWAYS

A. Meet requirements of UL 870.

B. Type: Steel-enclosed, lay-in type.

C. Cover: Hinged with friction latch.

D. Rating: NEMA 4X.

E. Finish: Rust inhibiting phosphatizing primer and gray baked enamel.

F. Hardware: Plated to prevent corrosion; screws installed toward the inside protected by spring nuts or otherwise guarded to prevent wire insulation damage.

G. Knockouts: Without knockouts, unless otherwise indicated.

H. Manufacturers:

1. Circle AW.
2. Hoffman.
3. Square D.


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## 2.08 PRECAST MANHOLES AND HANDHOLES

A. Concrete Strength: Minimum, 3,000 pounds per square inch compressive, in 28 days.

B. Loading: AASHTO, H-20 in accordance with ASTM C857.

C. Access: Provide cast concrete 6-inch or 12-inch risers and access hole adapters between top of manhole and finished grade at required elevations.

D. Drainage:

1. Slope floors toward drain points, leaving no pockets or other nondraining areas.
2. Provide drainage outlet or sump at low point of floor constructed with a heavy, cast iron, slotted or perforated hinged cover, and a minimum 4-inch outlet and outlet pipe.

E. Raceway Entrances:

1. Provide on all four sides.
2. Provide knockout panels or precast individual raceway openings.
3. At entrances where raceways are to be installed by others, provide minimum 12-inch high by 24-inch wide knockout panels for future raceway installation.

F. Embedded Pulling Iron:

1. Material: 3/4-inch diameter stock, fastened to overall steel reinforcement before concrete is placed.
2. Location:
   a. Wall: Opposite each raceway entrance and knockout panel for future raceway entrance.
   b. Floor: Centered below manhole or handhole cover.

G. Cable Racks:

1. Arms and Insulators: Adjustable, of sufficient number to accommodate cables for each raceway entering or leaving manhole, including spares.
2. Wall Attachment:
   a. Adjustable inserts in concrete walls. Bolts or embedded studs not permitted.
   b. Insert Spacing: Maximum 3 feet on center for inside perimeter of manhole.
   c. Arrange in order that spare raceway ends are clear for future cable installation.


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H. Manhole Frames and Covers:

1. Material: Machined cast iron.
2. Diameter: 36-1/2 inch.
3. Cover Type: Indented, solid top design, with two drop handles each.
4. Cover Loading: AASHTO H-20.
5. Cover Designation:
    a. Cast, on upper side, in integral letters, minimum 2 inches in height, appropriate titles:
        1) Above 600 Volts: ELECTRIC HV.
        2) 600 Volts and Below: ELECTRIC LV.
        3) TELEPHONE.

I. Handhole Frames and Covers:

1. Material: Steel, hot-dipped galvanized.
2. Cover Type: Solid, hinged, of nonskid design.
3. Cover Loading: AASHTO H-20.
4. Cover Designation:
    a. Burn by welder, on upper side in integral letters, minimum 2 inches in height, appropriate titles:
        1) 600 Volts and Below: ELECTRIC LV.
        2) TELEPHONE.

J. Hardware: Steel, hot-dip galvanized.

K. Furnish knockout for ground rod in each manhole.

L. Manufacturers:

1. Utility Vault Co.
2. Penn-Cast Products, Inc.
3. Concrete Conduit Co.
4. Associated Concrete Products, Inc.
5. Pipe, Inc.

## 2.09 ACCESSORIES

A. Duct Bank Spacers:

1. Modular Type:
    a. Nonmetallic, interlocking, for multiple conduit sizes.
    b. Suitable for all types of conduit.
    c. Manufacturers:
        1) Underground Device, Inc.
        2) Carlon.


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2. Template Type:
    a. Nonmetallic, custom made one-piece spacers.
    b. Suitable for all types of conduit.
    c. Material: HDPE or polypropylene, 1/2-inch minimum thickness.
    d. Conduit openings cut 1 inch larger than conduit outside diameter.
    e. Additional openings for stake-down, rebar, and concrete flow through as required.
    f. Manufacturer and Product: SP Products; Quik Duct.

B. Identification Devices:

1. Raceway Tags:
    a. Material: Permanent, nylon.
    b. Shape: Round.
    c. Raceway Designation: Pressure stamped, embossed, or engraved.
    d. Tags relying on adhesives or taped-on markers not permitted.
2. Warning Tape:
    a. Material: Polyethylene, 4-mil gauge with detectable strip.
    b. Color: Red.
    c. Width: Minimum 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.
    f. Manufacturers and Products:
        1) Panduit; Type HTDU.
        2) Reef Industries; Terra Tape.
3. Buried Raceway Marker:
    a. Material: Sheet bronze, consisting of double-ended arrows, straight for straight runs and bent at locations where runs change direction.
    b. Designation: Engrave to depth of 3/32-inch; ELECTRIC CABLES, in letters 1/4-inch high.
    c. Minimum Dimension: 1/4-inch thick, 10 inches long, and 3/4-inch wide.

C. Heat Shrinkable Tubing:

1. Material: Heat-shrinkable, cross-linked polyolefin.
2. Semi-flexible with meltable adhesive inner liner.
3. Color: Black.
4. Manufacturers:
    a. Raychem.
    b. 3M.


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D. Wraparound Duct Band:

1. Material: Heat-shrinkable, cross-linked polyolefin, precoated with hot-melt adhesive.
2. Width: 50 mm minimum.
3. Manufacturer and Product: Raychem; Type TWDB.

## PART 3 EXECUTION

3.01 GENERAL

A. Conduit and tubing sizes shown are based on use of copper conductors. Reference Section 26 05 05, Conductors, concerning conduit sizing for aluminum conductors.

B. Comply with NECA Installation Standards.

C. Crushed or deformed raceways not permitted.

D. Maintain raceway entirely free of obstructions and moisture.

E. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.

F. Aluminum Conduit: Do not install in direct contact with concrete. Install in PVC sleeve or cored hole through concrete walls and slabs.

G. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.

H. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.

I. Group raceways installed in same area.

J. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.

K. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.

L. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.

M. Block Walls: Do not install raceways in same horizontal course or vertical cell with reinforcing steel.



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N. Install watertight fittings in outdoor, underground, or wet locations.

O. Paint threads and cut ends, before assembly of fittings, galvanized conduit, PVC-coated galvanized conduit, or IMC installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.

P. Metal conduit shall be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.

Q. Do not install raceways in concrete equipment pads, foundations, or beams without Engineer approval.

R. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.

S. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.

T. Separate conduits for analog signal and data communications cables from conduits for power conductors and cables in parallel runs by a minimum of 12 inches.

U. Separate conduits for discrete signal cables from conduits for power conductors and cables in parallel runs over 50 feet by a minimum of 6 inches.

V. Separate conduits for VFD cables from other conduits in parallel runs by a minimum of 12 inches.

W. Install conduits for fiber optic cables, telephone cables, and Category 6 data cables in strict conformance with the requirements of TIA 569B.

X. Refer to Section 40 95 80, Fiber Optic Communication System, for coordination with process instrumentation and control systems.

## 3.02 REUSE OF EXISTING CONDUITS

A. Where the Drawings indicate existing conduits may be reused, they may be reused only where they meet the following criteria.

1. Conduit is in useable condition with no deformation, corrosion, or damage to exterior surface.
2. Conduit is sized per the NEC.
3. Conduit is of the type specified in Contract Documents.
4. Conduit is supported as specified in Contract Documents.


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B. Conduit shall be reamed with wire brush, then with a mandrel approximately 1/4 inch smaller than raceway inside diameter then cleaned prior to pulling new conductors.

3.03 INSTALLATION IN CAST-IN-PLACE STRUCTURAL CONCRETE

A. Minimum Cover: 2 inches, including fittings.

B. Conduit placement shall not require changes in reinforcing steel location or configuration.

C. Provide nonmetallic support during placement of concrete to ensure raceways remain in position.

D. Conduit larger than 1 inch shall not be embedded in concrete slabs, walls, foundations, columns, or beams unless approved by Engineer.

E. Slabs and Walls (Requires Engineer Approval):

1. Trade size of conduit not to exceed one-fourth of slab or wall thickness.
2. Install within middle two-fourths of slab or wall.
3. Separate conduit less than 2-inch trade size by a minimum ten times conduit trade size, center-to-center, unless otherwise shown.
4. Separate conduit 2-inch and greater trade size by a minimum eight times conduit trade size, center-to-center, unless otherwise shown.
5. Cross conduit at an angle greater than 45 degrees, with minimum separation of 1-inch.
6. Separate conduit by a minimum six times the outside dimension of expansion/deflection fittings at expansion joints.
7. Conduit shall not be installed below the maximum water surface elevation in walls of water holding structures.

F. Columns and Beams (Requires Engineer Approval):

1. Trade size of conduit not to exceed one-fourth of beam thickness.
2. Conduit cross-sectional area not to exceed 4 percent of beam or column cross-section.

3.04 CONDUIT APPLICATION

A. Diameter: Minimum 3/4-inch.

B. Exterior, Exposed: Rigid aluminum.



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C. Process areas:

1. Interior, Exposed: Rigid aluminum.
2. Interior, Concealed (Not Embedded in Concrete): Rigid aluminum.
3. Aboveground, Embedded in Concrete Walls, Ceilings, or Floors: PVC Schedule 40.

D. Admin Facility: Only for circuits not leaving the boundary of the facility.

1. Interior, Exposed: Rigid aluminum.
2. Interior, Concealed (Not Embedded in Concrete): EMT.
3. Aboveground, Embedded in Concrete Walls, Ceilings, or Floors: PVC Schedule 40.

E. Direct Earth Burial: PVC Schedule 40 for ac circuits, PVC-Coated Rigid Galvanized Steel for VFD circuits.

F. Concrete-Encased Ductbank: PVC Schedule 40 for ac circuits, PVC-Coated Rigid Galvanized Steel for VFD circuits.

G. Under Slabs-On-Grade: PVC Schedule 40 for ac circuits, PVC-Coated Rigid Galvanized Steel for VFD circuits.

H. Transition from Underground or Concrete Embedded to Exposed: PVC-coated rigid steel conduit, entire elbow below grade to a minimum of 6 inches above grade.

I. Under Equipment Mounting Pads: PVC Schedule 40 conduit.

J. Exterior Light Pole Foundations: PVC Schedule 40 conduit.

K. Corrosive Areas: PVC-coated rigid aluminum.

L. Hazardous Gas Areas: PVC-coated Rigid aluminum.

## 3.05 FLEXIBLE CONNECTIONS

A. For motors, wall or ceiling mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other locations approved by Engineer where flexible connection is required to minimize vibration:

1. Conduit Size 4 Inches or Less: Flexible, liquid-tight conduit.
2. Conduit Size Over 4 Inches: Nonflexible.
3. Wet or Corrosive Areas: Flexible metal liquid-tight.
4. Dry Areas: Flexible, metallic liquid-tight.


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5. Hazardous Areas: Flexible coupling suitable for Class I, Division 1 and Division 2 areas.

B. Suspended Lighting Fixtures in Dry Areas: Flexible steel, nonliquid-tight conduit.

C. Outdoor Areas, Process Areas Exposed to Moisture, and Areas Required to be Oiltight and Dust-Tight: Flexible metal, liquid-tight conduit.

D. Flexible Conduit Length: 18 inches minimum, 60 inches maximum; sufficient to allow movement or adjustment of equipment.

## 3.06 PENETRATIONS

A. Make at right angles, unless otherwise shown.

B. Notching or penetration of structural members, including footings and beams, not permitted.

C. Fire-Rated Walls, Floors, or Ceilings: Firestop openings around penetrations to maintain fire-resistance rating as specified in Section 07 84 00, Firestopping.

D. Apply heat shrinkable tubing to metallic conduit protruding through concrete floor slabs to a point 2 inches above and 2 inches below concrete surface.

E. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack, or use watertight seal device.

F. Entering Structures:

1. General: Seal raceway at first box or outlet with oakum or expandable plastic compound to prevent entrance of gases or liquids from one area to another.
2. Concrete Roof or Membrane Waterproofed Wall or Floor:
    a. Provide a watertight seal.
    b. Without Concrete Encasement: Install watertight entrance seal device on each side.
    c. With Concrete Encasement: Install watertight entrance seal device on accessible side.
    d. Securely anchor malleable iron body of watertight entrance seal device into construction with one or more integral flanges.
    e. Secure membrane waterproofing to watertight entrance seal device in a permanent, watertight manner.


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3. Heating, Ventilating, and Air Conditioning Equipment:
   a. Penetrate equipment in area established by manufacturer.
   b. Terminate conduit with flexible metal conduit at junction box or condulet attached to exterior surface of equipment prior to penetrating equipment.
   c. Seal penetration with Type 5 sealant, as specified in Section 07 92 00, Joint Sealants.
4. Existing or Precast Wall (Underground): Core drill wall and install watertight entrance seal device.
5. Nonwaterproofed Wall or Floor (Underground, without Concrete Encasement):
   a. Provide Schedule 40 galvanized pipe sleeve, or watertight entrance seal device.
   b. Fill space between raceway and sleeve with expandable plastic compound or oakum and lead joint, on each side.
6. Manholes and Handholes:
   a. Metallic Raceways: Provide insulated grounding bushings.
   b. Nonmetallic Raceways: Provide bell ends flush with wall.
   c. Install such that raceways enter as near as possible to one end of wall, unless otherwise shown.

## 3.07 SUPPORT

A. Support from structural members only, at intervals not exceeding NFPA 70 requirements. Do not exceed 10 feet in any application. Do not support from piping, pipe supports, or other raceways.

B. Multiple Adjacent Raceways: Provide ceiling trapeze. For trapeze-supported conduit, allow 30 percent extra space for future conduit.

C. Application/Type of Conduit Strap:

1. Aluminum Conduit: Aluminum or stainless steel.
2. Rigid Steel or EMT Conduit: Zinc-coated steel, pregalvanized steel or malleable iron.
3. PVC-Coated Rigid Steel Conduit: PVC-coated metal.
4. Nonmetallic Conduit: Nonmetallic or PVC-coated metal.

D. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:

1. Hollow Masonry Units: Toggle bolts.
2. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.
3. Steelwork: Machine screws.


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4. Location/Type of Hardware:
    a. Dry, Noncorrosive Areas: Galvanized.
    b. Wet, Noncorrosive Areas: Stainless steel.
    c. Corrosive Areas: Stainless steel.

E. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.

F. Support aluminum conduit on concrete surfaces with stainless steel or nonmetallic spacers, or aluminum or nonmetallic framing channel.

3.08 BENDS

A. Install concealed raceways with a minimum of bends in the shortest practical distance.

B. Make bends and offsets of longest practical radius. Bends in conduits and ducts being installed for fiber optic cables shall be not less than 20 times cable diameter, 15 inches minimum.

C. Install with symmetrical bends or cast metal fittings.

D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.

E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.

F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.

G. PVC Conduit:

1. Bends 30 Degrees and Larger: Provide factory-made elbows.
2. 90-Degree Bends: Provide rigid steel elbows, PVC-coated where direct buried.
3. Use manufacturer’s recommended method for forming smaller bends.

H. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.



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3.09 EXPANSION/DEFLECTION FITTINGS

A. Provide on raceways at structural expansion joints and in long tangential runs.

B. Provide expansion/deflection joints for 50 degrees F maximum temperature variation.

C. Install in accordance with manufacturer’s instructions.

3.10 PVC CONDUIT

A. Solvent Welding:

1. Apply manufacturer recommended solvent to joints.
2. Install in order that joint is watertight.

B. Adapters:

1. PVC to Metallic Fittings: PVC terminal type.
2. PVC to Rigid Metal Conduit or IMC: PVC female adapter.

C. Belled-End Conduit: Bevel unbelled end of joint prior to joining.

3.11 PVC-COATED RIGID STEEL AND RIGID ALUMINUM CONDUIT

A. Install in accordance with manufacturer’s instructions.

B. Tools and equipment used in cutting, bending, threading and installation of PVC-coated rigid conduit shall be designed to limit damage to PVC coating.

C. Provide PVC boot to cover exposed threading.

3.12 TERMINATION AT ENCLOSURES

A. Cast Metal Enclosure: Install manufacturer’s premolded insulating sleeve inside metallic conduit terminating in threaded hubs.

B. Nonmetallic, Cabinets, and Enclosures:

1. Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.
2. Metallic Conduit: Provide ground terminal for connection to maintain continuity of ground system.


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C. Sheet Metal Boxes, Cabinets, and Enclosures:

1. General:
   a. Install insulated bushing on ends of conduit where grounding is not required.
   b. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.
   c. Utilize sealing locknuts or threaded hubs on sides and bottom of NEMA 3R and NEMA 12 enclosures.
   d. Terminate conduits at threaded hubs at the tops of NEMA 3R and NEMA 12 boxes and enclosures.
   e. Terminate conduits at threaded conduit hubs at NEMA 4 and NEMA 4X boxes and enclosures.
2. Rigid Galvanized or Aluminum Conduit:
   a. Provide one lock nut each on inside and outside of enclosure.
   b. Install grounding bushing at source enclosure.
   c. Provide bonding jumper from grounding bushing to equipment ground bus or ground pad.
3. Electric Metallic Tubing: Provide gland compression, insulated connectors.
4. Flexible Metal Conduit: Provide two screw type, insulated, malleable iron connectors.
5. Flexible, Nonmetallic Conduit: Provide nonmetallic, liquid-tight strain relief connectors.
6. PVC-Coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector.
7. PVC Schedule 40 Conduit: Provide PVC terminal adapter with lock nut, except where threaded hubs required above.

D. Motor Control Center, and Free-Standing Enclosures:

1. Terminate metal conduit entering bottom with grounding bushing; provide grounding jumper extending to equipment ground bus or grounding pad.
2. Terminate PVC conduit entering bottom with bell end fittings.

## 3.13 UNDERGROUND RACEWAYS

A. Grade: Maintain minimum grade of 4 inches in 100 feet, either from one manhole, handhole, or pull box to the next, or from a high point between them, depending on surface contour.

B. Cover: Maintain minimum 2-foot cover above conduit and concrete encasement, unless otherwise shown.

C. Make routing changes as necessary to avoid obstructions or conflicts.


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D. Couplings: In multiple conduit runs, stagger so couplings in adjacent runs are not in same transverse line.

E. Union type fittings not permitted.

F. Spacers:

1. Provide preformed, nonmetallic spacers designed for such purpose, to secure and separate parallel conduit runs in a trench or concrete encasement.
2. Install at intervals not greater than that specified in NFPA 70 for support of the type conduit used, but in no case greater than 10 feet.

G. Support conduit so as to prevent bending or displacement during backfilling or concrete placement.

H. Transition from Underground to Exposed: PVC-coated rigid steel conduit.

I. Installation with Other Piping Systems:

1. Crossings: Maintain minimum 12-inch vertical separation.
2. Parallel Runs: Maintain minimum 12-inch separation.
3. Installation over valves or couplings not permitted.

J. Concrete Encasement:

1. As specified in Section 03 30 00, Cast-in-Place Concrete.
2. Concrete Color: Red.

K. Backfill:

1. As specified in Section 31 23 23.15, Trench Backfill. Controlled low strength fill is an acceptable bedding and pipe zone material.
2. Do not backfill until inspected by Engineer.

## 3.14 UNDER SLAB RACEWAYS

A. Make routing changes as necessary to avoid obstructions or conflicts.

B. Support raceways so as to prevent bending or displacement during backfilling or concrete placement.

C. Install raceways with no part embedded within slab and with no interference with slab on grade construction.


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D. Raceway spacing, in a single layer or multiple layers:

1. 3 inches clear between adjacent 2-inch or larger raceway.
2. 2 inches clear between adjacent 1-1/2-inch or smaller raceway.

E. Multiple Layers of Raceways: Install under slab on grade in trench below backfill zone, as specified in Section 31 23 23.15, Trench Backfill.

F. Individual Raceways and Single Layer Multiple Raceways: Install at lowest elevation of backfill zone with spacing as specified herein. Where conduits cross at perpendicular orientation, installation of conduits shall not interfere with placement of under slab fill that meets compaction and void limitations of earthwork specifications.

G. Under slab raceways that emerge from below slab to top of slab as exposed, shall be located to avoid conflicts with structural slab rebar. Coordinate raceway stub ups with location of structural rebar.

H. Fittings:

1. Union type fittings are not permitted.
2. Provide expansion/deflection fittings in raceway runs that exit building or structure below slab. Locate fittings 18 inches, maximum, beyond exterior wall. Raceway type between building exterior wall to fitting shall be PVC-coated rigid steel.
3. Couplings: In multiple raceway runs, stagger so couplings in adjacent runs are not in same traverse line.

## 3.15 OUTLET AND DEVICE BOXES

A. General:

1. Install plumb and level.
2. Install suitable for conditions encountered at each outlet or device in wiring or raceway system, sized to meet NFPA 70 requirements.
3. Open no more knockouts in sheet steel device boxes than are required; seal unused openings.
4. Install galvanized mounting hardware in industrial areas.

B. Size:

1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted.
    a. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.



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2. Ceiling Outlet: Minimum 4-inch octagonal device box, unless otherwise required for installed fixture.
3. Switch and Receptacle: Minimum 2-inch by 4-inch device box.

C. Locations:

1. Drawing locations are approximate.
2. To avoid interference with mechanical equipment or structural features, relocate outlets as directed by Engineer.
3. Light Fixture: Install in symmetrical pattern according to room layout, unless otherwise shown.

D. Mounting Height:

1. General:
   a. Dimensions given to centerline of box.
   b. Where specified heights do not suit building construction or finish, adjust up or down to avoid interference.
   c. Do not straddle CMU block or other construction joints.
2. Light Switch:
   a. 48 inches above floor.
   b. When located next to door, install on lock side of door.
3. Thermostat: 54 inches above floor.
4. Telephone Outlet:
   a. 15 inches above floor.
   b. 6 inches above counter tops.
   c. Wall Mounted: 52 inches above floor.
5. Convenience Receptacle:
   a. General Interior Areas: 15 inches above floor.
   b. General Interior Areas (Counter Tops): Install device plate bottom or side flush with top of backsplash, or 6 inches above counter tops without backsplash.
   c. Industrial Areas, Workshops: 48 inches above floor.
   d. Outdoor Areas: 24 inches above finished grade.
6. Special-Purpose Receptacle: As shown.
7. Switch, Motor Starting: 48 inches above floor, unless otherwise indicated on the Drawings.

E. Flush Mounted:

1. Install with concealed conduit.
2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.
3. Holes in surrounding surface shall be no larger than required to receive box.


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F. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.
2. Install bar hangers in frame construction or fasten boxes directly as follows:
   a. Concrete or Brick: Bolts and expansion shields.
   b. Hollow Masonry Units: Toggle bolts.
   c. Steelwork: Machine screws.
3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
4. Provide plaster rings where necessary.
5. Boxes embedded in concrete or masonry need not be additionally supported.

G. Install separate junction boxes for flush or recessed lighting fixtures where required by fixture terminal temperature.

H. Boxes Supporting Fixtures: Provide means of attachment with adequate strength to support fixture.

## 3.16 JUNCTION AND PULL BOXES

A. General:

1. Install plumb and level.
2. Installed boxes shall be accessible.
3. Do not install on finished surfaces.
4. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.
5. Use conduit bodies as junction and pull boxes where no splices are required and allowed by applicable codes.
6. Install pull boxes where necessary in raceway system to facilitate conductor installation.
7. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.
8. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.

B. Flush Mounted:

1. Install with concealed conduit.
2. Holes in surrounding surface shall be no larger than required to receive box.
3. Make edges of boxes flush with final surface.


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C. Mounting Hardware:

1. Noncorrosive Dry Areas: Stainless steel.
2. Noncorrosive Wet Areas: Stainless steel.
3. Corrosive Areas: Stainless steel.

D. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.
2. Install bar hangers in frame construction or fasten boxes directly as follows:
   a. Concrete or Brick: Bolts and expansion shields.
   b. Hollow Masonry Units: Toggle bolts.
   c. Steelwork: Machine screws.
3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
4. Boxes embedded in concrete or masonry need not be additionally supported.

E. At or Below Grade:

1. Install boxes for below grade conduit flush with finished grade in locations outside of paved areas, roadways, or walkways.
2. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location.
3. Obtain Owner’s written acceptance prior to installation in paved areas, roadways, or walkways.
4. Use boxes and covers suitable to support anticipated weights.

F. Install Drain/breather fittings in NEMA 250 Type 4 and Type 4X enclosures.

## 3.17 TELEPHONE AND DATA OUTLET

A. Provide empty 4-11/16-inch square, deep outlet box.

B. Provide blank single gang raised device cover if cables are not installed.

## 3.18 MANHOLES AND HANDHOLES

A. Excavate, shore, brace, backfill, and final grade in accordance with Section 31 23 16, Excavation, and Section 31 23 23.15, Trench Backfill.

B. Do not install until final raceway grading has been determined.


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C. Install such that raceway enters at nearly right angle and as near as possible to end of wall, unless otherwise shown.

D. Grounding: As specified in Section 26 05 26, Grounding and Bonding for Electrical Systems.

E. Identification: Field stamp covers with manhole or handhole number as shown. Stamped numbers to be 1-inch minimum height.

## 3.19 EMPTY RACEWAYS

A. Provide permanent, removable cap over each end.

B. Provide PVC plug with pull tab for underground raceways with end bells.

C. Provide nylon pull cord.

D. Identify, as specified in Article Identification Devices, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

## 3.20 IDENTIFICATION DEVICES

A. Raceway Tags:

1. Identify origin and destination
2. For exposed raceways, install tags at each terminus, near midpoint, and at minimum intervals of every 50 feet, whether in ceiling space or surface mounted.
3. Install tags at each terminus for concealed raceways.
4. Provide nylon strap for attachment.

B. Warning Tape: Install approximately 18 inches above underground or concrete-encased raceways. Align parallel to, and within 12 inches of, centerline of run.

C. Buried Raceway Marker:

1. Install at grade to indicate direction of underground raceway.
2. Install at bends and at intervals not exceeding 100 feet in straight runs.
3. Embed and secure to top of concrete base, sized 14 inches long, 6 inches wide, and 8 inches deep; top set flush with finished grade.



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3.21 PROTECTION OF INSTALLED WORK

A. Protect products from effects of moisture, corrosion, and physical damage during construction.

B. Provide and maintain manufactured watertight and dust-tight seals over conduit openings during construction.

C. Touch up painted conduit threads after assembly to cover nicks or scars.

D. Touch up coating damage to PVC-coated conduit with patching compound approved by manufacturer. Compound shall be kept refrigerated according to manufacturers' instructions until time of use.

**END OF SECTION**


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# SECTION 26 05 70
# ELECTRICAL SYSTEMS ANALYSIS

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American National Standards Institute (ANSI).
2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. C57.12.00, Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.
   b. 242, Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.
   c. 399, Recommended Practice for Industrial and Commercial Power System Analysis.
   d. 1584, Guide for Performing Arc Flash Hazard Calculations.
3. National Electrical Manufacturers Association (NEMA): Z535.4, Product Safety Signs and Labels.
4. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 70E, Standard for Electrical Safety in the Workplace.
5. Occupational Safety and Health Standards (OSHA): 29 CFR, Part 1910 Subpart S, Electrical.

### 1.02 SUBMITTALS

A. Action Submittals:

1. Short circuit study.
2. Protective Device Coordination Study: Submit within 90 days after approval of short circuit study.
3. Arc Flash Study: Submit initial study with protective Device Coordination Study. Submit final study prior to equipment energization.
4. Arc flash warning labels; submit sample with initial study.
5. Electronic files on thumb drive of final studies including all engineering software input files, output reports, and libraries.

### 1.03 QUALITY ASSURANCE

A. Short circuit and protective device coordination and arc flash studies shall be prepared by manufacturer furnishing Motor control Center or a professional electrical engineer registered in the State of Oklahoma.


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## 1.04 SEQUENCING AND SCHEDULING

A. Initial complete short circuit study shall be submitted and reviewed before Engineer will review Shop Drawings for padmounted switches, padmounted transformer and motor control center equipment.

B. Initial complete protective device coordination and arc flash studies shall be submitted within 90 days after approval of initial short circuit study.

C. Initial complete arc flash study shall be submitted and accepted prior to energization of the electrical equipment.

D. Revised short circuit, protective device coordination, and arc flash studies, and arc flash labels shall be submitted 20 days before energizing electrical equipment.

E. Final short circuit, protective device coordination, and arc flash studies shall be completed prior to Project Substantial Completion. Final version of study shall include as-installed equipment, materials, and parameter data or settings entered into equipment based on study.

F. Submit final arc flash labels described herein and in compliance with NEMA Z535.4 prior to Project Substantial Completion.

## 1.05 GENERAL STUDY REQUIREMENTS

A. Equipment and component titles used in the studies shall be identical to equipment and component titles shown on the Drawings.

B. Perform studies using one of the following electrical engineering software packages:

1. SKM Power Tools for Windows.
2. ETAP.
3. Easy Power.

C. Perform complete fault calculations for each existing source combination.

1. Source combination may include present and future power company supply circuits, large motors, or generators.

D. Utilize proposed and existing load data for study obtained from Contract Documents and obtained from field investigation of system configuration, wiring information, and equipment.


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E. Existing System and Equipment:

1. Extent of existing system to be included in study is all of the existing system and equipment
2. Include fault contribution of existing motors and equipment in study.
3. Include impedance elements that affect new system and equipment.
4. Include protective devices in series with new equipment.

F. Device coordination time-current curves for medium and low voltage distribution system; include individual protective device time-current characteristics.

1.06 SHORT CIRCUIT STUDY

A. General:

1. Prepare in accordance with IEEE 399 and IEE 3002.
2. Use cable impedances based on copper conductors, except where aluminum conductors are specified or shown.
3. Use bus impedances based on copper bus bars, except where aluminum bus bars are specified or shown.
4. Use cable and bus resistances calculated at 25 degrees C.
5. Use medium-voltage cable reactances based on use of typical dimensions of shielded cables with 133 percent insulation levels.
6. Use 600-volt cable reactances based on use of typical dimensions of THHN/THWN and XHHW for conductors larger than 6 AWG conductors.
7. Use transformer impedances 92.5 percent of “nominal” impedance based on tolerances specified in IEEE C57.12.00.

B. Provide:

1. Calculation methods and assumptions.
2. Typical calculation.
3. Tabulations of calculated quantities.
4. Results, conclusions, and recommendations.
5. Selected base per unit quantities.
6. One-line diagrams.
7. Source impedance data, including electric utility system and motor fault contribution characteristics.
8. Impedance diagrams.
9. Zero-sequence impedance diagrams.


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C. Calculate short circuit interrupting and momentary (when applicable) duties for an assumed three-phase bolted fault at each:

1. Electric utility's supply termination point.
2. Main switchgear service entrance equipment.
3. Low-voltage switchboards.
4. Motor control centers.
5. Branch circuit panelboards.

D. Provide bolted line-to-ground fault current study for areas as defined for three-phase bolted fault short circuit study.

E. Verify:

1. Equipment and protective devices are applied within their ratings.
2. Adequacy of switchgear, switchboard, and motor control centers bus bars to withstand short circuit stresses.
3. Adequacy of transformer windings to withstand short circuit stresses.
4. Cable and busway sizes for ability to withstand short circuit heating, in addition to normal load currents.

F. Tabulations:

1. General Data:
   a. Short circuit reactances of rotating machines.
   b. Cable and conduit material data.
   c. Bus data.
   d. Transformer data.
   e. Circuit resistance and reactance values.
2. Short Circuit Data:
   a. Fault impedances.
   b. X to R ratios.
   c. Asymmetry factors.
   d. Motor contributions.
   e. Short circuit kVA.
   f. Symmetrical and asymmetrical fault currents.
3. Equipment Evaluation:
   a. Equipment bus bracing, equipment short circuit rating, transformer, cable, busway.
   b. Maximum fault current available.

G. Written Summary:

1. Scope of studies performed.
2. Explanation of bus and branch numbering system.
3. Prevailing conditions.


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4. Selected equipment deficiencies.
5. Results of short circuit study.
6. Comments or suggestions.

H. Suggest changes and additions to equipment rating and/or characteristics.

I. Notify Engineer in writing of existing circuit protective devices improperly rated for new fault conditions.

J. Revise data for “as-installed” condition.

1.07 PROTECTIVE DEVICE COORDINATION STUDY

A. General:

1. Prepare in accordance with IEEE 242 and IEEE 3004.
2. Proposed protective device coordination time-current curves for distribution system, graphically displayed on conventional log-log curve sheets.
   a. Provide separate curve sheets for phase and ground fault coordination for each scenario.
   b. Each curve sheet to have title and one-line diagram that applies to specific portion of system associated with time-current curves on that sheet. Limit number of devices shown to four to six.
   c. Identify device associated with each curve by manufacturer type, function, and, if applicable, recommended tap, time delay, instantaneous and other settings recommended.
   d. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
   e. Apply motor protection methods that comply with NFPA 70.

B. Plot Characteristics on Curve Sheets:

1. Electric utility’s relays.
2. Electric utility’s fuses including manufacturer’s minimum melt, total clearing, tolerance, and damage bands.
3. Medium-voltage equipment relays.
4. Medium-voltage and low-voltage fuses including manufacturer’s minimum melt, total clearing, tolerance, and damage bands.
5. Low-voltage equipment circuit breaker trip devices, including manufacturers tolerance bands.
6. Pertinent transformer full-load currents at 100 percent.
7. Transformer magnetizing inrush currents.
8. Transformer damage curves; appropriate for system operation and location.


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9. ANSI transformer withstand parameters.
10. Significant symmetrical and asymmetrical fault currents.
11. Motor overload relay settings for motors greater than 40 hp.
12. Ground fault protective device settings.
13. Other system load protective devices for largest branch circuit and feeder circuit breaker in each motor control center.

C. Primary Protective Device Settings for Delta-Wye Connected Transformer:

1. Secondary Line-to-Ground Fault Protection: Primary protective device operating band within transformer's characteristics curve, including a point equal to 58 percent of IEEE C57.12.00 withstand point.
2. Secondary Line-to-Line Faults: 16 percent current margin between primary protective device and associated secondary device characteristic curves.

D. Separate medium voltage relay characteristics curves from curves for other devices by at least 0.4-second time margin.

E. Tabulate Recommended Protective Device Settings:

1. Relays:
   a. Current tap.
   b. Time dial.
   c. Instantaneous pickup.
   d. Electronic settings data file.
2. Circuit Breakers:
   a. Adjustable pickups.
   b. Adjustable time-current characteristics.
   c. Adjustable time delays.
   d. Adjustable instantaneous pickups.
   e. $I^2t$ In/Out.
   f. Zone interlocking.
   g. Electronic settings data file.

F. Written Summary:

1. Scope of studies performed.
2. Summary of protective device coordination methodology.
3. Prevailing conditions.
4. Selected equipment deficiencies.
5. Results of coordination study.
6. Appendix of complete relay and circuit breaker electronic setting files, submit electronic data files from manufacturer's software.
7. Comments or suggestions.


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## 1.08 ARC FLASH STUDY

A. Perform arc flash hazard study after short circuit and protective device coordination study has been completed, reviewed and accepted.

B. Perform arc flash study in accordance with NFPA 70E, OSHA 29 CFR, Part 1910 Subpart S, and IEEE 1584.

C. Base Calculation:

1. For each major part of electrical power system, determine the following:
   a. Flash hazard protection boundary.
   b. Limited approach boundary.
   c. Restricted approach boundary.
   d. Incident energy level.
   e. Glove class required.
   f. Date the assessment was performed.

D. Produce arc flash warning labels that list items in Paragraph Base Calculation and the following additional items.

1. Bus name.
2. Bus voltage.

E. Produce bus detail sheets that list items in Paragraph Base Calculation and the following additional items:

1. Bus name.
2. Upstream protective device name, type, and settings.
3. Bus line-to-line voltage.

F. Produce arc flash evaluation summary sheet listing the following additional items:

1. Bus name.
2. Upstream protective device name, type, settings.
3. Bus line-to-line voltage.
4. Bus bolted fault.
5. Protective device bolted fault current.
6. Arcing fault current.
7. Protective device trip/delay time.
8. Breaker opening time.
9. Solidly grounded column.
10. Equipment type.
11. Gap.
12. Arc flash boundary.


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13. Working distance.
14. Incident energy.

G. Analyze short circuit, protective device coordination, and arc flash calculations and highlight equipment that is determined to be underrated or causes incident energy values greater than 8 cal/cm$^2$. Propose approaches to reduce energy levels.

H. Prepare report summarizing arc flash study with conclusions and recommendations which may affect integrity of electric power distribution system. As a minimum, include the following:

1. Equipment manufacturer's information used to prepare study.
2. Assumptions made during study.
3. Reduced copy of one-line drawing; 11 inches by 17 inches maximum.
4. Arc flash evaluations summary spreadsheet.
5. Bus detail sheets.
6. Arc flash warning labels printed in color on thermally bonded adhesive backed UV and weather-resistant labels.

## PART 2 PRODUCTS

### 2.01 ARC FLASH WARNING LABELS

A. Arc flash warning labels printed in color on thermally bonded adhesive backed, UV-resistant and weather-resistant labels. An example label is located following end of section in Figure 1.

## PART 3 EXECUTION

### 3.01 GENERAL

A. Adjust relay and protective device settings according to values established by coordination study.

B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.

C. Notify Engineer in writing of required major equipment modifications.

D. Provide laminated one-line diagrams (minimum size 11 inches by 17 inches) to post on interior of electrical room doors.

E. Provide arc flash warning labels on equipment as specified in this section.


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3.02 SUPPLEMENT

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Figure 1: Example Arc Flash Label.

**END OF SECTION**


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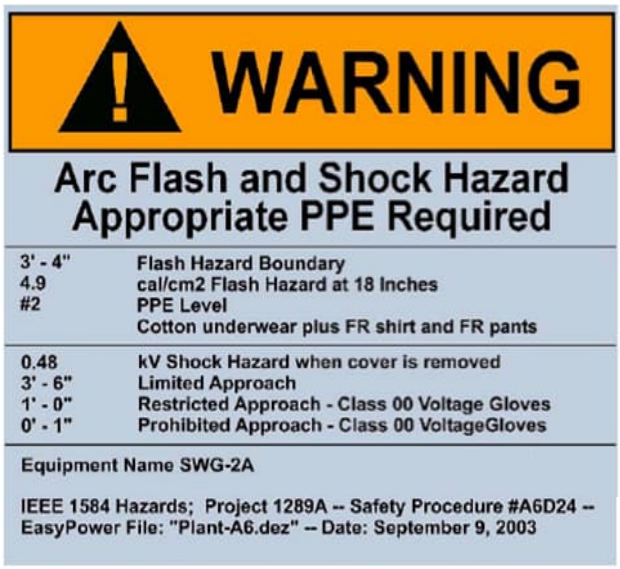


**Figure 1**
Example Arc Flash Label


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# SECTION 26 08 00
# COMMISSIONING OF ELECTRICAL SYSTEMS

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. ASTM International (ASTM):
   a. D877/D877M, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
   b. D923, Standard Practices for Sampling Electrical Insulating Liquids.
   c. D924, Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
   d. D971, Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
   e. D974, Standard Test Method for Acid and Base Number by Color-Indicator Titration.
   f. D1298, Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
   g. D1500, Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
   h. D1524, Standard Test Method for Visual Examination of Used Electrical Insulating Liquids in the Field.
   i. D1533, Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration.
   j. D1816, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using VDE Electrodes.
2. Institute of Electrical and Electronics Engineers (IEEE):
   a. 43, Recommended Practice for Testing Insulation Resistance of Electric Machinery.
   b. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminators Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV.
   c. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
   d. 95, Recommended Practice for Insulation Testing of AC Electric Machinery (2,300V and Above) with High Direct Voltage.


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e. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
f. 400, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems Rated 5 kV and Above.
g. 450, Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
h. C2, National Electrical Safety Code.
i. C37.20.1, Standard for Metal-Enclosed Low-Voltage (1,000 Vac and below, 3,200 Vdc and below) Power Circuit Breaker Switchgear.
j. C37.20.3, Standard for Metal-Enclosed Interrupter Switchgear.
k. C37.23, Standard for Metal-Enclosed Bus.
l. C62.33, Standard Test Methods and Performance Values for Metal-Oxide Varistor Surge Protective Components.

3. Insulated Cable Engineers Association (ICEA):
   a. S-93-639, 5-46 kV Shielded Power Cables for Use in the Transmission and Distribution of Electric Energy.
   b. S-94-649, Concentric Neutral Cables Rated 5 kV through 46 kV.
   c. S-97-682, Standard for Utility Shielded Power Cables Rated 5 kV through 46 kV.
4. InterNational Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Equipment and Systems.
5. National Electrical Manufacturers Association (NEMA):
   a. AB 4, Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
   b. PB 2, Deadfront Distribution Switchboards.
   c. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.
6. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 70B, Recommended Practice for Electrical Equipment Maintenance.
   c. 70E, Standard for Electrical Safety in the Workplace.
   d. 101, Life Safety Code.
7. National Institute for Certification in Engineering Technologies (NICET).
8. Occupational Safety and Health Administration (OSHA): CFR 29, Part 1910, Occupational Safety and Health Standards.


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1.02 SUBMITTALS

A. Informational Submittals:

1. Submit 30 days prior to performing inspections or tests:
   a. Testing firm qualifications.
   b. Schedule for performing inspection and tests.
   c. List of references to be used for each test.
   d. Sample copy of equipment and materials inspection form(s).
   e. Sample copy of individual device test form.
   f. Sample copy of individual system test form.
2. Energization Plan:
   a. Prior to initial energization of electrical distribution equipment; include the following:
      1) Owner's representative sign-off form for complete and accurate arc flash labeling and proper protective device settings for equipment to be energized.
      2) Staged sequence of initial energization of electrical equipment.
      3) Lock-Out-Tag-Out plan for each stage of the progressive energization.
      4) Barricading, signage, and communication plan notifying personnel of newly energized equipment.
3. Submit test or inspection reports and certificates for each electrical item tested within 30 days after completion of test.
4. Operation and Maintenance Data:
   a. In accordance with Section 01 78 23, Operation and Maintenance Data.
   b. After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in Operation and Maintenance Manual.
5. Programmable Settings:
   a. At completion of Performance Demonstration Test, submit final hardcopy printout and electronic files on USB drive of as-left setpoints, programs, and device configuration files for:
      1) Protective relays.
      2) Intelligent overload relays.
      3) Adjustable frequency drives.
      4) Power metering devices.
      5) Uninterruptible power supplies.
      6) Electrical communications modules.


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## 1.03 QUALITY ASSURANCE

A. Testing Firm Qualifications:

1. Corporately and financially independent organization functioning as an unbiased testing authority.
2. Professionally independent of manufacturers, suppliers, and installers of electrical equipment and systems being tested.
3. Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems.
4. Supervising engineer accredited as Certified Electrical Test Technologist by NICET or NETA and having a minimum of 5 years' testing experience on similar projects.
5. Technicians certified by NICET or NETA.
6. Assistants and apprentices assigned to Project at ratio not to exceed two certified to one noncertified assistant or apprentice.
7. Registered Professional Engineer to provide comprehensive Project report outlining services performed, results of such services, recommendations, actions taken, and opinions.
8. In compliance with OSHA CFR 29, Part 1910.7 criteria for accreditation of testing laboratories or a full member company of NETA.

B. Test equipment shall have an operating accuracy equal to or greater than requirements established by NETA ATS.

C. Test Instrument Calibration: In accordance with NETA ATS.

## 1.04 SEQUENCING AND SCHEDULING

A. Perform inspection and electrical tests after equipment listed herein has been installed.

B. Perform tests with apparatus de-energized whenever feasible.

1. Scheduled with Owner prior to de-energization.
2. Minimized to avoid extended period of interruption to the operating plant equipment.

C. Notify Owner at least 24 hours prior to performing tests on energized electrical equipment.


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## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION

3.01 GENERAL

A. Perform tests in accordance with requirements of Section 01 91 14, Equipment Testing and Facility Startup.

B. Tests and inspections shall establish:

1. Electrical equipment is operational within industry and manufacturer's tolerances and standards.
2. Installation operates properly.
3. Equipment is suitable for energization.
4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E, NFPA 101, and IEEE C2.

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

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

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

F. Verify nameplate data for conformance to Contract Documents and approved Submittals.

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/screw driver to manufacturer's recommendations, or as otherwise specified in NETA ATS.

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

K. Provide proper lubrication of applicable moving parts.

L. Inform Engineer of working clearances not in accordance with NFPA 70.


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M. Investigate and repair or replace:

1. Electrical items that fail tests.
2. Active components not operating in accordance with manufacturer's instructions.
3. Damaged electrical equipment.

N. Electrical Enclosures:

1. Remove foreign material and moisture from enclosure interior.
2. Vacuum and wipe clean enclosure interior.
3. Remove corrosion found on metal surfaces.
4. Repair or replace, as determined by Engineer door and panel sections having dented surfaces.
5. Repair or replace, as determined by Engineer poor fitting doors and panel sections.
6. Repair or replace improperly operating latching, locking, or interlocking devices.
7. Replace missing or damaged hardware.
8. Finish:
    a. Provide matching paint and touch up scratches and mars.
    b. If required because of extensive damage, as determined by Engineer refinish entire assembly.

O. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents or approved Submittals.

P. Replace transformer insulating oil not in compliance with ASTM D923.

## 3.02 CHECKOUT AND STARTUP

A. Voltage Field Test:

1. Check voltage at point of termination of power company supply system to Project when installation is essentially complete and is in operation.
2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
3. Record supply voltage (all three phases simultaneously on same graph) for 24 hours during normal working day.
    a. Submit Voltage Field Test Report within 5 days of test.
4. Unbalance Corrections:
    a. Make written request to power company to correct condition if balance (as defined by NEMA) exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded condition more than plus or minus 4 percent of nominal.


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b. Obtain written certification from responsible power company official that voltage variations and unbalance are within their normal standards if corrections are not made.

B. Equipment Line Current Tests:

1. Check line current in each phase for each piece of equipment.
2. Make line current check after power company has made final adjustments to supply voltage magnitude or balance.
3. If phase current for a piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken.

3.03 PANELBOARDS

A. Visual and Mechanical Inspection:

1. Include the following inspections and related work:
   a. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.
   b. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer's instruction manual.
   c. Check panelboard mounting, area clearances, and alignment and fit of components.
   d. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
   e. Perform visual and mechanical inspection for overcurrent protective devices.

B. Electrical Tests:

1. Include the following items performed in accordance with manufacturer's instruction:
   a. Insulation Resistance Tests:
      1) Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
      2) Each phase of each bus section.
      3) Phase-to-phase and phase-to-ground for 1-minute.
      4) With breakers open.
      5) With breakers closed.


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6) Control wiring except that connected to solid state components.
7) Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.

b. Ground continuity test ground bus to system ground.

3.04 DRY TYPE TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Physical and insulator damage.
2. Proper winding connections.
3. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
4. Defective wiring.
5. Proper operation of fans, indicators, and auxiliary devices.
6. Removal of shipping brackets, fixtures, or bracing.
7. Free and properly installed resilient mounts.
8. Cleanliness and improper blockage of ventilation passages.
9. Verify tap-changer is set at correct ratio for rated output voltage under normal operating conditions.
10. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.5 for each:
      1) Winding-to-winding.
      2) Winding-to-ground.
   b. Test Duration: 10 minutes with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
   c. Results temperature corrected in accordance with NETA ATS, Table 100.14.
   d. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
   e. Insulation resistance test results to compare within 1 percent of adjacent windings.
2. Perform tests and adjustments for fans, controls, and alarm functions as suggested by manufacturer.




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## 3.05 LIQUID FILLED TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Physical and insulator damage.
2. Proper winding connections.
3. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
4. Defective wiring.
5. Proper operation of fans, indicators, and auxiliary devices.
6. Effective core and equipment grounding.
7. Removal of shipping brackets, fixtures, or bracing.
8. Tank leaks and proper liquid level.
9. Integrity and contamination of bus insulation system.
10. Verify tap-changer is set at correct ratio for rated voltage under normal operating conditions.
11. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.5 for each:
      1) Winding-to-winding.
      2) Winding-to-ground.
   b. Test Duration: 10 minutes with resistances tabulated at 30 seconds, 1-minute, and 10 minutes.
   c. Results temperature corrected in accordance with NETA ATS, Table 100.14.
   d. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
   e. Insulation resistance test results to compare within 1 percent of adjacent windings.
2. Perform tests and adjustments for fans, controls, and alarm functions as suggested by manufacturer.
3. Sample insulating oil in accordance with ASTM D923 and have laboratory test for:
   a. Dielectric breakdown voltage in accordance with ASTM D877/D877M or ASTM D1816.
   b. Acid neutralization number in accordance with ASTM D974.
   c. Interfacial tension in accordance with ASTM D971.
   d. Color in accordance with ASTM D1500.
   e. Visual condition in accordance with ASTM D1524.
   f. Specific gravity in accordance with ASTM D1298.


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g. Water content, in parts per million, in accordance with ASTM D1533.
h. Dielectric fluid test results in accordance with NETA ATS, Table 100.4.
i. Power factor at 25 degrees C and at 100 degrees, in accordance with ASTM D924.
j. Maximum power factor, corrected to 20 degrees C, in accordance with manufacturer's specifications.

3.06 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect each individual exposed power cable No. 6 and larger for:
   a. Physical damage.
   b. Proper connections in accordance with single-line diagram.
   c. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.
   d. Color coding conformance with specification.
   e. Proper circuit identification.
2. Mechanical Connections for:
   a. Proper lug type for conductor material.
   b. Proper lug installation.
   c. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
3. Shielded Instrumentation Cables for:
   a. Proper shield grounding.
   b. Proper terminations.
   c. Proper circuit identification.
4. Control Cables for:
   a. Proper termination.
   b. Proper circuit identification.
5. Cables Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests for Conductors No. 6 and Larger:

1. Insulation Resistance Tests:
   a. Utilize 1,000V dc megohmmeter for 600-volt insulated conductors
   b. Test each conductor with respect to ground and to adjacent conductors for 1-minute.
   c. Evaluate ohmic values by comparison with conductors of same length and type.
   d. Investigate values less than 50 megohms.


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2. Continuity test by ohmmeter method to ensure proper cable connections.

## 3.07 MEDIUM-VOLTAGE CABLES, 15 KV MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect each individual exposed cable for:
   a. Physical damage plus jacket and insulation condition.
   b. Proper connections in accordance with single-line diagram or approved Submittals.
   c. Proper shield grounding.
   d. Proper cable support.
   e. Proper cable termination.
   f. Cable bends not in conformance with manufacturer's minimum allowable bending radius.
   g. Proper arc and fireproofing in common cable areas.
   h. Proper circuit and phase identification.
2. Mechanical Connections:
   a. Proper lug type for conductor material.
   b. Proper lug installation.
   c. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturers.
3. Conductors Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 5,000-volt megohmmeter for 8 kV and 15 kV conductors.
   b. Test each cable individually with remaining cables and shields grounded.
   c. Test each conductor with respect to ground and to adjacent conductors for 1 minute.
   d. Evaluate ohmic values by comparison with conductors of same length and type.
   e. Investigate values less than 50 megohms.
2. Shield Continuity Tests:
   a. By ohmmeter method on each section of conductor.
   b. Investigate values in excess of 10 ohms per 1,000 feet of conductors.


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3. Acceptance Tests:
   a. In accordance with IEEE 400, ICEA S-93-639, NEMA WC 74, ICEA S-94-649, and ICEA S-97-682 for insulated conductors.
   b. Each conductor section tested with:
      1) Splices and terminations in place but disconnected from equipment.
      2) Remaining conductors and shields grounded in accordance with IEEE 400.
   c. Apply maximum test voltage per NETA ATS, Table 100.6, based on method (DC, AC, PD, or VLF) used.
   d. Measure only leakage current associated with conductor.
   e. Utilize guard ring or field reduction sphere to suppress corona at disconnected terminations.
   f. Maximum test voltage shall not exceed limits for terminators specified in IEEE 48, IEEE 386, or manufacturer's specifications.
   g. Apply test voltage in a minimum of five equal increments until maximum acceptable test voltage is reached.
      1) Increments not to exceed ac voltage rating of conductor.
      2) Record dc leakage current at each step after a constant stabilization time consistent with system charging current.
   h. Raise conductor to specified maximum test voltage and hold for 15 minutes or as specified by conductor manufacturer. Record leakage current at 30 seconds and 1-minute, and at 1-minute intervals, thereafter.
   i. Immediately following test, ground conductor for adequate time period to drain insulation stored charge.
   j. Test results evaluated on a pass/fail basis.
4. New Conductors Spliced to Existing Conductors:
   a. Prior to performing splices, high potential dc test new conductor sections.
   b. After splicing new conductors to existing conductors, disconnect existing conductors and perform the following tests:
      1) Shield continuity test.
      2) Insulation resistance test.
      3) High potential test with test voltage not to exceed 60 percent of applied acceptance dc test voltage.

## 3.08 SAFETY SWITCHES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Proper blade pressure and alignment.
2. Proper operation of switch operating handle.
3. Adequate mechanical support for each fuse.
4. Proper contact-to-contact tightness between fuse clip and fuse.



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5. Cable connection bolt torque level in accordance with NETA ATS, Table 100.12.
6. Proper phase barrier material and installation.
7. Verify fuse sizes and types correspond to one-line diagram or approved Submittals.
8. Perform mechanical operational test and verify mechanical interlocking system operation and sequencing.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
   b. Phase-to-phase and phase-to-ground for 1 minute on each pole.
   c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Contact Resistance Tests:
   a. Contact resistance in microhms across each switch blade and fuse holder.
   b. Investigate deviation of 50 percent or more from adjacent poles or similar switches.

## 3.09 MEDIUM-VOLTAGE METAL-ENCLOSED AIR SWITCHES

A. Visual and Mechanical Inspection:

1. Proper blade pressure, alignment, and arch interrupter operation.
2. Proper operation of operating mechanism.
3. Proper contact condition.
4. Adequate mechanical support for each fuse.
5. Proper contact-to-contact tightness between fuse clip and fuse.
6. Bus and cable connection tightness.
7. Proper phase barrier material and installation.
8. Proper operation of indicating devices.
9. Installation of expulsion limiting devices on expulsion type element holders.
10. Verify fuse links and types correspond to one-line diagram or approved Submittals.
11. Perform mechanical operational test to verify mechanical interlocking system operation and sequencing.
12. Perform phasing check on double-ended air switch arrangements to ensure proper bus phasing from each source.


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B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
   b. Phase-to-phase and phase-to-ground for 1 minute on each pole.
   c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Contact Resistance Tests:
   a. Contact resistance in microhms across each switch blade and fuse holder.
   b. Investigate values exceeding 500 microhms or deviation of 50 percent or more from adjacent poles or similar switches.
3. Overpotential Tests:
   a. Applied ac or dc voltage in accordance with NETA ATS, Table 100.19.
   b. Phase-to-phase and phase-to-ground for 1-minute.
   c. Test results evaluated on pass/fail basis.

## 3.10 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated 70 amperes and larger and to motor circuit protector breakers rated 50 amperes and larger.

B. Visual and Mechanical Inspection:

1. Proper mounting.
2. Proper conductor size.
3. Feeder designation according to nameplate and one-line diagram.
4. Cracked casings.
5. Connection bolt torque level in accordance with NETA ATS, Table 100.12.
6. Operate breaker to verify smooth operation.
7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.
8. Verify that terminals are suitable for 75 degrees C rated insulated conductors.

C. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 1,000V dc megohmmeter for 480-volt and 600-volt circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1-minute.


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c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1-minute.
d. Test values to comply with NETA ATS, Table 100.1.

2. Contact Resistance Tests:
   a. Contact resistance in microhms across each pole.
   b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
3. Primary Current Injection Test to Verify:
   a. Long-time minimum pickup and delay.
   b. Short-time pickup and delay.
   c. Ground fault pickup and delay.
   d. Instantaneous pickup by run-up or pulse method.
   e. Trip characteristics of adjustable trip breakers shall be within manufacturer's published time-current characteristic tolerance band, including adjustment factors.
   f. Trip times shall be within limits established by NEMA AB 4, Table 5-3. Alternatively, use NETA ATS, Table 100.7.
   g. Instantaneous pickup value shall be within values established by NEMA AB 4, Table 5-4. Alternatively, use NETA ATS, Table 100.8.

## 3.11 METERING

A. Visual and Mechanical Inspection:

1. Verify meter connections in accordance with appropriate diagrams.
2. Verify meter multipliers.
3. Verify meter types and scales conform to Contract Documents.
4. Check calibration of meters at cardinal points.
5. Check calibration of electrical transducers.

## 3.12 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Equipment and circuit grounds in motor control center, panelboard, transformers and pad mounted switches assemblies for proper connection and tightness.
2. Ground bus connections in motor control center, panelboard, transformers and pad mounted switches assemblies for proper termination and tightness.
3. Effective transformer core and equipment grounding.


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4. Accessible connections to grounding electrodes for proper fit and tightness.
5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

B. Electrical Tests:

1. Fall-of-Potential Test:
   a. In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.
   b. Main ground electrode system resistance to ground to be no greater than 3 ohms.
2. Two-Point Direct Method Test:
   a. In accordance with IEEE 81, Section 8.2.1.1 for measurement of ground resistance between main ground system, equipment frames, and system neutral and derived neutral points.
   b. Equipment ground resistance shall not exceed main ground system resistance by 0.25 ohm.

## 3.13 AC INDUCTION MOTORS

A. General: Inspection and testing limited to motors rated 1 hp and larger.

B. Visual and Mechanical Inspection:

1. Proper electrical and grounding connections.
2. Shaft alignment.
3. Blockage of ventilating air passageways.
4. Operate motor and check for:
   a. Excessive mechanical and electrical noise.
   b. Overheating.
   c. Correct rotation.
   d. Check vibration detectors, resistance temperature detectors, or motor inherent protectors for functionability and proper operation.
   e. Excessive vibration, in excess of values in NETA ATS, Table 100.10.
5. Check operation of space heaters.

C. Electrical Tests:

1. Insulation Resistance Tests:
   a. In accordance with IEEE 43 at test voltages established by NETA ATS, Table 100.1 for:
      1) Motors above 200 horsepower for 10-minute duration with resistances tabulated at 30 seconds, 1-minute, and 10 minutes.


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2) Motors 200 horsepower and less for 1-minute duration with resistances tabulated at 30 seconds and 60 seconds.

b. Insulation resistance values equal to, or greater than, ohmic values established by manufacturers.

2. Calculate polarization index ratios for motors above 200 horsepower. Investigate index ratios less than 1.5 for Class A insulation and 2.0 for Class B insulation.
3. Insulation resistance test on insulated bearings in accordance with manufacturer's instructions.
4. Measure running current and voltage, and evaluate relative to load conditions and nameplate full-load amperes.

## 3.14 LOW-VOLTAGE MOTOR CONTROL

A. Visual and Mechanical Inspection:

1. Proper barrier and shutter installation and operation.
2. Proper operation of indicating and monitoring devices.
3. Proper overload protection for each motor.
4. Improper blockage of air-cooling passages.
5. Proper operation of drawout elements.
6. Integrity and contamination of bus insulation system.
7. Check door and device interlocking system by:
   a. Closure attempt of device when door is in OFF position.
   b. Opening attempt of door when device is in ON position.
8. Check key interlocking systems for:
   a. Key captivity when device is in ON position.
   b. Key removal when device is in OFF position.
   c. Closure attempt of device when key has been removed.
   d. Correct number of keys in relationship to number of lock cylinders.
   e. Existence of other keys capable of operating lock cylinders; destroy duplicate sets of keys.
9. Check nameplates for proper identification of:
   a. Equipment title and tag number with latest one-line diagram.
   b. Pushbuttons.
   c. Control switches.
   d. Pilot lights.
   e. Control relays.
   f. Circuit breakers.
   g. Indicating meters.
10. Verify fuse and circuit breaker sizes and types conform to Contract Documents.
11. Verify current and potential transformer ratios conform to Contract Documents.


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12. Check bus connections for high resistance by low-resistance ohmmeter and calibrated torque wrench applied to bolted joints.
13. Ohmic value to be zero.
    a. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
14. Check operation and sequencing of electrical and mechanical interlock systems by:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
    c. Key exchange to operate devices in OFF-NORMAL positions.
15. Verify performance of each control device and feature furnished as part of motor control center.
16. Control Wiring:
    a. Compare wiring to local and remote control, and protective devices with elementary diagrams.
    b. Check for proper conductor lacing and bundling.
    c. Check for proper conductor identification.
    d. Check for proper conductor lugs and connections.
17. Exercise active components.
18. Inspect contactors for:
    a. Correct mechanical operations.
    b. Correct contact gap, wipe, alignment, and pressure.
    c. Correct torque of connections.
19. Compare overload heater rating with full-load current for proper size.
20. Compare fuse, motor protector, and circuit breaker with motor characteristics for proper size.
21. Perform phasing check on double-ended motor control centers to ensure proper bus phasing from each source.

B. Electrical Tests:

1. Insulation Resistance Tests:
    a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
    b. Bus section phase-to-phase and phase-to-ground for 1-minute on each phase.
    c. Contactor phase-to-ground and across open contacts for 1-minute on each phase.
    d. Starter section phase-to-phase and phase-to-ground on each phase with starter contacts closed and protective devices open.
    e. Test values to comply with NETA ATS, Table 100.1.
2. Current Injection through Overload Unit at 300 Percent of Motor Full-Load Current and Monitor Trip Time:
    a. Trip time in accordance with manufacturer’s published data.
    b. Investigate values in excess of 120 seconds.


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3. Control Wiring Tests:
    a. Apply secondary voltage to control power and potential circuits.
    b. Check voltage levels at each point on terminal board and each device terminal.
    c. Insulation resistance test at 1,000V dc on control wiring, except that connected to solid state components; 1 megohm minimum insulation resistance.
4. Operational test by initiating control devices to affect proper operation.

## 3.15 BATTERY SYSTEM

A. Visual and Mechanical Inspection:

1. Physical damage and electrolyte leakage.
2. Evidence of corrosion.
3. Intercell bus link integrity.
4. Battery cable insulation damage and contaminated surfaces.
5. Operating conditions of ventilating equipment.
6. Visual check of electrolyte level.

B. Electrical Tests:

1. Measure:
    a. Bank charging voltage.
    b. Individual cell voltage.
    c. Electrolyte specific gravity in each cell.
    d. Measured test values to be in accordance with manufacturer’s published data.
2. Verify during recharge mode:
    a. Charging rates from charger.
    b. Individual cell acceptance of charge.
3. Load tests for integrity and capacity; test values in accordance with IEEE 450.

## 3.16 UNINTERRUPTIBLE POWER SUPPLIES (UPS)

A. UPS Start-up Inspection and Testing:

1. Visual Inspection:
    a. Inspect equipment for signs of damage.
    b. Verify installation per the Drawings.
    c. Inspect cabinets for foreign objects.
    d. Verify neutral and ground conductors are properly sized and configured per vendor requirements as noted in vendor drawings supplied with installation manuals or submittal package.


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e. Inspect all battery cell cases.
f. Inspect each cell for proper polarity.

2. Mechanical Inspection:
   a. Check all control wiring connections for tightness.
   b. Check all power wiring connections for tightness.
   c. Check all terminal screws, nuts, and spade lugs for tightness.
3. Electrical Inspection:
   a. Check all fuses for continuity.
   b. Confirm input bypass voltage and phase rotation is correct.
   c. Verify control transformer connections are correct for voltages being used.
   d. Assure connections and voltage of the battery string(s).
   e. Battery inspection and certification according to IEEE standards.
4. Unit Start-Up:
   a. Energize control power.
   b. Perform control/logic checks and adjust to meet manufacturer specification.
   c. Verify DC float and equalize voltage levels.
   d. Verify DC voltage clamp and over-voltage shutdown levels.
   e. Verify battery discharge, low-battery warning, and low-battery shutdown levels.
   f. Verify fuse monitor alarms and system shutdown.
   g. Verify inverter voltages and regulation circuits.
   h. Verify inverter/bypass sync circuits and set overlap time.
   i. Perform manual transfers and returns.
   j. Simulate utility outage at no load.
   k. Verify proper recharge.

B. Provide test instruments to record elapsed time between transfers, voltage, current, frequency, waveform, and transients.

1. Include services of an experienced technician to make final adjustments, final connections, and perform final testing.
2. Evidence of transients or phase shifts in graphs will be cause for rejection of system.

## 3.17 THERMOGRAPHIC SURVEY

A. Provide thermographic survey per NETA ATS Table 100.18 of connections associated with incoming service conductors, bus work, and branch feeder conductors No. 4 and larger at each:

1. Medium Voltage Padmounted switches.
2. Low voltage motor control center.
3. Panelboard.



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B. Provide thermographic survey of feeder conductors No. 4 and larger terminating at:

1. Motors rated 50 hp and larger.
2. Medium and low voltage disconnect switches.
3. Transfer switches.

C. Remove necessary enclosure metal panels and covers prior to performing survey.

D. Perform with equipment energized during periods of maximum possible loading per NFPA 70B, Section 20.17.

E. Do not perform survey on equipment operating at less than 40 percent of rated load. If plant load is insufficient, perform test with supplemental load bank producing rated load on item being measured.

F. Use thermographic equipment capable of:

1. Detecting emitted radiation.
2. Converting detected radiation to visual signal.
3. Detecting 1-degree C temperature difference between subject area and reference point of 30 degrees C.

G. Temperature Gradients:

1. 3 degrees C to 7 degrees C indicates possible deficiency that warrants investigation.
2. 7 degrees C to 15 degrees C indicates deficiency that is to be corrected as time permits.
3. 16 degrees C and above indicates deficiency that is to be corrected immediately.

H. Provide written report of:

1. Areas surveyed and the resultant temperature gradients.
2. Locations of areas having temperature gradients of 3 degrees C or greater.
3. Cause of heat rise and actions taken to correct cause of heat rise.
4. Detected phase unbalance.

**END OF SECTION**


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# SECTION 26 13.16.02
# PAD-MOUNTED SWITCHGEAR

## PART 1 GENERAL

1.01 REFERENCES

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

1. ASTM International (ASTM):
   a. B117, Standard Practice for Operating for Salt Spray (Fog) Apparatus.
   b. B187, Standard Specification for Copper Bar, Bus Bar, Rod, and Shapes.
   c. B236, Standard Specification for Aluminum Bars for Electrical Purposes (Bus Bars).
   d. D523, Standard Test Method for Specular Gloss.
   e. D543, Standard Practice for Evaluating for Resistance of Plastics to Chemical Reagents.
   f. D570, Standard Test Method for Water Absorption of Plastics.
   g. D635, Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
   h. D714, Standard Test Method for Evaluating Degree of Blistering of Paints.
   i. D756, Standard Practice for Determination of Weight and Shape Changes of Plastics under Accelerated Service Conditions.
   j. D790, Standard Test Method for Flexural Properties of Unreinforced and Reinforced Plastic and Electrical Insulating Materials.
   k. D1654, Standard Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments.
   l. D2247, Standard Practice for Testing Water Resistance of Coatings in 100 Percent Relative Humidity.
   m. D2794, Standard Test Method for Resistance or Organic Coatings to the Effects of Rapid Deformation.
   n. D3359, Standard Test Methods for Measuring Adhesion by Tape Test.
   o. D4060, Standard Test Method for Abrasion Resistance to Organic Coatings by the Taber Abraser.
   p. D4214, Test Method for Evaluating Degree of Chalking of Exterior Paint Films.
   q. G154, Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials.


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2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
    a. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems above 600V.
    b. C37.20.3, Metal Enclosed Interrupter Switchgear.
    c. C37.46, Specifications for Power Fuses and Fused Disconnecting Switches.
    d. C37.57, Metal Enclosed Interrupter Switchgear Assemblies—Conformance Testing.
    e. C37.58, Indoor AC Medium-Voltage Switches for Use in Metal-Enclosed Switchgear—Conformance Test Procedures.
    f. C37.91, Guide for Protective Relay Applications to Power Transformers.
    g. C57.12.28, Switchgear and Transformers, Pad-Mounted Equipment, Enclosure Integrity.
    h. C62.11, Metal-Oxide Surge Arrestors for Alternating-Current Power Circuits (>1 KV).
3. National Electrical Manufacturers Association (NEMA):
    a. C2, National Electrical Safety Code.
    b. C29.9, Wet-Process Porcelain Insulators - Apparatus Post-Type.
    c. C29.10, Wet Process Porcelain Insulators - Indoor Apparatus Type.
    d. LA 1, Surge Arrestors.
    e. SG 2, High Voltage Fuses.
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).

## 1.02 SUBMITTALS

A. Action Submittals:

1. Descriptive product information.
2. Dimensional drawings.
3. Itemized bill of material.
4. Operational description.
5. Installation instructions.
6. Switchgear configurations.
7. Interrupter switch data.
8. Bus data.
9. Fuse data and time-current characteristics on transparencies.
10. Concrete pad details.
11. Polymer concrete vault details.


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B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
3. Factory test reports.
4. Manufacturer's installation instructions.
5. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
6. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services

1.03 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following special tools and material:

1. Fuse handling tool, compatible with installed fuses.
2. Two sets of three grounding jumpers 3 feet in length, complete with canvas storage bag for each set.
3. Voltage tester with audio and visual signals, batteries, shotgun clamp-stick adapter, and storage case.
4. 6 feet 5-1/2 inches long shotgun clamp stick with canvas storage bag.
5. Solid material fuse end fittings, holders, and fuse, refill units for each installed fuse size.
6. Electron fuse interrupting module and fuse units for each installed fuse size.
7. A complete set of spare fuses.

**PART 2 PRODUCTS**

2.01 LISTING

A. Equipment shall include UL listing.

2.02 MANUFACTURERS

A. Oberlender/S&C Co.

B. Provide pad-mounted switchgear that is the product of a single manufacturer. Assembled units with component parts of several manufacturers will not be acceptable with the exception that minor items such as, terminal blacks, test switch, and wiring, may be manufactured by others.


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## 2.03 GENERAL

A. Equipment suitable for 13,200 volts, three-phase, three-wire solid grounded-wye electrical system having an available short-circuit current at line terminals of 14,000 amperes rms symmetrical.

B. Pad-mounted switchgear complete with self-supporting enclosure for directly operable accessible components.

C. Switchgear shall be manually operated.

D. Primary selective interrupter switch configuration as shown on one-line diagram.

E. Design, test, and assemble in accordance to IEEE C37.20.3, IEEE C37.57, and IEEE C57.12.28.

F. Operating Conditions:

1. Ambient Temperature: Maximum 40 degrees C.
2. Provide equipment fully rated without derating for these operating conditions.

G. Anchor Bolts: Type 316 stainless steel, 5/8-inch diameter, length sized by manufacturer, and as specified in Section 05 50 00, Metal Fabrications.

## 2.04 EQUIPMENT RATINGS

A. Integrated switchgear assembly ratings at 60-Hz.

1. Voltage: 14.4 kV nominal, 17.0 kV maximum.
2. Insulation Level: 95 kV BIL.
3. Bus Current: 600 amperes continuous.
4. Three-Pole Interrupter Switches:
   a. Current: 200 continuous amperes, 200 load dropping amperes.
   b. Two-Time Duty-Cycle Fault Closing: 22,400 amperes rms asymmetrical.
5. Fuses with Integral Load Interrupter:
   a. Current: 200 maximum amperes, 200 load dropping amperes.
   b. Two-Time Duty-Cycle Fault Closing: 13,000 amperes rms asymmetrical.
1. Short-Circuit Rating: 14,000 amperes rms symmetrical at rated nominal voltage.


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B. Fault-closing ratings to equal, or exceed, the short-circuit ratings of the pad mounted switchgear with:

1. Momentary and two-time duty-cycle rating of switches.
2. Momentary rating of bus.
3. Interrupting ratings of fuses.
4. One-time duty-cycle capabilities of fuses with integral load interrupters.

2.05 ENCLOSURE

A. Monocoque, freestanding, self-supporting construction with welded structural and butt joints having external seams ground flush and smooth.

B. Enclosure sides, doors, roof, bottom flange, base spacer, and steel barriers constructed with 22-gauge galvanized sheet steel complete with fiberglass-reinforced polyester barriers.

C. Tamper resistant with no externally accessible hardware in accordance with security requirements of IEEE C57.12.28.

D. Removable lifting tabs bolted to blind-tapped sockets with resilient anticorrosion material between tabs and enclosure.

E. Enclosure Base:

1. Consisting of continuous 90-degree steel flanges welded to enclosure and turned inward for bolting to base spacer.
2. Resilient closed-cell PVC gasket applied between flange bottom and base spacer.
3. Coat enclosure flange with wax-based anticorrosion moisture barrier.

F. Enclosure Roof:

1. Overlapping edges creating mechanical maze and ventilating openings.
2. Insulating nondrip compound applied to underside.

G. Doors:

1. Constructed with edge flanges overlapping door openings to form mechanical maze.
2. Two extruded-aluminum hinges with Type 316 stainless steel pins, full length of door extruded-aluminum interlocking supports, and stainless steel mounting hardware for each door.
3. Access door to power fuses equipped with storage space for replacement fuse components.


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4. Hidden galvanized steel door holders swinging outward when door is in opened position.

H. Door Latch:

1. Automatic positive action, three-point, spring-loaded latching mechanism for each door or set of doors.
2. Pentahead socket wrench to actuate mechanism for unlatching door and recharging spring for next closing operation in same motion.
3. Tamper-proof padlocking shackle coordinated with latches to prevent:
   a. Unlatching mechanism until padlock is removed.
   b. Inserting padlock until mechanism is completely latched closed.

I. Fuse-Storage Feature: Enclosure shall have a compartment for three spare fuse assemblies located in compartment 2.

J. Viewing Window in Door: Mounting provisions for a fault indicator in each switch compartment with viewing window in each door.

K. Finish:

1. Multistage process applied to interior and exterior surfaces, joints, and blind areas prior to enclosure assembly.
   a. Pretreatment protective film.
   b. Baked epoxy finished coating.
   c. Baked acrylic enamel top coating in accordance with IEEE C57.12.28.
2. Color: Olive green or Manufacturer’s Standard.
3. Tests:
   a. Salt-spray test in accordance with ASTM B117.
   b. Humidity test in accordance with ASTM D2247 and ASTM D714.
   c. Accelerated weather tests in accordance with ASTM G154, ASTM D4214, and ASTM D523.
   d. Adhesion tests in accordance with ASTM D3359, Method B and ASTM D2794.
   e. Corrosion tests in accordance with ASTM D1645.
   f. Abrasion tests in accordance with ASTM D4060.
   g. Oil resistance testing with no shift in color, streaking, blistering, or loss of hardness.

2.06 BARRIERS

A. In compliance with NEMA C2.

B. Full-length steel barriers separating side-by-side compartments.



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C. BIL Rated Fiberglass-Reinforced Polyester Barriers:

1. Fixed interphase and end barriers for each interrupter switch and each set of fuses.
2. Front and rear compartments isolated by fixed barriers.

2.07 GROUND-CONNECTION PADS

A. Provided in each compartment on inside at bottom door stile with momentary rating equal to, or exceeding, short-circuit ratings of switchgear.

B. Constructed of 5/8-inch thick nickel-plated steel, with oxide inhibitor and sealant coating, welded to enclosure.

C. Ground studs of each fuse terminal plus one ground stud at ground connection pad in each fuse compartment and switch terminals.

2.08 INSULATORS

A. Interrupter switch and fuse mounting insulators, insulated operating shafts, and push rods constructed of cycloaliphatic epoxy resin in accordance with NEMA C29.9 and NEMA C29.10.

2.09 HIGH VOLTAGE BUS

A. Aluminum bus bar of 56 percent IACS conductivity.

B. Bus rated 600-ampere with provisions for one-cable terminations per phase.

2.10 INTERRUPTER SWITCHES

A. External handle-operated, three-pole, nonfused, group-operated with quick-make quick-break mechanism for live, full load, open and close switching in accordance with IEEE C37.58.

B. Single insulated shaft with blades and journals permanently molded in-place for positive and inherently sequenced blade position.

C. One-piece, formed hard-drawn copper blades with silver-clad contact surfaces.

D. Multifinger, convexed, silver-clad copper jaw contacts with stainless steel springs for constant contact pressure.

E. Equip each switchblade assembly with arc compressor, strain-guard terminals, and support insulators.


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F. Mount each switch assembly and operator on a rigid, welded steel frame.

G. Switch and bus compartment terminals to accommodate one cable per phase.

H. Base mounted metal-oxide type distribution class surge arrests rated 15 kV at all source switch terminals.

I. Shaft lock for each switch.

2.11 FUSE INTERRUPTERS

A. Disconnect style interrupter switches suitable for solid material power fuses, complete with steel base, insulators, terminal pads, mounting contacts, and lower hinge and pull-ring operated latch.

B. Fuse mounting jaw contacts with integral load interrupter for live switching with hookstick.

C. Cycloaliphatic epoxy resin housing for load interrupters.

D. Load interrupters with continuous current path, self-resetting, separate contacts for fault-closing and load currents, and self-guiding fuse hinge.

E. Integral load interrupters to have one-time duty-cycle fault-closing capability equal to interrupting rating of fuse, and two-time duty-cycle fault-closing capability of 13,000-ampere rms asymmetrical at 14.4 kV.

F. Equip each fuse interrupter with tin-plated copper terminal pads having two-position adapter.

2.12 FUSES

A. Solid Material Power Fuse:

1. In accordance with NEMA SG 2.
2. End fitting, upper end pull ring fitting, blown-fuse target, expendable fuse unit, aluminum-bronze lower end fitting, and silencer.
3. Manufacturer and Product: S&C Co.; Type SM-20.

2.13 CONTROL WIRING

A. NFPA 70, Type SIS, single-conductor, Class B, stranded copper, rated 600 volts for control, instrumentation, and power circuits.

B. Individual seven-strand, copper conductors, twisted and covered with a 100 percent aluminum, polyester shield with tinned copper drain wire and


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overall outer jacket, rated 600 volts, 90 degrees C minimum for transducer output and analog circuits.

C. Conductor Lugs: Preinsulated, self-locking, spade type with reinforced sleeves.

D. Wire Markers: Each wire individually identified with permanent markers at each end.

E. Internal circuit wiring crossing shipping splits to have plug connectors.

F. Splices: Not permitted.

2.14 SURGE PROTECTION

A. Sets of three metal-oxide, in accordance with IEEE C62.11 and NEMA LA 1.

B. Base mounted at switch terminals and bus terminals in Compartment 1 and Compartment 2.

C. Connect to line side of switch terminals and ground to switchgear ground bus.

D. Class: Distribution.

E. Rating: 12 kV for 13.8 kV system.

2.15 BASE SPACERS

A. Steel compartmented type bolted to enclosure flange and anchor to on-grade concrete pad.

B. Spacer height of 6 inches.

C. Complete with resilient closed-cell gasket between bottom flange and concrete pad.

D. Finish identical to that specified for enclosure finish.

2.16 LABELING

A. Nonmetallic, self-sticking with integral lettering and symbols.

B. Warning Labels:

1. Attach to exterior surface of each external door labels reading CAUTION—HIGH VOLTAGE-KEEP OUT.


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2. Attach to internal surface of each external door and on all barriers used to prevent access to live parts, labels reading DANGER—HIGH VOLTAGE—KEEP OUT—QUALIFIED PERSONS ONLY.
3. Provide inside each interrupter switch access door, labels reading SWITCH BLADES MAY BE ENERGIZED IN ANY POSITION.
4. Provide inside each fuse access door, labels reading FUSES MAY BE ENERGIZED IN ANY POSITION.

C. Rating Labels:

1. Attach inside each door, or set of double doors, labels indicating:
   a. Voltage rating.
   b. Main bus continuous rating.
   c. Short-circuit ratings in amperes rms symmetrical and mVa three-phase symmetrical at rated nominal voltage.
   d. Fuse type.
   e. Fuse rating, including duty-cycle fault-closing capability.
   f. Interrupter switch ratings, including duty-cycle fault-closing and short time momentary, amperes rms asymmetrical and 1 second, amperes rms symmetrical.

D. Connection Labels: Attach inside each door, or set of double doors, and inside each switch-operating hub access cover, labels showing three-line connection diagram for interrupter switches, fuses with integral load interrupter, and bus along with manufacturer’s model number.

E. Phase identification number 1, number 2, and number 3 above each phase connection at each fuse unit and interrupter switch.

2.17 NAMEPLATES

A. Deep etched aluminum on outside of each door, or set of double doors, indicating manufacturer’s name, catalog number, model number, date of manufacture, and serial number.

B. Riveted to door surface.

2.18 ACCESSORIES

A. One fuse handling tool compatible with installed fuses.

B. Two sets of three grounding jumpers, 3 feet in length, complete with storage bag for each set.

C. One voltage tester with audio and visual signals, batteries, shotgun clamp-stick adapter, and storage case.


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D. 6-foot, 5-1/2-inch long, shotgun clamp-stick with canvas storage bag.

E. Solid material fuse, end fittings, holders and fuse refill units for each installed fuse size.

2.19 KEY INTERLOCKS

A. Mechanical lock cylinder located at each interrupter switch shaft.

B. Key and Lock Cylinder Type: Superior.

C. One keys available for each group of two locks for loop primary distribution systems.

D. Interlock to prevent opening of fuse termination-compartment doors unless all switches are locked open.

2.20 FAULT INDICATORS

A. Factory installed with sensing transformer located at cable entrances to each incoming service and interrupter switches and fuse interrupters.

B. As specified in Section 26 05 05, Conductors.

2.21 SOURCE QUALITY CONTROL

A. Switchgear assembly shall be production tested in accordance with IEEE C37.20.3.

B. Fuses shall be production tested in accordance with IEEE C37.46.

**PART 3 EXECUTION**

3.01 INSTALLATION

A. Install equipment in accordance with manufacturer’s instructions and recommendations.

B. Secure equipment to concrete pad with anchor bolts of sufficient size and number adequate for specified seismic conditions.

C. Tighten current-carrying bolted bus connections and enclosure framing and panel bolts to manufacturer’s recommendations.

D. Coordinate terminal connections with installation of secondary feeders.


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3.02 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative in accordance with Section 01 43 33, Manufacturers' Field Services, for the following services at Site, for minimum person-days listed below, travel time excluded:

1. 1 person-day for installation assistance, final adjustment, and initial energization of equipment.
2. 1 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
3. 1 person-day for post-startup training.

B. Furnish training of Owner's personnel at such times as requested by Owner.

**END OF SECTION**




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# SECTION 26 20 00
# LOW-VOLTAGE AC INDUCTION MOTORS

## PART 1 GENERAL

### 1.01 RELATED SECTIONS

A. This section applies to low-voltage AC induction motors, whether or not referenced by a motor-driven equipment specification. If equipment specification section deviates from this section in requirements such as, application, horsepower, enclosure type, mounting, shaft type, or synchronous speed, then those listed requirements shall take precedence over this section.

### 1.02 REFERENCES

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

1. American Bearing Manufacturers Association (ABMA):
   a. 9, Load Ratings and Fatigue Life for Ball Bearings.
   b. 11, Load Ratings and Fatigue Life for Roller Bearings.
2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
   b. 620, Guide for the Presentation of Thermal Limit Curves for Squirrel Cage Induction Machines.
   c. 841, Standard for Petroleum and Chemical Industry—Premium Efficiency Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors—Up to and Including 370 kW (500 hp).
3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. C50.41, Polyphase Induction Motors for Power Generating Stations.
   c. MG 1, Motors and Generators.
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. UL:
   a. 83, Standard for Safety for Thermoplastic-Insulated Wire and Cables.
   b. 674, Standard for Safety for Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.
   c. 2111, Standard for Safety for Overheating Protection for Motors.


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1.03 DEFINITIONS

A. CISD-TEFC: Chemical industry, severe-duty enclosure.

B. DIP: Dust-ignition-proof enclosure.

C. EXP: Explosion-proof enclosure.

D. Inverter Duty Motor: Motor meeting applicable requirements of NEMA MG 1, Section IV, Parts 30 and 31.

E. Inverter Ready Motor: Motor meeting applicable requirements of NEMA MG 1, Section IV, Part 31.4.4.2.

F. Motor Nameplate Horsepower: That rating after any derating required to allow for extra heating caused by the harmonic content in the voltage applied to the motor by its controller.

G. ODP: Open drip-proof enclosure.

H. TEFC: Totally enclosed, fan-cooled enclosure.

I. TENV: Totally enclosed, nonventilated enclosure.

J. VPI: Vacuum pressure impregnated.

K. WPI: Open weather protected enclosure, Type I.

L. WPII: Open weather protected enclosure, Type II.

1.04 SUBMITTALS

A. Action Submittals:

1. Descriptive information.
2. Nameplate data in accordance with NEMA MG 1.
3. Additional Rating Information:
    a. Service factor.
    b. Locked rotor current.
    c. No load current.
    d. Safe stall time for motors 100 hp and larger.
    e. Adjustable frequency drive motor load classification (for example, variable torque) and minimum allowable motor speed for that load classification.
    f. Guaranteed minimum full load efficiency and power factor.
4. Enclosure type and mounting (such as, horizontal, vertical).
5. Dimensions and total weight.


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6. Conduit box dimensions and usable volume as defined in NEMA MG 1 and NFPA 70.
7. Bearing type.
8. Bearing lubrication.
9. Bearing life.
10. Space heater voltage and watts.
11. Description, ratings, and wiring diagram of motor thermal protection.
12. Motor sound power level in accordance with NEMA MG 1.
13. Maximum brake horsepower required by the equipment driven by the motor.
14. Description and rating of submersible motor moisture sensing system.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Factory test reports.
3. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
4. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
5. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

## PART 2 PRODUCTS

### 2.01 MANUFACTURERS

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

1. ABB/Baldor.
2. Nidec/ U.S. Electrical Motors.
3. TECO-Westinghouse Motor Co.
4. Toshiba International Corp., Industrial Division.
5. WEG Electric Motors Corp.

### 2.02 GENERAL

A. For multiple units of the same type of equipment, furnish identical motors and accessories of a single manufacturer.


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B. In order to obtain single source responsibility, use a single supplier to provide drive motor, its driven equipment, and specified motor accessories.

C. Meet requirements of NEMA MG 1.

D. For motors used in hazardous (classified) locations, Class I, Division 1, Groups B, C, and D, and Class II, Division 1, Groups E, F, and G provide motors that conform to UL 674 and have an applied UL listing mark.

E. Provide motors specifically designed for the use and conditions intended, with a NEMA design letter classification to fit the application.

F. Lifting lugs on motors weighing 100 pounds or more.

G. Operating Conditions:

1. Maximum ambient temperature not greater than 40 degrees C.
2. Provide motors suitable for operating conditions without reduction in nameplate rated horsepower or exceeding rated temperature rise.
3. Overspeed in either direction in accordance with NEMA MG 1.

2.03 HORSEPOWER RATING

A. As designated in motor-driven equipment specification.

B. Constant Speed Applications: Brake horsepower of driven equipment at any head capacity point on pump curve not to exceed motor nameplate horsepower rating, excluding service factor.

C. Adjustable Frequency and Adjustable Speed Applications (Inverter Duty Motor, Inverter Ready Motor): Driven equipment brake horsepower at any head capacity point on pump curve not to exceed motor nameplate horsepower rating, excluding service factor.

2.04 SERVICE FACTOR

A. Inverter-Duty Motors: 1.0 at rated ambient temperature, unless otherwise noted.

B. Other Motors: 1.15 minimum at rated ambient temperature, unless otherwise noted.


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## 2.05 VOLTAGE AND FREQUENCY RATING

A. System Frequency: 60 Hz.

B. Voltage Rating:

1. Unless otherwise indicated in motor-driven equipment specification:

| Voltage Rating | | |
|---|---|---|
| **Size** | **Voltage** | **Phase** |
| 1/2 hp and smaller | 115 | 1 |
| 3/4 hp through 400 hp | 460 | 3 |

C. Suitable for full voltage starting.

D. Suitable for accelerating the connected load with supply voltage at motor starter supply terminals dipping to 90 percent of motor rated voltage.

## 2.06 EFFICIENCY AND POWER FACTOR

A. For all motors except single-phase, under 1 hp, multispeed, short-time rated and submersible motors, or motors driving gates, valves, elevators, cranes, trolleys, and hoists:

1. Efficiency:
   a. Tested in accordance with NEMA MG 1, Paragraph 12.59.
   b. Guaranteed minimum at full load in accordance with NEMA MG 1 Table 12-12, Full-load Efficiencies for NEMA Premium Efficiency Electric Motors Rated 600 Volts or Less (Random Wound), or as indicated in motor-driven equipment specification.
2. Power Factor: Guaranteed minimum at full load shall be manufacturer's standard or as indicated in motor-driven equipment specification.

## 2.07 LOCKED ROTOR RATINGS

A. Locked rotor kVA Code G or lower, if motor horsepower not covered by NEMA MG 1 tables.

B. Safe Stall Time: 12 seconds or greater.

## 2.08 INSULATION SYSTEMS

A. Single-Phase, Fractional Horsepower Motors: Manufacturer's standard winding insulation system.


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B. Three-phase and Integral Horsepower Motors: Unless otherwise indicated in motor-driven equipment specification, Class F with Class B rise at nameplate horsepower and designated operating conditions, except provide Class B with Class B rise insulation for EXP and DIP motors.

2.09 ENCLOSURES

A. Conform to NEMA MG 1.

B. TEFC and TENV: Furnish with drain hole with porous drain/weather plug.

C. Explosion-Proof (EXP):

1. TEFC listed to meet UL 674 and NFPA 70 requirements for Class I, Division 1, Group D hazardous locations.
2. Drain holes with drain and breather fittings.
3. Integral thermostat opening on excessive motor temperature in accordance with UL 2111 and NFPA 70.
4. Terminate thermostat leads in terminal box separate from main terminal box.

D. Dust-Ignition-Proof (DIP):

1. TEFC listed to meet UL 674 and NFPA 70 requirements for Class II, Division 1, Group G.
2. Integral thermostat opening on excessive motor temperature in accordance with UL 2111 and NFPA 70.
3. Thermostat leads to terminate in a terminal box separate from main terminal box.

E. Submersible: In accordance with Article Special Motors.

F. Chemical Industry, Severe-Duty (CISD-TEFC): In accordance with Article Special Motors.

2.10 TERMINAL (CONDUIT) BOXES

A. Oversize main terminal boxes for motors.

B. Diagonally split, rotatable to each of four 90-degree positions. Threaded hubs for conduit attachment.

C. Except ODP, furnish gaskets between box halves and between box and motor frame.


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D. Minimum usable volume in percentage of that specified in NEMA MG 1, Section 1, Paragraph 4.19, and NFPA 70, Article 430:

| Terminal Box Usable Values | | |
|---|---|---|
| **Voltage** | **Horsepower** | **Percentage** |
| Below 600 | 15 through 125 | 500 |
| Below 600 | 150 through 300 | 275 |
| Below 600 | 350 through 600 | 225 |

E. Terminal for connection of equipment grounding wire in each terminal box.

F. Coordinate motor terminal box conduit entries versus size and quantity of conduits shown on the Drawings.

2.11 BEARINGS AND LUBRICATION

A. Horizontal Motors:

1. 3/4 hp and Smaller: Permanently lubricated and sealed ball bearings, or regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
2. 1 hp through 400 hp: Regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
3. For Direct Drive Equipment: Minimum 100,000 hours L-10 bearing life for ball and roller bearings as defined in ABMA 9 and ABMA 11.
4. For Belt Driven Equipment: Minimum 30,000 hours L-10 bearing life for ball and roller bearings as defined in ABMA 9 and ABMA 11.

B. Vertical Motors:

1. Thrust Bearings:
   a. Antifriction bearing.
   b. Manufacturer’s standard lubrication 100 hp and smaller.
   c. Oil lubricated 125 hp and larger.
   d. Minimum 50,000 hours L-10 bearing life.
2. Guide Bearings:
   a. Manufacturer’s standard bearing type.
   b. Manufacturer’s standard lubrication 200 hp and smaller.
   c. Oil lubricated 250 hp and larger.
   d. Minimum 100,000 hours L-10 bearing life.


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C. Regreasable Antifriction Bearings:

1. Readily accessible, grease injection fittings.
2. Readily accessible, removable grease relief plugs.

D. Oil Lubrication Systems:

1. Oil reservoirs with sight level gauge.
2. Oil fill and drain openings with opening plugs.
3. Provisions for necessary oil circulation and cooling.

E. Inverter Duty Rated Motors Larger than 50 hp, Bearing Isolation: Provide electrically isolated bearings to prevent stray current damage.

2.12 NOISE

A. Measured in accordance with NEMA MG 1.

B. Maximum Sound Level for Motors Controlled by Adjustable Frequency Drive Systems: 3 dBA higher than NEMA MG 1.

2.13 BALANCE AND VIBRATION CONTROL

A. In accordance with NEMA MG 1, Part 7.

2.14 EQUIPMENT FINISH

A. Protect Motor for Service Conditions:

1. ODP Enclosures: Indoor industrial atmospheres.
2. Other Enclosures: Outdoor industrial atmospheres, including moisture and direct sunlight exposure.

B. External Finish: Prime and finish coat manufacturer’s standard.

C. Internal Finish: Bore and end turns coated with clear polyester or epoxy varnish.

2.15 SPECIAL FEATURES AND ACCESSORIES

A. Screen Over Air Openings: Stainless steel on motors with ODP, WPI, and WPII enclosures meeting requirements for guarded machine in NEMA MG 1, and attached with stainless steel screws.


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B. Winding Thermal Protection:

1. Thermostats:
   a. Motors for constant speed application 5 hp through 40 hp.
   b. Bi-metal disk or rod type thermostats embedded in stator windings.
   c. Automatic reset contacts rated 120V ac, 5 amps minimum, opening on excessive temperature. (Provide manual reset at motor controller).
2. Thermistors:
   a. Motors for constant speed application 40 hp through 250 hp. Motors for adjustable speed application 5 hp through 250 hp.
   b. Thermistor embedded in each stator phase winding before winding dip and bake process.
   c. In intimate contact with winding conductors.
   d. Epoxy-potted, solid-state thermistor control module for mounting in motor controller cabinet.
   e. Control module rated for 120V ac power supply.
   f. Control module automatically reset contact for external use rated 120V ac, 5 amps minimum, opening on abnormally high winding temperature. Provide manual reset at motor controller.

C. Space Heaters:

1. Provide winding space heaters with leads wired out to motor terminal box for less than 100 hp; separate terminal box for greater than 100 hp.
2. Provide extra hole or hub on motor terminal box as required.
3. Unless shown otherwise, heater shall be suitable for 120V ac supply, with wattage suitable for motor frame size.

D. Nameplates:

1. Raised or stamped letters on stainless steel or aluminum.
2. Display motor data required by NEMA MG 1, Paragraph 10.39 and Paragraph 10.40 in addition to bearing numbers for both bearings.
3. Premium efficiency motor nameplates to display NEMA nominal efficiency, guaranteed minimum efficiency, full load power factor, and maximum allowable kVAR for power factor correction capacitors.

E. Anchor Bolts: Provide meeting manufacturer’s recommendations and of sufficient size and number for specified seismic condition.

## 2.16 SPECIAL MOTORS

A. Requirements in this article take precedence over conflicting features specified elsewhere in this section.


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B. Chemical Industry, Severe-Duty (CISD-TEFC):

1. In accordance with IEEE 841.
2. TEFC in accordance with NEMA MG 1.
3. Suitable for indoor or outdoor installation in severe-duty applications including high humidity, chemical (corrosive), dirty, or salty atmospheres.
4. Motor Frame, End Shields, Terminal Box, and Fan Cover: Cast iron.
5. Ventilating Fan: Corrosion-resistant, nonsparking, external.
6. Drain and Breather Fittings: Stainless steel.
7. Nameplate: Stainless steel.
8. Gaskets between terminal box halves and terminal box and motor frame.
9. Extra slinger on rotor shaft to prevent moisture seepage along shaft into motor.
10. Double shielded bearings.
11. 125,000 hours minimum L-10 bearing life for direct-connected loads.
12. External Finish: Double-coated epoxy enamel.
13. Coated rotor and stator air gap surfaces.
14. Insulation System, Windings, and Connections:
    a. Class F insulation, Class B rise or better at 1.0 service factor.
    b. Multiple dips and bakes of nonhygroscopic polyester varnish.
15. Service Factor:
    a. At 40 Degrees C Ambient: 1.15.
    b. At 65 Degrees C Ambient: 1.00.
16. Safe Stall Time Without Injurious Heating: 20 seconds minimum.

C. Severe-duty Explosion-proof: Meet requirements for EXP enclosures and CISD-TEFC motors.

D. Severe-duty, Dust-ignition-proof: Meet requirements for DIP enclosures and CISD-TEFC motors.

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

F. Inverter Duty Motor:

1. Motor Supplied Power by Adjustable Voltage and Adjustable Frequency Drives: Inverter duty rated in accordance with NEMA Parts 30 and 31.
2. Provide winding insulation rated 1,600 peak volts, minimum.
3. Meet or exceed NEMA MG 1 corona inception voltage rating.
4. Provide one insulated bearing.
5. Suitable for operation over entire speed range indicated.


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6. Provide forced ventilation where speed ratio is greater than published range for motor provided.
7. When installed in Division 2 hazardous (classified) locations, provide motor identified by manufacturer as suitable for use with a variable speed drive in a Division 2 location.
8. Shaft Grounding Device, Motors Larger than 20 hp: Furnish with shaft grounding brush or conductive micro fiber shaft grounding ring solidly bonded to grounded motor frame in accordance with manufacturer's recommendations.
    a. Manufacturer:
        1) Grounding Ring: EST-Aegis.

G. Submersible Pump Motor:

1. Manufacturers:
    a. Reliance Electric.
    b. Xylem Flygt Corp.
2. At 100 Percent Load:
    a. Motors with Speeds Less than 1,200 rpm: Manufacturer's standard.
    b. Motors with Speeds 1,200 rpm and Greater:

| **Submersible Pump Motors** | | |
|---|---|---|
| **Horsepower** | **Guaranteed Minimum Efficiency** | **Guaranteed Minimum Power Factor** |
| 5 through 10 | 80 | 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.


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b. Switches normally closed, open upon excessive winding temperature, and automatically reclose when temperature has cooled to safe operating level.
c. Switch contacts rated at 5 amps, 120V ac.

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 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 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.
    b. Each cable suitable for hard service, submersible duty with watertight seal where cable enters motor.
    c. Length: 50 feet minimum.
    d. UL 83 listed and sized in accordance with NFPA 70.

## 2.17 FACTORY TESTING

A. Tests:

1. In accordance with IEEE 112 for polyphase motors.
2. Routine (production) tests in accordance with NEMA MG 1. Test multispeed motors at all speeds.
3. For energy efficient motors, test efficiency and power factor at 50 percent, 75 percent, and 100 percent of rated horsepower:
   a. In accordance with IEEE 112, Test Method B, and NEMA MG 1, Paragraph 12.59. and Paragraph 12.60.
   b. For motors 500 hp and larger where facilities are not available to test by dynamometer (Test Method B), determine efficiency by IEEE 112, Test Method F.
   c. On motors of 100 hp and smaller, furnish certified copy of motor efficiency test report on an identical motor.
4. Provide test reports for all polyphase motors.


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B. Test Report Forms:

1. Routine Tests: IEEE 112, Form A-1.
2. Efficiency and power factor by Test Method B, IEEE 112, Form A-2, and NEMA MG 1, Table 12-12.
3. Temperature Test: IEEE 112, Form A-2.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. In accordance with manufacturer's instructions and recommendations.

B. Align motor carefully and properly with driven equipment.

C. Secure equipment to mounting surface with anchor bolts.

### 3.02 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection, equipment testing, and startup assistance.

**END OF SECTION**


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# SECTION 26 22 00
# LOW-VOLTAGE TRANSFORMERS

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. Code of Federal Regulations (CFR): 10 CFR Part 431, DOE 2016 efficiency.
2. Institute of Electrical and Electronics Engineers (IEEE):
   a. C57.96, Guide for Loading Dry Type Transformers.
   b. C57.12.91, Test Code for Dry Type Distribution and Power Transformers.
   c. C57.12.01, General Requirements for Dry-Type Distribution and Power Transformers Including Those with Solid Cast and/or Resin-Encapsulated Windings.
3. National Electrical Contractor's Association (NECA): 409, Recommended Practice for Installing and Maintaining Dry-Type Transformers.
4. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. ST 20, Dry-Type Transformers for General Applications.
5. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
6. UL:
   a. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   b. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   c. 1561, Standard for Dry-Type, General Purpose, and Power Transformers.

### 1.02 SUBMITTALS

A. Action Submittals:

1. Descriptive information.
2. Dimensions and weight.
3. Transformer nameplate data, including efficiency.
4. Schematic and connection diagrams.


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B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Test Report: Sound test certification for dry type power transformers (0-volt to 600 volts, primary).
3. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.

## PART 2 PRODUCTS

2.01 GENERAL

A. UL 1561, NEMA ST 20, unless otherwise indicated.

B. Dry-type, self-cooled, two-winding, with copper windings.

C. Units larger than 5 kVA suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

D. Efficiency: Meet or exceed DOE 2016 efficiency requirements.

E. Maximum Sound Level per NEMA ST 20:

1. 40 decibels for 0 kVA to 9 kVA.
2. 45 decibels for 10 kVA to 50 kVA.
3. 50 decibels for 51 kVA to 150 kVA.
4. 55 decibels for 151 kVA to 300 kVA.
5. 60 decibels for 301 kVA to 500 kVA.

F. Overload Capability: Short-term overload per IEEE C57.96.

G. Wall Bracket: For single-phase units, 15 kVA to 37-1/2 kVA, and for three-phase units, 15 kVA to 30 kVA.

H. Vibration Isolators:

1. Rated for transformer’s weight.
2. Isolation Efficiency: 99 percent, at fundamental frequency of sound emitted by transformer.
3. Less Than 30 kVA: Isolate entire unit from structure with external vibration isolators.
4. 30 kVA and Above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator.


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I. Manufacturers:

1. ABB.
2. Schneider Electric/Square D.
3. Eaton.

2.02 GENERAL PURPOSE TRANSFORMER

A. Insulation Class and Temperature Rise: Manufacturer's standard.

B. Core and Coil:

1. Encapsulated for single-phase units 1/2 kVA to 25 kVA and for three-phase units 3 kVA to 15 kVA.
2. Thermosetting varnish impregnated for single-phase units 37.5 kVA and above, and for three-phase units 30 kVA and above.

C. Enclosure:

1. Single-Phase, 3 kVA to 25 kVA: NEMA 250, Type 3R, nonventilated.
2. Single-Phase, 37-1/2 kVA and Above: NEMA 250, Type 2, ventilated.
3. Three-Phase, 3 kVA to 15 kVA: NEMA 250, Type 3R, nonventilated.
4. Three-Phase, 30 kVA and Above: NEMA 250, Type 2, ventilated.
5. Outdoor Locations: NEMA 250, Type 3R.
6. Corrosive Locations: NEMA 250, Type 3R stainless steel.

D. Voltage Taps:

1. Single-Phase, 3 kVA to 10 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
2. Single-Phase, 15 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
3. Three-Phase, 3 kVA to 15 kVA: 2-1/2 percent, full capacity; two above and two below normal voltage rating.
4. Three-Phase, 30 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.

E. Impedance: 1.9 percent minimum on units 75 kVA and larger.

**PART 3 EXECUTION**

3.01 INSTALLATION

A. Install in accordance with NECA and manufacturer's instructions.

B. Load external vibration isolator such that no direct transformer unit metal is in direct contact with mounting surface.


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C. Provide moisture-proof, flexible conduit for electrical connections.

D. Connect voltage taps to achieve (approximately) rated output voltage under normal plant load conditions.

E. Provide wall brackets for single-phase units, 15 kVA to 167-1/2 kVA, and three-phase units, 15 kVA to 30 kVA.

**END OF SECTION**


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# SECTION 26 24 16
# PANELBOARDS

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. National Electrical Contractor's Association (NECA): 407, Recommended Practice for Installing and Maintaining Panelboards.
2. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. 289, Application Guide for Ground Fault Circuit Interrupters.
   c. KS 1, Enclosed Switches.
   d. PB 1, Panelboards.
   e. PB 1.1, General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
4. UL:
   a. 67, Standard for Panelboards.
   b. 98, Standard for Enclosed and Dead-Front Switches.
   c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   d. 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   e. 508, Standard for Industrial Control Equipment.
   f. 870, Wireways, Auxiliary Gutters and Associated Fittings.
   g. 943, Ground-Fault Circuit-Interrupters.
   h. 1699, Standard for Arc-Fault Circuit-Interrupters.

### 1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's data sheets for each type of panelboard, protective device, accessory item, and component.
2. Manufacturer's Shop Drawings including dimensioned plan, section, and elevation for each panelboard type, enclosure, and general arrangement.
3. Tabulation of features for each panelboard to include the following:
   a. Protective devices with factory settings.
   b. Provisions for future protective devices.


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c. Space for future protective devices.
d. Voltage, frequency, and phase ratings.
e. Enclosure type.
f. Bus and terminal bar configurations and current ratings.
g. Provisions for circuit terminations with wire range.
h. Short circuit current rating of assembled panelboard at system voltage.
i. Features, characteristics, ratings, and factory settings of auxiliary components.
j. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's recommended installation instructions.
3. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
4. Circuit directory spreadsheet with final location of each breaker and load in excel format.

1.03 QUALITY ASSURANCE

A. Listing and Labeling: Provide products specified in this section that are listed and labeled as defined in NEC Article 100.

**PART 2 PRODUCTS**

2.01 MANUFACTURERS

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

1. Schneider Electric/Square D Co.
2. Eaton/Cutler-Hammer.
3. ABB.

B. Panelboards shall be of the same manufacturer as equipment furnished under Section 26 24 19, Low-Voltage Motor Control.



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## 2.02 GENERAL

A. Provide equipment in accordance with NEMA PB 1, NFPA 70, and UL 67.

B. Wire Terminations:

1. Provide panelboard assemblies, including protective devices, suitable for use with 75 degrees C or greater wire insulation systems at NFPA 70, 75 degrees C conductor ampacity, and in accordance with UL 486E.
2. Lugs for termination of conductors shall comply with Section 26 05 05, Conductors.
3. Lugs for termination of copper feeder phase and neutral conductors shall be replaceable, bolted mechanical or crimp compression type

C. Load Current Ratings:

1. Unless otherwise indicated, load current ratings for panelboard assemblies, including bus and circuit breakers, are noncontinuous as defined by NEC. Continuous ratings shall be 80 percent of noncontinuous rating.
2. Where indicated “continuous” or “100 percent,” selected components and protective devices shall be rated for continuous load current at value shown.

D. Short Circuit Current Rating (SCCR):

1. Integrated equipment short circuit rating for each panelboard assembly shall be no less than the following:
   a. Minimum SCCR at 208Y/120 or 120/240 volts shall be 10,000 amperes rms symmetrical.
   b. Minimum SCCR at 480Y/277 volts shall be 22,000 amperes rms symmetrical.

E. Series-Connected Short Circuit Current Ratings: Panelboards shall be fully rated; application of series-connected device ratings is unacceptable.

## 2.03 OVERCURRENT PROTECTIVE DEVICES

A. Overcurrent Device Mounting and Arrangement: Design panelboards to accommodate device installation and replacement without disturbing adjacent devices and without removing main bus.

B. Overcurrent Protective Devices: In accordance with NEMA KS 1, UL 98, and UL 489. Protective devices shall be adapted to panelboard installation.


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C. Provisions for Future Overcurrent Device:

1. Provide space, mountings, and bus connections such that like device may be installed without additional hardware.
2. Panel openings shall be closed with individual removable cover for each provision for future device.
3. Unless otherwise indicated, “spaces” in panelboards shall be fully equipped provision for future like devices.
4. Provisions for future devices shall be suitable devices rated no less than 60 amperes.

D. Protective Device Locking: Furnish provisions for handle padlocking for main and subfeed breakers.

E. Branch Protective Devices:

1. Provide Wire Lug Load Connections: Mechanical or crimp compression type removable/replaceable, and suitable for 75 degrees C rated conductors without derating switch nor conductor ampacity.
2. Provide a nameplate for each circuit, blanks for spares.

## 2.04 CIRCUIT BREAKERS

A. General: Thermal-magnetic unless otherwise indicated, quick-make, quick-break, molded case, of indicating type showing ON/OFF and TRIPPED positions of operating handle. Circuit breakers shall comply with Section 26 05 04, Basic Electrical Materials and Methods.

B. Bus Connection: Bolt-on circuit breakers in 480Y/277-volt, and plug-in circuit breakers in 208Y/120 and 240/120-volt panelboards.

C. Trip Mechanism:

1. Individual permanent thermal and magnetic trip elements in each pole.
2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
3. Two and three pole, common trip.
4. Automatically opens all poles when overcurrent occurs on one pole.
5. Test button on cover.
6. Calibrated for 40 degrees C ambient, unless shown otherwise.

D. Unacceptable Substitution:

1. Do not substitute single-pole circuit breakers with handle ties for multi-pole breakers.
2. Do not use tandem or dual circuit breakers in normal single-pole spaces.



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E. Specialty Breakers:

1. Where indicated, provide breakers with the following features:
   a. Ground Fault Circuit Interrupter (GFCI): Rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel). Ground fault sensor shall be rated same as circuit breaker. Breaker shall include push-to-test and reset buttons.
   b. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker with ground fault sensor and rated to trip on 30-mA ground fault (UL listed for equipment ground fault protection).
   c. Arc Fault Circuit Interrupter (AFCI): Where indicated, equip breaker with arc fault sensor to detect and trip the circuit breakers when an arcing fault occurs (UL 1699 listed).

2.05 ENCLOSURES

A. General:

1. Provide as specified in Section 26 05 04, Basic Electrical Materials and Methods.
2. Type 1, Type 3R, and Type 3S material code-gauge, hot-dip galvanized sheet steel with reinforced steel frame.
3. Provide surface-mount panelboard from trim with same dimensions as box front.

B. Finish: Rust inhibitor prime followed by manufacturer’s standard gray baked enamel or lacquer. NEMA Type 1 enclosure box may be unfinished galvanized sheet steel.

C. NEMA 250 Type 1 Branch Panelboard Enclosure:

1. Secure front trim to box with concealed trim clamps.
2. Overlap flush panelboards front trims with box nominal 3/4-inch on all sides.
3. Provide door in panelboard front trim, with concealed hinges, to access protective device operating handles.
4. Provide multi-point latching for doors over 30 inches in height.
5. Door Lock: Secure with flush catch and tumbler lock; all panelboards keyed alike, with two milled keys each lock.
6. Circuit Directory: Metal frame with transparent plastic face and enclosed card, mounted inside each panel door.


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7. For 480V Column-Type Panelboard Configuration: Narrow cabinet extended as wireway to overhead junction box equipped with ground and neutral terminal buses.
8. For 120V Hinged Front Cover (Door In Door): Entire front trim hinged to surface box with standard door within hinged trim cover.

D. Multi-Section Panelboards: Where more than one section is required, provide multiple panelboard sections with separate fronts.

1. Sections shall be suitable for individual mounting to be field interconnected to form a single electrical unit.
2. Recessed-mount sections of the same panel shall all have the same size tubs and flush covers.
3. Surface-mount multi-section panelboards may be comprised of sections of unequal heights.
4. Provide feed-through and main lugs in individual sections as required for field assembly of a complete multi-section panelboard. Unless otherwise indicated, provide feed-through lugs on each section but last.
5. Provide neutral and ground terminal bars in each section.

## 2.06 BUSSING AND TERMINAL BARS

A. Bus:

1. Material: Tin-plated copper full sized throughout length.
2. Provide for mounting of future protective devices along full length of bus regardless of number of units and spaces shown. Machine, drill, and tap as required for current and future positions.

B. Equipment Ground Terminal Bus: Copper with suitably sized provisions for termination of ground conductors, and bonded to box.

1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
2. Provide individual termination points for all other grounding conductors such as feeder and grounding electrode.
3. Termination points shall be bolted crimp compression lugs for conductors 6 AWG and larger.

C. Neutral Terminal Bus: Copper with suitably sized provisions for termination of neutral conductors, and isolated from box.

1. Provide individual mechanical termination points no less than the quantity of breaker pole positions.
2. Provide individual termination points for all other neutral conductors.



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3. Termination Points: Bolted crimp compression lugs for conductors 6 AWG and larger.

D. Provision for Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances for future protective device ampere ratings indicated.

2.07 SPECIAL FEATURES

A. General: Where indicated on the Drawings or schedules, provide special features as specified.

B. Extra Gutter Space: Dimensions and arrangement indicated.

C. Gutter Barrier: Arranged to isolate section of gutter as shown.

D. Surge Arresters:

1. Comply with Section 26 43 00, Surge Protection Devices.
2. Provide protective device within panelboard as disconnecting means and short circuit protection per manufacturer's recommendation.
3. Provide factory mounting within panelboard utilizing UL-recognized mounting device.

**PART 3 EXECUTION**

3.01 GENERAL

A. Install in accordance with NECA 407, NEMA PB 1.1, and manufacturers' written installation instructions.

B. Install securely, plumb, in-line and square with walls.

C. Install top of cabinet trim 78 inches above floor, unless otherwise shown. Install cabinet so tops of protective device operating handles are no more than 78 inches above the floor.

D. Ground Fault Protection: Install panelboard ground fault circuit interrupter devices in accordance with installation guidelines of NEMA 289.

E. Install filler plates in unused spaces.

F. Wiring in Panel Gutters: Train conductors neatly in groups; bundle and wrap with nylon wire ties.

G. Mount flush panels uniformly flush with wall finish.


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H. Provide typewritten circuit directory for each panelboard.

1. Submit an excel circuit directory to the client.

I. Provision for Future Circuits at Flush Panelboards: Stub four 1-inch empty conduits from panel into accessible ceiling space or space designated to be ceiling space in future. Stub four 1-inch empty conduits into raised floor space or to accessible location below slab above grade.

J. Provide engraved identification for each protective device.

**END OF SECTION**


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# SECTION 26 24 19
# LOW-VOLTAGE MOTOR CONTROL

## PART 1 GENERAL

### 1.01 REFERENCES

A. The following is a list of standards which shall be followed for this section:

1. Institute of Electrical and Electronics Engineers (IEEE):
   a. C2, National Electrical Safety Code (NESC).
   b. C37.20.7, Guide for Testing Metal Enclosed Switchgear Rated up to 38 kV for Internal Arcing Faults.
2. National Electrical Contractors Association (NECA): 402, Standard for Installing and Maintaining Motor Control Centers.
3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 volts maximum).
   b. ICS 1, Industrial Control and Systems: General Requirements.
   c. ICS 2, Controllers, Contactors, and Overload Relays Rated 600 Volts.
   d. ICS 2.3, Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers Rated Not More Than 600V.
   e. ICS 18, Motor Control Centers.
   f. KS 1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. UL:
   a. 98, Enclosed and Dead-Front Switches.
   b. 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   c. 845, Motor Control Centers.

### 1.02 DEFINITIONS

A. LCD: Liquid Crystal Display.

B. N.C.: Normally Closed.

C. N.O.: Normally Open.

D. SPD: Surge Protection Device.


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## 1.03 SUBMITTALS

A. Action Submittals:

1. Descriptive information.
2. Itemized Bill of Material.
3. Dimensional drawings.
4. Front Panel Elevations.
5. Conduit entrance locations.
6. Bus data.
7. Protective Devices: Copies of time-current characteristics.
8. Interior Network/Communication cabling and components.
9. Communications protocol setup and parameter setting information for plant control system communication programming.
10. Anchoring instructions and details.
11. Typed Tabulation:
    a. Motor name; tag (equipment) numbers as shown on the Drawings.
    b. Motor horsepower.
    c. Nameplate full load current.
    d. Measured load current and voltage.
    e. Overload model number and setting.
    f. Protective device trip settings.
    g. Manufacturer’s solid state starter switch or dip switch or program settings.
    h. Attach above typed, tabulated data to a copy of starter manufacturer’s overload relay or setting selection tables for starters provided.
12. Control diagrams.
13. One-line diagrams.
14. Schematic (elementary) diagrams.
15. Outline diagrams.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer’s installation instructions.
3. Factory test reports, certified.
4. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

## 1.04 QUALITY ASSURANCE

A. Provide products manufactured within scope of UL that conform to UL Standards and have applied UL Listing Mark.


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1.05 DELIVERY, STORAGE, AND HANDLING

A. Shipping Splits: Established by Contractor to facilitate ingress of equipment to final installation location within building.

**PART 2 PRODUCTS**

2.01 MANUFACTURERS

A. Provide materials, equipment, and accessories specified in this section manufactured by:

1. Schneider Electric/Square D Services.
2. Eaton Electrical/Cutler-Hammer.
3. ABB/GE Industrial Systems.

2.02 GENERAL

A. Like Items of Equipment: End product of one manufacturer and same manufacturer as panelboards for standardization.

B. Make adjustments necessary to wiring, conduit, disconnect devices, motor starters, branch circuit protection, and other affected material or equipment to accommodate motors actually provided under this Contract.

C. Controllers: NEMA ICS 1, NEMA ICS 2, Class A.

D. Control Transformer:

1. Two winding, 120-volt secondary, primary voltage to suit.
2. Two current-limiting fuses for primary circuit.
3. One fuse in secondary circuit with blown fuse indicator.
4. Mount within starter unit.

E. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

F. Lifting lugs on equipment and devices weighing over 100 pounds.

G. Anchor Bolts: Type 316 stainless steel.

H. Operating Conditions:

1. Ambient Temperature: Maximum 40 degrees C.
2. Altitude: 700 feet above sea level.
3. Equipment to be fully rated.


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I. Enclosures: In accordance with NEMA 250.

J. Equipment Finish:

1. Electrocoating process applied over rust-inhibiting phosphated base coating.
2. Exterior Color: Light gray or Manufacturer's standard.

## 2.03 MOTOR CONTROL CENTERS

A. General:

1. In accordance with NEMA ICS 1, NEMA ICS 2, NEMA ICS 18, and UL 845.
2. Voltage Rating: 600 volts.
3. Provide an Ethernet/IP communications network within the motor control center to interconnect adjustable frequency drives, and metering devices equipped with communications.
4. Provide network devices, cabling, and connectors ODVA compliant for Ethernet/IP networks.
5. Short Circuit Rating: 42,000 amperes rms symmetrical at 480 volts for entire motor control center as a complete assembly.
6. Main and branch circuit breakers, controllers, wire connections, and other devices to be front mounted and accessible, unless otherwise noted.
7. NEMA ICS 18, Part 3.
   a. Class: II.
   b. Type: B.

B. Enclosure:

1. Type: NEMA 250, Type 1, indoor gasketed.
2. Vertical Section Standard Indoor Dimensions for NEMA 1 Type:
   a. Nominal, 90 inches high, 20 inches wide, 21 inches deep.
   b. Alternative width dimensions of 24 inches and 30 inches are acceptable for oversize devices or panels.
   c. Do not exceed space shown.
3. Construction:
   a. Sheet steel reinforced with channel or angle irons.
   b. Butt sections flush, end-to-end against similar section without bolts, nuts, or cover plates causing interference.
   c. Removable top cover plates and bottom cover plates.
   d. Removable plates on end panels for future bus extension.
4. Section Mounting: Removable formed-steel channel sills and lifting angles.


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5. Horizontal Wiring Compartments: Accessible from front, full width, top and bottom.
6. Vertical Wiring Compartment:
   a. Full height, isolated from unit starters with separate hinged door and tie supports.
   b. No terminal blocks allowed in vertical wireway compartment.
7. Unit Compartment: Individual compartments separated by steel barriers for each starter, feeder, or other unit capable of being wired from front without unit removal.
8. Compartment Doors: Separate hinged doors for each starter, feeder, or other unit.
9. Door Interlocking: Mechanically interlock starter and feeder doors so doors cannot be opened with unit energized. Provide defeater mechanism to allow intentional access and energizing at any time by qualified individual.
10. External disconnect handles with ON/OFF and trip positions showing, padlockable in OFF position with up to three-lock capability.
11. Cable Entrance at Compost Admin Building: Main leads enter from bottom; control and feeder circuits enter from bottom.
12. Cable Entrance at Dewatering Building: Main leads enter from top; control and feeder circuits enter from top.

C. Bus:

1. Horizontal Power Bus:
   a. Three-phase tin-plated, copper, entire width of control center, rated as shown.
   b. Tin or silver-plated at joints.
   c. Construct to allow future extension of additional sections.
   d. Pressure type solderless lugs for each incoming line cable.
   e. Isolated from top horizontal wireway.
   f. Provide Belleville washers on bus connection bolts.
2. Vertical Power Bus:
   a. Three-phase tin-plated, copper, full height of section, rated a minimum 600 amperes.
   b. Sandwich type bus insulation providing deadfront construction with starter units removed except for bus stab openings.
   c. Insulated and isolated barrier, complete with shutters.
   d. Provide Belleville washers on bus connection bolts.
3. Neutral Bus: None.
4. Ground Bus: Copper, tin-plated, entire width of control center.
5. Bus Bracing: 65,000 amperes rms symmetrical.


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D. Motor Controller Unit:

1. Provide indicated individual components and control devices including pushbuttons, selector switches, indicating lights, control relays, time delay relays, and elapsed time meters as specified in Section 26 05 04, Basic Electrical Materials and Methods.
2. Construction:
   a. Drawout combination type with stab connections for starters NEMA ICS, Size 5 and smaller.
   b. Bolt-on combination type with cable connection to riser for starters NEMA ICS, Size 6 and larger.
   c. Readily interchangeable with starters of similar size.
   d. Pull-apart unit control wiring terminal boards capable of accepting up to two 14 AWG wires minimum on all units.
3. Motor Controller Communications:
   a. Communicate the following commands and status with the plant control system via the Ethernet/IP network:
      1) Receive Commands:
         a) RUN/STOP.
         b) SPEED (Adjustable Frequency Drives Only).
         c) RUN PRESET SPEED (Adjustable Frequency Drives Only).
         d) RESET (Adjustable Frequency Drives Only).
      2) Status Feedback:
         a) STOPPED/RUNNING.
         b) LOCAL/REMOTE.
         c) SPEED (Adjustable Frequency Drives Only).
         d) POWER FAIL (Adjustable Frequency Drives Only).
         e) BACKUP MODE ACTIVE (Adjustable Frequency Drives Only).
         f) FAIL.
   b. Communication Devices: Connect to the Plant Control System as shown on the Network Block Diagrams in the Contract Documents.
4. Starters:
   a. NEMA ICS 18, standard rating, except none smaller than NEMA ICS, Size 1.
   b. Rating: Horsepower rated at 600 volt, UL labeled for 65,000 amperes at 480 volts short circuit capacity with overload protection.
   c. Three-phase, nonreversing, unless specified otherwise.
   d. Disconnect Type: Motor circuit protector.
   e. Combination Full Voltage, Magnetic Starter:
      1) Control: HAND/OFF/AUTO selector switch.
      2) Pilot Lights: Red–ON and Green–OFF.


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f. Combination Reduced Voltage, Solid State Starter:
   1) Control: HAND/OFF/AUTO selector switch.
   2) Bypass contactor.
   3) Class 10/20/30 electronic overload relay, switch, or dip switch selectable.
   4) Kick start, with adjustable torque and time settings.
   5) Ramp start, selectable current or torque, and adjustable time.
   6) Smooth stop ramp, adjustable time.
   7) Phase loss unbalance and phase reversal protection.
   8) LED display or LCD of fault, N.O. contact to communicate fault condition.

g. Combination Adjustable Frequency Drive, Solid State Starter: Drives as specified in Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.

h. Communications: Microprocessor interface capability to computer.

i. Padlockable operating handle when de-energized with up to three-lock capability.

j. Unit door interlocked to prevent opening when disconnect is in closed position.

k. Mechanical interlocked to prevent placing disconnect in ON position when unit door is open.

l. Minimum Dimensions: 12 inches high by full section width, less vertical wireway.

5. Disconnecting Device:
   a. As indicated.
   b. Padlockable in OPEN position for up to three locks.

6. Circuit Breaker:
   a. Meet requirements of UL 489.
   b. Molded case with manufacturer’s recommended trip setting for maximum motor protection.
   c. Thermal-magnetic trip or electronic trip as shown.
   d. Tripping indicated by operating-handle position.
   e. Interrupting capacity required for connection to system with short-circuit capacity indicated.
   f. Padlockable operating handle when de-energized with up to three-lock capability.

7. Solid State Motor Overload (SSOL) and Motor Management Relay:
   a. Protective Functions:
      1) Thermal overload.
      2) Phase loss, phase imbalance and phase failure.
      3) Power factor variation.
      4) Load fluctuations (current, voltage, power).
      5) Interface with motor temperatures protect relays (thermistor or thermostats).


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6) Locked rotor.
7) No load.

b. Metering Functions: Measure values of individual phase currents, average rms current voltage, motor temperature, and line frequency.

c. Statistic and Diagnostic Functions:
1) History of detected faults.
2) Motor statistics.
3) Warning of pending faults.

d. Reset: Manual via external reset button.

e. Provide a minimum of six discrete inputs and three discrete outputs.

f. Operator-Interface Unit: LCD Display and interface panel with contextual navigation keys for control, monitoring, and alarming functions. All protective, metering, statistic and diagnostic functions listed above shall be accessible through the operator-interface unit.

g. Mount within starter unit.

h. Communications: Shall communicate on MCC Ethernet/IP Data link as specified in MCC Network communication.

i. Manufacturers and Products:
1) Siemens; Simocode Pro.
2) Square D; Tesys T.

8. Motor Thermal Protector Interface: Manual-reset interposing relay for connection to motor-mounted thermal protector system.

9. Ground Fault Protection: Where indicated and as specified in Paragraph Main Protective Device and Feeder Units, except provide instantaneous operation device.

E. Control Unit:

1. Disconnecting Device: Pull-apart terminal blocks capable of de-energizing external source control circuits in unit.

2. Control Devices: As indicated and as specified in Section 26 05 04, Basic Electrical Materials and Methods.

3. Control Wiring:
a. Copper, 14 AWG, minimum.
b. Permanent sleeve type markers with wire numbers applied to each end of wires.
c. Terminate wires using insulated locking fork or ring type crimp terminals.
d. Terminate current transformer leads on shorting type terminal blocks.


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F. Incoming Line Terminal:

1. Construction: As specified in Paragraph Motor Controller Unit.
2. Incoming Service Feeder: Cable.
3. Mechanical type CU-/AL lugs for 75 degrees C cable.

G. Main Protective Device and Feeder Unit:

1. Construction: As specified in Paragraph Motor Controller Unit.
2. Incoming Service Feeder: Cable.
3. Solid State Trip Circuit Breaker:
   a. In accordance with UL 489.
   b. Main and feeder protective device where shown on the Drawings.
   c. UL labeled as suitable for service entrance where shown on the Drawings.
   d. Insulated or molded case breakers with ambient insensitive solid-state trips and having current sensors and logic circuits integral in breaker frame.
   e. Solid-state current control with adjustable ampere setting, adjustable long-time delay, adjustable short-time trip and delay band, fixed or adjustable instantaneous trip, and adjustable ground fault trip and delay band.
   f. Setting adjustments to be covered by a sealable, tamper-proof, transparent cover (insulated case breakers only) or by compartment door for other breakers).
   g. Locate trip button on front cover of breaker to permit mechanical simulation overcurrent tripping for test purposes and to trip breaker quickly in emergency situation.
4. Molded Case Circuit Breaker:
   a. In accordance with UL 489.
   b. Main and feeder protective device where shown on the Drawings.
   c. Thermal-magnetic trip and interrupting capacity required for connection to system with short circuit capacity indicated.
   d. Indicate tripping by operating-handle position.
   e. Suitable for use with 75 degrees C wire at full NEC 75 degrees C ampacity.
5. Ground Fault Protection:
   a. Suitable for 480-volt, three-phase, three-wire, solidly grounded wye system.
   b. Ground sensors to encircle phase conductors and neutral conductor where used, and connected to ground relays with adjustable pickup settings and time-current characteristics indicated.
   c. Circuit breaker shunt trip and relay operating from fused 120V ac control source within control center.


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d. Manufacturers and Products:
   1) Cutler-Hammer; GFR.
   2) General Electric; Ground Break GFM.

6. Phase Monitoring Relay:
   a. Three-phase monitoring relay to protect against low voltage, voltage unbalance, and phase reversal.
   b. Manufacturer and Products: Schneider Electric/Square D; Class 8430 Type MPS or Class 8430 Type MPD.

H. Digital Instruments:

1. Digital Power Meter:
   a. Microprocessor-based electronic monitoring package, complete with keypad or entry keys.
   b. Displays: Phase current, phase-to-phase and phase-to-neutral voltage, watts, volt amps, volt-amperes reactive, watt-hours, volt-ampere hours, volt-amperes reactive hours. Power factors frequency, percent THD, present demand current and watts; minimum and maximum current, voltage, watts, volt amperes, power factor and frequency.
   c. Communications: Ethernet.
      1) Data exchange: Phase current, phase-to-phase and phase-to-neutral voltage, watts, volt amps, volt-amperes reactive, watt-hours, volt-ampere hours, volt-amperes reactive hours. Power factors frequency, percent THD, present demand current and watts; minimum and maximum current, voltage, watts, volt amperes, power factor and frequency.
2. Ground Detection Lights: Heavy-duty oiltight type, with operation explanation nameplate.

I. SPD: As specified in Section 26 43 00, Surge Protection Devices.

J. Transformers: As specified in Section 26 22 00, Low-Voltage Transformers.

K. Panelboards: As specified in Section 26 24 16, Panelboards.

L. Pushbuttons, Indicating Lights, Selector Switches, Elapsed Time Meters, Control Relays, Time-Delay Relays, and Reset Timers: As specified in Section 26 05 04, Basic Electrical Materials and Methods.

M. Nameplates:

1. As specified in Section 26 05 02, Basic Electrical Requirements.
2. Provide for each motor control center and each unit.
3. Engrave with inscription shown on single-line diagram.


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4. Provide blank nameplates on spaces for future units.
5. Attach with stainless steel panhead screws on face of control center.

N. Space Heaters: Thermostatically controlled. Locate in bottom of each vertical section for operation from 120-volt power source derived internal to MCC.

## 2.04 SOURCE QUALITY CONTROL

A. Factory Testing:

1. Applicable Standards: NEMA ICS 18, UL 845, and NEC Article 430, Part VIII.
2. Perform standard factory inspection and tests in accordance with NEMA requirements to verify components have been designed to specification, assembled in accordance with applicable standards, and each unit functions in accordance with electrical diagrams.
3. Actual operation shall be performed wherever possible. Otherwise, inspect and perform continuity checks.
4. Verify component devices operated correctly in circuits as shown on diagrams or as called for in specification.
5. Control Circuits and Devices:
   a. Energize circuit at rated voltage.
   b. Operate control devices.
   c. Perform continuity check.
6. Instruments, Meters, Protective Relays, and Equipment:
   a. Verify devices functioned by energizing potential to rated values with connection to devices made at outgoing terminal blocks.
   b. Verify protective relays operated for functional checks and trips manually initiated to verify functioning of operation for indicator and associated circuits.
7. Perform dielectric tests on primary circuits and equipment, except potential transformers.
   a. Tests: Phase-to-phase and phase-to-around with 60-cycle test voltages applied for 1-second at 2,640 volts.
8. Verify equipment passed tests and inspection.
9. Provide standard factory inspection and test checklists, and final certified and signed test report.

B. Witnessed Factory Testing:

1. In accordance with Section 40 90 00, Instrumentation and Control for Process Systems.
2. Perform Equipment Communications Test (ECT) at the factory, with the PICS subcontractor, using the same PLC as being installed at the plant. PLC to be provided by the PICS subcontractor.


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3. Include Testing and Coordination Activities:
    a. Drive parameter verification.
    b. Nodes/addressing coordination.
    c. Functional testing of communications-capable devices mounted in the MCC.
4. Complete Witnessed Factory Testing prior to shipping MCC to the Site.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. General:

1. Install equipment in accordance with NEMA ICS 2.3, IEEE C2, NECA 402, Submittals, and manufacturer's written instructions and recommendations.
2. Secure equipment to mounting pads with anchor bolts of sufficient size and number adequate for specified conditions.
3. Install equipment plumb and in longitudinal alignment with pad or wall.
4. Coordinate terminal connections with installation of secondary feeders.
5. Grout mounting channels into floor or mounting pads.
6. Retighten current-carrying bolted connections and enclosure support framing and panels to manufacturer's recommendations.
7. Motor Data: Provide typed, self-adhesive label attached inside each motor starter enclosure door displaying the following information:
    a. Motor served by tag number and equipment name.
    b. Nameplate horsepower.
    c. Motor code letter.
    d. Full load amperes.
    e. Service factor.
    f. Installed overload relay catalog number.

B. Circuit Breakers:

1. Field adjust trip settings of motor starter magnetic-trip-only circuit breakers.
2. Adjust to approximately 11 times motor rated current.
3. Determine motor rated current from motor nameplate following installation.

C. Solid State Overload Relay:

1. Select and install overload relay and apply settings based upon actual full-load current of motor. At a minimum, the following settings shall be made:
    a. Motor FLA: Set as recommended by manufacturer.


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b. Jam: 400 percent of FLA, 4-second time delay.
c. Current Unbalance: 15 percent, 10-second time delay.
d. Ground Fault: Set per manufacturer's recommendations, 2-second time delay.
e. Phase Reversal: Set per manufacturer's recommendations, use default time delay.
f. Overvoltage: 550V, 10-second time delay. Set to alarm only, no trip.
g. Undervoltage: 410V, 10-second time delay. Set to alarm only, no trip.
h. Voltage Unbalance: 6 percent, 10-second time delay. Set to alarm only, no trip.
i. Trip Class: Selectable Quick, Class 10 and Standard, Class 20.

3.02 MOTOR DATASHEET

A. Provide typed, self-adhesive label attached inside each motor starter enclosure door displaying the following information:

1. Motor served by tag number and equipment name.
2. Nameplate horsepower.
3. Motor code letter.
4. Full load amperes.
5. Service factor.
6. Installed overload relay catalog number.

3.03 FIELD QUALITY CONTROL

A. In accordance with Section 26 08 00, Commissioning of Electrical Systems.

3.04 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative in accordance with Section 01 43 33, Manufacturers' Field Services, for the following services at Job Site or classroom as designated by Owner, for minimum person-days listed below, travel time excluded:

1. 1/2 person-day for installation assistance, and inspection of installation.
2. 1/2 person-day for functional and performance testing.
3. 1/2 person-day for plant startup.
4. 1/2 person-day for training of Owner's personnel.

**END OF SECTION**


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# SECTION 26 27 26
# WIRING DEVICES

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. ASTM International (ASTM): A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
2. Federal Specifications (FS):
   a. W-C-596G, General Specification for Connector, Electrical, Power.
   b. W-S-896F, Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).
3. Institute of Electrical and Electronic Engineers, Inc. (IEEE):
   a. C62.41.2, Recommended Practice on Characterization of Surges in Low-Voltage (1,000V and less) AC Power Circuits.
   b. C62.45, Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1,000V and less) AC Power Circuits.
4. National Electrical Contractors Association (NECA): 1, Standard Practice of Good Workmanship in Electrical Contracting.
5. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. FB 11, Plugs, Receptacles, and Connectors of the Pin and Sleeve Type for Hazardous Locations.
   c. WD 1, General Color Requirements for Wiring Devices.
   d. WD 6, Wiring Devices – Dimensional Specifications.
6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
7. UL:
   a. 498, Standard for Safety for Attachment Plugs and Receptacles.
   b. 508, Standard for Safety for Industrial Control Equipment.
   c. 943, Standard for Safety for Ground-Fault Circuit-Interrupters.
   d. 1010, Standard for Safety for Receptacle-Plug Combinations for Use in Hazardous (Classified) Locations.
   e. 1436, Standard for Safety for Outlet Circuit Testers and Similar Indicating Devices.
   f. 1449, Standard for Safety for Surge Protective Devices (SPD).


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1.02 SUBMITTALS

A. Action Submittals: Manufacturer’s product data for wiring devices.

**PART 2 PRODUCTS**

2.01 SWITCHES

A. Switch, General Purpose:

1. NEMA WD 1 and FS W-S-896F.
2. Totally enclosed, ac type, with quiet tumbler switch and screw terminal.
3. Rivetless one-piece brass or copper alloy contact arm with silver alloy contact.
4. Rating: 20 amps, 120/277 volts.
5. Automatic grounding clip and integral grounding terminal on mounting strap.
6. Special Features:
   a. Provide the following features in comparable devices where indicated:
      1) Three-way and four-way.
1. Manufacturers and Products, Industrial Grade:
   a. Cooper Arrow Hart; AH1200 Series.
   b. Bryant; 4801 Series.
   c. Hubbell; 1201 Series.
   d. Leviton; 1201 Series.
2. Manufacturers and Products, Commercial Grade:
   a. Cooper Arrow Hart; CSB120 Series.
   b. Bryant; CSB120 Series.
   c. Hubbell; CSB120 Series.
   d. Leviton; CSB1-20 Series.

2.02 RECEPTACLES

A. Receptacle, General Purpose:

1. NEMA WD 1 and FS W-C-596G.
2. Duplex, two-pole, three-wire grounding type with screw type wire terminals.
3. Impact resistant nylon cover and body, with finder grooves in face, unless otherwise indicated.
4. One-piece mounting strap with integral ground contact (rivetless construction).
5. Contact Arrangement: Contact to be made on two sides of each inserted blade without detent.



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6. Rating: 125 volts, NEMA WD 1, Configuration 5-20R, 20 amps, unless otherwise indicated.
7. Size: For 2-inch by 4-inch outlet box.
8. Special Features:
    a. Provide the following features in comparable devices where indicated:
        1) Listed weather-resistant per NEC 406.8 for installation in damp or wet locations.
9. Industrial Grade Manufacturers and Products:
    a. Cooper Arrow Hart; 5362 Series.
    b. Hubbell Bryant; HBL5362 Series.
    c. Leviton; 5362 Series.
10. Commercial Grade Manufacturers and Products:
    a. Cooper Arrow Hart; CR20 Series.
    b. Hubbell Bryant; CRF20 Series.
    c. Leviton; BR20 Series.

B. Receptacle, Ground Fault Circuit Interrupter:

1. Meet requirements of general-purpose receptacle.
2. Listed Class A to UL 943, tripping at 5 mA.
3. Rectangular smooth face with push-to-test and reset buttons.
4. Listed weather-resistant per NEC 406.8 for installation in damp or wet locations.
5. Feed-through Capability: 20 amps.
6. Manufacturers and Products:
    a. Hubbell Bryant; GFTR20 Series.
    b. Cooper Arrow Hart WRVGF20 Series.
    c. Leviton; 7899 Series.

C. Receptacle, Special-Purpose:

1. Rating and number of poles as indicated or required for anticipated purpose.
2. Where indicated provide matching plug with cord-grip features for each special-purpose receptacle.

D. Receptacle, USB Charger:

1. Meet requirements of general-purpose receptacle.
2. Duplex receptacle with two-port USB charger.
3. Listed UL 498 and UL 1310.


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4. Commercial Grade Manufacturers and Products:
    a. Leviton; T5832 Series.
    b. Cooper; TR7746 Series.
    c. Hubbell; USB20X2 Series.

2.03 TELEPHONE AND DATA JACK

A. Compatible with Category 6 cable, and backwards compatible with Category 5 and Category 5e.

1. High-impact thermoplastic body.
2. Termination Type:
    a. IDC with pair separation towers.
    b. Compatible with 110-style termination tool.
3. Snap-on cap to secure connections.
4. Listed UL 1863.
5. Manufacturers and Products:
    a. Hubbell; HXJ6 Series.
    b. Leviton; 61110 Series.

2.04 DEVICE PLATES

A. Sectional type plate 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. Stainless Steel:

1. Material: Specification grade, one-piece, 0.040-inch nominal thickness stainless steel.
2. Finish: ASTM A167, Type 302/304, satin.
3. Mounting Screw: Oval-head, finish matched to plate.

D. Weatherproof:

1. Receptacle, Weatherproof Type 1:
    a. Gasketed, cast-aluminum, with individual cap over each receptacle opening.
    b. Mounting Screw and Cap Spring: Stainless steel.


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c. Manufacturers and Products:
1) Crouse-Hinds; Type WLRD-1.
2) Appleton; Type FSK-WRD.

2. Receptacle, Weatherproof Type 2:
a. UL listed for wet location while in use.
b. Polycarbonate cover.
c. Manufacturer and Product: TayMac; Type Multi-Mac.

3. Switch:
a. Gasketed, cast-metal or cast-aluminum, incorporating external operator for internal switch.
b. Mounting Screw: Stainless steel.
c. Manufacturers and Products:
1) Crouse-Hinds; DS-181 or DS-185.
2) Appleton; FSK-1VTS or FSK-1VS.

E. Raised Sheet Steel: 1/2-inch high zinc- or cadmium-plated steel designed for one-piece drawn type sheet steel box.

## 2.05 OCCUPANCY SENSOR, WALL SWITCH

A. Description:

1. Passive-infrared type, 120/277-volt, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 square feet (84 square meters).
2. Provide dual switch unit where indicated.
3. Color: Manufacturer’s standard white.

B. Manufacturers and Products:

1. Hubbell; WS1277.
2. Leviton; ODS 10-ID.
3. Pass & Seymour; WS3000.
4. Watt Stopper (The); WS-200.

## 2.06 FINISHES

A. Wiring device catalog numbers specified in this section do not designate device color. Unless otherwise indicated, or required by code, provide colors as specified below.

B. Wiring Device:

1. Office Areas: White.
2. Other Areas: Gray.


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C. Special purpose and hazardous location devices may be manufacturer's standard color (black).

D. Corrosion-resistant receptacle may be manufacturer's standard color (yellow).

## PART 3 EXECUTION

### 3.01 INSTALLATION, GENERAL

A. Comply with NECA 1.

B. Coordination with Other Trades:

1. Ensure device and its box are protected. Do not place wall finish materials over device box and do not cut holes for box with router that is guided by riding against outside of box.
2. Keep outlet box free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate raceway system, conductors, and cables.
3. Install device box in brick or block wall such that cover plate does not cross a joint, unless otherwise indicated. Where indicated or directed to cross joint, trowel joint flush with face of wall.
4. Install wiring device after wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
2. Strip insulation evenly around conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. Length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
   a. Cut back and pigtail, or replace damaged conductors.
   b. Straighten conductors that remain and remove corrosion and foreign matter.
   c. Pigtailing existing conductors is permitted provided outlet box is large enough.


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D. Device Installation:

1. Replace devices that have been in temporary use during construction or that show signs they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (150 mm) in length.
5. Use torque screwdriver when a torque is recommended or required by manufacturer.
6. When conductors larger than 12 AWG are installed on 15-amp or 20-amp circuits, splice 12 AWG pigtails for device connections.
7. Tighten unused terminal screws on device.
8. Device Plates:
   a. Do not use oversized or extra deep plate.
   b. Repair wall finishes and remount outlet box when standard device plate does not fit flush or does not cover rough wall opening.

3.02 SWITCH INSTALLATION

A. Switch, General Purpose:

1. Mounting Height: See Section 26 05 33, Raceway and Boxes.
2. Install with switch operation in vertical position.
3. Install single-pole, two-way switch such that toggle is in up position when switch is on.

B. Switch, Motor Rated:

1. Mounting Height: See Section 26 05 33, Raceway and Boxes.
2. Install with switch operation in vertical position such that toggle is in up position when ON.
3. Install within sight of motor when used as disconnect switch.

C. Occupancy Sensor, Wall Switch: Install in accordance with manufacturer’s instructions.


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## 3.03 RECEPTACLE INSTALLATION

A. Duplex Receptacle:

1. Install with grounding slot down, except where horizontal mounting is shown, in which case install with neutral slot down.
2. Ground receptacle to box with grounding wire only.
3. Weatherproof Receptacle:
   a. Install in cast aluminum box.
   b. Install such that hinge for protective cover is above receptacle opening.
4. Ground Fault Interrupter: Install feed-through model at locations where ground fault protection is specified for “downstream” conventional receptacles.
5. Special-Purpose Receptacle: Install in accordance with manufacturer’s instructions.

## 3.04 DEVICE PLATE INSTALLATION

A. Securely fasten to wiring device; ensure tight fit to box.

B. Flush Mounted: Install with all four edges in continuous contact with finished wall surface without use of mat or similar material. Plaster fillings will not be acceptable.

C. Surface Mounted: Plate shall not extend beyond sides of box, unless plate has no sharp corners or edges.

D. Install with alignment tolerance to box of 1/16-inch.

A. Label with designated title.

1. Engrave:
   a. Character Height: 1/8-inch.
   b. Filler: Black.

B. Type (Exterior):

1. Switch: Weatherproof.
2. Receptacle in Damp Location: Weatherproof Type 1.
3. Receptacle in Wet Location: Weatherproof Type 2.

C. Type (Interior):

1. Office Areas: Stainless steel.
2. Other Areas: Stainless steel.


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3. Flush Mounted Box: Stainless steel.
4. Surface Mounted, Metal Box:
   a. General Purpose Areas (Dry, Non-process): Stainless steel.
   b. Other Areas: Cast aluminum.
5. Surface Mounted, Aluminum Box:
   a. General Purpose Areas: Stainless steel.
   b. Other Areas: Cast aluminum.
6. Surface Mounted, Sheet Steel Box: Raised sheet steel.
7. Surface Mounted, Cast Box: Cast.
8. Surface Mounted, Nonmetallic Box: Manufacturer's standard.
9. Receptacle Shown as Weatherproof on the Drawings: Weatherproof Type 1.

## 3.05 IDENTIFICATION

A. Use tape labels for identification of individual wall switches and receptacles in dry indoor locations.

1. Degrease and clean device plate surface to receive tape labels.
2. Use 3/16-inch Kroy black letters on white background, unless otherwise indicated.
3. Identify panelboard and circuit number from which item is served on face of plate.

B. Identify conductors with durable wire markers or tags inside outlet boxes where more than one circuit is present.

## 3.06 FIELD QUALITY CONTROL

A. Perform tests and inspections, and prepare test reports.

B. Test Instrument for 125-Volt 20-Amp Receptacle: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

C. Using test plug, verify device and its outlet box are securely mounted.

D. Line Voltage Range: 105 volts to 132 volts.

E. Percent Voltage Drop under 15-Amp Load: Less than 6 percent; 6 percent or higher is not acceptable.

F. Ground Impedance: 2 ohms, maximum.

G. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.


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H. Tests shall be diagnostic, indicating damaged conductors, high resistance at circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

**END OF SECTION**


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# SECTION 26 29 23
# LOW-VOLTAGE ADJUSTABLE FREQUENCY DRIVE SYSTEM

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. Electronic Industries Alliance (EIA): 359-A-1, Special Colors.
2. Hydraulic Institute Standards (HIS).
3. Institute of Electrical and Electronics Engineers (IEEE):
   a. 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
   b. 519, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
   c. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
4. National Electrical Manufacturer's Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. CP 1, Shunt Capacitors.
   c. MG 1, Motors and Generators.
   d. WC 57, Standard for Control, Thermocouple Extensions, and Instrumentation Cables.
5. National Fire Protection Association (NFPA): 79, Electrical Standard for Industrial Machinery.

### 1.02 DEFINITIONS

A. Terms that may be used in this section:

1. AFD: Adjustable frequency drive.
2. CMOS: Complementary metal oxide semiconductor.
3. CSI: Current source inverter.
4. EMU: Energy monitoring unit.
5. GTO: Gate turn-off thyristor.
6. MPR: Motor protection relay.
7. MTBF: Mean time between failure.
8. PWM: Pulse width modulation.
9. ROM: Read only memory.
10. RTD: Resistance temperature detector.
11. RTU: Remote Telemetry Unit.
12. Rated Load: Load specified for equipment.


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13. Rated Speed: Nominal rated (100 percent) speed specified for equipment.
14. TDD: Total demand distortion.
15. THD: Total harmonic distortion.
16. TTL: Transistor transistor logic.

1.03 SYSTEM DESCRIPTION

A. Performance Requirements:

1. Composite drive/motor efficiency (CE) is defined as ratio of motor shaft kW to drive input kW. AFD system minimum requirements:
   a. At 60-Hz drive output and 100 percent load, CE equals 92 percent.
   b. At 50-Hz drive output and 60 percent load CE equals 89 percent.
   c. At 40-Hz drive output and 30 percent load CE equals 84 percent.
   d. At 30-Hz drive output and 12.5 percent load CE equals 77 percent.
2. Rated Continuous Operation Capacity: Not less than 1.15 times full load current rating of driven motor, as indicated on motor nameplate, and suitable for continuous operation at continuous overload which may be imposed on motor by driven pump operating over specified speed range.
3. Basis for Harmonic Computations: Using Simplified Plant One-Line Diagram for current and voltage distortion computations, furnish harmonic filters, line reactors, isolation transformers, or higher pulse converter arrangements required to meet current/voltage distortion limits.
4. Normal Source Current Harmonic Distortion:
   a. Compute normal source individual and total current harmonic distortion at location identified as PCC1, in accordance with IEEE 519.
   b. Individual current harmonic distortion and total demand distortion expressed as percent of maximum demand load current $I_L$ shall not exceed values specified in Table 1 below:

**Table 1**

| **Individual Harmonic Order (Odd Harmonics)** | **Harmonic Current Distortion Percent of Max. Demand Load Current IL** |
|---|---|
| h <11 | 1 |
| 11 h <17 | 0.5 |


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| Table 1 | |
|---|---|
| **Individual Harmonic Order (Odd Harmonics)** | **Harmonic Current Distortion Percent of Max. Demand Load Current IL** |
| 17 h <23 | 0.375 (2.598 percent for h=17,19) |
| 23 h <35 | 0.15 |
| 35 h | 0.075 (0.520 percent for h=35,37) |
| Total Demand Distortion (TDD) | 5 |

c. Limits specified in Table 1 are for drives utilizing 6-pulse rectifiers. Should manufacturer propose 12-pulse rectifiers, limits for characteristic harmonics can be increased by a factor of 1.41 times values listed in Table 1.

5. Normal Source Voltage Harmonic Distortion: Compute normal source voltage harmonic distortion at location identified as PCC2 THD shall not exceed 5 percent, and individual voltage harmonic distortion shall not exceed 3 percent.
6. Furnish isolating transformers or series reactors, harmonic filters, or other devices necessary for proper system operation. Furnish necessary devices and circuits to prevent operation of one drive from adversely affecting operation of other drives supplied from same transformer or same bus.
7. When isolation transformers are used, design to meet K-factor requirements of drive(s) connected.

B. Design Requirements:

1. Drive system consisting of adjustable frequency controller, drive motor, auxiliary items, and components necessary for complete operating system.
2. Other equipment is being powered from same bus as adjustable frequency drives. Ensure proper operation of drives and other loads under normal and emergency conditions.
3. Furnish AFDs rated on basis of actual motor full load nameplate current rating times the service factor.
4. Drive System: Convert incoming three-phase, 60-Hz ac power to variable voltage, adjustable frequency output for adjustable speed operation of a standard ac induction squirrel-cage motor, using pulse-width-modulation (PWM) technique to produce adjustable frequency output.


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5. System rated for continuous industrial duty and suitable for use with NEMA MG 1, Design B motors.
6. Incoming Line Circuit Breaker: Provide positive means of disconnecting incoming power, and overcurrent protection for drive system.
7. Incoming Line Reactor: Design to minimize harmonic distortion on incoming power feeder.

1.04 SUBMITTALS

A. Action Submittals:

1. Overall drive system operating data, including efficiencies, input currents, and power factors, at driven equipment actual load and rated system input voltage, at 0, 40, 60, 80, 100, and 110 percent of rated speed.
2. Individual and total harmonic content (voltage and current) reflected in system normal source supply at driven equipment actual load at 70 percent and 100 percent of rated speed at locations specified in Contract Documents and load conditions specified. Normal source system short-circuit available at drive shall be calculated from data furnished in Contract Documents. Use TDD and THD factors as defined in IEEE 519 to designate total harmonic content.
3. AFD output pulse maximum peak voltage, pulse rise time, and pulse rate of rise including justification for proposed deviation from specified values. Include motor manufacturer’s certification motor insulation will withstand long-term overvoltages caused at motor terminals due to specified output pulse data or proposed deviation from this data.
4. Data on shelf life of “dc link” capacitor.
5. Complete system rating, including nameplate data, continuous operation load capability throughout speed range of 0 percent to 120 percent of rated speed.
6. Complete adjustable frequency controller rating coordinated with motor full load nameplate current rating; list controller special features being supplied.
7. Controller, reactor, harmonic filter, and isolating transformer (if applicable) dimensional drawings; information on size and location of space for incoming and outgoing conduit.
8. Maximum heat dissipation from enclosure.
9. Should separate enclosures and equipment be necessary for filter elements or power factor correction equipment, provide complete dimensional information including location of space for incoming and outgoing conduit, weight, maximum heat loss, and minimum current carrying capacity and recommended wire size for required interconnecting circuits.


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10. Layout of controller face showing pushbuttons, switches, instruments, and indicating lights.
11. Complete system operating description.
12. Complete system schematic (elementary) wiring diagrams.
13. Complete system interconnection diagrams between controller, drive motor, and related components or controls external to system, including wire numbers and terminal board point identification.
14. One-line diagram of system, including component ratings.
15. Description of diagnostic features being provided.
16. Descriptive literature for control devices such as relays and timers.
17. Itemized bill-of-materials listing system components.
18. Specific description of provisions, such as filtering and harmonic suppression, being made to ensure proper system operation when power factor correction capacitors are included in system
19. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Statement of Supplier qualifications.
2. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
3. Special shipping, storage and protection, and handling instructions.
4. Manufacturer’s printed installation instructions.
5. Factory functional test reports.
6. Certified copy of test report for identical motor tested in accordance with NEMA MG 1-12.53a and IEEE 112, Test Method B, showing rated load, rated speed efficiency meeting or exceeding specified values; motors not as specified will be rejected.
7. Field test reports.
8. Suggested spare parts list to maintain equipment in service for period of 1 year and 5 years. Include list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
9. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
10. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
11. Manufacturer’s Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers’ Field Services

## 1.05 QUALITY ASSURANCE

A. Supplier: Minimum 5 years’ experience in furnishing similar size and type adjustable frequency, controlled speed, drive systems.


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1.06 EXTRA MATERIALS

A. Furnish for each drive unit: Complete set of components likely to fail in normal service.

**PART 2 PRODUCTS**

2.01 MANUFACTURERS

A. Components and accessories specified in this section shall be products of:

1. Schneider Electric.
2. Eaton Cutler Hammer.
3. ABB.

2.02 SERVICE CONDITIONS

A. Ambient Operating Temperature: 32 degrees F to 104 degrees F.

B. Storage Temperature: Minus 40 degrees F to 158 degrees F.

C. Humidity: 0 percent to 95 percent relative (noncondensing).

D. Altitude: 0 foot to 3,300 feet.

E. Frequency Stability: Plus or minus 0.1 percent of maximum frequency.

2.03 COMPONENTS

A. Drive Units:

1. Incorporate switching power supply operating from dc bus, to produce PWM output waveform simulating sine wave and providing power loss ride through of 2 milliseconds at full load, full speed.
2. Current-limiting semiconductor fuses for protection of internal power semiconductors.
3. Employ diode bridge rectifier providing constant displacement power factor of 0.95 minimum at all operating speeds and loads.
4. Use transistors for output section, providing a minimum 97 percent drive efficiency at full speed, full load.
5. Employ dc power discharge circuit so that after removal of input power dc link capacitor voltage level will decay below 50V dc within 1 minute after de-energizing following NEMA CP 1 and NFPA 79. Design dc link capacitor for a MTBF of 5 years.
6. Operate with open circuited output.
7. Input Voltage: 480V ac plus or minus 10 percent.


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8. Output Voltage: 0 volt to 480 volts, three-phase, 0-Hz to 66-Hz, minimum.
9. Maximum peak voltage of PWM AFD output pulse of 1,000 volts, with pulse rise time of not less than 2 microseconds, and maximum rate of rise of 500 volts per microsecond. Maximum frequency of PWM AFD output pulse (carrier) frequency of 3,000-Hz. Should magnitudes of these characteristics be more stressful to motor insulation than specified values, furnish insulation systems on motors suitable for proposed values.
10. Motor Audible Noise Level: When operating throughout speed range of PWM AFD, no more than 3 dBA above that designated in NEMA MG 1 for same motor operated at constant speed with a 60-Hz supply voltage.
11. Short-Time Overload Capacity: 125 percent of rated load in rms current for 1 minute following full load, full speed operation.
12. Equipment Short-Circuit Rating: Suitable for connection to system with maximum source three-phase, bolted fault, short-circuit available of 42,000 amps rms symmetrical at 480 volts.
13. Furnish drives with output current-limiting reactors mounted within equipment enclosure.
14. Diagnostics:
    a. Comprehensive for drive adjustment and troubleshooting:
        1) Memory battery backup; 100-hour minimum during power loss.
        2) Status messages will not stop drive from running but will prevent it from starting.
        3) Fault Condition Messages and History:
            a) First fault protection function to be activated, ability to store six successive fault occurrences in order. Minimum faults numerically:
                (1) Overcurrent (time and instantaneous).
                (2) Overvoltage.
                (3) Undervoltage (dc and ac).
                (4) Overtemperature (drive, motor windings, motor bearing, pump bearing).
                (5) Serial communication fault.
                (6) Short-circuit/ground fault (motor and drive).
                (7) Motor stalled.
                (8) Semiconductor fault.
                (9) Microprocessor fault.
                (10) Single-phase voltage condition.
15. Drive Protection:
    a. Fast-acting semiconductor fuses.
    b. Overcurrent, instantaneous overcurrent trip.
    c. Dc undervoltage protection, 70 percent dropout.
    d. Dc overvoltage protection, 130 percent pickup.


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e. Overtemperature, drive, inverter, converter, and dc link components.
f. Overtemperature, motor, and pump.
g. Single-phase protection.
h. Reset overcurrent protection (manual or automatic reset).
i. Active current limit/torque limit protection.
j. Semiconductor fault protection.
k. Short-circuit/ground fault protection.
l. Serial communication fault protection.
m. Microprocessor fault.
n. Surge protection for transient overvoltage (6,000 volts, 80 joule surge, tested per IEEE C62.41).
o. Visual display of specific fault conditions.

16. Operational Features:
    a. Use manufacturer's standard unless otherwise indicated.
    b. Sustained power loss.
    c. Momentary power loss.
    d. Power interruption.
    e. Power loss ride through (0.1 second).
    f. Start on the fly.
    g. Electronic motor overload protection.
    h. Stall protection.
    i. Slip compensation.
    j. Automatic restart after power return (ability to enable/disable function).
    k. Critical frequency lockout (three selectable points minimum, by 1.5-Hz steps in 10-Hz bands, to prevent resonance of system).
    l. Drive maintenance system software for complete programming and diagnostics.
    m. Ground fault protection, drive, and motor.
    n. Operate with no motor connected to output terminals.

B. Rectifier: Three-phase 6-pulse with matrix harmonic filter (larger than 50 hp), 6-pulse with 5-percent-line reactor (50 hp and less) full wave diode bridge rectifier to provide constant dc voltage to drive's dc bus

C. Harmonic Filtering:

1. Drives 50 hp or Less: 5 percent line reactor.
2. Drives Larger Than 50 hp: Matrix harmonic filters. Matrix filters manufactured by MTE "Or-equal," approved.

D. Both harmonic filters (active or passive) and 5 percent line reactors located internal to drive enclosure.


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E. Furnish series choke and capacitors on dc bus to reduce ripple in rectifier output and to reduce harmonic distortion reflected into incoming power feeders.

F. Controller: Microprocessor-controller PWM inverter to convert to dc voltage to variable voltage, adjustable frequency, three-phase ac output. Output voltage shall vary proportionally with frequency to maintain constant ratio of volts to hertz up to 60-Hz; above 60-Hz, voltage shall remain constant with drive operating in constant horsepower output mode.

G. Enclosure:

1. NEMA 250, Type 1, gasketed, freestanding, enclosure for mounting against wall, completely front accessible, and hinged doors. Properly sized to dissipate heat generated by controller within limits of specified operating conditions (including ambient temperature and ambient airflow). Enclosure not to exceed dimensions shown on the Drawings.
2. Cable termination compartment door interlocked main circuit breaker, defeatable (lockable in the open position), emergency stop pushbutton, alphanumeric keypad and display, and operator's controls. Components and controls specified in Section 26 05 04, Basic Electrical Materials and Methods.
3. Wire drive from below in the compost admin facility and above in the dewatering facility for power and control wiring.
4. Size forced-ventilation for periodic operation to cool each unit with maximum room ambient temperature of 95 degrees F. Furnish redundant fans such that if one fan fails remaining fans furnish adequate ventilation for drive when operating at maximum capacity. Furnish filters on ventilation intakes.
5. Wiring:
    a. Bundle stranded copper wiring neatly with nylon tie wraps or with continuous plastic spiral binding.
    b. Label each terminal for permanent identification of leads.
    c. Identify each wire at each end with imprinted mylar adhesive-back wire markers.
    d. Incorporate in as-installed wiring diagrams for wire and terminal numbers shown.
    e. Wiring across door hinge, use 19-strand, NEMA WC 57 Class C stranding looped for proper twist rather than bending at hinge.
    f. Wire connections internal to panels by crimp-on terminal types.
    g. For multiple enclosure systems, complete interconnection wiring with gasketed enclosure openings for wiring.
    h. Multipoint plug receptacles for control wiring crossing equipment shipping splits.


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6. Selector switches, indicating lights, potentiometers, instruments, protective devices, and major system components identified by means of mechanically attached, engraved, laminated nameplates.

H. Operator Interface:

1. Controls:
   a. Mount drive local control on front door of enclosure and include control switch and membrane type keypad for the following operator functions:
      1) Start (when in LOCAL mode).
      2) Stop (when in LOCAL mode).
      3) Speed increase (when in LOCAL mode).
      4) Speed decrease (when in LOCAL mode).
      5) Parameter mode selection (recall programmed parameters).
      6) LOCAL/OFF/REMOTE control selection (in remote, furnish for remote RUN command digital input and speed increase/decrease via remote 4 mA to 20 mA analog signal).
      7) Fault reset, manual for faults, except loss of ac voltage which is automatic upon return.
      8) RUN/preset speed.
      9) Parameter lock, password or key switch lockout of changes to parameters.
      10) Start disable, key switch or programmed code.
2. Control circuit disconnect shall de-energize circuits in units that are not de-energized by main power disconnect device
3. 120 volts, single-phase, 60-Hz circuits for control power and operator controls from internal control power transformer. Furnish power for motor space heaters rated 120 volts.
4. Arrange component and circuit such that failure of a single component cannot cause cascading failure(s) of other component(s).
5. Alphanumeric Display:
   a. During normal operation and routine test, the following parameters shall be available:
      1) Motor current (percent of drive rated current).
      2) Output frequency (Hertz).
      3) Output voltage.
      4) Running time.
      5) Local/remote indicator.
      6) Status of digital inputs and outputs.
      7) Analog input and output values.
      8) Output motor current per leg.
      9) All test points.


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6. Adjustable Parameters:
    a. Set drive operating parameters and indicate in numeric form. Potentiometers may not be used for parameter adjustment. Minimum setup parameters available:
        1) Frequency range, minimum, maximum.
        2) Adjustable acceleration/deceleration rate.
        3) Volts per Hertz (field weakening point).
        4) Active current limit/torque limit, 0 percent to 140 percent of drive rating.
        5) Adjustable voltage boost (IR compensation).
        6) Preset speed (adjustable, preset operating point).
        7) Provision for adjustment of minimum and maximum pump speed to be furnished as function of 4 mA to 20 mA remote speed signal.

I. Signal Interface:

1. Digital Input:
    a. Accept a remote RUN command contact closure input.
    b. High temperature contact closure input from field mounted motor temperature monitoring relay.
2. Digital Output: Furnish three discrete output dry contact closures rated 5 amps at 120V ac.
    a. DRIVE RUNNING.
    b. DRIVE FAULT (with common contact closure for all fault conditions).
    c. DRIVE IN REMOTE MODE.
3. Analog Input: When LOCAL/OFF/REMOTE switch is in REMOTE, control drive speed from remote 4 mA dc to 20 mA dc signal.
    a. Make provisions for adjustment of minimum and maximum motor speed which shall result from this signal.
    b. Factory set this adjustment to comply with operating speed range designated in driven equipment specifications.
    c. Frequency resolution shall be 0.1 percent of base speed.
4. Analog Output: Furnish two 4 mA dc to 20 mA dc signals for actual frequency, actual load.
5. Communication Interface:
    a. Drives must be able to connect to a Modbus TCP/IP Ethernet network. If needed provide communication gateway to convert native protocol to Modbus TCP/IP. Information available over Ethernet link shall include the following as a minimum:
        1) Motor current.
        2) Output frequency (Hertz).
        3) Output voltage.
        4) Running time.


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5) LOCAL/REMOTE indicator.
6) Status of digital inputs and outputs.
7) Low level cut out alarm.
8) Drive fault.
9) Analog input and output values.

6. Provide data exchange listing addresses of the date points listed here for use by System integrator. Coordinate with system integrator for proper implementation of SCADA data exchange.
7. Communications Watchdog: Provide a value to monitor the active datalink between the drive and remote partner (SCADA system). Value shall be continuously updated to verify communications.
8. See motor control diagrams in contract documents for additional requirements.

J. Accessories:

1. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in readily visible location.
2. Lifting Lugs: Equipment weighing over 100 pounds.
3. Anchor Bolts: Type 316 stainless steel, and as specified in Section 05 50 00, Metal Fabrications.

## 2.04 FACTORY FINISHING

A. Enclosure:

1. Primer: One coat of rust-inhibiting coating.
2. Finish:
   a. Interior: One coat white enamel.
   b. Exterior: One coat manufacturer’s standard gray enamel or EIA 359-A-1, No. 61.
3. Manufacturer’s standard enamel finish.

## 2.05 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.

B. Factory Tests and Adjustments: Test all control panels actually furnished.

C. Record test data for report.

D. Functional Test: Perform manufacturer’s standard.

E. Motor Test: See Section 26 20 00, Low-Voltage AC Induction Motors.


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## PART 3 EXECUTION

### 3.01 INSTALLATION

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

### 3.02 FIELD QUALITY CONTROL

A. Functional Test:

1. Conduct on each controller.
2. Inspect controller for electrical supply termination connections, interconnections, proper installation, and quiet operation.
3. Vibration Test:
   a. Complete assembly, consisting of motor, load, and flexible shafting, connected and in normal operation shall not develop amplitudes of vibration exceeding limits recommended by HIS.
   b. Where loads and drives are separated by intermediate flexible shafting, measure vibration both at top motor bearing and at two points on top pump bearing, 90 degrees apart.
4. Record test data for report.

B. Performance Test:

1. Conduct on each controller.
2. Perform under actual or approved simulated operating conditions.
3. Test for continuous 12-hour period without malfunction.
4. Demonstrate performance by operating continuous period while varying application load, as input conditions allow, to verify system performance.
5. With plant load connected to normal utility source, measure the following to show parameters within specified limits:
   a. Total and individual current harmonic distortion, up to and including 35th harmonic, at location identified as PCC1 in Simplified Plant One-Line Diagram, under following load conditions:
      1) AFDs running at full load and half load.
      2) Half of specified AFDs running at full load and half load.
   b. Power factor at input side of each drive. Documented verification that power factor is maintained at 95 percent as speed of drive goes down from 100 percent to 33 percent.
   c. THD at location identified as PCC2 under following conditions:
      1) AFDs running at full load and half load.
      2) Half of specified AFDs running at full load and half load.
6. Record test data for report.


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C. Test Equipment:

1. Use Dranetz; Model No. 626-PA, harmonic distortion monitor and Series 626 disturbance analyzer or equivalent instrument to document results.
2. Provide diagnostic plug-in test card complete with instructions, multiposition selector switch, and meters or built-in diagnostic control panel or ROM-based processor for monitoring ac, dc, and digital signals to assist in troubleshooting and startup of drive.

3.03 MANUFACTURERS' SERVICES

A. Manufacturer's Representative:

1. Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:
   a. 1 person-day for installation assistance and inspection.
   b. 1 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
   c. 1/2 person-day for prestartup classroom or Site training.
   d. 1/2 person-day for facility startup.
   e. 1 person-day for post-startup training of Owner's personnel. Owner and Engineer.

B. See Section 01 43 33, Manufacturers' Field Services, and Section 01 91 14, Equipment Testing and Facility Startup.

**END OF SECTION**



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# SECTION 26 41 00
# FACILITY LIGHTNING PROTECTION

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. Lightning Protection Institute (LPI): 175, Standard of Practice.
2. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 780, Standard for the Installation of Lightning Protection Systems.
3. UL:
   a. 96, Standard for Lightning Protection Components.
   b. 96A, Standard for Installation Requirements for Lightning Protection Systems.

### 1.02 DESIGN REQUIREMENTS

A. Provide lightning protection system design for the following new structures of the Project.

1. Sludge Mixing Building.
2. Sludge Holding Tank No. 1.
3. Composting Building.
4. Composting Operations Building.
5. Finished Composting Storage Building.
6. Roadway Luminaires.

B. Provide lightning protection system design for the following existing structures of the Project.

1. Dewatering Centrifuge Building.

C. Design lightning protection system to comply with applicable provisions of LPI 175, UL 96, UL 96A, and NFPA 780.

### 1.03 SUBMITTALS

A. Action Submittals:

1. Reproducible Drawings:
   a. Lightning protection system layout.
   b. Component locations.
   c. Detailed plans.


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2. Down conductor.
3. Connecting conductor.
4. Bond strap.
5. Air terminals.
6. Fittings.
7. Connectors.
8. Ground rods.

B. Informational Submittals:

1. Field test report.
2. Ground Witness Certification-Form LPI-175A.
3. Post-Installation Certification-Form LPI-175B.
4. UL 96 Master Label “C” Certification.

1.04 QUALITY ASSURANCE

A. Designer: Lightning protection system design shall be prepared by an LPI-certified master designer. Shop Drawings shall be stamped by a professional engineer in the State of Oklahoma.

B. System components shall be the product of a manufacturer regularly engaged in the manufacturing of lightning protection components in accordance with UL 96.

C. Lightning protection system shall be installed under direct supervision of an LPI 175 Certified Master Installer.

D. Inspection of final installation and grounding connection shall be performed by an LPI-certified inspector.

E. Provide the Work in accordance with NFPA 70. Where required by Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.

F. Materials and equipment manufactured within the scope of standards published by UL shall conform to those standards and shall have an applied UL listing mark.


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## PART 2 PRODUCTS

2.01 MANUFACTURERS

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

1. Thompson Lightning.
2. IPC Protection.
3. Erico Eritech Lightning Protection Systems.
4. VFC, Inc.

2.02 GENERAL

A. Complete system shall bear UL 96 Master Label C.

B. System Material: Copper or high copper content, heavy-duty bronze castings unless otherwise specified.

C. Material shall comply in weight, size, and composition for the class of structure to be protected as established by NFPA 780.

2.03 COMPONENTS

A. Air Terminal:

1. Material: Solid copper rods with tapered or blunt points as required for application.
2. Diameter: 5/8 inch.
3. Length: Sufficient to extend minimum 10 inches above object being protected.
4. UL 96 Label B applied to each terminal.

B. Conductors:

1. Lightning System Conductors: Bare medium hard-drawn stranded copper, or stranded aluminum as required for the application.
2. Main down and connecting conductors shall bear the UL 96 Label A, applied every 10 feet.
3. Grounding Conductors: Stranded bare copper.

C. Cable Fastener and Accessories: Capable of withstanding minimum pull of 100 pounds.


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D. Fittings:

1. Heavy-duty.
2. Bolts, Screws, and Related Hardware: Stainless steel.

E. Ground Rods:

1. Material: Copper.
2. Diameter: 5/8 inch.
3. Length: Minimum 12 feet.

F. Grounding Connections:

1. Welds: Exothermic process.
2. Fasteners: Bolted clamp type, corrosion-resistant copper alloy.
3. Hardware: Silicone bronze.

G. Cable Connections and Splicers:

1. Welds: Exothermic process.
2. Fasteners: Bolted clamp type, corrosion-resistant copper alloy.
3. Through-Roof Connectors: Straight or right angle with bronze and lead seal flashing washer.

H. Conduit: Schedule 40 PVC, as specified in Section 26 05 33, Raceway and Boxes.

## PART 3 EXECUTION

3.01 GENERAL

A. Workmanship to comply with all applicable provisions of LPI 175, UL 96, UL 96A, and NFPA 780.

B. Aluminum materials shall be used where required to meet the galvanic corrosion requirements of UL 96A.

C. Provide pitch pockets or method compatible with roofing to waterproof roof penetrations.

D. Install system in inconspicuous manner so components blend with building aesthetics.

3.02 EXAMINATION

A. Verify conditions prior to installation. Actual conditions may require adjustments in air terminal and ground rod locations.


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## 3.03 INSTALLATION

A. Air Terminals:

1. Supports: Brackets or braces.
2. Parapet Bracket Attachment: Lag or expansion bolts.
3. Secure base to roof surface with adhesive or pitch compatible with roofing bond.
4. Provide terminal flashing at roof penetrations.
5. Perimeter Terminals:
   a. Maximum Spacing: 20 feet.
   b. Maximum Distance from Outside Edge of Building: 2 feet.
6. Roof Ridge Terminals: Maximum spacing 20 feet.
7. Mid-Roof Terminals: Maximum spacing 50 feet.
8. Provide blunt point air terminals for applications exposed to personnel.

B. Conductors:

1. Conceal whenever practical.
2. Provide 1-inch PVC conduit in building walls or columns for main downleads and roof risers.
3. Support: Maximum spacing for exposed conductors.
   a. Vertical: 3 feet.
   b. Horizontal: 4 feet.
4. Maintain horizontal and vertical conductor courses free from dips or pockets.
5. Bends: Maximum 90 degrees, with minimum 8-inch radius.
6. Install air terminal conductors on the structural roof surface before roofing composition is applied.

C. Bonding:

1. Bond to Main Conductor System:
   a. Roof-mounted ventilators, fans, air handlers, masts, flues, cooling towers, handrails, and other sizeable metal objects.
   b. Roof flashing, gravel stops, insulation vents, ridge vents, roof drains, soil pipe vents, and other small metal objects if located within 6 feet of main conductors or another grounded object.
2. Bond each steel column or major framing members to grounding system.
3. Bond each main down conductor to grounding system.


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D. Grounding System:

1. Grounding Conductor:
   a. Completely encircle building structure.
   b. Bury minimum 1 foot below finished grade.
   c. Minimum 2 feet from foundation walls.
2. Interconnect ground rods by direct-buried copper cables.
3. Maximum Resistance: 3 ohms when connected to ground rods.
4. Connections:
   a. Install ground cables continuous between connections.
   b. Exothermic welded connections to ground rods, cable trays, structural steel, handrails, and buried and nonaccessible connections.
   c. Provide bolted clamp type mechanical connectors for all exposed secondary connections.
   d. Use bolted offset parapet bases or through-roof concealed base assemblies for air terminal connections.
   e. Provide interconnections with electrical and telephone systems and all underground water, gas, and sewer metal pipes.
   f. Provide electric service arrestor ground wire to building water main.

## 3.04 FIELD QUALITY CONTROL

A. Field Testing:

1. Isolate lightning protection system from other ground conditions while performing tests.
2. Resistance: Test ground resistance of grounding system by the fall-of-potential method.
   a. Test Resistance to Ground: Maximum 3 ohms.
   b. Install additional ground rods as required to obtain maximum allowable resistance.
3. Test Report:
   a. Description of equipment tested.
   b. Description of test.
   c. Test results.
   d. Conclusions and recommendations.
   e. Appendix, including appropriate test forms.
   f. Identification of test equipment used.
   g. Signature of responsible test organization authority.

**END OF SECTION**


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# SECTION 26 43 00
# SURGE PROTECTIVE DEVICES

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American National Standards Institute (ANSI).
2. Department of Defense: MIL-STD-220C, Test Method Standard – Method of Insertion Loss Measurement.
3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. C62.41.1, IEEE Guide on the Surge Environment in Low-Voltage (1,000 V and less) AC Power Circuits.
   b. C62.41.2, IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1,000 V and less) AC Power Circuits.
   c. C62.45, IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1,000 V and less) AC Power Circuits.
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. UL:
   a. 497A, Standard for Secondary Protectors for Communications Circuits.
   b. 1283, Standard for Electromagnetic Interference Filters.
   c. 1449, Standard for Surge Protective Devices.

### 1.02 SUBMITTALS

A. Action Submittals:

1. Product data on each suppressor type, indicating component values, part numbers, and conductor sizes. Include dimensional drawing for each, showing mounting arrangements.
2. Electrical single-line diagram showing location of each SPD.
3. Manufacturer’s UL certified test data and nameplate data for each surge protective device (SPD).


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1.03 QUALITY ASSURANCE

A. UL Compliance and Labeling:

1. SPDs for Power and Signal Circuits: Comply with UL 1449 and complimentary listed to UL 1283 as an electromagnetic interference filter. Provide units listed and labeled by UL.
2. SPDs for Telephone Circuit Protection: Comply with UL 497A.

B. ANSI Compliance: Use SPD devices in compliance with the recommendations of IEEE C62.41.1, IEEE C62.41.2, and IEEE C62.45.

**PART 2 PRODUCTS**

2.01 MANUFACTURER

A. Eaton, SPD Series.

B. ABB, Tranquell.

C. Square D, Surelogic.

2.02 GENERAL

A. Unless indicated otherwise, provide direct bus-connected and factory-installed SPDs inside distribution equipment.

B. SPD Operating Conditions: Capable of performing at ambient temperatures between minus 40 degrees C and 60 degrees C, at relative humidity ranging from 0 percent to 95 percent, and at altitudes ranging from sea level to 12,000 feet.

C. Connect SPDs through a fused switch or circuit breaker as selected by manufacturer. Provide overcurrent protection to allow full surge handling capabilities and afford safety protection from thermal overloads and short circuits.

D. SPD Short Circuit Current Rating (SCCR): No less than the SCCR of distribution equipment.

E. Design SPD devices to protect all modes (L-L, L-N, L-G, N-G) of electrical system being used.

F. Power Filter: Include a high-frequency extended range power filter for each SPD complimentary listed to UL 1283 as an electromagnetic interference filter.


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G. Provide SPDs with the following monitoring and diagnostics:

1. LED-type indication lights to show normal and failed status of each protected phase.
2. Surge event counter.
3. Form C dry contact which operates when unit fails.

H. Provide UL Type 2 SPDs.

I. EMI/RFI Noise Suppression: Minus 50 dB attenuation at 100 kHz, tested per MIL-STD 220C.

J. Voltage Protection Rating (VPR):

| Voltage Rating | L-N | N-G | L-G | L-L |
|---|---|---|---|---|
| 208Y/120 | 800 | 800 | 800 | 1200 |
| 480Y/277 | 1200 | 1200 | 1200 | 2000 |

2.03 SERVICE ENTRANCE AND DISTRIBUTION SPD

A. Provide SPD meeting IEEE C62.41.1 and IEEE C62.41.2 Location in accordance with Category C.

B. Surge Current Capacity:

1. Service Entrance:
   a. 240 kA per phase.
   b. 120 kA per mode.
2. Distribution:
   a. 160 kA per phase.
   b. 80 kA per mode.

C. Maximum Continuous Operating Voltage (MCOV): Not less than 115 percent of nominal system voltage.

D. Nominal Discharge Current ($I_N$): 20 kA.

2.04 PANELBOARD SPD

A. Provide SPD meeting IEEE C62.41.1 and IEEE C62.41.2 Location in accordance with Category B.


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B. Surge Current Capacity:

1. Distribution: 160 kA per phase; 80 kA per mode.
2. Branch: 120 kA per phase; 60 kA per mode.

C. Maximum Continuous Operating Voltage (MCOV): Not less than 125 percent of the nominal system voltage.

D. Nominal Discharge Current ($I_N$): 10 kA.

2.05 PAIRED CABLE DATA LINE INTERIOR SUPPRESSORS

A. Provide units meeting IEEE C62.41, Location Category A.

B. Use bi-polar 1,500-watt silicon avalanche diodes between protected conductor and earth ground.

C. Provide units with a maximum single impulse current rating of 80 amperes (10 microsecond-waveform by 1,000 microsecond-waveform).

D. Breakdown voltage shall not exceed 36 volts.

2.06 PAIRED CABLE DATA LINE EXTERIOR SUPPRESSORS

A. Provide units meeting IEEE C62.41, Location Category A.

B. Design Requirements: A hybrid design with a minimum of three stages, using solid-state components and operating bi-directionally.

C. Meet or exceed the following criteria:

1. Maximum single impulse current rating of 10,000 amperes (8 microsecond-waveform by 20 microsecond-waveform).
2. Pulse Life Rating: 3,000 amperes (8 by 20 microsecond-waveform); 2,000 occurrences.
3. Maximum clamping voltage at 10,000 amperes (8 by 20 microsecond current waveform), shall not exceed the peak of normal applied signal voltage by 200 percent.

## PART 3 EXECUTION

3.01 APPLICATION REQUIREMENTS

A. Provide SPDs when indicated on the Drawings or in the equipment specifications.


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B. Provide factory-installed SPDs as integral components to new switchgear, switchboards, motor control centers, panelboards and transfer switches. Externally mounted SPDs are not acceptable for new distribution equipment.

C. Externally mounted SPDs are acceptable for SPDs added to existing equipment as described below.

D. Electronic Equipment Paired Cable Conductors: Install data line suppressors at the low voltage input and output of each piece of equipment, including telephone cable entrance.

1. Use secondary protectors on lines that do not exit the structure.
2. Use primary protectors on lines that exit and enter the structure.

3.02 GENERAL INSTALLATION REQUIREMENTS

A. Install suppressors according to manufacturer’s recommendations.

B. Install suppressors directly to the cabinet which houses the circuit to be protected so that the suppressor leads are straight and short, with conductors laced, running directly to the point of connection within the panel, without loops or bends. If bends are unavoidable, no bend may exceed 90 degrees and bending radius may not be less than 6 inches.

C. Provide connecting wires as short as possible with gently twisted conductors, tied together, to prevent separation.

1. Maximum Length: 24 inches.

D. Field Installed Conductors: As specified for building wire, not smaller than 8 AWG and not larger than 4 AWG. Provide device leads not longer than the maximum length recommended by manufacturer, unless specifically reviewed and approved by manufacturer.

E. Provide dedicated disconnecting means for SPD devices installed at main service entrance location, switchgear, and motor control centers. Provide dedicated 30-ampere to 60-ampere circuit breakers (size dependent upon wire size used) with number of poles as required, as disconnecting means for SPD devices. Provide circuit breakers with interrupting capacity equal to that specified for other breakers at that location.

**END OF SECTION**


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# SECTION 26 50 00
# LIGHTING

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. ASTM International (ASTM):
   a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   b. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   c. A572/A572A, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
   d. A588/A588M, Standard Specification for High-Strength Low-Alloy Structural Steel, with 50 ksi Minimum Yield Point to 4-in. Thick.
   e. A595/A595M, Standard Specification for Steel Tubes, Low-Carbon or High-Strength Low-Alloy, Tapered for Structural Use.
   f. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   g. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
   h. D6576, Standard Specification for Flexible Cellular Rubber Chemically Blown.
2. Federal Communications Commission (FCC).
3. Illuminating Engineering Society of North America (IESNA).
   a. HB-9, Lighting Handbook.
   b. LM-79, IES Electrical and Photometric Measurements of Solid-State Lighting Products.
   c. LM-80, IESNA Approved Method for Measuring Lumen Maintenance of LED Light Sources.
   d. RP (Recommended Practices) Series.
   e. TM-21, Projecting Long Term Lumen Maintenance of LED Light Sources.
4. Institute of Electrical and Electronics Engineers (IEEE): C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.


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5. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. ICS 6, Industrial Control and Systems: Enclosures.
6. National Energy Policy Act.
7. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
8. Rural Utilities Service (RUS): 1728F-700, Specification for Wood Poles, Stubs and Anchor Logs.
9. UL:
   a. 773, UL Standard for Safety Plug-In Locking Type Photocontrols for Use with Area Lighting - Fourth Edition; Reprint with Revisions Through and Including March 08, 2002.
   b. 844, Electric Lighting Fixtures for Use in Hazardous (Classified) Locations.
   c. 924, Emergency Lighting and Power Equipment.
   d. 1598, UL Standard for Safety Luminaires.
   e. 2108, UL Standard for Safety Low Voltage Lighting Systems - First Edition; Reprint with Revisions through and Including February 24, 2014.
   f. 8750, UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products - First Edition; Reprint with Revisions Through and Including April 1, 2015.
10. U.S. Environmental Protection Agency and U.S. Department of Energy: Energy Star.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. General:
      1) Provide catalog data sheets and pictures for all products listed below.
      2) Proposed Luminaire Substitutions (Interior and Exterior): Provide an electronic photometric file in standard ‘.ies’ file format per the Illumination Engineering Society of North America (IESNA) for any proposed luminaire substitution not identified on the Project Luminaire Schedule. Obtain file from the luminaire manufacturer or approved independent photometric testing laboratory. Include the proposed substitute luminaire with all options identified on the Project Luminaire Schedule.


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b. Interior Luminaires:
   1) Catalog data sheets with pictures.
   2) Luminaire material, finish, dimensions, and metal gauge.
   3) Lens material, pattern, and thickness.
   4) Candle power distribution curves in two or more planes.
   5) Candle power chart 0 degree to 90 degrees.
   6) Lumen output chart.
   7) Average maximum brightness data in foot lamberts.
   8) Coefficients of utilization for zonal cavity calculations.
   9) Mounting or suspension details.

c. Exterior Luminaires:
   1) Catalog data sheets with pictures. Luminaire material, finish, dimensions, and metal gauge.
   2) Lens material, pattern, and thickness. Filters.
   3) IESNA lighting classification (BUG rating).
   4) Isolux diagram.
   5) Lighting distribution data and lighting distribution classification type as defined in IESNA HB 9.
   6) Fastening details to wall, pendant, or pole.
   7) For light poles, submit catalog sheet, wind loading, pole deflection with fixture attached, total weight, all accessories, complete dimensions, and finish.
   8) For concrete poles, include section and details to indicate quantities and position of prestressing steel, spiral steel, inserts, and through holes, initial prestressing steel tension, and concrete strengths at release and at 28 days.
   9) Brackets and supports.
   10) Pole foundations.

d. LED Source Systems:
   1) General:
      a) IESNA LM-80 test reports.
      b) IESNA TM-21 ratings.
      c) Operating temperature range. Data sheet (chart/graph) describing life as a function of temperature.
      d) Warranty: Light engine and driver.
      e) Rated life.
      f) Surge protection.
      g) Thermal control device, heat sink.
      h) Enclosure and wiring information.
      i) Operating voltage range.
   2) Electronic Module/Light Engine:
      a) Correlated Color Temperature (CCT).
      b) Color Rendering Index (CRI).


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3) Drivers:
a) Input Current Total Harmonic Distortion.
b) Power factor.
c) Sound rating.

e. Lighting Contactor:
1) Type (mechanically or electrically held).
2) Enclosure.
3) Contact ratings and configuration.
4) Coil operating voltage.

f. Photoelectric Switches (Photocells):
1) Voltage.
2) Power consumption.
3) Load capacity (watts).
4) Contact ratings and configuration.
5) Time delay.
6) Light operating level controls.
7) Enclosure type and dimensions.
8) Mounting type.
9) Temperature range.
10) Features and options.

g. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

2. Samples: Submit Samples of each substituted luminaire if requested by Engineer.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer’s printed installation instructions.
3. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, provide material and equipment labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ to provide a basis for approval under NEC.
2. Provide materials and equipment manufactured within the scope of standards published by UL in conformance with those standards and with an applied UL listing mark.


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B. Standard Products:

1. Provide materials and equipment of manufacturers regularly engaged in the production of products specified in this section and that are of equal material, design, and workmanship.
2. Provide products that have been in satisfactory commercial or industrial use for 2 years prior to Bid opening in similar applications under similar circumstances and of similar size. Provide products that have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.
3. Material and Equipment Manufacturing Date: Do not use products manufactured more than 3 years prior to date of delivery to Site.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Aluminum Poles:

1. Provide manufacturer's standard protection for the finish during shipment and installation. At minimum, spirally wrap each pole shaft with protective paper secured with tape, and ship small parts in boxes.
2. Do not store poles on ground.
3. Support poles so they are at least 1 foot above ground level and growing vegetation.
4. Do not remove factory-applied pole wrappings until just before installing pole.
5. Ship poles with bolt circle template, base cover, handhold cover, and shaft cap or tenon.

1.05 EXTRA MATERIALS

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

| Item | Quantity |
|---|---|
| Spare LED fixture of each type | One complete set per unit |

**PART 2 PRODUCTS**

2.01 LUMINAIRES

A. Specific requirements relative to execution of the Work of this section are located in Luminaire Schedule on the Drawings.

B. Provide luminaires and components tested, listed, and labeled by UL, or other approved testing agency.


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C. Provide luminaires with Illumination Engineering Society of North America (IESNA) formatted photometric files, ".ies" format, certified by the luminaire manufacturer for use with lighting software.

D. Luminaire Labels:

1. External label per ANSI C136.15.
2. Internal label per ANSI C136.22.

E. Provide luminaires rated by the manufacturer to start and operate to their full lumen capacity for rated life of the luminaire at the minimum low and maximum high ambient temperatures as defined in the Contract Documents at their installation location.

F. Feed-through type, or separate junction box.

G. Wire Leads: Minimum 18 AWG.

H. Component Access: Accessible and replaceable without removing luminaire from ceiling.

I. Soffit Installations (Interior or Exterior Damp Locations):

1. UL Labeled: SUITABLE FOR DAMP LOCATIONS.
2. Ballast: Removable, prewired.

J. Exterior Installations:

1. UL Labeled: SUITABLE FOR WET LOCATIONS.
2. Ballast: Removable, prewired.
3. When factory-installed photocells are provided, entire assembly shall have UL label.

K. Illuminated Exit Signs:

1. Body: As scheduled.
2. Face: Stencil.
   a. Letters:
      1) 6-inch high by 3/4-inch stroke.
      2) Color: Red As required by the AHJ.
3. Mounting: Universal.
4. Directional Arrows: As indicated on the Drawings.


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L. Emergency Lighting Units:

1. Power Pack: Self-contained, 120/277-volt transformer, inverter/charger, sealed nickel cadmium battery, and indicator switch in accordance with UL 924.
2. Lighted, push-to-test indicator.
3. Capable of providing full illumination for 1-1/2 hours in emergency mode.
4. Capable of full recharge in 24 hours, automatically upon resumption of normal line voltage.
5. Capable of protecting against excess charging and discharging.

M. Hazardous Classified Areas:

1. UL Labeled: CLASS I, DIVISION 2, GROUPS C AND D. As indicated in the Luminaire Schedule.
2. Fixture Enclosure and Fittings: Copper-free, cast aluminum in accordance with UL 844.

2.02 LED SOURCE SYSTEMS

A. General:

1. Provide IESNA LM-80 test reports.
2. Provide Energy Star compliance for solid state luminaires.
3. Listed To: UL 8750 Standard for Safety for Light Emitting Diode (LED) Equipment for use in Lighting Products.
4. Provide RoHS compliant LED light source(s) and driver(s).
5. Warranty: 5 years minimum.

B. Electronic Module/Light Engine:

1. Mount all components to a single plate and factory prewired with quick-disconnect plugs.
2. Include a driver, thermal control device, thermal protector device, and surge protector device.
   a. Provide surge protector tested in accordance with IEEE/ANSI C62.41.2 to Category C Low.
3. Provide LEDs mounted to a metal-core circuit board and aluminum heat sink for optimal thermal management and long life.
4. Light Engine Rating per TM-21: 100,000 at 25 degrees C, L70.
5. Correlated Color Temperature (CCT): As indicated on the Luminaire Schedule.
6. Color Rendering Index (CRI): Minimum of 80.


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C. Drivers:

1. Expected life of 60,000 hours at 65 degrees C.
2. Provide drivers mounted in an all metal can.
3. Operating Voltage Range: 50/60-Hz input source, voltage range as indicated on the Luminaire Schedule with sustained variations of plus or minus 10 percent voltage with no damage to the driver.
4. Input Current Total Harmonic Distortion: Less than 20 percent up to 50 percent of full load rating.
5. Power Factor: Greater than 0.90 for primary application up to 50 percent of full load rating.
6. Sound Rating: Class A.
7. Comply with NEMA 410 for inrush current limits.
8. Dimming:
   a. Continuously dimmable from 10 percent to 100 percent.
   b. Dimming Control: 0V to 10V.
   c. Provide driver compatible with standalone dimming controls and/or dimming systems used.

## 2.03 LIGHTING CONTROL

A. Time Switch, Electronic Programmable Type:

1. Provide digital electronic time switch with number of channels indicated on the Drawings.
2. Programming:
   a. Each channel shall be independently programmable and include:
      1) A Form C dry contact, output rated for 20 amps at 120V ac for operation on LED driver loads.
      2) Provide channels with eight ON/OFF set points in a 24-hour period for each day or the week.
      3) 365-day capability.
      4) Astronomic time functionality.
      5) Holiday override capability.
      6) Four seasonal schedule capabilities.
      7) Automatic daylight savings changeover.
      8) Automatic leap year compensation.
3. Time Switch Minimum Features:
   a. Selectable am/pm or 24-hour format.
   b. 1-minute time resolution.
   c. Control Inputs: Up to four control inputs capable of connection to input devices including photoelectric relays, discrete input devices, etc. for use in programming output channels.
   d. Battery backup with rechargeable batteries and 72-hour capacity.
   e. Individual manual ON/OFF override control for each channel.


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4. Manufacturers:
   a. Tork.
   b. Intermatic.
   c. Paragon Electric Company.

B. Photoelectric Switch (Photocell):

1. Automatic Solid State ON/OFF Switching Photo Control:
   a. Dry Contacts: Compatible with connected load device indicated on the Drawings.
2. Housing: Self-contained, die-cast aluminum, unaffected by moisture, vibration, or temperature changes.
3. Mounting Type: Twist lock plug.
4. Setting: ON at dusk and OFF at dawn.
5. Time delay feature to prevent false switching.
6. Field adjustable to control operating light levels.
7. Integral surge protection.
8. Manufacturers:
   a. Tork.
   b. Intermatic.
   c. Paragon Electric Company.

C. Photo Sensors/Controls for Daylight Harvesting Control:

1. General:
   a. Operating Temperature: 32 degrees F to 120 degrees F.
   b. Environment: Indoor dry.
   c. Illumination Sensing Levels:
      1) 10 Foot-candles to 200 Foot-candles: General interior spaces.
      2) 100 Foot-candles to 1,000 Foot-candles: Atriums, light shelves.
      3) 1,000 Foot-candles to 10,000 Foot-candles: Light wells, skylights.
   d. Output: Compatible with individual lighting load characteristics controlled.
2. Switching Control:
   a. Sensor shall sense relative lighting levels in interior spaces as daylight contribution varies throughout the day and shall convey changes to a control unit/power pack switching device. Switching device shall open and close load contacts based on field programmable set points.


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b. Power Pack:
1) Dry contacts rated 20A at 120/277V ac.
2) Adjustable Time Delay: 5 seconds to 300 seconds.
3) Set point adjustment for both on and off operation.

3. Dimming Control:
a. Sensor shall sense relative lighting levels in interior spaces as daylight contribution varies throughout the day and modulate electric luminaire lighting output to maintain a fixed lighting level in the space.
b. Controller Unit:
1) 120/277V ac input.
2) 24V dc output to power the sensor.
c. Sensor Output: 0V dc to 10V dc.
d. Light level set point adjustment performed by separate hand held remote control device.

D. Wall Box Dimmers:

1. General:
a. Modular gangable design.
b. Solid-state circuitry.
c. Voltage: As required on the Drawings
d. ON/OFF switch integral to the unit. ON/OFF switch shall be independent of dimming level function.
e. Single-pole or three-way as indicated on the Drawings.
f. Operator:
1) Continuous adjustability throughout the dimming range.
2) UP/DOWN buttons.
g. Integral suppression for audible frequency and EMI/RFI.
h. Comply with UL 1472.
2. LED System Dimmers: Certified by manufacturer to operate on dimming drivers provided with luminaires in this Project.

E. Low Voltage Remote Control Wiring System:

1. Provide a complete low-voltage, remote control wiring system for control of lighting fixtures as indicated on the Drawings and Schedules. Provide complete system including transformers, rectifiers, relays, switches, master switches, electronic controls, enclosures, wall plates, and wiring of same manufacturer.
2. Remote Control Wiring: In accordance with Article 725, Class 2 of NFPA 70.


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3. Provide for Direct-Wired Connection of:
    a. Standard of pilot light switches for individual control of relays.
    b. Two independent master override inputs which allow ON/OFF control of all relays while still supporting individual control of each relay.
4. Provide relay panels configured to allow future addition of up to two master controls of programmable control of all relays.

F. Occupancy Sensors:

1. General:
    a. Capable of operating normally with any electronic ballast and PL lamp systems.
    b. Coverage of sensors shall remain constant after sensitivity control has been set. No automatic reduction shall occur in coverage due to cycling of air conditioner or heating fans.
    c. Provide sensors with readily accessible, user adjustable controls for time delay and sensitivity.
    d. Provide a bypass manual OVERRIDE ON key on each sensor to allow operation in the event of sensor failure. When bypass is utilized, lighting shall remain on constantly or control shall divert to a wall switch until sensor is replaced. Recess bypass control to prevent tampering.
2. Sensor Technology:
    a. Dual Technology:
        1) Sensors use a combination of passive infrared and ultrasonic technologies to detect occupants in coverage area.
        2) Provide technology mode selection to allow installer to configure the operation mode between dual technology, passive infrared only, or ultrasonic only functionality.
        3) Detection Range (IR Range) on Axis: 2,000 square feet.
        4) No audio dual technology units will be accepted.
3. Sensor Mounting:
    a. Ceiling:
        1) Directional Coverage: 360 degrees.
    b. Switch Box:
        1) Directional Coverage: 180 degrees.
        2) Coverage Area: At desk top level up to 300 square feet and gross motion up to 1,000 square feet.
        3) Switch Types:
            a) Single circuit switches shall control a single switched circuit.
            b) Bi-level switches shall accommodate up to two switched circuits.


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4) Loads:
   a) Wall box switches shall include an integral power supply.
   b) Switches shall accommodate loads from 0 watt to 800 watts at 120 volts; 0 watt to 1,200 watts at 277 volts.

2.04 POLES

A. General:

1. Design for wind load as specified in Section 01 61 00, Common Product Requirements, while supporting luminaires and other appurtenances. Use effective projected areas (EPA) of luminaires and appurtenances in calculations specific to the actual products proposed on each pole.
2. Poles 40 feet and Shorter: One-piece construction.
3. Pole Height: As indicated on Luminaire Schedule.
4. Handhole:
   a. Provide oval-shaped handhole having a minimum clear opening of 2.5 inches by 5 inches.
   b. Secure cover with stainless steel captive screws.
   c. Metal Poles: Provide an internal grounding connection accessible from handhole near bottom of each pole.
5. Do not install scratched, stained, chipped, or dented poles.

B. Aluminum Poles:

1. Manufactured of corrosion-resistant aluminum alloys. Seamless extruded or spun seamless type with minimum 0.188-inch wall thickness.
2. Shape: Tapered.
3. Provide pole grounding connection designed to prevent electrolysis when used with copper ground wire.
4. Shaft Top: Fitted with round tenon.
5. Base:
   a. Anchor bolt mounted and machined to receive lower end of shaft.
   b. Welded joint between shaft and base.
   c. Base Cover: Cast aluminum alloy.
   d. Hardware, Except Anchor Bolts: either anodized aluminum alloy or stainless steel.
   e. Handhole.
6. Provide pole cast-in-place foundations with galvanized steel anchor bolts, threaded at the top end and bent 90 degrees at the bottom end.



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7. Provide base covers to match pole and galvanized nuts and washers for anchor bolts.
8. Pole and Bracket Finish: Uniform satin finish to match fixture.

2.05 BRACKETS AND SUPPORTS

A. Features:

1. Not less than 1-1/4-inch aluminum secured to pole.
2. Slip-fitter or pipe-threaded brackets may be used, but coordinate brackets to luminaires provided. Provide identical brackets for use with one type of luminaire
3. Select brackets for pole-mounted street lights to correctly position luminaire no lower than mounting height indicated.
4. Mount brackets not less than 24 feet above street.
5. Provide special mountings or brackets as indicated on the Drawings fabricated of metal which will not promote galvanic reaction with luminaire head.

2.06 POLE FOUNDATIONS

A. Anchor Bolts: Steel rod having a minimum yield strength of 50,000 psi; at minimum, galvanize the top 12 inches of the rod.

B. Concrete: As specified in Section 03 30 00, Cast-in-Place Concrete.

2.07 EMERGENCY LUMINAIRE

A. In accordance with UL 924.

2.08 IN-LINE FUSE HOLDER AND FUSE

A. Fuse Holder:

1. General: Waterproof of corrosion-resistant material.
2. Rating: 600 volts.

B. Fuse:

1. General: Midget, dual element.
2. Rating: 5-amp, voltage as required by application.

C. Manufacturer: Methods Electronics Inc. Network, Buss Div.


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2.09 LANDSCAPE LIGHTING

A. Materials:

1. Fixtures shall meet UL standards and be suitable for outdoor installation.
2. Types of lamps used, but not limited to: LED.
3. Wire Type:
   a. Low Voltage: 12-gauge, two-wire, UV-rated coating.
   b. Line Voltage: 12 AWG, THHN.
   c. UL approved.
4. Wire Fastening: Hardware shall be composed of corrosion resistant materials.
5. Transformers:
   a. UL approved in addition to meeting NEC codes.
   b. Overcurrent protection in accordance with NEC.
6. Conduit: In accordance with Section 26 05 33, Raceway and Boxes.
7. Pull Boxes and Junction Boxes: Suitable for outdoor installation per Section 26 05 33, Raceway and Boxes.

2.10 EQUIPMENT IDENTIFICATION

A. Manufacturer’s Nameplate: Provide each item of equipment with a nameplate bearing manufacturer’s name, address, model number, and serial number securely affixed in a conspicuous place; nameplate of distributing agent will not be acceptable.

B. Provide clear markings located to be readily visible to service personnel.

2.11 FACTORY FINISH

A. Provide electrical equipment with factory-applied painting systems that, at minimum, meet the requirements of NEMA 250 corrosion-resistance test.

**PART 3 EXECUTION**

3.01 LUMINAIRES

A. General:

1. Install in accordance with manufacturer’s recommendations.
2. Provide proper hangers, pendants, and canopies as necessary for complete installation.
3. Provide additional ceiling bracing, hanger supports, and other structural reinforcements to building and to concrete pole bases required to safely mount.


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4. Install plumb and level.
5. Install each luminaire outlet box with galvanized stud.

B. Mounting:

1. General:
   a. Coordinate mounting, fastening, and environmental conditions with Section 26 05 02, Basic Electrical Requirements.
   b. Refer to Fastener Schedule in Section 05 50 00, Metal Fabrications.
2. Wall Mounted: Measure mounting heights from center of mounting plate to finished floor or finished grade, whichever is applicable.
3. Pendant Mounted:
   a. Provide swivel type hangers and canopies to match luminaires, unless otherwise noted.
   b. Space single-stem hangers on continuous-row LED luminaires nominally 48 inches apart.
   c. Provide twin-stem hangers on single luminaires.
   d. Measure mounting heights from bottom of luminaire to finished floor or finished grade, whichever is applicable.
4. Pole Mounted:
   a. Provide precast concrete base.
   b. Provide branch circuit in-line fuses in pole base handhole.

C. Swinging Type: Provide, at each support, safety cable capable of supporting four times vertical load from structure to luminaire.

D. Finished Areas:

1. Install symmetrically with tile pattern.
2. Locate with centerlines either on centerline of tile or on joint between adjacent tile runs.
3. Install recessed luminaires tight to finished surface such that no spill light will show between ceilings and sealing rings.
4. Combustible Low Density Cellulose Fiberboard: Provide spacers and mount luminaires 1-1/2 inches from ceiling surface, or use fixtures suitable for mounting on low density ceilings.
5. Junction Boxes:
   a. Flush and Recessed Luminaires: Locate minimum 1-foot from luminaire.
   b. In concealed locations, install junction boxes to be accessible by removing luminaire.
6. Wiring and Conduit:
   a. Provide wiring of temperature rating required by luminaire.
   b. Provide flexible steel conduit.


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7. Provide plaster frames when required by ceiling construction.
8. Independent Supports:
    a. Provide each recessed luminaire with two safety chains or two No. 12 soft-annealed galvanized steel wires of length needed to secure luminaire to building structure independent of ceiling structure.
    b. Select chain or wire with tensile strength and method of fastening to structure adequate to support luminaire weight.
    c. Fasten chain or wire to each end of luminaire.

E. Unfinished Areas: Locate luminaires to avoid conflict with other building systems or blockage of luminaire light output.

1. Fixture Suspension: Provide 3/8-inch threaded steel hanger rods. Scissor type hangers not permitted.
2. Attachment to Steel Beams: Provide flanged beam clips and straight or angled hangers.

F. Building Exterior: Flush-mounted back box and concealed conduit, unless otherwise indicated.

3.02 LAMPS

A. Provide in each fixture, number and type for which fixture is designed, unless otherwise noted.

3.03 LIGHTING CONTROL

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

B. Dimming Systems:

1. Install in accordance with manufacturer’s recommendations.
2. Do not connect ballasts or equipment to dimming system unless acceptable to dimming system manufacturer.

C. Occupancy Sensors: Locate and aim sensors in correct location required for complete and proper volumetric coverage within range of coverage(s) of controlled areas per manufacturer’s recommendations. Provide 90 percent to 100 percent room coverage to accommodate all occupancy habits of single or multiple occupants at any location within room(s). Locations and quantities of sensors shown on the Drawings are diagrammatic and only indicate which rooms are to be provided with sensors. Provide additional sensors if required to properly and completely cover respective room.


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3.04 POLES

A. Electrical Installations: Conform to IEEE C2 and requirements specified herein.

B. Pole Setting:

1. Depth: As indicated on the Drawings or footing detail.
2. Install poles in straight runs in a straight line.
3. Setting Depth:

| **Length of Pole (feet)** | **Setting in Soil (feet)** |
|---|---|
| 25 | 5.5 |

4. Soil Setting: Depths shall apply where pole holes are in soil, sand, or gravel or any combination of these.
5. Setting on Sloping Ground: On sloping ground, measure depth of hole from low side of hole.
6. Backfill: Tamp pole backfill for the full depth of hole and mound excess fill around pole.
7. Dig holes large enough to permit the proper use of tampers to the full depth of the hole.
8. Place backfill in the hole in 6-inch maximum layers and thoroughly tamp.
9. Place surplus earth around the pole in a conical shape and pack tightly to drain water away.

C. Aluminum Poles: Install according to pole manufacturer's instructions.

1. Provide precast concrete base.
2. Provide branch circuit in-line fuses in pole base handhole.

D. Photocell Switch Aiming: Mount and aim switch according to manufacturer's recommendations.

E. Grounding: Ground noncurrent-carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures as specified in Section 26 05 26, Grounding and Bonding for Electrical Systems. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.


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## 3.05 LANDSCAPE LIGHTING

A. General: Electrical work and installation shall be in accordance with Article 411 of the NEC.

B. Installation:

1. Aboveground:
   a. Locate wire, hardware, and fixtures so as to allow for “normal” unobstructed plant growth with attention paid to the following:
      1) Hardware or fixtures should not be mounted in such a way that wire needs to be routed through a tree branch or trunk union.
      2) Branches or trunks should not be encircled with wire or other hardware.
      3) Maintain 10 inches minimum between new and existing installations of tree hardware.
   b. Protect wire by PVC conduit or water-resistant flexible conduit to a minimum of 8 feet abovegrade.
   c. Make connections in approved junction boxes.
   d. Secure conduit to tree with appropriate approved clips and hardware.
      1) Wire is to be fastened only with galvanized wire staples which have standoff nubs.
      2) Do not drive staples into tree past the standoff nubs to avoid pinching wire. Leave wire loose to allow for tree sway, tree growth, and wire expansion and contraction.
   e. Leave 10-inch slack or service loop at each end junction or fixture to allow:
      1) Wire contraction.
      2) Servicing.
      3) Relocation.
2. Belowgrade Wiring:
   a. Excavating and Backfill:
      1) Excavate trenches for electrical conduit and wiring of sufficient width to permit proper handling and installation of pipe and fittings.
      2) Trenches containing conduit for line voltage wiring must have a minimum cover of at least 15 inches wherever possible and 18 inches minimum in vehicle areas.
      3) Trenches containing conduit for low voltage wiring must have a minimum cover of at least 6 inches wherever possible.
      4) Compact backfill up to original grade level to 90 percent of the modified Proctor density.


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b. Pulling:
   1) Size pull boxes in accordance with Section 26 05 33, Raceway and Boxes.
   2) Keep interior of conduit free from dirt and debris.
c. Underground Conduit: Install per Section 26 05 33, Raceway and Boxes.
d. Pull Boxes and Junction Boxes:
   1) Install in accordance with Section 26 05 33, Raceway and Boxes.
   2) Boxes shall remain accessible at all times.

3.06 FIELD FINISHES

A. Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Paint as specified in Section 09 90 00, Painting and Coating.

3.07 FIELD QUALITY CONTROL

A. Upon completion of installation, verify equipment is properly installed, connected, and adjusted. Conduct an operating test to show equipment operates in accordance with the requirements of this section.

B. Coordinate lighting and controls installation and testing with commissioning as specified in Section 01 91 14, Equipment Testing and Facility Startup.

3.08 MANUFACTURER'S SERVICES

A. Occupancy Sensors:

1. Furnish manufacturer's representative at Job Site in accordance with Section 01 43 33, Manufacturers' Field Services, to inspect installation, test unit, and put into service.
2. Provide, at Owner's facility, training necessary to familiarize Owner's personnel with operation, use, adjustment, and problem solving diagnosis of occupancy sensing devices and systems.

3.09 CLEANING

A. Remove labels and markings, except UL listing mark.

B. Wipe luminaires inside and out to remove construction dust.

C. Clean luminaire plastic lenses with antistatic cleaners only.


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D. Touch up painted surfaces of luminaires and poles with matching paint ordered from manufacturer.

E. Replace defective lamps at time of Substantial Completion.

**END OF SECTION**


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# SECTION 28 31 00
# FIRE DETECTION AND ALARM

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. Institute of Electrical and Electronics Engineers (IEEE): C62.41, Surge Voltages in Low-Voltage AC Power Circuits.
2. International Fire Code (IFC).
3. International Building Code (IBC).
4. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 72, National Fire Alarm and Signaling Code.
   c. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
   d. 820, Fire Protection in Wastewater Treatment and Collection Facilities.
   e. 1221 Standard for the Installation, Maintenance and Use of Emergency Services Communications Systems.
5. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
6. National Institute for Certification in Engineering Technologies (NICET).
7. UL:
   a. 217, Single and Multiple Station Smoke Alarms.
   b. 228, Door Closures-Holders, With or Without Integral Smoke Detectors.
   c. 268, Smoke Detectors for Fire Protective Signaling Systems.
   d. 286A, Smoke Detectors for Duct Application.
   e. 464, Audible Signal Appliances.
   f. 497B, Protectors for Data Communication and Fire Alarm Circuits.
   g. 864, Control Units for Fire-Protective Signaling Systems.
   h. 1449, Standard for Transient Voltage Surge Suppressors.
   i. 1480, Speakers for Fire-Protective Signaling Systems.
   j. 1604, Electrical Equipment for Use in Class I and Class II, Division 2, and Class III Hazardous (Classified) Locations.
   k. 1638, Visual Signaling Appliances – Private Mode Emergency and General Utility Signaling.
   l. 1971, Signaling Devices for the Hearing Impaired.


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1.02 DEFINITIONS

A. Addressable: A fire alarm system component with a unique identification that can have its status individually identified or that is used to individually control other functions.

B. AHJ: Authority Having Jurisdiction.

C. CAD: Computer-Aided Design.

D. Coded: Audible or visible signal that conveys information about alarm event. Examples include number of rings of a bell or flashes of a strobe. This could be used to convey location or type of alarm.

E. dB: Decibels.

F. DXF: Drawing Interchange Format.

G. ECP: Environmental Control Panel.

H. ETL: Engineering Technical Letter.

I. FACP: Fire Alarm Control Panel.

J. HVAC: Heating, Ventilating, and Air Conditioning.

K. I/O: Input/Output.

L. IDC: Initiating Device Circuit.

M. LCD: Liquid Crystal Display.

N. LED: Light-Emitting Diode.

O. MOV: Metal Oxide Varistor.

P. NAC: Notification Appliance Circuit.

Q. RAM: Random Access Memory.

R. SLC: Signaling Line Circuit.

S. SOM: Sequence of Operations Matrix.

T. Zone: A defined area within the protected premises. A zone can define an area from which an alarm signal can be received or an area to which a signal can


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be sent. The term zone is typically used when describing conventional, nonaddressable systems.

1.03 SYSTEM DESCRIPTION

A. Design Requirements:

1. The Drawings show location of fire alarm panel(s), duct detectors, and fan monitoring components required by NFPA 820.
   a. Other Component Locations and Quantities: Determined by fire alarm system installer and included as part of installer's design.
   b. Other components include, but are not limited to, smoke detectors, heat detectors, manual pull stations, and notification appliances.
   c. Design and Installation: Meet requirements of local AHJ.
2. The Drawings show location of fire alarm system components.
3. Design, coordinate, and provide system in accordance with building codes indicated in Section 01 61 00, Common Product Requirements.
4. Design conduit layout and wiring interconnection of devices specified herein.
5. Coordinate, and include in design, requirements for interfacing with HVAC system.
6. Equipment suitable for addressable fire alarm system.
7. Fire Alarm Control Panel and System: Listed for use with Monaco BT2-7 Radio Alarm Transmitter or equivalent compatible with monitoring station.
8. Fire Alarm Control Panel to have a second dry contact connection to the site SCADA system.

B. Performance Requirements:

1. Actuation of alarm (smoke or heat detector, or other normally open initiating device contact) or trouble (trouble or supervisory switch) shall cause the following operations:
   a. Audible and visual indications of alarmed devices on fire alarm control panel display.
   b. Master fire alarm control panel shall transmit common alarm or trouble signal to plant SCADA system.
2. Actuation of duct smoke detectors shall, send signal (contact closure) to environmental control panel (ECP) to shut off HVAC equipment and send a Supervisory Alarm to the fire control panel. Fan equipment shall shutdown in accordance with Section 23 09 00, Instrumentation and Control Devices for HVAC. Contact output to ECP shall be rated for no less than 5A, 250V ac.


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## 1.04 SUBMITTALS

A. Action Submittals:

1. Descriptive product information for each individual system component.
2. Dimensional drawings of panels and associated equipment.
3. Itemized bill of material.
4. Operating and programming instructions.
5. Control panel configuration and module data.
6. Complete point to point wiring diagrams of system and device interconnection. Identify spare connection points.
7. Alarm initiating, indicating, and supervisory device electrical data.
8. Plans showing device and panel locations as well as conduit and cable sizes. Prepare drawings and diagrams on drawing sheets of uniform size without extraneous information. Marked up electrical, HVAC, lighting or similar drawings or copies of catalog data sheets are not acceptable in lieu of required drawings or diagrams.
9. Sequence of Operation Matrix.
10. Battery sizing calculations.
11. Supervisory power requirements for equipment.
12. Alarm power requirements for equipment.
13. Power supply rating justification showing power requirements for system power supplies.
14. Voltage drop calculations for wiring runs, demonstrating worst case condition.
15. Conduit fill calculations.
16. Sample warranty.
17. Recommended types and quantities for spare parts.
18. For each system’s control panel, provide written schedule of active and spare addresses provided on each addressable circuit.
19. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Experience and qualifications of firm(s) proposed to design and install system.
2. Certifications documenting service technician’s training. Certification shall indicate name of individual, training, dates, systems qualified, and current status.
3. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
4. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.


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5. Copy of design documents, Shop Drawings, and calculations submitted to code-enforcement authorities.
6. Code-enforcement authority approval letter.
7. Factory test reports.
8. Detailed program and schedule for testing, inspection, and maintenance of fire alarm system that satisfies requirements of NFPA 72, manufacturer's recommendations, and local authority having jurisdiction.
9. Written documentation for logic modules as programmed, for system operation, with matrix showing interaction of input signals with output commands.
10. System program hard copy and electronic file in format acceptable to Engineer showing system functions, controls, and labeling of equipment and devices.
11. Documentation of system voltage, current, and resistance readings taken during installation, testing, and ATP phases of system installation.
12. System Record Drawings and wiring details including one set of reproducible masters and drawings in electronic file in a DXF format suitable for use in a CAD drafting program.
13. NFPA 72, Record of Completion: Submit to Owner and code-enforcement authorities.
14. NFPA 72, Inspection and Testing Form: Submit to Owner and code enforcement authorities.
15. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

## 1.05 QUALITY ASSURANCE

A. Qualifications:

1. Provide names of projects, locations, and telephone numbers of persons to contact for at least two installations where Contractor or Subcontractor has installed detection and alarm systems that are similar in size and scope to the Work.
2. Licensed Firm Responsible for System Design, Installation and Testing: Document established reputation in fire alarm system industry having 10 years' experience in design, installation, and testing of fire alarm systems.
3. System Shop Drawings for code enforcement authority approval shall be prepared by a technician with minimum of NICET Level IV Certification for fire alarm systems, or a professional engineer registered in State of Oklahoma.
4. Technician with minimum of NICET Level III Certification for fire alarm systems shall provide general supervision of Project execution and shall perform final testing and certification of the system.


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5. Technician with minimum of NICET Level II Certification for fire alarm systems shall directly supervise all onsite installation activities.
6. Service technician shall be formally trained by manufacturer.

B. Regulatory Requirements: Submit Shop Drawings and system design calculations for approval to the following code enforcement authorities.

1. City of Tulsa Development Services.

1.06 SPECIAL GUARANTEE

A. Provide manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of Work specified in this specification section found defective during a period of 1 year after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in the General Conditions.

1.07 MAINTENANCE

A. Maintenance Service: For 2 years after Correction Period, provide maximum of two service calls, at Owner's request, to make adjustments or repairs required to keep system in satisfactory, full operation.

1.08 EXTRA MATERIALS

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

| Item | Quantity |
|---|---|
| Printer Paper | Quantity to cover 1 year of typical operation |
| Initiation Devices | One complete set |
| Notification Appliances | One complete set |
| Special tools required to maintain or dismantle | One complete set |

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.


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## PART 2 PRODUCTS

### 2.01 MANUFACTURERS

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

1. Siemens Building Technologies.
2. Simplex Grinnell.
3. Gamewell-FCI.
4. Notifier.
5. GE-EST.
6. Honeywell.

B. Notification appliances, initiating devices, and accessories of fire alarm systems specified in this section shall be products of:

1. Siemens Building Technologies.
2. Simplex Grinnell.
3. Gamewell-FCI.
4. Notifier.
5. GE-EST.
6. Honeywell.
7. Gentex.
8. System Sensor.
9. Wheelock.

### 2.02 GENERAL

A. Material and Equipment:

1. Standard products of their respective manufacturers.
2. Models produced for not less than 3 years.
3. Equipment: Supported by a service organization that is, in the opinion of Owner, reasonably convenient to Site.

B. Review details of Project prior to start of the Work, verify dimensions in field, and revise conduit and equipment locations to avoid obstructions and allow installation of new equipment.

C. Do not begin system installation prior to receiving written approval of Shop Drawings from Engineer.


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2.03 UL COMPLIANCE

A. Products manufactured within scope of UL: Conform to UL Standards and have an applied UL listing mark.

B. Provide equipment UL listed in accordance with requirements of NFPA.

2.04 SERVICE CONDITIONS

A. Altitude: Not greater than 3,300 feet above sea level.

B. Ambient Temperature:

1. Maximum: 40 degrees C.
2. Minimum: 0 degree C.

C. Provide equipment fully rated without derating for these conditions.

2.05 RADIO ALARM TRANSMITTER

A. Provide four zone (minimum) Monaco BT2-7 radio fire alarm transceiver, narrow band type. Provide factory-assembled and tested transceiver, complete with manufacturer’s locking cabinet, 60-hour rechargeable battery set, automatic battery charger, antenna surge arrestor, and coaxial cable.

B. Provide with manufacturer’s standard wall mounted omni-directional antenna and UHF antenna kit.

C. Provide manufacturer recommended lightning arrestor with NEMA 4 rated enclosure.

2.06 POSTED OPERATING INSTRUCTIONS (POI)

A. Prepare POIs on full size drawing sheets.

B. Provide POIs framed in extruded metal frames, mounted under glass, water-resistant, and weather-resistant. Permanently mount instructions on reserved wall area in space shown on the Drawings.

C. POIs Include:

1. Facility floor plans showing location of fire equipment and devices with coordinated identification. Show items such as firewalls, fire dampers, and fire alarm devices.
2. Fire alarm wiring diagrams and schematics with zone identification and device address list.


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## 2.07 FIRE ALARM CONTROL PANELS

A. General:

1. Control panel circuit for 24V dc, power limited, initiating circuits in accordance with NFPA 70, Article 760.
2. Assembled panel UL 864 listed Product Category UOJ2, as an integrated control system.
3. Enclosure:
   a. NEMA 250 Type suitable for location installed.
   b. Color: Red.
4. Internally Mounted Module with:
   a. Transformer with 120V ac input and 21.5V ac output.
   b. Solid state rectifier for 21.5V ac input and fuse protected, filtered, and regulated 26V dc no-load output.
   c. Solid state transfer switch, minimum 8 amp-hours.
   d. Standby sealed, gelled electrolyte (lead acid) batteries sized for system operating period of 24 hours of standby mode operation.
   e. Solid state battery charger.
   f. Over/under voltage monitor supervisory circuit.
   g. LEDs for status of normal power, battery trouble, and power supply module trouble.
   h. Alarm mode of 10 minutes after standby operation.
5. Local differentiating audible sound device for alarm, trouble, and supervisory conditions.
6. Full digital transmission protocol.
7. Addressable signal transmission protocol to be either digital pole/response protocol or proprietary communication protocol, with all antilog sensing device signals digitally transmitted to control panel.
8. Radio transmitter monitoring output circuitry for remote alarm control panel.
9. Dry contact connection for additional monitoring by the site SCADA system.
10. MOV/gas discharge transient protection for power supply module.
11. For addressable systems provide additional 25 percent capacity for future indicating and initiating devices.
12. EMI/RF Protection:
    a. Protect control equipment, devices, and wiring against unwanted radiated electro-magnetic interference (EMI) and from effects of audio and radio frequencies (RF) that can cause transmission of spurious alarms.
    b. Design system and install to be unaffected (with control cabinet faceplates installed) by operation of handheld, portable radios of up to 5 watts, or portable cellular telephones up to 1 watt, within 12 inches of system components.


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B. Addressable Control Panel:

1. Modular construction with solid state, microprocessor-based components, programmable central processor unit, back lighted display of primary control status and essential alarm operating conditions, and concealed, maintenance, purpose operator's keypad.
2. With Class B Signaling Line Circuits and Class B Notification Appliance Circuits.
3. Main control module consisting of operator's keyboard/keypad, local and remote communications and supervision capabilities, system control memory, and programming interface.
    a. Two-line, back lighted, 80 alphanumerical LCD characters with:
        1) Visible cursor for entering data information.
        2) Displayable when cabinet door is open.
    b. Primary operators keypad with:
        1) Acknowledge keys and LEDs for system alarm, supervisory service, and system trouble conditions.
        2) Power on LED.
        3) Alarm silence reset keys.
        4) Displayable when cabinet door is closed.
    c. Pass code protected action display keypad for:
        1) Circuit/device enable or disable.
        2) Control on/off.
        3) Test/status.
        4) Auto or manual.
        5) Activate/reset.
        6) Display historical logs/real time.
        7) Function/menu.
        8) Program.
        9) Delete.
        10) Displayable when cabinet door is open.
    d. Numerical entry and selection keypad, used in conjunction with action display keypad, to perform control function on system zones, initiating circuits, or auxiliary relays, and to gain access to system information. Displayable when cabinet door is closed.
    e. Programmable control keypad with five pass code keys, associated LEDs, and identification labels for:
        1) Manual evacuation.
        2) HVAC shutdown disable.
        3) Displayable when door is open.
    f. Four function keys for control of variable functions related to primary operations keypad, displayable when door is open.
4. TIA 485, NFPA 72, Class A, Class B, Class C, or Class X data circuit capability for remote annunciators.
5. Form C relay contacts rated 2 amperes, 24V dc.


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6. Down loader port for connection to microprocessor-based transponder.
7. Power supply interface module generating digital voltage and current data to LCD with:
    a. DC power conversion and output terminals.
    b. Supervision and control of power supply.
8. Modules with coded input on first alarm, local trouble LED, and in/out capabilities for:
    a. 120 addressable initiating alarm sensors consisting of analog/addressable or traditional detector methods.
    b. Four hardwired I/O points, field selectable in any combination to be either NFPA 72, Class A or Class B, initiating device circuits or NFPA 72, Class A or Class B, indicating appliance circuits or auxiliary control circuits.
    c. Auxiliary Control Circuit Contacts: Double-pole, double-throw, rated 2 amperes at 24V dc and 0.5 ampere at 120V ac.
9. Auxiliary Control Circuit Contacts: Double-pole, double-throw rated, 2 amperes at 24V dc and 0.5 ampere at 120V ac.
10. Two isolated TIA 232 communication port modules.

2.08 ADDRESSABLE DETECTOR BASE

A. Solid state circuitry with integral LED visual alarm, dip switch or program selectable addressing, and common base receptacle for ionization, photoelectric, and heat detectors. Locate device address in base.

B. Constantly monitors detector status and status changes.

C. Suitable for mounting on standard outlet box.

D. Normally open, single-pole contacts rated 3 amperes, 30V dc.

2.09 INDIVIDUAL ADDRESSABLE MODULE

A. Solid state circuitry with selectable latch/nonlatch operating conditions and mounting plate.

B. Monitors single and multiple devices with dry contacts.

C. Suitable for installing inside 4-inch by 4-inch by 2-1/2-inch electrical box.

2.10 INITIATING DEVICE

A. Pull Station, Fire:

1. Double-action station for general alarm.


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2. Constructed of red molded polycarbonate material and raised white letters stating “FIRE.”
3. Surface-mounted with hinged front cover having keyed or allen-wrench reset lock.
4. Where required, rated for use in hazardous environments.
5. Lift door or push plate and pull handle for double action operating station with plastic break rod.
6. Activated station pull handle, latched in protruding position until reset by key.
7. Stations keyed alike with fire alarm control panel.
8. Screw terminal for field connections.
9. Normally open, single-pole contacts rated 3 amperes, 30V dc for resistive loads.
10. Manual Pull Station: Microprocessor-based communication circuit or Dip switch selectable address, and compatible with fire alarm control panel.

B. Smoke Detector:

1. Photoelectric type with plug-in, twist-lock addressable base in accordance with UL 268.
2. Solid state circuitry, nonradioactive photo-optic sensing chamber, suitable for device releasing service.
3. Concealed, field adjustable, sensitivity test switch.
4. LED; pulsed indication for power availability and steady indication for activated detectors.
5. Self-Compensating Circuitry:
   a. Voltage Range: 15V dc to 30V dc, 24V dc nominal.
   b. Temperature Range: 0 degree C to 38 degrees C.
   c. Operating Temperature Range: Minus 10 degrees C to 50 degrees C.
   d. Humidity Range: 0 percent to 95 percent relative humidity.
6. Normally open, double-pole contacts, rated 3 amperes, 30V dc for resistive loads.
7. Auxiliary relay for fan shutdown.
8. Provide remote LED alarm indicators for above ceiling mounted detectors.
9. Detectors equipped with insect screen.
10. Photoelectric sensors adjusted to within 3 percent of UL 217 window obturation sensitivity value.

C. Air Duct Smoke Detector:

1. Duct mounted housing with prealigned sampling and exhaust tubes, analog sensing, solid state circuitry, and plug-in, twist-lock addressable


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base for photoelectric detector in accordance with UL 286A, NFPA 72, NFPA 90A, and NFPA 101.

2. Sampling tubes to extend full width of branch air return duct.
3. Self-Compensating Circuitry:
   a. Voltage Range: 15V dc to 30V dc, 24V dc nominal.
   b. Temperature Range: 0 degree C to 38 degrees C.
   c. Humidity Range: 10 percent to 90 percent relative humidity.
   d. Velocity Range: 400 feet to 4,000 feet per minute.
4. Front mounted LED with pulsed indication for alarm condition.
5. Normally open, double-pole, double-throw auxiliary relay with 2 amperes, 28V dc rated contacts for resistive loads.

D. Detector Accessories:

1. Remote test station and power-on indicator with LED alarm indicator and two-position, key-operated switch for air duct smoke detectors.
2. Remote LED alarm indicator.
3. End-of-line device with normally open relay contacts for zone voltage monitoring.

## 2.11 NOTIFICATION APPLIANCES

A. Audible Alarm:

1. General:
   a. Polarized, 24V dc device with sound power measured dB in accordance with UL 464.
   b. Separate in/out wire leads for field connections.
   c. Baked red enamel finish.
   d. Audibility: In accordance with NFPA 72 and local requirements.
2. Modular Horn:
   a. Surface basic unit, complete with single projector, designed for mounting on 4-inch square standard electrical box.
   b. Manufacturer supplied box with flush grille plate and basic surface unit for recessed horns.
   c. Explosion-Proof Horns: Vibrating diode type with sealed wires, and tapped for 3/4-inch conduit in accordance with UL 1604.
3. Standard electrical box.
4. Multiple-Tone Horn:
   a. Microprocessor-based, field programmable tone selection and volume control, suitable for installation indoors and outdoors.
   b. Program by setting miniature switches to obtain horn tone.


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B. Visual Alarm, Fire:

1. Polarized, 24V dc, multi-candela indicating output in accordance with UL 1638.
2. Solid state circuitry for high intensity control of xenon flashtube.
3. Tamper-proof, translucent molded, polycarbonate, pyramidal shaped lens with “FIRE” in red lettering visible from 180-degree viewing field; red enclosure.
4. Polarized in/out wiring.
5. Designed for mounting on wall or ceiling, as indicated on the Drawings, single-gang electrical box, or as part of audible/visible base housing.
6. Synchronized unit.

C. Visual Alarm, Emergency Alarm:

1. Polarized, 24V dc, 100 candela indicating output in accordance with UL 1638.
2. Solid state circuitry for high intensity control of xenon flashtube.
3. Tamper-proof, translucent blue, molded polycarbonate, pyramidal shaped lens with “EMERGENCY” in lettering visible from 180-degree viewing field; blue enclosure.
4. Polarized in/out wiring.
5. Designed for mounting on wall or ceiling, single-gauge electrical box, or as part of audible/visible base housing.
6. Synchronized unit.

D. Combination Audible and Visual Alarm:

1. Audible/visible base housing with visual alarm and front mounted horn as specified.
2. Semi-flush mounting on recessed 4-gauge square electrical box or surface mounted on backbox with adapter.
3. Audibility: In accordance with NFPA 72 and local requirements.
4. Synchronous audible/visible output.

E. Bi-Color Warning Lights:

1. Corrosion-resistant metal fixture with green and red globes.
2. 24V dc, LED lamps; green steady, red flashing.
3. UL Listed for wet and outdoor installation.
4. Wall mount design.
5. Manufacturer and Product: Edwards Signal; 101 series.


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2.12 WIRING

A. AC power wiring shall meet requirements of Section 26 05 05, Conductors.

B. Low voltage wiring shall be solid copper or bunch tinned (bonded) stranded copper, minimum 14 AWG, and shall meet NEC Article 760 for nonpower limited service.

C. Network or addressable loop cables shall be as recommended by manufacturer for installation of their system and UL Listed for Fire Alarm Systems.

2.13 RACEWAYS

A. Conduit used for installation of Fire Alarm system shall follow requirements as identified in Section 26 05 33, Raceway and Boxes.

2.14 END-OF-LINE RESISTORS

A. Ohmic value and power rating as determined by manufacturer based upon number of circuit devices supplied and circuit configuration as installed.

B. Single-gang, stainless steel plate mounted in recessed box.

2.15 SURGE SUPPRESSORS

A. Transient Voltage Surge Suppressors (TVSS): In accordance with Section 26 43 00, Surge Protective Devices.

2.16 INTRINSICALLY SAFE MODULE

A. Fused, resistor/zener diode barrier module with output currents limited for NFPA 70, Class I, Class II, Class III, Division 1, Groups A, B, C, D, E, F, and G atmospheres.

B. Surface-mounted backbox with secured, full-hinged access door and baked red enamel finish.

**PART 3 EXECUTION**

3.01 GENERAL

A. Coordinate with other trades for mounting and interfacing with fire alarm system related devices.

B. Install control panels, initiating and alarm devices, conduit, and wiring for interconnection of devices specified herein for complete and operable system.


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## 3.02 INSTALLATION

A. Install and connect fire detection and alarm equipment in accordance with manufacturer's instructions and recommendations, and in accordance with applicable codes and standards.

B. Mount devices in accordance with manufacturer's instructions.

C. Provide outlet and junction boxes that are compatible with raceway system.

D. Mount detector LEDs so they are readily visible from floor.

E. Program or configure panels and devices, as required to operate as defined by Sequence of Operations Matrix.

F. Install conductors in accordance with Section 26 05 05, Conductors, and NFPA 70, Article 760.

G. Install initiating alarm, signal, and communication conductors in separate and independent raceway system.

H. Circuit wiring color-code, as established by installer, to be maintained throughout installation.

I. Size conductors in accordance with device manufacturer's recommendations. Increase AWG size of alarm conductors, if necessary, to maintain terminal voltage drop within acceptable level required by NEC and NFPA.

J. Do not install detectors until after construction cleanup is complete, in accordance with requirements of NFPA. If earlier installation is required by AHJ for protection during construction, clean or replace detectors installed prior to final clean-up.

K. Duct Smoke Detector: Furnish, wire, and connect to fire alarm system in accordance with this specification. Install in accordance with Section 23 09 13, HVAC Controls, Field Components, and Instruments.

L. HVAC Equipment: Wire and connect fire alarm system to air handling system, smoke exhaust fan and smoke damper control circuits, and fan status contacts. Coordinate work with Section 23 09 00, Instrumentation and Control Devices for HVAC.

## 3.03 RADIO ALARM TRANSMITTER (RAT)

A. Install in strict accordance with manufacturer's recommended practices, product listings or approvals, NFPA 70, NFPA 72, and NFPA 1221. Ground transceiver and antenna to a driven ground rod and facility electrical ground


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system. Do not provide a separate ground rod. Mount transceiver adjacent to fire alarm panel. Supply power to transceiver through a line voltage surge suppressor as shown.

B. Monaco BT2-7:

1. Program transceiver in accordance with instructions from monitoring station.
2. Programming of Head End Equipment: By Contractor.

3.04 CONDUIT, ELECTRICAL ENCLOSURES, TERMINAL CABINETS, PULL BOXES, AND BACKPLATES

A. Conduit Systems: Dedicated to fire alarm system and containing no unrelated conductors.

B. Fire Alarm System Conduits: Size and type specified under Section 26 05 33, Raceway and Boxes.

1. Conduit: As specified in Section 26 05 33, Raceway and Boxes.
   a. Flexible Metallic Conduit: Allowable for whips to devices only.
      1) Maximum Length: 6 feet.
      2) Minimum Diameter: 3/4-inch.
      3) Set screw type couplings or connectors are specifically prohibited.
2. Size conduits according to conductors contained therein.
3. Maximum Cross-Sectional Area Percentage Fill for Fire Alarm System Conduits: 40 percent.

C. Route and install conduit to minimize potential for physical damage, either mechanical or by fire; avoid interference with existing building systems, facilities or equipment; and to facilitate service and minimize maintenance. Coordinate installation between different trades to avoid conflicts.

1. Solidly attach conduit to building structural members or permanent walls, except flexible conduit whips to devices. Do not attach conduit to existing conduit, ductwork, cable trays, other ceiling equipment, drop ceiling hangers/grids or partition walls, except where necessary to connect to initiating, evacuation signaling, or auxiliary function devices.
2. Route conduit either parallel or perpendicular to building structural members.
3. Install conduit at a height to avoid obstructing any portion of a window, doorway cable tray, stairway, or passageway. Do not interfere with operation of existing mechanical or electrical equipment.


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4. Locate conduit, junction boxes, pull boxes, terminal cabinets, electrical enclosures, and device backboxes to be readily accessible for inspection, testing, service, and maintenance.
5. Arrange conduit to minimize possibility of water in those conduits draining through control panels.
    a. Arrange conduit, except nipples between control panels, to enter control cabinets from below.
    b. Provide three 1/4-inch drain holes in conduit at horizontal low point beneath each control cabinet.
6. Provide bushings at termination of conduit, prior to wire installation.
7. Install junction boxes as necessary. Pull conductors through junction boxes, without splices.
8. Install pullboxes in each conduit at intervals not to exceed 100 feet.
9. Minimum Pullbox Size: 4-inch square, minimum.
10. Size device backboxes and junction boxes to accommodate number of conductors contained. Extension rings or extension boxes are prohibited.
11. Provide junction boxes, pull boxes, terminal cabinets, device backboxes, and raceways gasketed and weather-tight in accordance with requirements of Section 26 05 33, Raceway and Boxes.

D. Installation Requirements:

1. Conduit, Junction Boxes, Panels, Electrical Enclosures, Relays and Device Backboxes in Unfinished Areas: Exposed.
2. Conduit and Device Backboxes in Finished Areas: Concealed in walls, ceiling spaces, electrical shafts or closets, in finished areas, except as noted on the Drawings.
3. Provide escutcheon plates on either side of the wall at exposed conduit wall penetrations.

E. Seal penetrations of walls, floors, and ceilings around conduit(s) in accordance with Section 07 92 00, Joint Sealants, restoring walls, floors, and ceilings to their original condition, fire resistance, and integrity.

F. Paint pull boxes, junction boxes, conduit bodies, and terminal cabinets “fire engine red” prior to installation. Provide touch-up painting, of normally visible pull boxes, junction boxes, and terminal cabinets prior to final acceptance testing.

G. Ground conduit by approved ground clamps, and in accordance with NEC requirements.

H. Mount end-of-line resistors on terminal blocks.



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I. Install detection and alarm wire in separate conduits. Route outgoing and return conductors for each supervised circuit separately as required by NFPA 72.

J. Minimum Separation of Outgoing and Return Conduits: 1 foot vertically and 4 feet horizontally.

3.05 IDENTIFICATION

A. Paint junction, terminal, and pulling box covers red and identify with engraved labels by loop number and circuit that it contains.

B. Provide engraved alphanumeric identification for detection and terminal devices keyed to posted operations and maintenance instructions.

3.06 CONDUCTORS

A. Requirements apply to fire alarm system conductors, including all signaling line, initiating device, indicating appliance, releasing function, remote signaling, ac and dc power and grounding/shield drain circuits.

B. Conductors:

1. New; do not use wire that has scrapes, nicks, gouges or crushed insulation.
2. Install in conduit.
3. Continuous between devices and between devices and intermediary terminal cabinets.
4. Low voltage conductors shall be minimum size 14 AWG.
5. In accordance with requirements of NEC, Article 760 for power limited service.

C. Splices in conductors are specifically prohibited.

D. Types:

1. Conductors, Except AC Power Conductors and Grounding Conductors: Solid copper or bunch tinned (bonded) stranded copper.
2. Stranded copper conductors are acceptable for ac power conductors and grounding conductors only.


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E. Terminations, including field connections to supervisory resistors, diodes, relays or other devices shall be to numbered terminals or terminal strips and readily accessible for inspection, service, testing and maintenance.

1. Terminations shall be within junction boxes, device backboxes, terminal cabinets, control panels or other suitable metal enclosures.
2. Terminals and terminal strips shall be suitable for the size and number of conductors connected to them.
3. Uniquely number each conductor termination with durable plastic tags or uniquely identifiable by a combination of numbers and color codes. Show conductor numbers on Contractor's Record Drawings (floor plans and detailed wiring diagrams) in a manner allowing ready identification of conductor terminations.
4. Wire nuts are prohibited.
5. Where pigtail devices are factory provided with wires too short to be connected to terminal strips (such as, solenoids), provide soldered and taped connections.

F. Control Panel Wiring:

1. Fully dressed and bundled with nylon tie wraps at 3-inch intervals.
2. Route bundled wiring parallel to terminal strips within control panels, with individual conductors turned out at 90 degree angles to their associated terminal connections.
3. Bundle AC power conductors and route separately from low voltage conductors. Maintain a minimum 2-inch separation between AC power conductors and low voltage conductors wherever possible.
4. Size control cabinets to accommodate the requirements of this section.
5. Do not use control panels as raceways. Do not route conductors that do not terminate within a control panel through that control panel.

G. Separate conductors into the following categories:

1. Low voltage circuits that serve devices.
2. AC power circuits.

H. Install each category of conductors in physically separated, dedicated conduits, and isolate each category except at common associated control equipment. Further segregate conductors as necessary to conform to fire alarm system manufacturer's recommendations and as necessary to prevent electrical crosstalk between conductors installed in common conduits.

I. Wiring: THHN or TFFN stranded. Use of multi-conductor twisted pair or similar wiring is not permitted.



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J. Install as power limited circuits in accordance with NFPA 72, and NEC, Article 760.

K. Conductors looped around terminals are prohibited.

L. Wire nut splices are prohibited.

M. T-tapping of circuits is prohibited.

N. Circuits shall be megger tested to voltage rating of their insulation before final terminations are made.

3.07 OVERVOLTAGE AND SURGE PROTECTION

A. Install TVSS for fire alarm control panel and radio alarm transmitter in accordance with manufacturer’s requirements.

3.08 REPAIR/RESTORATION

A. Touch up scratches, mars, and dents, incurred during shipment or installation of equipment.

B. If required because of extensive damage, as determined by Engineer, refinish entire assembly.

C. Keep covers on smoke detectors until areas have been thoroughly cleaned.

3.09 TESTS AND INSPECTION

A. In accordance with Section 01 91 14, Equipment Testing and Facility Startup, and NFPA 72.

B. Demonstrate entire system meets performance requirements specified in Article System Description.

C. Perform tests in presence of code-enforcement authorities, Owner or Owner’s Representative.

D. Individually field test each smoke detector prior to installing device at its designated location to confirm operating condition after shipping and storage. Maintain a dated log indicating system address, type of device, sensitivity and initials of technician performing test, using test equipment specifically designed for that purpose, and submit as part of final acceptance documentation. After testing detection devices, base shall be labeled with system address, date, and initials of installing technician. Labeling shall not be visible after installation is complete.


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E. Test wiring runs for continuity, short circuits, and grounds before system is energized. Take resistance, current, and voltage readings as work progresses and document results.

1. Maintain a systematic record of all readings using schedules or charts of tests and measurements. Include readings, dates, and witnesses on the logging form.
2. Notify Fire Marshal and Owner before start of any required tests. Correct items found at variance with the Drawings or these Specification during testing or inspection.
3. Deliver test reports to Fire Marshal and Owner as completed.

F. Prepare final as-built Sequence of Operations Matrix referencing each alarm input to every output function affected as a result of an alarm, trouble, or supervisory condition on that. For outputs programmed using more complex logic functions involving “any”, “or”, “not”, “count”, “time”, and “timer” statements; reflect complete output equation in matrix.

G. Prepare complete listing of device labels for alphanumeric annunciator displays and logging printers prior to acceptance test.

1. Test system wiring to demonstrate correct system response and correct subsequent system operation in event of:
   a. Open, shorted, and grounded intelligent analog signaling line circuit.
   b. Open, shorted, and grounded network signaling line circuit.
   c. Open, shorted, and grounded conventional initiating device circuits.
   d. Primary power or battery disconnected.
   e. Intelligent device removal.
   f. Incorrect device address.
   g. Printer trouble, off line or out of paper.
2. Demonstrate system evacuation alarm indicating appliances as follows:
   a. Alarm notification appliances actuate as programmed.
   b. Audibility and visibility at required levels.
3. System indications shall be demonstrated as follows:
   a. Correct message display for each alarm input, at control panel, each remote alphanumeric LCD display.
4. Demonstrate system onsite and offsite reporting functions as follows:
   a. Correct alarm custom message display, address, device type, date and time transmitted, for each alarm input.
   b. Correct trouble custom message display, address, device type, date and time transmitted, for each alarm input.
   c. Trouble signals received for disconnect.


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5. Demonstrate secondary power capabilities as follows:
    a. Disconnect system primary power for a period of time as specified herein; at end of period, confirm alarm condition shall be created and system performance as specified for required duration.
    b. Restore system primary power for 48 hours and confirm that system-charging current is normal trickle charge for fully charged battery bank.
    c. Check system battery voltages and charging currents at fire alarm control panel using test codes and LCD displays.

H. If system fails to perform as specified and programmed during acceptance test, test will be terminated at discretion of acceptance inspector.

1. Retest system, correcting deficiencies and providing test documentation to acceptance inspector.
2. If software changes are required during acceptance test, provide a utility program to compare edited program with original and furnish a printed list of changes and the system functions, inputs, and outputs affected by changes. Retest items listed as changed before resuming acceptance test. Submit printed list and log of successful retesting of changed elements before scheduling completion of acceptance test.
3. Acceptance inspector may elect to require complete acceptance test to be performed again if, in their opinion, modifications to system hardware or software warrant complete retesting.

I. Upon completion of tests, complete and provide the following:

1. NFPA 72, Record of Completion, and Inspection and Testing Form.
2. Certification that final system meets UL.

## 3.10 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative in accordance with Section 01 43 33, Manufacturers' Field Services, for the following services at Site or classroom as designated by Owner, for minimum person-days listed below, travel time excluded:

1. 1 person-day for installation assistance and inspection.
2. 1 person-day for functional and performance testing.
3. 1 person-day for prestartup classroom or Site training.

**END OF SECTION**


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# SECTION 31 10 00
# SITE CLEARING

## PART 1 GENERAL

### 1.01 DEFINITIONS

A. Clearing: Removal of interfering or objectionable material lying on or protruding above ground surface including but not limited to stumps, bushes, rubbish, refuse, and other deleterious materials.

B. Debris: Broken concrete or asphalt, trash, rubbish, rubble, destroyed ruins, or other similar items.

C. Grubbing: Removal by raking or by excavation of vegetation and other organic matter including stumps, debris, grass, buried logs, and roots greater than 2-inch caliper to depth of 6 inches below subgrade.

D. Interfering or Objectionable Material: Trash, rubbish, and junk; vegetation and other organic matter, whether alive, dead, or decaying; topsoil.

E. Project Limits: Areas, as shown or specified, within which Work is to be performed.

F. Stripping: Removal of topsoil.

### 1.02 SUBMITTALS

A. Action Submittals: Overall Site Plan along with applicable drawings clearly showing clearing, grubbing, and stripping limits for planned work prior to construction and as part of the Quality Assurance.

### 1.03 QUALITY ASSURANCE

A. Obtain Engineer’s approval of staked clearing, grubbing, and stripping limits, prior to commencing clearing, grubbing, and stripping.

### 1.04 SCHEDULING AND SEQUENCING

A. Prepare Site only after adequate erosion and sediment controls are in place and in accordance with Section 01 57 13, Temporary Erosion and Sediment Control.


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## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION

3.01 GENERAL

A. Comply with federal, state, and local regulations concerning control of erosion and sediment. Sequence work to reduce erosion as directed in construction sequence. Comply with erosion and sedimentation regulations and permit conditions.

B. Do not commence site clearing operations until temporary erosion and sedimentation control measures are in place.

C. Locate and clearly flag trees and vegetation to remain.

D. Clear, grub, and strip areas needed for waste disposal, borrow, or Site improvements within limits shown or specified.

E. Do not injure or deface vegetation that is not designated for removal.

F. Protect remaining Site improvements from damage during construction. Restore damaged improvements to their original condition.

3.02 UTILITY LINE PROTECTION

A. Verify existing above grade and below grade utilities had been identified and flagged in field.

B. Protect existing utility lines that are indicated to remain from damage.

C. Repair damage to existing utility lines identified to remain.

D. Coordinate in accordance with Section 01 31 13, Project Coordination.

3.03 LIMITS

A. As follows, but not to extend beyond Project limits.

1. Excavation: 4 feet beyond top of cut slopes.
2. Fill:
   a. Clearing and Grubbing: 6 feet beyond toe of permanent fill.
   b. Stripping: 3 feet beyond toe of permanent fill.
3. Waste Disposal:
   a. Clearing: 5 feet beyond perimeter.
   b. Stripping: 5 feet beyond perimeter.



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c. Grubbing: Around perimeter as necessary for neat, finished appearance.

4. Structures:10 feet outside of new structures.
5. Roadways: Clearing, grubbing, and stripping 5 feet from roadway shoulders.
6. Overhead Utilities:
   a. Clearing and Grubbing: Entire width of easements and rights-of-way.
   b. Stripping: Wherever grading is required.

B. Remove rubbish, trash, and junk from entire area within Project limits.

3.04 CLEARING

A. Clear areas within limits shown or specified.

B. Fell trees so they fall away from facilities and vegetation not designated for removal.

C. Clearing materials are not allowed to be placed in wetlands, streams, or buffers.

D. Cut off shrubs, brush, weeds, and grasses flush with ground surface.

3.05 GRUBBING

A. Grub areas within limits shown or specified.

3.06 STRIPPING

A. Strip areas within limits specified and to a maximum depth of 6 inches or depth identified by local soil experts. Do not remove subsoil with topsoil.

B. Stockpile strippings, meeting requirements of Section 32 91 13, Soil Preparation, for topsoil, separately from other excavated material.

3.07 TREE REMOVAL OUTSIDE CLEARING LIMITS

A. Remove Within Project Limits: Dead, dying, leaning, or otherwise unsound trees that may strike and damage Project facilities in falling.

B. Cut stumps off flush with ground, remove debris, and if disturbed, restore surrounding area to its original condition.


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## 3.08 DISPOSAL

A. Timber: Remove felled timber from Site.

B. Clearing and Grubbing Debris:

1. Dispose of debris offsite.
2. Burning of combustible debris onsite will not be allowed.
3. Woody debris may be chipped. Chips may be sold to Contractor's benefit or used for landscaping onsite as mulch or uniformly mixed with topsoil, provided that resulting mix will be fertile and not support combustion. Maximum dimensions of chipped material used onsite shall be 1/4-inch by 2 inches. Dispose of chips that are unsaleable or unsuitable for landscaping or other uses with unchipped debris outside limits of Work.
4. Limit offsite disposal of clearing and grubbing debris to locations that are approved by federal, state, and local authorities, and that will not be visible from Project.

C. Strippings:

1. Dispose of strippings that are unsuitable for topsoil or that exceed quantity required for topsoil offsite.
2. Stockpile topsoil in sufficient quantity to meet Project needs. Dispose of excess strippings as specified for clearing and grubbing.

**END OF SECTION**


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# SECTION 31 23 13
# SUBGRADE PREPARATION

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. ASTM International (ASTM):
   a. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 feet-lb/feet$^3$ (600 kN-m/m$^3$)).
   b. D6938, Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

### 1.02 DEFINITIONS

A. Optimum Moisture Content: As defined in Section 31 23 23, Fill and Backfill.

B. Prepared Ground Surface: Ground surface after completion of clearing and grubbing, stripping of topsoil, dewatering, excavation to grade, and scarification and compaction of subgrade.

C. Proof-Rolling: Test rolling of subgrade by heavily loaded vehicle or roller to identify areas that will not support the future loading without excessive settlement or rutting.

D. Relative Compaction: As defined in Section 31 23 23, Fill and Backfill.

E. Subgrade: Layer of existing soil after completion of clearing, grubbing, stripping of topsoil prior to placement of fill, roadway structure or base for floor slab.

F. Unsuitable Material: Subgrade material unsuitable for the project consisting of rubble, debris, vegetation, and undocumented fill.

### 1.03 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in Section 02 41 00, Demolition; Section 31 10 00, Site Clearing; and Section 31 23 16, Excavation, prior to subgrade preparation.


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1.04 QUALITY ASSURANCE

A. Notify Engineer when subgrade is ready for compaction or proof-rolling or whenever compaction or proof-rolling is resumed after a period of extended inactivity.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Prepare subgrade when unfrozen and free of ice and snow.

**PART 2 PRODUCTS (NOT USED)**

**PART 3 EXECUTION**

3.01 GENERAL

A. Keep subgrade free of water, debris, and foreign matter during compaction or proof-rolling.

B. Bring subgrade to proper grade and cross-section and uniformly compact surface.

C. Do not use sections of prepared ground surface as haul roads. Protect prepared subgrade from traffic.

D. Maintain prepared ground surface in finished condition until next course is placed.

3.02 COMPACTION

A. Under Earthfill or Structural Fill: Proof roll the prepared subgrade in the presence of the Engineer. Perform two passes with a loaded tandem-axle dump truck with a minimum weight of 20 tons or similar heavy-wheeled vehicle providing an equivalent subgrade loading.

B. Under Structures or Pavement: Compact the upper 8 inches to minimum of 95 percent relative compaction as determined in accordance with ASTM D698.

3.03 MOISTURE CONDITIONING

A. Dry Subgrade: Add water, then mix to make moisture content uniform throughout. Adjust moisture content to within 2 percent of the optimum content in accordance with ASTM D698 prior to compaction.

B. Wet Subgrade: Aerate material by blading, discing, harrowing, or other methods, to hasten drying process. Turn material repeatedly during aeration


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until lift is uniform moisture throughout. Adjust moisture content to within 2 percent of the optimum content in accordance with ASTM D698 prior to compaction.

3.04 TESTING

A. In-place density test in accordance with ASTM D6938 to be performed by independent material testing firm retained by owner. Test as follows:

1. One test every 2,000 square feet of subgrade or portion thereof.

B. Proof-roll subgrade with equipment specified in Article Compaction to detect soft or loose subgrade or unsuitable material, as determined by Engineer.

3.05 CORRECTION

A. Contractor is responsible to perform corrections necessary to result in a firm and unyielding subgrade prior to fill placement or construction of structures on subgrade.

B. Soft or Loose Subgrade:

1. Adjust moisture content to within 2 percent of the optimum moisture content and recompact.
2. Alternatives to Item 1:
   a. Overexcavate soft or loose subgrade material as specified in Section 31 23 16, Excavation, and replace with Foundation Stabilization Rock as specified in Section 31 23 23, Fill and Backfill.
   b. Stabilize soil with Class “C” fly ash, placed, mixed, and compacted in accordance with ODOT “Standard Specifications for Highway Construction, Section 307” (2009).
   c. Stabilize soil with Cement Kiln Dust, placed, mixed, and compacted in accordance with ODOT “Standard Specifications for Highway Construction, Section 307” (2009).

C. Unsuitable Material: Overexcavate as specified in Section 31 23 16, Excavation, and replace with imported material or suitable material from the excavation, as specified in Section 31 23 23, Fill and Backfill.

**END OF SECTION**


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# SECTION 31 23 16
# EXCAVATION

## PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Excavation Plan, Detailing:
   a. Methods and sequencing of excavation.
   b. Proposed locations of stockpiled excavated material.
   c. Proposed offsite spoil disposal sites.
   d. Design calculations demonstrating temporary cut slopes for excavations are stable such that no existing facilities or completed Work will be impacted.
   e. Excavation Plan and design calculations shall be stamped by a professional engineer, licensed in the State of Oklahoma.
   f. Review of Excavation Plan shall only be for compliance with topics included, preparation or performance by registered engineer, and similar specified requirements, and not for accuracy or adequacy of plan or facilities which shall be solely responsibility of the Contractor.
2. Required excavation permits from applicable governing agencies.

1.02 QUALITY ASSURANCE

A. Provide adequate survey control to avoid unauthorized overexcavation.

1.03 WEATHER LIMITATIONS

A. Material excavated when frozen or when air temperature is less than 32 degrees F shall not be used as fill or backfill until material completely thaws.

B. Material excavated during inclement weather shall not be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

1.04 SEQUENCING AND SCHEDULING

A. Demolition: Complete applicable Work specified in Section 02 41 00, Demolition, prior to excavating.


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B. Clearing, Grubbing, and Stripping: Complete applicable Work specified in Section 31 10 00, Site Clearing, prior to excavating.

C. Excavation Support: Install and maintain shoring as necessary to support sides of excavations and prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed Work.

## PART 2 PRODUCTS (NOT USED)

## PART 3 EXECUTION

### 3.01 GENERAL

A. Excavate to lines, grades, and dimensions shown and as necessary to accomplish Work. Excavate to within tolerance of plus or minus 0.1-foot, except where dimensions or grades are shown or specified as maximum or minimum. Allow for forms, working space, granular base, topsoil, and similar items, wherever applicable. Trim to neat lines where concrete is to be deposited against earth.

B. Do not overexcavate without written authorization of Engineer.

C. Remove or protect obstructions as shown and as specified in Section 01 50 00, Temporary Facilities and Controls, Article Protection of Work and Property.

### 3.02 UNCLASSIFIED EXCAVATION

A. Excavation is unclassified. Complete all excavation regardless of the type, nature, or condition of the materials encountered.

### 3.03 TRENCH WIDTH

A. Minimum Width of Trenches:

1. Single Pipes, Conduits, Direct-Buried Cables, and Duct Banks:
   a. Less than 4-inch Outside Diameter or Width: 18 inches.
   b. Greater than 4-inch Outside Diameter or Width: 18 inches greater than outside diameter or width of pipe, conduit, direct-buried cable, or duct bank.
2. Multiple Pipes, Conduits, Cables, or Duct Banks in Single Trench: 18 inches greater than aggregate width of pipes, conduits, cables, duct banks, plus space between.
3. Increase trench widths by thicknesses of sheeting.


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B. Maximum Trench Width: Unlimited, unless otherwise shown or specified, or unless excess width will cause damage to existing facilities, adjacent property, or completed Work.

3.04 EMBANKMENT AND CUT SLOPES

A. Shape, trim, and finish cut slopes to conform with lines, grades, and cross-sections shown, with proper allowance for topsoil or slope protection, where shown.

B. Remove loose stones and rock that exceed 3-inch diameter and that are loose and may roll downslope. Remove exposed roots from cut slopes.

C. Round tops of cut slopes in soil to not less than a 6-foot radius, provided such rounding does not extend offsite or outside easements and rights-of-way, or adversely impacts existing facilities, adjacent property, or completed Work.

3.05 STOCKPILING EXCAVATED MATERIAL

A. Stockpile excavated material that is suitable for use as fill or backfill until material is needed.

B. Post signs indicating proposed use of material stockpiled. Post signs that are readable from all directions of approach to each stockpile. Signs should be clearly worded and readable by equipment operators from their normal seated position.

C. Confine stockpiles to within easements, rights-of-way, and approved work areas. Do not obstruct roads or streets.

D. Do not stockpile excavated material adjacent to trenches and other excavations, unless excavation side slopes and excavation support systems are designed, constructed, and maintained for stockpile loads.

E. Do not stockpile excavated materials near or over existing facilities, adjacent property, or completed Work, if weight of stockpiled material could cause damage by structural failure or settlement.

3.06 DISPOSAL OF SPOIL

A. Dispose of excavated materials, which are unsuitable or exceed quantity needed for fill or backfill, offsite.

B. Dispose of debris resulting from removal of underground facilities as specified in Section 02 41 00, Demolition, for demolition debris.


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C. Dispose of debris resulting from removal of organic matter, trash, refuse, and junk as specified in Section 31 10 00, Site Clearing, for clearing and grubbing debris.

**END OF SECTION**




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# SECTION 31 23 23
# FILL AND BACKFILL

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. ASTM International (ASTM):
   a. C117, Standard Test Method for Materials Finer Than 75-Micrometers (No. 200) Sieve in Mineral Aggregates by Washing.
   b. C136, Standard Method for Sieve Analysis of Fine and Coarse Aggregates.
   c. D75, Standard Practice for Sampling Aggregates.
   d. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft$^3$ (600kN-m/m$^3$)).
   e. D6938, Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

### 1.02 DEFINITIONS

A. Borrow Material: Material from required excavations or from designated borrow areas on or near Site.

B. Completed Course: A course or layer that is ready for next layer or next phase of Work.

C. Imported Material: Materials obtained from sources offsite, suitable for specified use.

D. Influence Area:

1. Area within planes sloped downward and outward at 60-degree angle from horizontal measured from:
   a. 1 foot outside outermost edge at base of foundations or slabs.
   b. 1 foot outside outermost edge at surface of roadways or shoulder.
   c. 0.5 foot outside exterior at spring line of pipes or culverts.

E. Lift: Loose (uncompacted) layer of material.


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F. Optimum Moisture Content:

1. Determined in accordance with ASTM Standard specified to determine maximum dry density for relative compaction.
2. Determine field moisture content on basis of fraction passing 3/4-inch sieve.

G. Prepared Ground Surface: Ground surface after completion of required demolition, clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and subgrade preparation.

H. Relative Compaction:

1. Ratio, in percent, of as-compacted field dry density to laboratory maximum dry density as determined in accordance with ASTM D698.
2. Apply corrections for oversize material to either as-compacted field dry density or maximum dry density, as determined by Engineer.

I. Selected Backfill Material: Materials available onsite that Engineer determines to be suitable for specific use.

J. Structural Fill: Fill materials as required under structures, pavements, and other facilities.

K. Well-Graded:

1. A mixture of particle sizes with no specific concentration or lack thereof of one or more sizes.
2. Does not define numerical value that must be placed on coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters.
3. Used to define material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.

## 1.03 SUBMITTALS

A. Action Submittals: Proposed mixing plan and procedures for native and import materials, to produce a homogenous structural fill material where native soil is unsuitable because of high fines content.

B. Informational Submittals:

1. Manufacturer’s data sheets for compaction equipment.
2. Certified test results from independent testing agency.


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1.04 QUALITY ASSURANCE

A. Notify Engineer when:

1. Structure or tank is ready for backfilling, and whenever backfilling operations are resumed after a period of inactivity.
2. Soft or loose subgrade materials are encountered wherever embankment or site fill is to be placed.
3. Fill material appears to be deviating from these Specifications.

1.05 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in Section 02 41 00, Demolition; Section 31 10 00, Site Clearing; Section 31 23 16, Excavation; and Section 31 23 13, Subgrade Preparation, prior to placing fill or backfill.

B. Backfill against concrete structures only after concrete has attained compressive strength, specified in Section 03 30 00, Cast-in-Place Concrete. Obtain Engineer's acceptance of concrete work and attained strength prior to placing backfill.

C. Backfill around water-holding structures only after completion of satisfactory leakage tests as specified in Section 03 30 00, Cast-in-Place Concrete.

D. Do not place granular base, subbase, or surfacing until after subgrade has been prepared as specified in Section 31 23 13, Subgrade Preparation.

**PART 2 PRODUCTS**

2.01 SOURCE QUALITY CONTROL

A. Gradation Tests:

1. As necessary to locate acceptable sources of imported material.
2. During production of imported material, test as follows:
   a. Structural Fill: One test per 250 cubic yards.
   b. Base Course Rock: One test per 500 cubic yards.
   c. Foundation Stabilization Rock: One test per 500 cubic yards.

2.02 EARTHFILL

A. Excavated material from required excavations free from rocks larger than 3 inches, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials.

B. Provide imported material of equivalent quality, if required to accomplish Work.


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2.03 STRUCTURAL FILL

A. Well-graded from coarse to fine and containing sufficient fines to bind material when compacted.

B. Maximum of 35 percent passing the No. 200 sieve.

C. 100 percent passing the 3-inch sieve.

D. Nonplastic or low plasticity material (Liquid Limit less than 35, Plasticity Index less than 12).

E. Some of the native soil material consists of silt or silty sand that is unsuitable for structural fill without amendment. Refer to Report for Geotechnical Drilling and Laboratory Testing Services, Proposed Biosolids Improvements at Haikey Creek WWTP, prepared by Kleinfelder, 2025.

F. Excavated material from required excavations meeting the gradation and plasticity requirements may be used provided it is free from rocks larger than 3 inches, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials.

G. Provide imported material of equivalent quality, if required to accomplish Work.

2.04 WATER FOR MOISTURE CONDITIONING

A. Free of hazardous or toxic contaminates, or contaminants deleterious to proper compaction.

2.05 BASE COURSE ROCK

A. As specified in Section 32 11 23, Aggregate Base Courses.

2.06 FOUNDATION STABILIZATION ROCK

A. Angular, crushed rock or pit run rock.

B. Uniformly graded from maximum to minimum particle size.

C. Free from excessive dirt and other organic material.

D. Maximum 3-inch particle size.

E. Maximum 10 percent passing the No. 4 sieve.

F. Minimum 60 percent retained on the 1-inch sieve.


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## PART 3 EXECUTION

### 3.01 GENERAL

A. Keep placement surfaces free of water, debris, and foreign material during placement and compaction of fill and backfill materials.

B. Place and spread fill and backfill materials in horizontal lifts of uniform thickness, in a manner that avoids segregation, and compact each lift to specified densities prior to placing succeeding lifts. Slope lifts only where necessary to conform to final grades or as necessary to keep placement surfaces drained of water.

C. During filling and backfilling, keep level of fill and backfill around each structure and buried tank even.

D. Do not place fill or backfill, if fill or backfill material is frozen, or if surface upon which fill or backfill is to be placed is frozen.

E. If pipe, conduit, duct bank, or cable is to be laid within fill or backfill:

1. Fill or backfill to an elevation 2 feet above top of item to be laid.
2. Excavate trench for installation of item.
3. Install bedding, if applicable, as specified in Section 31 23 23.15, Trench Backfill.
4. Install item.
5. Backfill envelope zone and remaining trench, as specified in Section 31 23 23.15, Trench Backfill, before resuming filling or backfilling specified in this section.

F. Tolerances:

1. Final Lines and Grades: Within a tolerance of 0.1 foot unless dimensions or grades are shown or specified otherwise.
2. Grade to establish and maintain slopes and drainage as shown. Reverse slopes are not permitted.

G. Settlement: Correct and repair any subsequent damage to structures, pavements, curbs, slabs, piping, and other facilities, caused by settlement of fill or backfill material.

### 3.02 BACKFILL UNDER AND AROUND STRUCTURES

A. Under and Around Facilities: Within influence area beneath structures, slabs, pavements, curbs, piping, conduits, duct banks, and other facilities, backfill with Structural Fill, unless otherwise shown. Place Structural Fill in lifts of


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8-inch maximum thickness and compact each lift to minimum of 95 percent relative compaction as determined in accordance with ASTM D698.

B. Adjacent to Existing Walls: Compaction within 3-feet of existing walls shall be completed using hand-operated equipment approved and overseen by Design Geotechnical Engineer.

C. Subsurface Drainage: Backfill with granular drain material, where shown. Place granular drain material in lifts of 6-inch maximum thickness and compact each lift to minimum of 90 percent relative density.

D. Other Areas: Backfill with earthfill to lines and grades shown, with proper allowance for surfacing thickness where shown. Place in lifts of 8-inch maximum thickness and compact each lift to minimum 95 percent relative compaction as determined in accordance with ASTM D698.

3.03 FILL

A. Outside Influence Areas beneath Structures, Tanks, Pavements, Curbs, Slabs, Piping, and Other Facilities:

1. Unless otherwise shown, place earthfill as follows:
   a. Allow for 6-inch thickness of topsoil where required.
   b. Maximum 8-inch thick lifts.
   c. Place and compact fill across full width of embankment.
   d. Compact to minimum 90 percent relative compaction as determined in accordance with ASTM D698.

3.04 SITE TESTING

A. Gradation Testing by Contractor: One test for each material product with required gradation, submitted for approval.

B. Gradation Testing by Owner Representative:

1. One sample from each 1,500 tons of finished product or more often as determined by Engineer, if variation in gradation is occurring, or if material appears to depart from these Specifications.
2. If test results indicate material does not meet specification requirements, terminate material placement until corrective measures are taken.
3. Remove material placed in Work that does not meet specification requirements.

C. Compaction Curves by Owner’s Representative: In accordance with ASTM D698. One curve for each material type and a minimum of one curve


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for each 5,000 cubic yards of material placed. Perform supplemental curves as necessary to verify field measurements are consistent with laboratory curves.

D. In-Place Density Tests by Owner's Representative:

1. In accordance with ASTM D6938. During placement of materials, test as follows:
   a. Structural Fill and Earthfill: One per 250 cubic yards of material placed and at least one per vertical foot of fill placed.
   b. Base Course Rock: As specified in Section 32 11 23, Aggregate Base Courses.

3.05 GRANULAR BASE, SUBBASE, AND SURFACING

A. Place and Compact as specified in Section 32 11 23, Aggregate Base Courses.

3.06 REPLACING OVEREXCAVATED MATERIAL

A. Replace excavation carried below grade lines shown or established by Engineer as follows:

1. Beneath Footings: Concrete fill, as specified in Section 03 30 00, Cast-in-Place Concrete.
2. Beneath Fill or Backfill: Same material as specified for overlying fill or backfill.
3. Beneath Slabs-On-Grade: Aggregate base rock as specified in Section 32 11 23, Aggregate Base Courses.
4. Trenches:
   a. Unauthorized Overexcavation: Either trench stabilization material or granular pipe bedding material, as specified in Section 31 23 23.15, Trench Backfill.
   b. Authorized Overexcavation: Trench stabilization material, as specified in Section 31 23 23.15, Trench Backfill.
5. Permanent Cut Slopes (Where Overlying Area is Not to Receive Fill or Backfill):
   a. Flat to Moderate Steep Slopes (3:1, Horizontal Run: Vertical Rise or Flatter): Earthfill.
   b. Steep Slopes (Steeper than 3:1):
      1) Correct overexcavation by transitioning between overcut areas and designed slope adjoining areas, provided such cutting does not extend offsite or outside easements and right-of-ways, or adversely impacts existing facilities, adjacent property, or completed Work.
      2) Backfilling overexcavated areas is prohibited, unless in Engineer's opinion, backfill will remain stable, and overexcavated material is replaced as compacted earthfill.


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## 3.07 ACCESS ROAD SURFACING

A. Place and compact as specified in Section 32 11 23, Aggregate Base Courses.

**END OF SECTION**


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# SECTION 31 23 23.15
# TRENCH BACKFILL

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American Public Works Association (APWA): Uniform Color Code.
2. ASTM International (ASTM):
   a. C33/C33M, Standard Specification for Concrete Aggregates.
   b. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   c. C117, Standard Test Method for Materials Finer than 75 Micrometer (No. 200) Sieve in Mineral Aggregates by Washing.
   d. C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   e. C150/C150M, Standard Specification for Portland Cement.
   f. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
   g. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 feet-lbf/feet$^3$ (600 kN-m/m$^3$)).
   h. D1140, Standard Test Methods for Amount of Material in Soils Finer than No. 200 (75 micrometer) Sieve.
   i. D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
   j. D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
   k. D4832, Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
   l. D6913, Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis.
3. National Electrical Manufacturers Association (NEMA): Z535.1, Safety Colors.

### 1.02 DEFINITIONS

A. Base Rock: Granular material upon which manhole bases and other structures are placed.

B. Bedding Material: Granular material upon which pipes, conduits, cables, or duct banks are placed.


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C. Imported Material: Material obtained by Contractor from source(s) offsite.

D. Lift: Loose (uncompacted) layer of material.

E. Pipe Zone: Backfill zone that includes full trench width and extends from prepared trench bottom to an upper limit above top outside surface of pipe, conduit, cable or duct bank.

F. Prepared Trench Bottom: Graded trench bottom after excavation and installation of stabilization material, if required, but before installation of bedding material.

G. Relative Compaction: The ratio, in percent, of the as-compacted field dry density to the laboratory maximum dry density as determined by ASTM D698. Corrections for oversize material may be applied to either as-compacted field dry density or maximum dry density, as determined by Engineer.

H. Selected Backfill Material: Material available onsite that Engineer determines to be suitable for a specific use.

I. Well-Graded: As defined in Section 31 23 23, Fill and Backfill.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Manufacturer’s descriptive literature for marking tapes and tracer wire.

B. Informational Submittals:

1. Catalog and manufacturer’s data sheets for compaction equipment.
2. Certified Gradation Analysis: Submit not less than 30 days prior to delivery for imported materials or anticipated use for excavated materials, except for trench stabilization material that will be submitted prior to material delivery to Site.
3. Controlled Low Strength Material: Certified mix design and test results. Include material types and weight per cubic yard for each component of mix.

## PART 2 PRODUCTS

2.01 GEOTEXTILE

A. As specified in Section 31 32 19.16, Geotextile.


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## 2.02 MARKING TAPE

A. Nondetectable:

1. Inert polyethylene, impervious to known alkalis, acids, chemical reagents, and solvents likely to be encountered in soil.
2. Thickness: Minimum 4 mils.
3. Width: 3 inches.
4. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.
5. Manufacturers and Products:
   a. Reef Industries; Terra Tape.
   b. Mutual Industries; Non-detectable Tape.
   c. Presco; Non-detectable Tape.

B. Detectable:

1. Solid aluminum foil, visible on unprinted side, encased in protective high visibility, inert polyethylene plastic jacket.
2. Foil Thickness: Minimum 0.35 mils.
3. Laminate Thickness: Minimum 5 mils.
4. Width: 3 inches.
5. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.
6. Joining Clips: Tin or nickel-coated furnished by tape manufacturer.
7. Manufacturers and Products:
   a. Reef Industries; Terra Tape, Sentry Line Detectable.
   b. Mutual Industries; Detectable Tape.
   c. Presco; Detectable Tape.

C. Color: In accordance with APWA Uniform Color Code.

| **Color*** | **Facility** |
|---|---|
| Red | Electric power lines, cables, conduit, and lightning cables |
| Orange | Communicating alarm or signal lines, cables, or conduit |
| Yellow | Gas, oil, steam, petroleum, or gaseous materials |
| Green | Sewers and drain lines |
| Blue | Potable water |
| Purple | Reclaimed water, irrigation, and slurry lines |
| *As specified in NEMA Z535.1, Safety Color Code. | |


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## 2.03 TRENCH STABILIZATION MATERIAL

A. Clean, hard, durable 3-inch minus crushed rock or gravel, or pit run, free from clay balls, other organic materials, or debris.

B. Uniformly graded from coarse to fine, less than 8 percent by weight passing the 1/4-inch sieve.

## 2.04 BEDDING MATERIAL AND PIPE ZONE MATERIAL

A. Unfrozen, friable, and no clay balls, roots, or other organic material.

B. Clean or gravelly sand with less than 5 percent passing No. 200 sieve, as determined in accordance with ASTM D1140.

1. Duct Banks: 3/4-inch maximum particle size.
2. PVC Irrigation System Piping and Ductile Iron Pipe with Polyethylene Wrap: 3/8-inch maximum particle size.
3. Pipe Under 18-Inch Diameter: 3/4-inch maximum particle size, except 1/4 inch for stainless steel pipe, copper pipe, tubing, and plastic pipe under 3-inch diameter.
4. Pipe 18-Inch Diameter and Greater: 1-1/2-inch maximum particle size for ductile iron pipe, concrete pipe, welded steel pipe, and pretensioned or prestressed concrete cylinder pipe.
5. Perforated Pipe: Granular drain material.
6. Conduit and Direct-Buried Cable:
    a. Sand, clean or clean to silty, less than 12 percent passing No. 200 sieve.
    b. Individual Particles: Free of sharp edges.
    c. Maximum Size Particle: Pass a No. 4 sieve.
    d. If more than 5 percent passes No. 200 sieve, the fraction that passes No. 40 sieve shall be nonplastic as determined in accordance with ASTM D4318.

## 2.05 EARTH BACKFILL

A. Soil, loam, or other excavated material suitable for use as backfill.

B. Free from roots or organic matter, refuse, particles larger than 2 inches or other deleterious materials.

## 2.06 GRANULAR BACKFILL

A. As specified for base course in Section 32 11 23, Aggregate Base Courses.


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2.07 CONTROLLED LOW STRENGTH MATERIAL (CLSM)

A. A flowable, workable mixture of aggregate, cement, water, and admixtures as necessary.

B. Select and proportion ingredients to obtain compressive strength between 50 pounds per square inch and 150 pounds per square inch at 28 days in accordance with ASTM D4832.

C. Materials:

1. Cement: ASTM C150/C150M, Type I, Type IL, or Type II.
2. Aggregate: ASTM C33/C33M, Size 9, or fine aggregate.
3. Fly Ash (Pozzolan): Class F, Class N, or Class C fly ash in accordance with ASTM C618.
4. Water: Clean, potable, containing less than 500 ppm of chlorides.

2.08 GRAVEL SURFACING ROCK

A. As specified in Section 32 11 23, Aggregate Base Courses.

2.09 TOPSOIL

A. As specified in Section 32 91 13, Soil Preparation.

2.10 SOURCE QUALITY CONTROL

A. Perform gradation analysis in accordance with ASTM C136 or ASTM D6938, as applicable, for:

1. Earth backfill.
2. Trench stabilization material.
3. Bedding and pipe zone material.

B. Certify Laboratory Performance of Mix Designs:

1. Controlled low strength material.
2. Concrete.

**PART 3 EXECUTION**

3.01 TRENCH PREPARATION

A. Water Control:

1. Promptly remove and dispose of water entering trench as necessary to grade trench bottom and to compact backfill and install manholes, pipe,


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conduit, direct-buried cable, or duct bank. Do not place concrete, lay pipe, conduit, direct-buried cable, or duct bank in water.

2. Remove water in a manner that minimizes soil erosion from trench sides and bottom.
3. Provide continuous water control until trench backfill is complete.

B. Remove foreign material and backfill contaminated with foreign material that falls into trench.

## 3.02 TRENCH BOTTOM

A. Firm Subgrade: Grade with hand tools, remove loose and disturbed material, and trim off high areas and ridges left by excavating bucket teeth. Allow space for bedding material if shown or specified.

B. Soft Subgrade: If subgrade is encountered that may require removal to prevent pipe settlement, notify Engineer. Engineer will determine depth of overexcavation, if any required. Backfill overexcavation with Trench Stabilization Material.

## 3.03 GEOTEXTILE INSTALLATION

A. Where shown and as specified in Section 31 32 19.16, Geotextile, except as follows:

1. Extend geotextile for full width of trench bottom and up the trench wall to the top of the pipe zone, or base material for manholes and miscellaneous structures.
2. Anchor geotextile trench walls prior to placing trench stabilization.
3. Provide 24-inch minimum overlap at joints.

## 3.04 TRENCH STABILIZATION MATERIAL INSTALLATION

A. Rebuild trench bottom with trench stabilization material where bottom of trench is soft or yielding, as verified by Engineer.

B. Place material over full width of trench in 6-inch lifts to required grade, providing allowance for bedding thickness.

C. Compact each lift so as to provide a firm, unyielding support for the bedding material prior to placing succeeding lifts.

## 3.05 BEDDING

A. Furnish imported bedding material where, in the opinion of Engineer, excavated material is unsuitable for bedding or insufficient in quantity.


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B. Hand grade and compact each lift to provide a firm, unyielding surface.

C. Minimum Thickness: 4 inches.

D. Check grade and correct irregularities in bedding material. Loosen top 1-inch to 2 inches of compacted bedding material with a rake or by other means to provide a cushion before laying each section of pipe, conduit, direct-buried cable, or duct bank.

E. Install to form continuous and uniform support except at bell holes, if applicable, or minor disturbances resulting from removal of lifting tackle.

F. Bell or Coupling Holes: Excavate in bedding at each joint to permit proper assembly and inspection of joint and to provide uniform bearing along barrel of pipe or conduit.

3.06 BACKFILL PIPE ZONE

A. Upper limit of pipe zone shall not be less than following:

1. Pipe: 12 inches, unless shown otherwise.
2. Conduit, Cables, and Ductbanks: 3 inches, unless shown otherwise.

B. Restrain pipe, conduit, cables, and duct banks as necessary to prevent their movement during backfill operations.

C. Place material simultaneously in lifts on both sides of pipe and, if applicable, between pipes, conduit, cables, and duct banks installed in same trench.

1. Pipe 10-Inch and Smaller Diameter: First lift less than or equal to 1/2 pipe diameter. Subsequent lifts maximum 6 inches thick.
2. Pipe Over 10-Inch Diameter: Maximum 6-inch lifts.

D. Thoroughly tamp each lift, including area under haunches, with handheld tamping bars supplemented by “walking in” and slicing material under haunches with a shovel to ensure voids are completely filled before placing each succeeding lift.

E. Do not use power-driven impact compactors to compact pipe zone material. After full depth of pipe zone material has been placed as specified, compact material by a minimum of three passes with a vibratory plate compactor only over area between sides of pipe and trench walls.


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## 3.07 MARKING TAPE INSTALLATION

A. Continuously install marking tape along centerline of buried piping, on top of last lift of pipe zone material. Coordinate with piping installation drawings.

1. Detectable Marking Tape: Install with nonmetallic piping and waterlines.
2. Nondetectable Marking Tape: Install with metallic piping.

## 3.08 BACKFILL ABOVE PIPE ZONE

A. General:

1. Process excavated material to meet specified gradation requirements.
2. Adjust moisture content as necessary to obtain specified compaction.
3. Do not allow backfill to free fall into trench or allow heavy, sharp pieces of material to be placed as backfill until after at least 2 feet of backfill has been provided over top of pipe.
4. Do not use power driven impact type compactors for compaction until at least 4 feet of backfill is placed over top of pipe.
5. Backfill to grade with proper allowances for topsoil, crushed rock surfacing, and pavement thicknesses, wherever applicable.
6. Backfill around structures with same class backfill as specified for adjacent trench, unless otherwise shown or specified.

B. Unimproved Area:

1. Backfill with Earth Backfill.
2. Place in lifts not exceeding thickness of 9 inches.
3. Mechanically compact each lift to a minimum of 95 percent relative compaction prior to placing succeeding lifts.
    a. Correct excess or deficiency of backfill material apparent after settlement and within correction period by regrading and disposing of excess material or adding additional material where deficient.

C. Beneath Surface Improvements:

1. Backfill with Granular Backfill in lifts not exceeding 8 inches.
2. Mechanically compact each lift to a minimum of 95 percent relative compaction prior to placing succeeding lifts.



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D. Controlled Low Strength Material:

1. Discharge from truck mounted drum type mixer into trench.
2. Place in lifts as necessary to prevent uplift (flotation) of new and existing facilities.
3. Fill trench section as shown.

3.09 REPLACEMENT OF TOPSOIL

A. Replace topsoil in top 6 inches of backfilled trench.

B. Maintain finished grade of topsoil even with adjacent area and grade as necessary to restore drainage.

3.10 MAINTENANCE OF TRENCH BACKFILL

A. After each section of trench is backfilled, maintain surface of backfilled trench even with adjacent ground surface until final surface restoration is completed.

B. Gravel Surfacing Rock: Add gravel surfacing rock where applicable and as necessary to keep surface of backfilled trench even with adjacent ground surface, and grade and compact as necessary to keep surface of backfilled trenches smooth, free from ruts and potholes, and suitable for normal traffic flow.

C. Topsoil: Add topsoil where applicable and as necessary to maintain surface of backfilled trench level with adjacent ground surface.

D. Concrete Pavement: Replace settled slabs as specified in Section 32 12 16, Asphalt Paving.

E. Asphaltic Pavement: Replace settled areas or fill with asphalt as specified in Section 32 12 16, Asphalt Paving.

F. Other Areas: Add excavated material where applicable and keep surface of backfilled trench level with adjacent ground surface.

3.11 SETTLEMENT OF BACKFILL

A. Settlement of trench backfill, or of fill, or facilities constructed over trench backfill will be considered a result of defective compaction of trench backfill.

**END OF SECTION**


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# SECTION 31 32 19.16
# GEOTEXTILE

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. ASTM International (ASTM):
   a. D737, Standard Test Method for Air Permeability of Textile Fabrics.
   b. D4355, Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
   c. D4491, Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
   d. D4533, Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
   e. D4595, Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
   f. D4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
   g. D4716, Test Method for Determining the (In-Plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head.
   h. D4751, Standard Test Method for Determining Apparent Opening Size of a Geotextile.
   i. D5261, Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
   j. D6241, Standard Test Method for Measuring Static Puncture Strength of Geotextiles and Geosynthetic-Related Products Using a 50mm Probe.

### 1.02 DEFINITIONS

A. Fabric: Geotextile, a permeable geosynthetic comprised solely of textiles.

B. Maximum Average Roll Value (MaxARV): Maximum of series of average roll values representative of geotextile furnished.

C. Minimum Average Roll Value (MinARV): Minimum of series of average roll values representative of geotextile furnished.


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D. Nondestructive Sample: Sample representative of finished Work, prepared for testing without destruction of Work.

E. Overlap: Distance measured perpendicular from overlapping edge of one sheet to underlying edge of adjacent sheet.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Manufacturer material specifications and product literature.
   b. Installation drawings showing geotextile sheet layout, location of seams, direction of overlap, and sewn seams.
   c. Description of proposed method of geotextile deployment, sewing equipment, sewing methods, and provisions for holding geotextile temporarily in place until permanently secured.

B. Informational Submittals:

1. Certifications from each geotextile manufacturer that furnished products have specified property values. Certified property values shall be either minimum or maximum average roll values, as appropriate, for geotextiles furnished.
2. Field seam efficiency test results.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver each roll with sufficient information attached to identify it for inventory and quality control.

B. Handle products in manner that maintains undamaged condition.

C. Do not store products directly on ground. Ship and store geotextile with suitable wrapping for protection against moisture and ultraviolet exposure. Store geotextile in way that protects it from elements. If stored outdoors, elevate and protect geotextile with waterproof cover.

1.05 SCHEDULING AND SEQUENCING

A. Where geotextile is to be laid directly upon ground surface, prepare subgrade as specified in Section 31 23 13, Subgrade Preparation, first.

B. Notify Engineer whenever geotextiles are to be placed. Do not place geotextile without Engineer’s approval of underlying materials.


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## PART 2 PRODUCTS

2.01 NONWOVEN GEOTEXTILE

A. Pervious sheet of polyester, polypropylene, or polyethylene fabricated into stable network of fibers that retain their relative position with respect to each other. Nonwoven geotextile shall be composed of continuous or discontinuous (staple) fibers held together through needle-punching, spun-bonding, thermal-bonding, or resin-bonding.

B. Geotextile Edges: Selvaged or otherwise finished to prevent outer material from pulling away from geotextile.

C. Unseamed Sheet Width: Minimum 12 feet.

D. Nominal Weight per Square Yard:8 per ASTM D5261.

E. Physical Properties: Conform to requirements in Table No. 1.

**Table No. 1**
**Physical Property Requirements for Nonwoven Geotextile**

| Property | Requirement | Test Method |
|---|---|---|
| Water Permittivity | 1.3 $sec.^{-1}$, MinARV | ASTM D4491 (Falling Head) |
| Apparent Opening Size (AOS) | No. 80 U.S. Standard Sieve Size | ASTM D4751 |
| Puncture Strength | 500 lb, MinARV | ASTM D6241 |
| Trapezoid Tear Strength | 80 lb, MinARV | ASTM D4533 |


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## 2.02 SEDIMENT FENCE GEOTEXTILE

A. Geotextiles shall consist only of long chain polymeric fibers or yarns formed into a stable network such that the fibers or yarns retain their position relative to each other during handling, placement, and design service life. At least 95 percent by weight of the material shall be polyolefins or polyesters. The material shall be free from defects or tears. Geotextile shall also be free of any treatment or coating which might adversely alter its hydraulic or physical properties after installation. Geotextile properties shall be as described in Table 2.

**Table 2**
**Geotextile for Sediment Fence**

| Geotextile Property | ASTM Test Method | Geotextile Property Requirements | |
|---|---|---|---|
| | | Unsupported Between Posts | Supported Between Posts with Wire or Polymeric Mesh |
| AOS | D4751 | U.S. No. 30 max. for silt wovens, U.S. No. 50 for all other geotextile types, U.S. No. 100 min. | |
| Water Permittivity | D4491 | 0.2 $sec^{-1}$ min. | |
| Grab Tensile Strength, in machine and x-machine direction | D4632/ D4632M | 180 lb min. in machine direction, 100 lb min. in x-machine direction | 100 lb min. |
| Grab Failure Strain, in machine and x-machine direction | D4632/ D4632M | 30% max. at 180 lb or more | |
| Ultraviolet (UV) Radiation Stability | D4355 | 70% strength retained min., after 500 hours in xenon arc device | |

## 2.03 SEPARATION GEOTEXTILE

A. Geotextile shall conform to the requirements described in Section 712.05 of the Oklahoma Department of Transportation Standard Specifications for Highway Construction, 2019 Edition.

## 2.04 SECURING PINS

A. Steel Rods or Bars:

1. 3/16-inch diameter.
2. Pointed at one end.
3. With head on other end sufficiently large to retain washer.
4. Minimum Length: 12 inches.


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B. Steel Washers for Securing Pins:

1. Outside Diameter: Not less than 1.5 inches.
2. Inside Diameter: 1/4 inch.
3. Thickness: 1/8 inch.

C. Steel Wire Staples:

1. U-shaped.
2. 10 gauge.
3. Minimum Length: 6 inches.

## PART 3 EXECUTION

### 3.01 LAYING GEOTEXTILE

A. Lay and maintain geotextile smooth and free of tension, folds, wrinkles, or creases.

### 3.02 SHEET ORIENTATION ON SLOPES

A. Orient geotextile with long dimension of each sheet parallel to direction of slope.

### 3.03 JOINTS

A. Unseamed Joints:

1. Overlapped.
2. Overlap, 18 inches unless otherwise shown.

### 3.04 SECURING GEOTEXTILE

A. Secure geotextile during installation as necessary with sandbags or other means approved by Engineer.

B. Secure Geotextile with Securing Pins or Staples:

1. Insert securing pins with washers through geotextile.
2. Securing Pin Alignment:
   a. Midway between edges of overlaps.
   b. 6 inches from free edges.


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3. Spacing of Securing Pins:

| Slope | Maximum Pin Spacing |
|---|---|
| Steeper than 3:1 | 2 feet |
| 3:1 to 4:1 | 3 feet |
| Flatter than 4:1 | 5 feet |

4. Install additional pins across each geotextile sheet as necessary to prevent slippage of geotextile or to prevent wind from blowing geotextile out of position.
5. Push each securing pin through geotextile until washer bears against geotextile and secures it firmly to subgrade.
6. Where staples are used instead of securing pins, install in accordance with alignment and spacing above. Push in to secure geotextile firmly to subgrade.

3.05 PLACING PRODUCTS OVER GEOTEXTILE

A. Before placing material over geotextile, notify Engineer. Do not cover installed geotextile until after Engineer provides authorization to proceed.

B. If tears, punctures, or other geotextile damage occurs during placement of overlying products, remove overlying products as necessary to expose damaged geotextile. Repair damage as specified in Article Repairing Geotextile.

3.06 INSTALLING GEOTEXTILE IN TRENCHES

A. Place geotextile in a way to completely envelope granular drain material or trench stabilization material to be placed in trench and with specified overlap at joints. Overlap geotextile in direction of flow. Place geotextile in a way and with sufficient slack for geotextile to contact trench bottom and sides fully when trench is backfilled.

B. After granular drain or trench stabilization material is placed to required grade, fold geotextile over top of granular drain material or trench stabilization material, unless otherwise shown. Maintain overlap until overlying fill or backfill is placed.


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3.07 RIPRAP APPLICATIONS

A. Overlap geotextile at each joint with upstream sheet of geotextile overlapping downstream sheet.

B. Limit height of riprap fall onto geotextile to prevent damage.

3.08 REPAIRING GEOTEXTILE

A. Repair or replace torn, punctured, flawed, deteriorated, or otherwise damaged geotextile.

B. Repair Procedure:

1. Place patch of undamaged geotextile over damaged area and at least 18 inches in all directions beyond damaged area.
2. Remove interfering material as necessary to expose damaged geotextile for repair.
3. Sew patches or secure them with heat fusion tacking or with pins and washers, as specified above in Article Securing Geotextile, or by other means approved by Engineer.

3.09 REPLACING CONTAMINATED GEOTEXTILE

A. Protect geotextile from contamination that would interfere, in Engineer's opinion, with its intended function. Remove and replace contaminated geotextile with clean geotextile.

**END OF SECTION**


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# SECTION 32 11 23
# AGGREGATE BASE COURSES

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. T11, Standard Method of Test for Materials Finer Than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing.
   b. T27, Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates.
   c. T89, Standard Specification for Determining the Liquid Limit of Soils.
   d. T90, Standard Specification for Determining the Plastic Limit and Plasticity Index of Soils.
   e. T96, Standard Specification for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   f. T180, Standard Specification for Moisture-Density Relations of Soils Using a 4.54 kg (10-lb) Rammer and a 457 mm (18-inch) Drop.
2. ASTM International (ASTM):
   a. D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 feet-lb/feet$^3$ (2700 kN-m/m$^3$)).
   b. D4791, Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.
   c. D6938, Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
3. Oklahoma Department of Transportation (ODOT):
   a. Section 301, Standard Specification for General Requirements for Bases
   b. Section 303, Standard Specification for Aggregate Base.


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1.02 DEFINITIONS

A. Base Course: Crushed aggregate or similar as specified placed and compacted on prepared subgrade or subbase course.

B. Completed Course: Compacted, unyielding, free from irregularities, with smooth, tight, even surface, true to grade, line, and cross-section.

C. Completed Lift: Compacted with uniform cross-section thickness.

D. Gravel Surfacing: Aggregate used for construction of low-volume access and staging area that can be easily graded and compacted.

E. Standard Specifications: When referenced in this section, shall mean Oklahoma DOT Standard Specifications for Highway Construction.

1.03 SUBMITTALS

A. Informational Submittals:

1. Certified Test Results on Source Materials: Submit copies from commercial testing laboratory 20 days prior to delivery of materials to Project showing materials meeting the physical qualities specified.

**PART 2 PRODUCTS**

2.01 BASE COURSE

A. As specified in Section 303 of the Standard Specifications.

B. Clean, hard durable, pit run gravel or crushed stone graded from coarse to fine containing enough fines to bind material when compacted.

C. Physical Qualities: As specified in Section 703.01 of the Standard Specifications for Type C Aggregate Base.

2.02 GRAVEL SURFACING

A. Clean, tough, uniform quality, durable fragments of crushed rock, free from flat, elongated, soft or disintegrated pieces, or other objectionable matter occurring either free or as coating on stone.

B. Physical Qualities: As specified in Section 703.01 of the Standard Specifications for Type C Aggregate Base.


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2.03 SOURCE QUALITY CONTROL

A. Perform tests necessary to locate acceptable source of materials meeting specified requirements.

B. Final approval of aggregate material will be based on test results of installed materials.

C. Should separation of coarse from fine materials occur during processing or stockpiling, immediately change methods of handling materials to correct uniformity in grading.

**PART 3 EXECUTION**

3.01 SUBGRADE PREPARATION

A. As specified in Section 31 23 13, Subgrade Preparation.

B. Obtain Engineer's acceptance of subgrade before placing base course or surfacing material.

C. Do not place base course or surfacing materials on soft, muddy, or frozen subgrade.

3.02 EQUIPMENT

A. Compaction Equipment: Adequate in design and number to provide compaction and to obtain specified density for each layer.

3.03 HAULING AND SPREADING

A. In accordance with Section 303 of the Standard Specifications.

B. Hauling Materials:

1. Do not haul over surfacing in process of construction.
2. Loads: Uniform capacity.
3. Maintain consistent gradation of material delivered; loads of widely varying gradations will be cause for rejection.

C. Spreading Materials:

1. Distribute material to provide required density, depth, grade, and dimensions with allowance for subsequent lifts.
2. Produce even distribution of material upon roadway or prepared surface without segregation.


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3. Should segregation of coarse from fine materials occur during placing, immediately change methods of handling materials to correct uniformity in grading.

3.04 CONSTRUCTION OF COURSES

A. Construction of Courses: In accordance with Section 303 of the Standard Specifications.

B. Aggregate Base Course Surface:

1. Maximum Completed Lift Thickness: 4 inches.
2. Completed Course Total Thickness: As shown.
3. Lightly blade and roll surface until thoroughly compacted.

C. Gravel Surfacing:

1. Maximum Completed Lift Thickness: 9 inches.
2. Completed Course Total Thickness: As shown.
3. Spread on preceding course in accordance with cross-section shown.
4. Blade lightly and roll surface until material is thoroughly compacted.

3.05 ROLLING AND COMPACTION

A. Commence compaction of each layer of base and gravel surfacing after spreading operations and continue until density of 95 percent of maximum density has been achieved as determined by ASTM D1557 or AASHTO T180.

B. Roll each layer of material until material does not creep under roller before subsequent layer is applied.

C. Commence rolling at outer edges and continue toward center; do not roll center of road first.

D. Apply water as needed to obtain specified densities.

E. Place and compact each lift to the required density before succeeding lift is placed.

F. Remove floating or loose stone from surface of preceding course before placing leveling course.

G. Surface Defects: Remedy by loosening and rerolling. Reroll entire area, including surrounding surface, until thoroughly compacted.

H. Finished surface shall be true to grade and crown before proceeding with surfacing.



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## 3.06 SURFACE TOLERANCES

A. Blade or otherwise work surfacing as necessary to maintain grade and cross-section at all times, and to keep surface smooth and thoroughly compacted.

B. Finished Surface of Aggregate Base Course: Within plus or minus 0.04-foot of grade shown at any individual point.

C. Gravel Surfacing: Within 0.04 foot from lower edge of 10-foot straightedge placed on finished surface, parallel to centerline.

## 3.07 FIELD QUALITY CONTROL

A. Contractor to provide continuous quality control to place and compact materials that meet the specifications. Material placed and compacted that does not meet specifications shall be removed and replaced at no cost to the Owner.

B. Notify Engineer at least 72 hours prior to first use of new material so that material testing can be performed prior to stat of aggregate base placement.

C. Notify Engineer at least 24 hours before aggregate base placement work restarts and 24 hours before significant change in compaction equipment or procedures.

D. Perform moisture-density relationship test in accordance with ASTM D1557 or AASHTO T180 on each aggregate grading produced.

E. Owner to retain independent material testing company to act as Owner Representative and provide testing and inspection services to verify fill material placement conforms to these specifications. Quality assurance testing by the Owner does not relieve the contractor from quality control requirements and testing.

F. In-Place Density Tests in accordance with ASTM D6938: one test per 1,000 square feet of surface area for each lift.

## 3.08 CLEANING

A. Remove excess material from the Work area. Clean stockpile and staging areas of all excess aggregate.

**END OF SECTION**


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# SECTION 32 12 16
# ASPHALT PAVING

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. M17, Standard Specification for Mineral Filler for Bituminous Paving Mixtures.
   b. M81, Standard Specification for Cut-Back Asphalt (Rapid Curing Type).
   c. M82, Standard Specification for Cut-Back Asphalt (Medium Curing Type).
   d. M140, Standard Specification for Emulsified Asphalt.
   e. M208, Standard Specification for Cationic Emulsified Asphalt.
   f. T166, Standard Method of Test for Bulk Specific Gravity (Gmb) of Compacted Hot Mix Asphalt (HMA) Mixtures Using Saturated Surface-Dry Specimens.
   g. T176 Standard Method of Test for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test.
   h. T230, Standard Method of Test for Determining Degree of Pavement Compaction of Bituminous Aggregate Mixtures.
   i. T245, Standard Method of Test for Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus.
   j. T246, Standard Method of Test for Resistance to Deformation and Cohesion of Hot Asphalt Mixture by Means of Hveem Apparatus.
   k. T247, Standard Method of Test for Preparation of Test Specimens of Hot Mix Asphalt (HMA) by Means of California Kneading Compactor.
   l. T283, Standard Method of Test for Resistance of Compacted Hot Asphalt Mixtures to Moisture-Induced Damage.
   m. T304, Standard Method of Test for Uncompacted Void Content of Fine Aggregate.
2. Asphalt Institute (AI):
   a. Manual Series No. 2 (MS-2), Mix Design Methods for Asphalt Concrete.
   b. Superpave Series No. 2 (SP-2), Superpave Mix Design.


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3. ASTM International (ASTM):
    a. D2041/D2041M, Standard Test Method for Theoretical Maximum Specific Gravity and Density of Asphalt Mixtures.
    b. D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
    c. D4791, Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.
    d. D5821, Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate.
    e. E329, Standard Specification for Agencies Engaged in Construction Inspection Testing, or Special Inspection.
4. Oklahoma Department of Transportation (ODOT):
    a. Section 401, General Requirements for Surfaces.
    b. Section 407, Fog Seal and Tack Coat.
    c. Section 408, Prime Coat.
    d. Section 411, Hot Mix Asphalt.
    e. Section 708, Plant Mix Bituminous Bases and Surfaces.

1.02 DEFINITIONS

A. Combined Aggregate: All mineral constituents of asphalt concrete mix, including mineral filler and separately sized aggregates.

B. Maximum Aggregate Size: One sieve size larger than the nominal aggregate size.

C. Nominal Aggregate Size: One sieve size larger than the first sieve that retains more than 10 percent aggregate.

D. Prime Coat: Low viscosity cutback or emulsified asphalt applied to granular base in preparation of paving to coat and bond loose materials, harden the surface, plug voids, prevent moisture migration, and provide adhesion.

E. Reclaimed asphalt pavement (RAP): Removed and/or processed pavement materials containing binder and aggregate.

F. Seal Coat: Term used for various applications of emulsified asphalt, with or without sand or aggregate, to protect the asphalt surface from aging due to wear, degradation from the sun, wind, and water. Also used to improve skid resistance and aesthetics. The term seal coat can be used to define fog seal, slurry seal, chip seal or sand seal, depending on application.


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G. Standard Specifications: When referenced in this section, shall mean the 2019 Edition of the Oklahoma Department of Transportation Standard Specifications.

H. Tack Coat: Thin layer of emulsified asphalt applied to hard surfaces, including new pavement lifts, to promote adhesion and bonding.

1.03 SUBMITTALS

A. Informational Submittals:

1. Asphalt Concrete Mix Formula:
   a. Submit minimum of 15 days prior to start of production.
   b. Submittal to include the following information:
      1) Gradation and portion for each aggregate constituent used in mixture to produce a single gradation of aggregate within specified limits.
      2) Bulk specific gravity for each aggregate constituent.
      3) Measured maximum specific gravity of mix at optimum asphalt content determined in accordance with ASTM D2041.
      4) Properties as stated in the Standard Specifications for at least four different asphalt contents other than optimum, two below optimum, and two above optimum.
      5) Percent of asphalt lost due to absorption by aggregate.
      6) Index of Retained Strength (TSR) at optimum asphalt content as determined by AASHTO T283.
      7) Percentage of asphalt cement, to nearest 0.1 percent, to be added to mixture.
      8) Optimum mixing temperature.
      9) Optimum compaction temperature.
      10) Temperature-viscosity curve of asphalt cement to be used.
      11) Brand name of any additive to be used and percentage added to mixture.
2. Test Report for Asphalt Cement:
   a. Submit minimum 10 days prior to start of production.
   b. Show appropriate test method(s) for each material and the test results.
3. Manufacturer’s Certificate of Compliance, in accordance with the Standard Specifications, for the following materials:
   a. Aggregate: Gradation.
   b. Asphalt for Binder: Type, grade, and viscosity-temperature curve.
   c. Prime Coat: Type and grade of asphalt.
   d. Tack Coat: Type and grade of asphalt.


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e. Additives.
f. Mix: Conforms to job-mix formula.

4. Statement of qualification for independent testing laboratory.
5. Test Results:
   a. Mix design.
   b. Asphalt concrete core.
   c. Gradation and asphalt content of uncompacted mix.
   d. Field density.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Independent Testing Laboratory: In accordance with ASTM E329.
2. Asphalt concrete mix formula shall be prepared by approved certified independent laboratory under the supervision of a certified asphalt technician.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Temperature: Do not apply asphalt materials or place asphalt mixes when ground temperature is lower than 50 degrees F or air temperature is lower than 40 degrees F. Measure ground and air temperature in shaded areas away from heat sources or wet surfaces.

B. Moisture: Do not apply asphalt materials or place asphalt mixes when application surface is wet.

**PART 2 PRODUCTS**

2.01 MATERIALS

A. Prime Coat: Cutback asphalt, Grade MC-70 conforming to AASHTO M82 and conform to Section 408 of the Standard Specifications.

B. Tack Coat:

1. Emulsified Asphalt for Tack Coat or Seal Coat: Grade SS-1, SS-1h conforming to AASHTO M140 and conform to Section 407 of the Standard Specifications.

C. Sand for Blotter Material: Clean, dry, with 100 percent passing 4.75-millimeter (No. 4) sieve, and a maximum of 10 percent passing 75-µm (No. 200) sieve.


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2.02 ASPHALT CONCRETE MIX

A. General:

1. Mix formula shall not be modified except with written approval of Engineer.
2. Source Changes:
   a. Should material source(s) change, establish new asphalt concrete mix formula before new material(s) is used.
   b. Perform check tests of properties of plant-mix bituminous materials on first day of production and as requested by Engineer to confirm that properties are in compliance with design criteria.
   c. Make adjustments in gradation or asphalt content as necessary to meet design criteria.

B. Asphalt Concrete: Meeting the requirements of Section 708 of the Standard Specifications.

C. Composition: Hot-plant mix of aggregate, mineral filler if required, and paving grade asphalt cement. The several aggregate fractions shall be sized, uniformly graded, and combined in such proportions that resulting mixture meets grading requirements of mix formula.

D. Aggregate:

1. General: As specified in Section 708 of the Standard Specifications.

E. Mineral Filler: In accordance with Section 708 of the Standard Specifications.

F. Asphalt Cement: as specified in Section 708 of the Standard Specifications.

**PART 3 EXECUTION**

3.01 GENERAL

A. Traffic Control: Minimize inconvenience to traffic but keep vehicles off freshly treated or paved surfaces to avoid pickup and tracking of asphalt.

3.02 LINE AND GRADE

A. Provide and maintain intermediate control of line and grade, independent of underlying base, to meet finish surface grades and minimum thickness.

B. Shoulders: Construct to line, grade, and cross-section shown.


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## 3.03 APPLICATION EQUIPMENT

A. In accordance with Section 401 of the Standard Specifications.

## 3.04 PREPARATION

A. Prepare subgrade as specified in Section 31 23 13, Subgrade Preparation.

B. Existing Roadway:

1. Modify profile by grinding, milling, or overlay methods as approved, to provide meet lines and surfaces and to produce smooth riding connection to existing facility.
2. Remove existing material to a minimum depth of 1 inch (25 millimeters).
3. Paint edges of meet line with tack coat prior to placing new pavement.

C. Thoroughly coat edges of contact surfaces (curbs, manhole frames) with emulsified asphalt or asphalt cement prior to laying new pavement. Prevent staining of adjacent surfaces.

## 3.05 PAVEMENT APPLICATION

A. General: Place asphalt concrete mixture on approved, prepared base in conformance with this section.

B. Prime Coat:

1. Heat cutback asphalt prior to application.
2. Apply uniformly to clean, dry surfaces avoiding overlapping of applications.
3. Do not apply when moisture content of upper 3 inches (75 millimeters) of base exceeds optimum moisture content of base, or if free moisture is present.
4. Application Rate: 0.15 gallon to 0.50 gallon per square yard of surface area (0.68 liter to 2.28 liters per square meter).
5. Remove or redistribute excess material.
6. Allow a minimum of 5 full days for curing of primed surface before placing asphalt concrete.

C. Tack Coat:

1. Apply uniformly to clean, dry surfaces avoiding overlapping of applications.
2. Do not apply more tack coat than necessary for the day’s paving operation.


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3. Touch up missed or lightly coated surfaces and remove excess material.
4. Application Rate: 0.05 gallon per square yard to 0.15 gallon per square yard of asphalt (residual if diluted emulsified asphalt) (0.25 liter to 0.70 liter per square meter).

D. Pavement Mix:

1. Prior to Paving:
   a. Sweep primed surface free of dirt, dust, or other foreign matter.
   b. Patch holes in primed surface with asphalt concrete pavement mix.
   c. Blot excess prime material with sand.
2. Place asphalt concrete pavement mix in lifts with acceptable thicknesses as described by ODOT's Suggested Guidelines for Asphalt Pavements.
3. Compacted Lift Thickness:
   a. Minimum: Twice maximum aggregate size, but in no case less than 1 inch (25 millimeters).
   b. Maximum: 4 inches (100 millimeters).
4. Total Compacted Thickness: As shown.
5. Sequence placement so that meet lines are straight and edges are vertical.
6. Collect and dispose of segregated aggregate from raking process. Do not scatter material over finished surface.
7. Joints:
   a. Offset edge of each layer a minimum of 6 inches (150 millimeters) so joints are not directly over those in underlying layer.
   b. Offset longitudinal joints in roadway pavements so longitudinal joints in wearing layer coincide with pavement centerlines and lane divider lines.
   c. Form transverse joints by cutting back on previous day's run to expose full vertical depth of layer.
8. Succeeding Lifts: Apply tack coat to pavement surface between each lift.
9. After placement of pavement, seal meet line by painting a minimum of 6 inches (150 millimeters) on each side of joint with cutback or emulsified asphalt. Cover immediately with sand.

E. Compaction:

1. Roll until roller marks are eliminated and minimum density of 95 percent of mix design unit weight at optimum asphalt content is obtained.


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2. Joint Compaction:
    a. Place top or wearing layer as continuously as possible.
    b. Pass roller over unprotected end of freshly laid mixture only when placing of mix is discontinued long enough to permit mixture to become chilled.
    c. Cut back previously compacted mixture when Work is resumed to produce slightly beveled edge for full thickness of layer.
    d. Cut away waste material and lay new mix against fresh cut.

F. Tolerances:

1. General: Conduct measurements for conformity with crown and grade immediately after initial compression. Correct variations immediately by removal or addition of materials and by continuous rolling.
2. Completed Surface or Wearing Layer Smoothness:
    a. Uniform texture, smooth, and uniform to crown and grade.
    b. Maximum Deviation: 1/8 inch (3 millimeters) from lower edge of a 12-foot (3.6-meter) straightedge, measured continuously parallel and at right angle to centerline.
    c. If surface of completed pavement deviates by more than twice specified tolerances, remove and replace wearing surface.
3. Transverse Slope Maximum Deviation: 1/4 inch (6 millimeters) in 12 feet (3.6 meters) from rate of slope shown.
4. Finished Grade:
    a. Perform field differential level survey on maximum 50-foot (15-meter) grid and along grade breaks.
    b. Maximum Deviation: 0.02 foot (6 millimeters) from grade shown.

G. Seal Coat:

1. General: Apply seal coat of paving grade or emulsified asphalt to finished surface at longitudinal and transverse joints, joints at abutting pavements, areas where asphalt concrete was placed by hand, patched surfaces, and other areas as directed by Engineer.
2. Preparation:
    a. Surfaces that are to be sealed shall be maintained free of holes, dry, and clean of dust and loose material.
    b. Seal in dry weather and when temperature is above 35 degrees F (2 degrees C).
3. Application:
    a. Fill cracks over 1/16 inch (1.5 millimeters) in width with asphalt-sand slurry or approved crack sealer prior to sealing.
    b. When sealing patched surfaces and joints with existing pavements, extend minimum 6 inches (150 millimeters) beyond edges of patches.


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## 3.06 PATCHING

A. Preparation:

1. Remove damaged, broken, or unsound asphalt concrete adjacent to patches. Trim to straight lines exposing smooth, sound, vertical edges.
2. Prepare patch subgrade as specified in Section 31 23 13, Subgrade Preparation.

B. Application:

1. Patch Thickness: 6 inches (75 millimeters) or thickness of adjacent asphalt concrete, whichever is greater.
2. Place asphalt concrete mix across full width of patch in layers of equal thickness.
3. Spread and grade asphalt concrete with hand tools or mechanical spreader, depending on size of area to be patched.

C. Compaction:

1. Roll patches with power rollers capable of providing compression of 200 pounds per linear inch (350 Newtons per linear centimeter) to 300 pounds per linear inch (525 Newtons per linear centimeter). Use hand tampers where rolling is impractical.
2. Begin rolling top course at edges of patches, lapping adjacent asphalt surface at least one-half the roller width. Progress toward center of patch overlapping each preceding track by at least one-half width of roller.
3. Make sufficient passes over entire area to remove roller marks and to produce desired finished surface.

D. Tolerances:

1. Finished surface shall be flush with and match grade, slope, and crown of adjacent surface.
2. Tolerance: Surface smoothness shall not deviate more than plus 1/4 inch (6 millimeters) or minus 0 inch when straightedge is laid across patched area between edges of new pavement and surface of old surfacing.

## 3.07 FIELD QUALITY CONTROL

A. General: Provide services of approved certified independent testing laboratory to conduct tests. Testing laboratory shall be certified meeting the requirements of ASTM E329.


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B. Field Density Tests:

1. Perform tests from cores or sawed samples in accordance with AASHTO T230 and AASHTO T166.
2. Measure with properly operating and calibrated nuclear density gauge in accordance with ASTM D2950.
3. Maximum Density: In accordance with ASTM D2041, using sample of mix taken prior to compaction from same location as density test sample.

C. Testing Frequency:

1. Quality Control Tests:
   a. Asphalt Content, Aggregate Gradation: Once per every 500 tons (450 metric tons) of mix or once every 4 hours, whichever is greater.
   b. Mix Design Properties, Measured Maximum (Rice's) Specific Gravity: Once every 1,000 tons (900 metric tons)or once every 8 hours, whichever is greater.
2. Density Tests: Once every 500 tons (450 metric tons) of mix or once every 4 hours, whichever is greater.

**END OF SECTION**


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# SECTION 32 13 13
# CONCRETE PAVING

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO).
   a. M6, Standard Specification for Fine Aggregate for Portland Cement Concrete.
   b. M80, Standard Specification for Coarse Aggregate for Portland Cement Concrete.
   c. M153, Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
   d. M157, Standard Specification for Ready-Mixed Concrete.
   e. M213, Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
   f. M227/M227M, Standard Specification for Steel Bars, Carbon, Merchant Quality, Mechanical Properties.
2. American Concrete Institute (ACI):
   a. 305R, Hot Weather Concreting.
   b. 306R, Cold Weather Concreting.
   c. 308, Standard Practice for Curing Concrete.
   d. 318/318R, Building Code Requirements for Structural Concrete and Commentary.
   e. 325.9R, Guide for Construction of Concrete Pavements and Concrete Bases.
3. ASTM International (ASTM):
   a. A615/A615M, Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   b. C31/C31M, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   c. C33, Specification for Concrete Aggregates.
   d. C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   e. C42/C42M, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
   f. C78, Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).


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g. C88, Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
h. C94/C94M, Standard Specification for Ready-Mixed Concrete.
i. C143/C143M, Standard Test Method for Slump of Hydraulic Cement Concrete.
j. C150, Specification for Portland Cement.
k. C172, Standard Practice for Sampling Freshly Mixed Concrete.
l. C231, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
m. C260, Standard Specification for Air-Entraining Admixtures for Concrete.
n. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
o. C494/C494M, Standard Specification for Chemical Admixtures for Concrete.
p. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.
q. C803/C803M, Test Method for Penetration Resistance of Hardened Concrete.
r. C1330, Specification for Cylindrical Seal Backing for Use With Cold Liquid Applied Sealants.
s. C805, Test Method for Rebound Number of Hardened Concrete.
t. D920, Standard Specification for Elastomeric Joint Seals.
u. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
v. D1751, Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
w. D1752, Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
x. D2628, Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete.
y. D2828, Specification for Non-Bituminous Inserts for Contraction Joints in Portland Cement Concrete Airfield Pavements, Sawable Type.
z. D3406, Specification for Joint Sealant, Hot-Applied, Elastomeric-Type, for Portland Cement Concrete Pavements.
aa. D3569, Specification for Joint Sealant, Hot-Applied, Elastomeric, Jet-Fuel-Resistant Type for Portland Cement Concrete Pavements.
bb. D3581, Specification for Joint Sealant, Hot-Applied, Jet-Fuel-Resistant-Type, for Portland Cement and Tar-Concrete Pavements.


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cc. D5249, Specification for Backer Material for Use With Cold- and Hot-Applied Joint Sealants in Portland Cement Concrete and Asphalt Joints.
dd. D5893, Specification for Cold-Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements.
ee. E329, Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction.

4. National Ready Mixed Concrete Association (NRMCA).

1.02 DEFINITIONS

A. Standard Specification: Oklahoma Department of Transportation Standard Specifications, latest edition.

1.03 SUBMITTALS

A. Provide as required in Section 03 30 00, Cast-in-Place Concrete.

B. Action Submittals:

1. Product Data: Admixtures.
2. Design Data:
   a. Concrete mix design signed by concrete mix designer.
   b. Minimum Information:
      1) Name of ready-mix plant.
      2) Project.
      3) Engineer.
      4) Contractor.
      5) Mix design number.
      6) Specified concrete strength.
      7) Water-cement ratio.
      8) Maximum aggregate size.
      9) Cement content.
      10) Supplementary cementitious material content.
      11) Water content.
      12) Type, name, and amount of admixtures.
      13) Unit weight.
      14) Slump.
      15) Ingredient proportions corrected for average moisture content for particular times of year.
3. Jointing Drawings: Identify location and spacing of each type of joint.
4. Gradation for coarse and fine aggregates, and combined gradation. List percent passing each sieve size.


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5. Detailed plan for cold weather placements, including curing and protection.
6. Detailed plans for hot weather placements, including curing and protection.

C. Informational Submittals:

1. Manufacturers' Certificate of Compliance:
   a. Portland cement.
   b. Admixtures.
   c. Fly ash.
   d. Slag.
   e. Aggregates.
2. Statements of Qualifications:
   a. Mix designer.
   b. Batch plant.
   c. Testing laboratory.
3. Test Reports:
   a. Admixtures: Chemical ingredients and percentage of chloride in each admixture and fly ash.
   b. Fly Ash: Source test analysis and amount used in accordance with ASTM C94/C94M, Section 16.
   c. Mix Design: For each trial, signed by qualified mix designer.
   d. Laboratory Mixes: Cylinder test results.
4. Concrete Delivery Tickets:
   a. For each batch of concrete before unloading at Site.
   b. Minimum Delivery Ticket Information:
      1) Name of ready-mix plant.
      2) Serial number of ticket.
      3) Date and truck number.
      4) Name of Contractor.
      5) Job name and location.
      6) Mix design number.
      7) Amount of concrete (cubic yards).
      8) Type and amount of admixtures.
      9) Amount of water added at batch plant.
      10) Time of loading, arriving at Site, and unloading.
      11) Volume of water added by receiver of concrete and their initials.
   c. Record of drum revolution counter, type, and brand.


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1.04 QUALITY ASSURANCE

A. Qualifications:

1. Mix Designer: Licensed professional engineer registered in the state of Project or a certified concrete mix designer approved by local Department of Transportation.
2. Testing or Inspection Agency: In conformance with ASTM E329.
3. Batch Plant: Currently certified by the National Ready Mixed Concrete Association.

B. Prepaving Conference:

1. Held between Contractor, Subcontractor involved in concrete paving, and Engineer.
2. To be conducted a minimum of 14 days prior to commencing paving.
3. Conference cannot be held until mix design and admixture Submittals have been received by Engineer.
4. Items to discuss shall include, but not be limited to:
   a. Mix design.
   b. Method of placement.
   c. Curing.
   d. Finishing schedule.
   e. Traffic control.
   f. Protection of work.

C. Hot Weather Concreting: Conform to ACI 305R.

D. Cold Weather Concreting: Conform to ACI 306R.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Transporting of ready-mix concrete shall be in accordance with ASTM C94/C94M.

**PART 2 PRODUCTS**

2.01 CONCRETE MATERIALS

A. Cement:

1. Furnish cement for Project from one source.
2. Provide as specified in Section 03 30 00, Cast-in-Place Concrete.
3. Supplementary Cementitious Materials: As specified in Section 03 30 00, Cast-in-Place Concrete.


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B. Aggregates:

1. General: As specified in Section 03 30 00, Cast-in-Place Concrete.

C. Water: ASTM C94/C94M.

D. Admixtures: As specified in Section 03 30 00, Cast-in-Place Concrete.

2.02 ANCILLARY MATERIALS

A. Reinforcement: ASTM A615/A615M, Grade 60 as specified in Section 03 21 00, Steel Reinforcement.

B. Dowels: Conform to requirements of AASHTO M227/M227M, Grade 70.

C. Joint Filler:

1. As specified in Section 03 15 00, Concrete Joints and Accessories.
2. Fillers furnished under AASHTO M213 shall be tested in accordance with ASTM D1751.

D. Joint Sealant:

1. Preformed elastomeric joint seal conforming to ASTM D2628.
2. Hot-poured elastomeric joint seal conforming to ASTM D3406.
3. Cold-applied single component joint sealant conforming to ASTM D5893.
4. Elastomeric joint sealant conforming to ASTM C920.

E. Backer Rod:

1. Backer material conforming to ASTM D5249.
2. Cylindrical sealant backing conforming to ASTM C1330.

F. Curing Compound: As specified in Section 03 39 00, Concrete Curing.

G. Curing Membranes: As specified in Section 03 39 00, Concrete Curing.

2.03 EQUIPMENT

A. Ready-Mix Concrete Batch Plants: Certified by NRMCA.

B. Batch Plants: As specified in Section 03 30 00, Cast-in-Place Concrete.

C. Ready-Mix Concrete Trucks: As specified in Section 03 30 00, Cast-in-Place Concrete.


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D. Hauling Equipment: As specified in Section 03 30 00, Cast-in-Place Concrete.

E. Paving Equipment:

1. Slipform Paver:
   a. Place portland cement concrete with two separate machines, one a spreader and one a slipform paver. Machines, when operating in tandem shall spread, consolidate, screed, and float finish freshly placed portland cement concrete in one pass with a minimum of hand finishing. Each machine shall be fully self-propelled and equipped with electronic controls to control line and grade from both sides.
   b. Spreader shall be able to deliver mix without segregation or displacing reinforcing steel.
   c. Able to vibrate portland cement concrete for full width and depth and be equipped with vibrating tubes or arms to work in portland cement concrete. Sliding forms shall be held together rigidly to prevent them from spreading. Form shall be long enough so slumping of portland cement concrete will not exceed 1/4 inch.
   d. Supports of paver and other equipment which ride on previously placed pavement shall be equipped to prevent marring, edge breaking, or chipping of previously placed pavement.

F. Concrete Saws:

1. Provide power driven concrete saws for sawing joints or finishing concrete, adequate in number of units and power to complete sawing at required rate.
2. Saws and related equipment shall be of proven adequacy and design to perform efficiently and shall be subject to immediate replacement, if specified results are not obtained.
3. Standby saw shall be available at Site.

G. Smoothness Testing Equipment: Supply two 12-foot straightedges for determining smoothness.

## 2.04 CONCRETE MIX DESIGN

A. General: As specified in Section 03 30 00, Cast-in-Place Concrete. With a minimum flexural strength of 650 psi in accordance with ASTM C78.


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## PART 3 EXECUTION

### 3.01 WEATHER LIMITATIONS

A. Concrete shall not be placed:

1. Until the air temperature in the shade is 35 degrees F and rising and is forecast to remain above 35 degrees F.
2. On frozen ground.
3. During periods of rain or snow.

B. Concrete placement shall not continue when air temperature drops below 40 degrees F.

C. Protect concrete pavement from inclement weather for 7 days after it has been placed, when rain is imminent, and when air temperature drops or is forecast to drop below 35 degrees F.

### 3.02 PREPARATION

A. Prepare base as specified in Section 32 11 23, Aggregate Base Courses.

B. Dampen base thoroughly prior to concrete placement; standing water will not be permitted.

C. Formwork shall be complete prior to placement of concrete. Area in which concrete is to be placed, shall be smooth and free of ruts, projections, debris, spilled concrete, mud, sloughed soil, standing water, organic and other objectionable materials.

D. Construction Joints: Inspect prior to placement of concrete.

E. Prior to placing paving equipment in position, full width and length of the area on which the tracks of the paving equipment is to operate shall be brought to density and surface tolerances required.

F. Protect existing exposed surfaces such as grates, catch basins, air valves, manholes, and cleanout lids from splattered and spilled concrete during concrete placement by use of durable waterproof paper.

G. Furnish operable backup vibrator on Site prior to concrete placement.


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## 3.03 SLIP FORM PAVING

A. Deliver from hauling vehicles to paving machine hopper.

B. Contractor’s equipment hauling portland cement concrete or reinforcement will not be permitted on subgrade, but will be allowed on base, with turns or other maneuvering kept to a minimum. Damage to subgrade or base shall be corrected to satisfaction of Engineer.

C. Place in final position uniformly in one layer, so a minimum of finishing will be necessary to provide a dense, homogenous pavement conforming to true grade and cross-section.

1. Spreader shall receive portland cement concrete mixture in its hopper and uniformly spread and strike it off at proper thickness for full width of area being paved.
2. Paver shall vibrate, consolidate, and finish slab to proper grade and cross-section.

D. Paver:

1. Operated with as continuous forward movement as possible.
2. Coordinate mixing, delivering, and spreading portland cement concrete to provide uniform progress.
3. Stopping and starting paver shall be held to a minimum. If, for any reason, it is necessary to stop forward motion of paver, vibratory and tamping elements shall also be stopped immediately.
4. No external force shall be applied to paver, except with approval of Engineer.

E. While placing portland cement concrete, provision shall be made for constructing joints, placing dowels, tie bars, and other devices as called for by the Drawings and as provided in Article Joints.

F. Portland cement concrete shall be rejected if it:

1. Is not in place within 90 minutes after being mixed.
2. Has begun to take an initial set prior to placement.
3. Has been retempered with water.

G. If necessary, supplemental hand spreading and distributing shall be with shovels. Rakes will not be permitted.

H. Portland cement concrete shall not be fouled with foreign matter.


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I. Use vibrators to consolidate portland cement concrete pavement at least 6 feet each side of construction joints and expansion joints.

3.04 JOINTS

A. General:

1. Referred to as contraction or construction, either of which may be transverse or longitudinal, as called for by the Drawings or as approved by Engineer.
2. Joints, backer material, joint filler and joint sealants shall extend to pavement edges or to each other, as the case may be, and shall be constructed perpendicular to surface of pavement.
3. Joints shall not vary from specified or indicated line by more than 1/4 inch.
4. Contractor shall submit jointing plan and details to Engineer for approval. Take into consideration placement of joints in curb and gutter, at catch basins, and position of manholes and other large structures, as well as other limitations herein mentioned.
5. Place manhole or similar large structure in line of joint, or if impractical, isolate structure from pavement with premolded joint filler, 1/2-inch wide, conforming to AASHTO M213 and ASTM D1751.

B. Contraction Joints:

1. Sawed Type with Poured Filler:
   a. Sawing shall be to a depth as shown on the Drawings with a maximum width of 1/4 inch and a minimum width of 1/8 inch, in straight lines as shown or as approved by Engineer.
   b. Perform saw cuts as soon as portland cement concrete has set enough to permit sawing without tearing or raveling, before uncontrolled cracking results, and within 24 hours of placing portland cement concrete.
   c. Saws may be single or tandem, as Contractor may elect, and shall be controlled by guides to true line.
   d. Clean joints thoroughly of foreign matter before pouring approved rubber asphalt filler.
   e. Tops of joint filler shall be true to pavement cross-section within 1/8 inch and shall be protected from damage by portland cement concrete operations.
   f. Areas containing uncontrolled cracks shall be removed and replaced.
   g. Restore curing agents broken or damaged by sawing operations.


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2. Space longitudinal joints as shown on the Drawings at the interface between lanes, normally at intervals between 12 feet to 16 feet.
3. Transverse joints shall be as shown on the Drawings or as approved by Engineer, with intervals of 12 feet to 16 feet.

C. Construction Joints:

1. Construct when there is an interruption of longer 45 minutes in portland cement concrete placing operations or where specified.
2. Place parallel with intended contraction joint.
3. Tool both free edges of joints with 1/8 inch radius rounder to remove laitance and mortar resulting from finishing operations and to provide clean rounded edge. Tooling shall not form ridges on surface of concrete.
4. New portland cement concrete placed contiguous to joint shall conform to proportions and consistency of previously placed concrete.
5. Transverse Construction Joint:
    a. Doweled type using 1-inch by 18-inch long dowels at 12-inch centers coated with plastic, grease, heavy oil or other approved material that will neither bond with nor be harmful to operation at a depth of 1/2 the pavement thickness parallel to centerline.
    b. If sufficient portland cement concrete has not been mixed at the time of interruption to place a construction joint at least 3 feet from a planned contraction joint, remove excess portland cement concrete back to a position to satisfactorily meet these criteria and to satisfaction of Engineer.
    c. Fill joint which has opened to a width of 1/8 inch or greater during construction or maintenance periods with poured filler.
    d. Do not construct within 3 feet of a transverse contraction joint.
6. Longitudinal Construction Joint:
    a. Tied type using No. 5 by 30-inch deformed tie bars at 36-inch centers.
    b. Tie Bars:
        1) Not required at construction joint between portland cement concrete pavement and gutter, except where shown on the Drawings and mentioned above.
        2) Placement:
            a) Plastic Portland Cement Concrete: Insert before vibrating and finishing portland cement concrete; or
            b) Hardened Concrete:
                (1) Drill hole, insert, and grout tie bars into place.
                (2) Drill holes large and deep enough to allow tie bars to be inserted with grout.


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(3) Perform any time after portland cement concrete has attained enough strength to resist any damage caused by drilling.
(4) Tie bars shall be grouted a maximum of 3 hours prior to placement of adjacent portland cement concrete.

3) Replace loose tie bars by drilling and grouting as described.

D. Scored Joints:

1. Configuration: 1/4-inch wide by 1/4-inch deep at locations indicated on the Drawings formed by tooling of concrete while it is still fresh.
2. Do not fill or seal.
3. Layout of joints shall be straight and true and shall not vary from indicated line by more than 1/4 inch.

3.05 SURFACE FINISHING

A. Use temporary screeds. Wet screeding and jitterbugging shall not be permitted.

B. Pavement shall have surface tolerance of 1/4 inch in 10 feet in accordance with ACI 325.9R.

C. Salting, spreading of cement or cement and sand mixture to speed up hardening shall not be permitted.

D. Exposed pavement edges shall be edged to a 1/2-inch radius and construction joints shall be edged to 1/8-inch radius after finishing. Edging shall not form ridges on pavement surface.

E. Pavement shall be treated and protected by use of evaporation retardant applied in accordance with manufacturer’s written instructions. Flat surfaces shall be treated immediately after screeding and floating or if time period greater than 15 minutes occurs between finishing operations.

F. Pavement shall be screeded, floated, and given a burlap drag skid-resistant surface.

1. Burlap Drag Finish:
   a. Trail moistened coarse burlap from a device that allows control of the time and rate of texturing to provide a uniform finish with 1/16-inch- to 1/8-inch deep striations.
   b. As specified in ODOT Specification Section 414.03 Part B.3.b.


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## 3.06 CURING OF PORTLAND CEMENT CONCRETE

A. Immediately after the final floating, surface finishing, and edging has been completed, and while portland cement concrete surface is still moist, cover and cure entire exposed surface for at least 72 hours in accordance with one of the following provisions:

1. Liquid Membrane-Forming Compounds: Apply compound uniformly to portland cement concrete by pressure spray methods at a rate which will form an impervious membrane, but at least at a rate of 1 gallon per 150 square feet.
2. Other Membranes:
    a. Apply to damp portland cement concrete as soon as it can be placed without marring surface.
    b. Place in contact with surface, extend beyond sides or edges of slabs or forms, and fasten down to hold it in position as a waterproof and moistureproof covering.
    c. Laps shall be sufficient to maintain tightness equivalent to sheeting.
    d. Transverse laps for waterproof paper shall be at least 18 inches, and longitudinal seams shall be cemented.
    e. Cotton or jute mats shall be saturated with water prior to placing and kept fully wetted during curing period.

B. Concrete shall be cured by use of curing compound, for minimum of 7 days after concrete placement, in accordance with ACI 308. Curing compounds shall be applied in accordance with manufacturer’s written instructions.

C. Exposed surfaces shall be sprayed with curing compound immediately after free surface water has disappeared from finished surface.

D. Concrete temperature shall be maintained in accordance with ACI 306R.

E. Curing compounds shall not come in contact with hardened concrete that is to be concreted against.

## 3.07 FIELD QUALITY CONTROL

A. Retain independent testing or inspection agency to perform inspection, sampling, and testing.

B. Concrete Sampling: In accordance with ASTM C172. Take sample not less than every 5,000 square feet or fraction thereof of concrete placed each day.


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C. Perform following tests on each sampling:

1. Slump: ASTM C143/C143M.
2. Air Content: ASTM C231.
3. Compressive Strength: ASTM C39/C39M.
4. Flexural Strength: ASTM C78.

D. Strength Tests:

1. Make and cure cylinders and beams in accordance with ASTM C31/C31M.
2. Cylinders: Make four, standard 6-inch diameter by 12 inches high. Cure one in field and three in laboratory.
3. Beams: Make three, standard 6 inches by 6 inches by 21 inches. Cure in field.
4. Compressive: Test one field-cured cylinder at 7 days and two laboratory-cured cylinders at 28 days. Test last cylinder at 56 days if 28-day cylinder is below specified strength.
5. Flexural: Test one beam at 7 days and two beams at 28 days.

E. Acceptance of concrete shall be in accordance with ACI 318/318R.

F. Concrete with compressive strength less than specified, as evidenced by cylinder tested at 56 days, shall be additionally tested as follows:

1. Less Than 500 psi Low in Compression or Less Than 75 psi Low in Flexure:
   a. Penetration Resistance Test: ASTM C803.
   b. Rebound Hammer Test: ASTM C805.
   c. Perform tests within 24 hours of noncomplying strength tests.
2. More Than 500 psi Low in Compression or More Than 75 psi Low in Flexure:
   a. Concrete Coring: Take three standard cores from concrete representing original specimens.
   b. Take and prepare cores in accordance with ASTM C42/C42M.
   c. Test cores in accordance with ASTM C39/C39M.
   d. Take cores within 24 hours of noncomplying strength test.


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G. Pay Factor:

1. Portland cement concrete shall be accepted according to average compressive strengths of four or more cylinders taken for 28-day tests for each 500 cubic yards placed and the following acceptance schedule.

| **Acceptance Schedule Compressive Strength** | |
|---|---|
| **Pay Factor** | **Percent of Specified Strength** |
| 1.00 | 95 percent or higher |
| 0.90 | 90 to 95 percent |
| 0.70 | 80 to 90 percent |
| Remove and replace | Less than 80 |

2. Whenever percentage of specified compressive strength falls below the level of 80 percent, Engineer may require the portland cement concrete be removed and replaced to meet required specifications.
3. If the compressive strength, $f_c$, to comply with the flexural strength requirement is greater than 4,000 psi, then the specified strength shall be multiplied by:

$$\frac{F_c}{4000}$$

3.08 CLEANING

A. Clean concrete splatter from exposed surfaces.

B. Thoroughly broom and wash concrete surfaces before opening to traffic.

3.09 PROTECTION OF CONCRETE

A. Do not operate construction equipment or allow traffic on newly placed portland cement concrete until the following requirements are met:

1. Joints have been filled as per Article Joints.
2. Concrete has attained a compressive strength of at least 4,000 pounds per square inch.

B. Protect new concrete from construction operations, mechanical disturbances, water flow, and soiling until open for traffic.

C. Erect and maintain suitable barriers to protect concrete from traffic or other detrimental trespass until pavement is opened to traffic.


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D. Maintain watchmen after normal working hours for at least a 24-hour period to ensure barriers are not removed or destroyed, and that trespass and vandalism upon pavement does not occur.

E. Wherever it is necessary that traffic, including Contractor's vehicles and equipment, be carried from one side of pavement to the other, construct suitable bridges over pavement, and maintain them in good condition as long as they may be required. Leaving gaps in pavement to facilitate movement of traffic will not be allowed, unless prior written permission is obtained from Engineer.

F. Protect new concrete from dirt, asphalt, and other deleterious substances that may be tracked onto new pavement from construction activities.

G. Pavement damaged by traffic or damaged from any other cause, prior to its official acceptance, shall be repaired or replaced to the satisfaction of Engineer.

**END OF SECTION**


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# SECTION 32 16 00
# CURBS, SIDEWALKS, AND GUTTERS

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO): T 99, Standard Specification for the Moisture-Density Relations of Soils Using a 2.5 kg (5.5 pound) Rammer and a 305 mm (12 in.) Drop.
2. American Concrete Institute (ACI): 304R, Guide for Measuring, Mixing, Transporting, and Placing Concrete.
3. ASTM International (ASTM):
   a. C94, Standard Specification for Ready-Mixed Concrete.
   b. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
   c. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
4. Standard Specification: State of Oklahoma Department of Transportation Standard Specifications.

### 1.02 SUBMITTALS

A. General: Refer to Section 03 30 00, Cast-in-Place Concrete, for other applicable submittals specific to curbs, gutters, and sidewalks.

B. Action Submittals:

1. Form Material: Information on metal forms, if used, including type, condition, surface finish, and intended function.
2. Complete data on concrete mix, including aggregate gradations and admixtures in accordance with requirements of ASTM C94.

C. Informational Submittals:

1. Curing Compound: Manufacturer’s Certificate of Compliance and application instructions.
2. Ready-mix delivery ticket for each truck in accordance with ASTM C94.


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1.03 QUALITY ASSURANCE

A. Regulatory Requirements: Conform to the State of Oklahoma Standard Specifications for Highway Construction and City of Broken Arrow Standard Specifications.

**PART 2 PRODUCTS**

2.01 MATERIALS

A. Conform to the requirements of the referenced Standard Specification.

2.02 EXPANSION JOINT FILLER

A. As specified in Section 204.5 Curb and Gutter in the City of Broken Arrow Standard Construction Specifications.

2.03 CONCRETE

A. As specified in Section 03 30 00, Cast-in-Place Concrete.

B. Maximum Aggregate Size: 1-1/2 inch.

C. Slump: 2 inches to 4 inches.

2.04 CURING COMPOUND

A. In accordance with Section 03 39 00, Concrete Curing.

**PART 3 EXECUTION**

3.01 INSTALLATION

A. Perform Work in accordance with Section 03 30 00, Cast-in-Place Concrete.

3.02 FORMWORK

A. Lumber Materials:

1. 2-inch dressed dimension lumber, or metal of equal strength, straight, free from defects that would impair appearance or structural quality of completed curb and sidewalk.
2. 1-inch dressed lumber or plywood may be used where short-radius forms are required.

B. Metals: Steel in new undamaged condition.


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C. Setting Forms:

1. Construct forms to shape, lines, grades, and dimensions.
2. Stake securely in place.

D. Bracing:

1. Brace forms to prevent change of shape or movement resulting from placement.
2. Construct short-radius curved forms to exact radius.

E. Tolerances:

1. Do not vary tops of forms from gradeline more than 1/8 inch when checked with 10-foot straightedge.
2. Do not vary alignment of straight sections more than 1/8 inch in 10 feet.

3.03 PLACING CONCRETE

A. Prior to placing concrete, remove water from excavation and debris and foreign material from forms.

B. Place concrete as soon as possible, and within 1-1/2 hours after adding cement to mix without segregation or loss of ingredients, and without splashing.

C. Place, process, finish, and cure concrete in accordance with applicable requirements of ACI 304, and this section. Wherever requirements differ, the more stringent shall govern.

D. To compact, vibrate until concrete becomes uniformly plastic.

3.04 CURB CONSTRUCTION

A. Construct ramps at pedestrian crossings.

B. Expansion Joints: Place at maximum 45-foot intervals and at the beginning and end of curved portions of curb, and at connections to existing curbs. Install expansion joint filler at each joint.

C. Curb Facing: Do not allow horizontal joints within 7 inches from top of curb.

D. Contraction Joints:

1. Maximum 15-foot intervals in curb.
2. Provide open joint type by inserting thin, oiled steel sheet vertically in fresh concrete to force coarse aggregate away from joint.
3. Insert steel sheet to full depth of curb.


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4. Remove steel sheet with sawing motion after initial set has occurred in concrete and prior to removing front curb form.
5. Finish top of curb with steel trowel and finish edges with steel edging tool.

E. Front Face:

1. Remove front form and finish exposed surfaces when concrete has set sufficiently to support its own weight.
2. Finish formed face by rubbing with burlap sack or similar device to produce uniformly textured surface, free of form marks, honeycomb, and other defects.
3. Remove and replace defective concrete.
4. Apply curing compound to exposed surfaces of curb upon completion of finishing.
5. Continue curing for minimum of 5 days.

F. Backfill curb with earth upon completion of curing period, but not before 7 days has elapsed since placing concrete.

1. Backfill shall be free from rocks 2 inches and larger and other foreign material.
2. Compact backfill firmly.

3.05 SIDEWALK CONSTRUCTION

A. Thickness:4 inches.

B. Connection to Existing Sidewalk:

1. Remove old concrete back to an existing contraction joint.
2. Clean the surface.
3. Apply a neat cement paste immediately prior to placing new sidewalk.

C. Expansion Joints: Place in adjacent curb, where sidewalk ends at curb, and around posts, poles, or other objects penetrating sidewalk. Install expansion joint filler at each joint.

D. Contraction Joints:

1. Provide transversely to walks at locations opposite contraction joints in curb.
2. Dimensions: 3/16-inch by 1-inch weakened plane joints.
3. Construct straight and at right angles to surface of walk.


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E. Finish: Perform Work in accordance with Section 03 30 00, Cast-in-Place Concrete.

**END OF SECTION**


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# SECTION 32 17 23
# PAVEMENT MARKINGS

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. M237, Standard Specification for Epoxy Resin Adhesives for Bonding Traffic Markers to Hardened Portland Cement and Asphalt Concrete.
   b. M247, Standard Specification for Glass Beads Used in Traffic Paint.
   c. M248, Standard Specification for Ready-Mixed White and Yellow Traffic Paints.
   d. M249, Standard Specification for White and Yellow Reflective Thermoplastic Striping Material (Solid Form).
2. ASTM International (ASTM): D4280, Standard Specification Extended Life Type, Nonplowable, Prismatic, Raised, Retroreflective Pavement Markers.
3. Federal Specifications (FS):
   a. A-A-2886A, Paint, Traffic, Solvent Based.
   b. TT-B-1325C, Beads (Glass Spheres); Retroreflective.

### 1.02 DEFINITIONS

A. Standard Specifications: Oklahoma Department of Transportation Standard Specifications, latest edition.

### 1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product Data:
      1) Paint.
      2) Glass beads.
      3) Other materials as needed.
   b. Glass Beads: Proposed gradation.


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B. Informational Submittals:

1. Description of proposed methods for removal of drips, overspray, improper markings, paint and thermoplastic material tracked by traffic, and existing markings.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for products specified in this section.
3. Equipment List: Proposed equipment to be used, including descriptive data.
4. Manufacturer's Instructions:
   a. Application of preformed tape.
   b. Application of portland cement concrete primer.
   c. Application of glass beads.

## PART 2 PRODUCTS

2.01 GENERAL

A. All products shall be in accordance with the Standard Specifications.

2.02 PAINT

A. Color: White, yellow and blue.

B. Traffic paint in accordance with Section 854 of the Standard Specifications.

C. Homogeneous, easily stirred to smooth consistency, with no hard settlement or other objectionable characteristics during storage period of 6 months.

## PART 3 EXECUTION

3.01 GENERAL

A. Surface Preparation, Application, and Protection: In accordance with Section 854 of the Standard Specifications.

3.02 SURFACE PREPARATION

A. Cleaning:

1. Thoroughly clean surfaces to be marked before application of pavement marking material.
2. Remove dust, dirt, and other granular surface deposits by sweeping, blowing with compressed air, rinsing with water or a combination of these methods.


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3. Scrub areas of old pavement affected with oil or grease with several applications of trisodium phosphate solution or other approved detergent or degreaser, and rinse thoroughly after each application.
4. Surfaces shall be completely free of dirt and ice, and dry of water at the time of application of materials specified herein.
5. Oil-Soaked Areas: After cleaning, seal with cut shellac to prevent bleeding through the new paint.
6. Reclean surfaces when the Work has been stopped due to rain.

B. New Concrete Pavement:

1. Allow a minimum cure time of 30 days before cleaning and marking.
2. Clean by either sandblasting or water blasting to the following results:
   a. No visible evidence of curing compound on peaks of textured concrete surface.
   b. No heavy puddled deposits of curing compound in valleys of textured concrete surface.
   c. Remaining curing compound is intact, with loose and flaking material completely removed.
   d. Peaks of textured pavement surface are rounded in profile and free of sharp edges and irregularities.
3. Allow a minimum drying time of 24 hours after water blasting before applying thermoplastic markings.

C. New Asphalt Pavement: Allow a minimum pavement cure time of 30 days before applying paint.

## 3.03 PAINT APPLICATION

A. General:

1. Thoroughly mix pigment and vehicle together prior to application, and keep thoroughly agitated during application.
2. Do not add thinner.
3. Apply only when air and pavement temperatures are above 40 degrees F and less than 95 degrees F. Maintain paint temperature within these same limits.
4. Apply only when surface is dry.
5. Do not apply when conditions are windy to the point of causing overspray or fuzzy line edges.
6. Provide guidelines and templates to control paint application.
7. Take special precautions in marking numbers, letters, and symbols.
8. Sharply outline edges of markings and apply without running or spattering.


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B. Rate of Application: On new pavement, apply two coats of paint at a uniform rate of 210 square feet per gallon.

C. Drying:

1. Provide maximum drying time to prevent undue softening of bitumen and pickup, displacement, or discoloration by traffic.
2. If drying is abnormally slow, discontinue painting operations until cause is determined and corrected.

D. Protection:

1. Protect markings from traffic until paint is thoroughly dry.
2. Protect surfaces from disfiguration by paint spatters, splashes, spills, or drips.

E. Cleanup: Remove paint spatters, splashes, spills, or drips from the Work and staging areas including areas outside the immediate Work area where spills occur.

**END OF SECTION**


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# SECTION 32 31 13
# CHAIN LINK FENCES AND GATES

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. ASTM International (ASTM):
   a. A121, Standard Specification for Metallic-Coated Carbon Steel Barbed Wire.
   b. A313/A313M, Standard Specification for Stainless Steel Spring Wire.
   c. A392, Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.
   d. A491, Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric.
   e. A497/A497M, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
   f. A615/A615M, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   g. A780, Standard Specification for Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings.
   h. A824, Standard Specification for Metallic-Coated Steel Marcelled Tension Wire for Use with Chain Link Fence.
   i. 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.
   j. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   k. C150, Standard Specification for Portland Cement.
   l. C387, Standard Specifications for Packaged, Dry, Combined Materials for Mortar and Concrete.
   m. F552, Standard Terminology Relating to Chain Link Fencing.
   n. F567, Standard Practice for Installation of Chain-Link Fence.
   o. F626, Standard Specification for Fence Fittings.
   p. F668, Standard Specification for Polyvinyl Chloride (PVC) and Other Organic Polymer-Coated Steel Chain-Link Fence Fabric.
   q. F900, Standard Specification for Industrial and Commercial Swing Gates.
   r. F934, Standard Specification for Standard Colors for Polymer-Coated Chain Link Fence Materials.
   s. F1043, Standard Specification for Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework.


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t. F1083, Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures.
u. F1183, Standard Specifications for Aluminum Alloy Chain Link Fence Fabric.
v. F1184, Standard Specifications for Industrial and Commercial Horizontal Slide Gates.
w. F1379, Standard Terminology Relating to Barbed Tape.
x. F1911, Standard Practice for Installation of Barbed Tape.
y. F1916, Standard Specification for Selecting Chain Link Barrier Systems with Coated Chain Link Fence Fabric and Round Posts for Detention Applications.

2. Institute of Electrical and Electronic Engineers (IEEE), Inc.: C2, National Electrical Safety Code.
3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 volts max.).
4. Oklahoma Standard Specifications for Construction, Oklahoma Department of Transportation, latest edition (ODOT).

1.02 DEFINITIONS

A. Terms as defined in ASTM F552.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product Data: Include construction details, material descriptions, dimensions of individual components, and finishes for chain link fences and gates.
      1) Fence, gate posts, rails, and fittings.
      2) Chain link fabric.
      3) Gates and hardware.
      4) Accessories: Barbed wire.
2. Test Reports: Field test result for compliance of installation of chain link fence, and gates.

B. Informational Submittals:

1. Manufacturer’s recommended installation instructions.
2. Evidence of Supplier and installer qualifications.

1.04 QUALITY ASSURANCE

A. Erect fencing using skilled personnel experienced in chain link fence and gate construction.


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B. Preinstallation Conference: Conduct conference at project Site with gate installer to verify layout and operations of automatic gate operating system.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Site in undamaged condition. Store materials off the ground to provide protection against oxidation caused by ground contact.

1.06 SCHEDULING AND SEQUENCING

A. Complete necessary Site preparation and grading before installing chain link fence and gates.

B. Interruption of Existing Utility Service: Notify owner of utility 72 hours prior to interruption of utility services. Do not proceed with interruption of utility service without written permission from utility owner.

1.07 SPECIAL GUARANTEE

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

1. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
2. Deflection of fence fabric beyond limits.

**PART 2 PRODUCTS**

2.01 GENERAL

A. Match style, finish, and color of each fence component with that of other fence components.

2.02 CHAIN LINK FENCE FABRIC

A. Provide 9-gauge (0.148-inch) wire woven into fabric in 2-inch mesh in accordance with AASHTO M181. Conform to Section 732.07 of ODOT Standard Specifications.

B. Height: 72 inches, unless otherwise shown.

C. Core Wire Gauge: No. 9.


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D. Pattern: 2-inch diamond-mesh.

E. Diamond Count: Manufacturer's standard and consistent for fabric furnished of same height.

F. Loops of Knuckled Selvages: Closed or nearly closed with space not exceeding diameter of wire.

G. Wires of Twisted Selvages:

1. Twisted in a closed helix three full turns.
2. Cut at an angle to provide sharp barbs that extend minimum 1/4 inch beyond twist.

2.03 POSTS

A. General:

1. Conform to Section 732.06 of ODOT Standard Specifications.
2. Wire Attachments: Conform to Section 732.06 of ODOT Standard Specifications; do not furnish posts with punched tabs for fastening wires to post by closing tab.

2.04 TOP AND BRACE RAILS

A. Galvanized Round Steel Pipe: Conform to Section 732.06 of ODOT Standard Specifications.

B. Protective Coatings: As specified for posts.

2.05 FENCE FITTINGS

A. General: In conformance with Section 732.06 of ODOT Standard Specifications, except as modified by this article.

B. Post and Line Caps: Designed to accommodate passage of top rail through cap, where top rail required.

C. Tension Bars:

1. One-piece.
2. Length not less than 2 inches shorter than full height of chain link fabric.
3. Provide one bar for each gate and end post, and two for each corner and pull post.


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D. Truss Rod Assembly: 3/8-inch diameter, steel, hot-dip galvanized after threading rod and turnbuckle or other means of adjustment.

E. Barbed Wire Supporting Arms: Pressed steel or cast iron with clips, slots, or other means for attaching strands of barbed wire integral with post cap for each post, with single 45-degree arms for supporting three strands of barbed wire. Arms shall withstand 250 pounds of downward pull at outermost ends of the arms without failure.

2.06 TENSION WIRE

A. Provide tension wire in accordance with AASHTO M181, with a coating that matches the fence required by Contract.

2.07 BARBED WIRE

A. Zinc-Coated Barbed Wire: Per Section 732.06 of ODOT Standard Specifications.

1. Line Wire: Three strands of No. 12-1/2 gauge.
2. Barbs:
    a. Number of Points: Four.
    b. Length: 3/8 inch minimum.
    c. Shape: Round.
    d. Diameter: No. 14 gauge.
    e. Spacing: 5 inches.

B. Aluminum-Coated Steel Barbed Wire: Per Section 732.06 of ODOT Standard Specifications.

2.08 GATES

A. General:

1. Gate Operation: Opened and closed easily by one person.
2. Metal Pipe and Tubing: Galvanized steel. Comply with ASTM F1043 and ASTM F1083 for materials and protective coatings.
3. Frames and Bracing: Fabricate members from round galvanized steel tubing with outside dimension and weight according to ASTM F900.
4. Gate leaves more than 8-feet wide shall have intermediate tubular members and diagonal truss rods to provide rigid construction, free from sag or twist.
5. Gate Fabric Height: Same as for adjacent fence height.
6. Welded Steel Joints: Paint with zinc-based paint.
7. Chain Link Fabric: Attached securely to gate frame at intervals not exceeding 15 inches.


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8. Gate Posts and Frame Members: Extend gateposts and frame end members above top of chain-link fabric at both ends of gate frame to attach barbed wire assemblies.
9. Latches: Arranged for padlocking so padlock will be accessible from both sides of gate.

B. Swing Gates: Comply with ASTM F900 for double swing gate types.

1. Leaf Width: 5 feet for personnel gates and 15 feet for vehicle gates.
2. Hinges: Offset type, malleable iron.
   a. Furnished with large bearing surfaces for clamping in position.
   b. Designed to swing either 180 degrees outward, 180 degrees inward, or 90 degrees in or out, as shown, and not twist or turn under action of gate.
3. Latches: Plunger bar arranged to engage stop, except single gates of openings less than 10 feet wide may each have forked latch.
4. Gate Stops: Mushroom type or flush plate with anchors, suitable for setting in concrete.
5. Locking Device and Padlock Eyes: Integral part of latch, requiring one padlock for locking both leaves of double gate.
6. Hold-Open Keepers: Designed to automatically engage gate leaf and hold it in open position until manually released.

2.09 GATE OPERATOR SYSTEM

A. Gate operators shall be provided per Section 32 31 15, Gate Operator Systems.

2.10 CONCRETE

A. Provide as specified in Section 03 30 00, Cast-in-Place Concrete.

## PART 3 EXECUTION

3.01 GENERAL

A. Install chain link fences and gates in accordance with ASTM F567, except as modified in this section, and in accordance with fence manufacturer’s recommendations, as approved by Engineer. Erect fencing in straight lines between angle points.

B. Provide necessary hardware for a complete fence and gate installation.

C. Any damage to galvanized surfaces, including welding, shall be repaired with paint containing zinc dust in accordance with ASTM A780.


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## 3.02 PREPARATION

A. Clear area on either side of fence to the extent specified in Section 31 10 00, Site Clearing. Eliminate ground surface irregularities along fence line to the extent necessary to maintain a 2-inch clearance between bottom of fabric and finish grade.

B. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

## 3.03 POST SETTING

A. Drill or hand-excavate holes for posts to diameters and spacing indicated, in firm, undisturbed soil. Driven posts are not acceptable. Postholes shall be clear of loose materials. Waste materials from postholes shall be removed from Site or regraded into slopes on Site.

B. Posthole Depth:

1. Minimum 3 feet below finished grade.
2. 2 inches deeper than post embedment depth below finish grade.

C. Set posts with minimum embedment below finished grade of 34 inches and with top rail at proper height above finished grade. Verify posts are set plumb, aligned, and at correct height and spacing. Brace posts, as necessary, to maintain correct position and plumbness until concrete sets.

D. Backfill postholes with concrete to 2 inches above finished grade. Vibrate or tamp concrete for consolidation. Protect above ground portion of posts from concrete splatter.

E. Before concrete sets, crown and finish top of concrete to readily shed water.

F. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more.

G. Line Posts: Space line posts uniformly at 10 feet on centers between terminal end, corner, and gate posts.

## 3.04 POST BRACING

A. Install according to ASTM F567, maintaining plumb position, and alignment of fencing. Install braces at gate, end, pull, and corner posts diagonally to


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adjacent line posts to ensure stability. Install braces on both sides of corner and pull posts.

1. Locate horizontal braces at mid-height of fabric or higher, on fences with top rail, and 2/3-fabric height on fences without top rail. Install so posts are plumb when diagonal truss rod assembly is under proper tension.

3.05 TOP RAILS

A. Install according to ASTM F567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps and terminating into rail end attached to posts or posts caps fabricated to receive rail at terminal posts. Install top rail sleeves with springs at 105 feet maximum spacing to permit expansion in rail.

3.06 BARBED WIRE SUPPORTING ARMS

A. Barbed wire supporting arms shall be installed as indicated and as recommended by manufacturer. Bolt or rivet supporting arm to top of post in a manner to prevent easy removal with hand tools. Angle single arms to outside of fence.

3.07 TENSION WIRE

A. Install according to ASTM F567 and ASTM F1916, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with tie wires at a maximum spacing of 24 inches on center.

B. Install tension wire within 6 inches of bottom of fabric and tie to each post with not less than same diameter and type of wire.

3.08 CHAIN LINK FABRIC

A. Do not install fabric until concrete has cured minimum 7 days.

B. Apply fabric to outside of enclosing framework. Pull fabric taut to provide a smooth and uniform appearance free from sag, without permanently distorting fabric diamond or reducing fabric height. Tie fabric to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.

C. Splicing shall be accomplished according to ASTM F1916 by weaving a single picket into the ends of the rolls to be joined.


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D. Leave 2 inches between finish grade or surface and bottom selvage, unless otherwise indicated.

E. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than 15 inches on center.

F. Tie Wires: Fasten ties to wrap a full 360 degrees around rail or post and a minimum of one complete diamond of fabric. Twist ends of tie wire three full twists, and cut off protruding ends to preclude untwisting by hand.

1. Maximum Spacing: Tie fabric to line posts at 12 inches on center and to brace and top rails at 24 inches on center.

## 3.09 BARBED WIRE

A. Install barbed wire uniformly in configurations of three strands of barbed wire on supporting arms. Pull wire taut and install securely to supporting arms and secure to end terminal post or terminal arms.

## 3.10 GATES

A. Install gates according to manufacturer’s written instructions, level, plumb and secure for full opening without interference. Attach fabric and hardware to gate using tamper-resistant or concealed means. Adjust hardware for smooth operation and lubricate where necessary so gates operate satisfactorily from open or closed position.

B. Set gate stops in concrete to engage center drop rod or plunger bar.

## 3.11 FIELD QUALITY CONTROL

A. Post and Fabric Testing: Test fabric tension and line post rigidity according to ASTM F1916.

B. Gate Tests:

1. Prior to acceptance of installed gates, demonstrate proper operation of gates under each possible open and close condition specified.
2. Adjust gate to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range.
3. Confirm that latches and locks engage accurately and securely without forcing and binding.


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## 3.12 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, to train Owner's personnel to adjust, operate, and maintain gates.

## 3.13 CLEANUP

A. Remove excess fencing materials and other debris from Site.

**END OF SECTION**


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# SECTION 32 31 15
# GATE OPERATOR SYSTEMS

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. ASTM International (ASTM):
   a. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   b. A780/A780M, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings.
   c. A1064/A1064M, Standard Specification for Carbon-Steel and Welded Wire Reinforcement, Plan and Deformed, for Concrete.
   d. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   e. C150/C150M, Standard Specification for Portland Cement.
   f. C387/C387M REV B, Standard Specifications for Packaged, Dry, Combined Materials for Concrete and High Strength Mortar.
2. National Fire Protection Association (NFPA): 70, National Electrical Code.
3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 volts max.).

### 1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product Data:
      1) Include construction details, material descriptions, dimensions of individual components, and finishes, identifying any deviation from the specified requirements:
         a) Gate operators, motors, and mounting arrangements, switches, and controls; include operating instructions.
         b) Gate access system, including access control features, loop detectors, power and control wiring diagrams, and operating instructions.
2. Test Reports: Field test result for compliance of installation of gate operators compared to specified requirements.


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B. Informational Submittals:

1. Manufacturer’s recommended installation instructions.
2. Factory test reports, certified.
3. Evidence of Supplier and installer qualifications.
4. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
5. Manufacturer’s Certificate of Proper Installation.

## 1.03 QUALITY ASSURANCE

A. Qualifications:

1. Automatic Gate Operator System Supplier: 5 years’ experience in gate operator systems.
2. Automatic Gate Operator System Installer:
   a. Completed chain link fences and gates similar in material, design, and extent to those indicated for Project.
   b. Record of successful in-service performance.
   c. Minimum 3 years’ experience.

B. Equipment and components designed, supplied, installed and on-call service provided by an individual company meeting requirements specified.

C. Preinstallation Conference: Conduct conference at Project Site with gate installer to verify layout and operations of automatic gate operating system.

## 1.04 CODES AND REGULATORY REQUIREMENTS

A. Gate Operators:

1. Built to UL 325 standards.
2. Listed by a testing laboratory.
3. Electrical work completed according to local codes and National Electrical code.
4. Fieldwork performed in a neat and professional manner, completed to journeyman standards.

B. Safety standards require the use of multiple external sensors to be capable of reversing the gate in either direction upon sensing an obstruction.

## 1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Site in undamaged condition. Store materials off the ground in unopened packaging to provide protection against oxidation caused by ground contact.


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1.06 SCHEDULING AND SEQUENCING

A. Complete necessary Site preparation, grading, and installation of fence and gates before installing the operators.

B. Interruption of Existing Utility Service: Notify owner of utility 72 hours prior to interruption of utility services. Do not proceed with interruption of utility service without written permission from utility owner.

1.07 SPECIAL GUARANTEE

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

1. Faulty operations of gate operators and controls.
2. Deterioration of metals, metal finishes, and other materials beyond normal weathering.

**PART 2 PRODUCTS**

2.01 GENERAL

A. Like items of equipment provided hereunder shall be the end products of one manufacturer in order to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's service.

B. See Conditions of the Contract and Division 01, General Requirements, which contain information and requirements that apply to the work specified herein and are mandatory for this Project.

2.02 GATE OPERATOR SYSTEM

A. General:

1. Operator shall meet UL 325 requirements for Class III, Type A, B1, or B2 operators.
2. Provide factory-assembled automatic operating system designed for gate size, type, weight, and operation frequency. Provide operation control system with characteristics suitable for Project conditions, safety devices, and weatherproof enclosures; coordinate electrical requirements with Division 26, Electrical.


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3. Provide operator designed so motor may be removed without disturbing limit-switch adjustment and without affecting auxiliary emergency operator.
4. Provide operator with UL approved components.
5. Provide electronic components with built-in troubleshooting diagnostic feature.
6. Provide unit designed and wired for both right-hand/left-hand opening, permitting universal installation.
7. Unless otherwise indicated, provide all conduits and conductors specifically shown for gate operators and controls, including but not limited to, vehicle detector loops, and controller supports.
8. Coordinate gate operator system and gates to be installed at the site.
9. Raceway and Boxes: In accordance with Section 26 05 33, Raceway and Boxes.
10. Conductors: In accordance with Section 26 05 05, Conductors.
11. Motor: In accordance with Section 26 20 00, Low-Voltage AC Induction Motors.

B. Motor Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, within installed environment, with indicated operating sequence, and without exceeding nameplate rating or considering service factor.

C. Gate Operator:

1. Heavy-duty, high frequency, electrical models designed to open and close gates provided.
2. For each gate, supply manufacturer of gate operator with complete details of gate, hardware, track rollers, adjacent fence posts, and fence construction for development and detailing of gate operator.
3. Furnish with following features:
    a. Metal enclosure, including attachments, constructed with finish and design suitable for exterior installation in all-weather environment.
    b. Minimum 1-hp motor.
    c. Electric motor driven hydraulic power pack with hard rubber wheels in contact with operating type secured to gate. Transmission of opening or closing forces to gate:
        1) By rotation of wheels against operating type.
    d. Positive limit switch, to sense position of gate and provide control to prevent damage to gate operator.
    e. Motor Control Enclosure: In accordance with Section 26 05 04, Basic Electrical Materials and Methods.
    f. Disconnecting Means: Provide with external, NEMA 4X rated, disconnect switch capable of being padlocked in the OFF position.


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g. Motor Overload Protection: In accordance with Section 26 24 19, Low-Voltage Motor Control.
h. 24V ac control circuit to power remote control gate activation devices.
i. Manual operation feature or disconnect, without use of tools, for easy operation during power failure, malfunction, or emergency.
j. Aluminum drive rail designed for attachment to sliding gate in manner that reinforces gate assembly.
k. Gate Travel Speed:
    1) Minimum 1 foot per second.
    2) Speed adjusting feature that provides range of appropriate speeds for slide gate operation is acceptable but not required.
    3) Maximum Gate Weight: 3,000 pounds.
    4) Frequency of Use: 10 cycles per hour.
    5) Operating Type: Suitable for roller gates, with manual release.
l. Compatible with gate operator control devices provided. Coordinate requirements with manufacturers.
m. Gate edge sensors that provide a reverse signal to operator when gate hits any obstruction.
n. Fire department override key switch at entry.

4. Manufacturers:
    a. Hy-Security Gate Operator, Seattle, WA.
    b. Automated Equipment Co., Seattle, WA.
    c. Richards Wilcox, Aurora, IL.

D. Access System:

1. Coordinate access system devices with card reader in weatherproof enclosure mounted on steel tube post anchored to concrete foundation outside gate. Face lighted unit fully visible at night.
    a. Card Reader:
        1) Functions only when authorized card is presented.
        2) Reader Type: Proximity.
        3) Features:
            a) Timed anti-passback.
            b) Limited-time usage.
            c) Capable of monitoring and auditing gate activity.
2. For safety, provide loop detectors 5 feet away from each side of gate.
3. Gate Operation:
    a. Entry: Gate opens when activated by valid card in reader. Gate closes after adjustable time period up to 90 seconds.
    b. Exit: Gate opens when activated by detector loop in pavement. Gate closes as for entry.


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c. Override or 7-day timer to allow gate to remain open for up to 12 hours with equipment at rest.

4. Serial communication interface, including cable, with supervisory control system specified in Section 40 90 00, Instrumentation and Control for Process Systems, for remote monitoring of gate activity. Gate usage shall send code after each access to plant.

2.03 KNOX BOX

A. Lock Box: Door King; Model 1400, or approved equal.

1. 14-gauge steel painted bright red.
2. Padlock keeps door shut.
3. Built in micro-switch for gate activation.
4. Dimensions: 5.375 inches high, 4.5 inches wide, 3.67 inches deep.

2.04 CONCRETE

A. Provide as specified in Section 03 30 00, Cast-in-Place Concrete.

**PART 3 EXECUTION**

3.01 GENERAL

A. Provide necessary hardware for a complete and operational gate meeting specified requirements.

B. Any damage to galvanized surfaces, including welding, shall be repaired with paint containing zinc dust in accordance with ASTM A780/A780M.

3.02 PREPARATION

A. In accordance with manufacturer’s recommendations.

B. Eliminate ground surface irregularities where the gate operator and access system are located.

C. Clean surfaces thoroughly prior to installation.

3.03 GATE OPERATOR SYSTEMS

A. Install gate operator systems in accordance with manufacturer’s recommendations, aligned and true to fence line and grade.

B. Furnish with equipment and accessories necessary for complete installation.


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C. Hand excavate holes for pads in firm undisturbed soil to dimensions, depths, and locations as required by gate operator component manufacturer's written instructions and as shown on the Drawings.

D. Mount operator directly to concrete pad, firmly secured, plumb, and level.

E. Wire the system in accordance with NEC and local codes. Enclose all splices in easily accessible junction boxes or on terminal boards. Tag and identify all cable runs in all junction boxes.

F. Vehicle Loop Detector System: Cut grooves in pavement and bury and seal wire loop according to manufacturer's written instructions. Connect to equipment operated by detector.

3.04 KNOX BOX

A. Install Knox Box to access system support post and to manufacturer's recommendation.

3.05 FIELD QUALITY CONTROL

A. Automatic Gate Operator:

1. Energize circuits to electrical equipment and devices.
2. Adjust operators, controls, safety devises, and limit switches.
3. Start units to confirm proper motor rotation and unit operation free of binding. Test and adjust all gate controls for proper operation.
4. Demonstrate coordination with the access control system.
5. Replace damaged and malfunctioning controls and equipment.
6. Lubricate hardware, gate operator and other moving parts.

3.06 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of the installation, testing, startup assistance, and training of plant personnel.

B. Coordinate startup services and training of plant personnel with Owner, Engineer, and affected personnel.

3.07 CLEANUP

A. Remove excess materials and other debris from Site.

**END OF SECTION**



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# SECTION 32 91 13
# SOIL PREPARATION

## PART 1 GENERAL

1.01 REFERENCES

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

1. ASTM International (ASTM):
   a. C33/C33M, Standard Specification for Concrete Aggregates.
   b. C602, Standard Specification for Agricultural Liming Materials.
   c. D2974, Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils.
   d. D5268, Standard Specification for Topsoil Used for Landscaping Purposes.

1.02 SUBMITTALS

A. Informational Submittals:

1. Certified Topsoil Analysis Reports:
   a. Indicate quantities of materials necessary to bring onsite or imported topsoil into compliance with textural/gradation requirements.
   b. Indicate quantity of lime, quantity and analysis of fertilizer, and quantity and type of soil additive.

1.03 SEQUENCING AND SCHEDULING

A. Rough grade areas to be planted or seeded prior to performing Work specified under this section.

## PART 2 PRODUCTS

2.01 TOPSOIL

A. General: Natural, friable, sandy loam, obtained from well-drained areas, free from objects larger than 1-1/2 inches maximum dimension, and free of subsoil, roots, grass, other foreign matter, hazardous or toxic substances, and deleterious material that may be harmful to plant growth or may hinder grading, planting, or maintenance.

B. Organic Matter: Minimum 2 percent by dry weight as determined in accordance with ASTM D2974.


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C. pH: Range 6.0 to 7.0.

D. Textural Amendments: Amend as necessary to conform to required composition by incorporating sand, peat, manure, or sawdust.

E. Source: Stockpile material onsite. Import topsoil if onsite material is insufficient in quantity.

2.02 LIME

A. Composition: Ground limestone with not less than 85 percent total carbonates, ASTM C602.

B. Gradation:

1. Minimum 50 percent passing No. 100 sieve.
2. Minimum 90 percent passing No. 20 sieve.
3. Coarser material acceptable provided rates of application are increased proportionately on basis of quantities passing No. 100 sieve.

2.03 SOIL ADDITIVES

A. Fertilizer:

1. Osmocote 18-6-12.
2. “Or-equal.”

2.04 SOURCE QUALITY CONTROL

A. Topsoil Analysis/Testing: Performed by county or state soil testing service or approved certified independent testing laboratory.

**PART 3 EXECUTION**

3.01 SUBGRADE PREPARATION

A. Scarify subgrade to minimum depth of 6 inches where topsoil is to be placed.

B. Remove stones over 2-1/2 inches in any dimension, sticks, roots, rubbish, and other extraneous material.

C. Limit preparation to areas which will receive topsoil within 2 days after preparation.


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## 3.02 TOPSOIL PLACEMENT

A. Do not place topsoil when subsoil or topsoil is frozen, excessively wet, or otherwise detrimental to the Work.

B. Mix soil amendments, lime, and other soil additives, identified in analysis reports with topsoil before placement or spread on topsoil surface and mix thoroughly into entire depth of topsoil before planting or seeding. Delay mixing of fertilizer if planting or seeding will not occur within 3 days.

C. Place one-half of the total depth of topsoil and work into top 4 inches of subgrade soil to create a transition layer. Place remainder of topsoil to depth of 6 inches where seeding and planting are scheduled.

D. Uniformly distribute to within 1/2 inch of final grades. Fine grade topsoil eliminating rough or low areas and maintaining levels, profiles, and contours of subgrade.

E. Remove stones exceeding 1-1/2-inch diameter, roots, sticks, debris, and foreign matter during and after topsoil placement.

F. Remove surplus subsoil and topsoil from Site. Grade stockpile area as necessary and place in condition acceptable for planting or seeding.

**END OF SECTION**


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# SECTION 32 92 00
# TURF AND GRASSES

## PART 1 GENERAL

1.01 DEFINITIONS

A. Maintenance Period: Begin maintenance immediately after each area is planted and continue for a period of 8 weeks after all planting under this section is completed.

B. Satisfactory Stand:

1. Grass or section of grass of 10,000 square feet or larger that has:
   a. No bare spots larger than 3 square feet.
   b. Not more than 10 percent of total area with bare spots larger than 1 square foot.
   c. Not more than 15 percent of total area with bare spots larger than 6 square inches.

1.02 SUBMITTALS

A. Action Submittals: Product labels/data sheets.

B. Informational Submittals:

1. Seed:
   a. Certification of seed analysis, germination rate, and inoculation:
      1) Certify that each lot of seed has been tested by a testing laboratory certified in seed testing, within 6 months of date of delivery. Include with certification:
         a) Name and address of laboratory.
         b) Date of test.
         c) Lot number for each seed specified.
         d) Test Results: (i) name, (ii) percentages of purity and of germination, and (iii) weed content for each kind of seed furnished.
      2) Mixtures: Proportions of each kind of seed.
2. Seed Inoculant Certification: Bacteria prepared specifically for legume species to be inoculated.
3. Description of required maintenance activities and activity frequency.


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1.03 DELIVERY, STORAGE, AND PROTECTION

A. Seed:

1. Furnish in standard containers with seed name, lot number, net weight, percentages of purity, germination, and hard seed and maximum weed seed content, clearly marked for each container of seed.
2. Keep dry during storage.

B. Hydroseeding Mulch: Mark package of wood fiber mulch to show air dry weight.

1.04 WEATHER RESTRICTIONS

A. Perform Work under favorable weather and soil moisture conditions as determined by accepted local practice.

1.05 SEQUENCING AND SCHEDULING

A. Prepare topsoil as specified in Section 32 91 13, Soil Preparation, before starting Work of this section.

B. Complete Work under this section within 10 days following completion of soil preparation.

C. Notify Engineer at least 3 days in advance of:

1. Each material delivery.
2. Start of planting activity.

D. Planting Season: Those times of year that are normal for such Work as determined by accepted local practice.

1.06 MAINTENANCE SERVICE

A. Contractor:

1. Perform maintenance operations during maintenance period to include:
   a. Watering: Keep surface moist.
   b. Washouts: Repair by filling with topsoil, liming, fertilizing, seeding, and mulching.
   c. Mulch: Replace wherever and whenever washed or blown away.
   d. Mowing: Mow to 2 inches after grass height reaches 3 inches, and mow to maintain grass height from exceeding 3-1/2 inches.
   e. Reseed unsatisfactory areas or portions thereof immediately at the end of the maintenance period if a satisfactory stand has not been produced.



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f. Reseed/replant during next planting season if scheduled end of maintenance period falls after September 15.
g. Reseed/replant entire area if satisfactory stand does not develop by July 1 of the following year.

## PART 2 PRODUCTS

2.01 FERTILIZER

A. Commercial, uniform in composition, free-flowing, suitable for application with equipment designed for that purpose. Minimum percentage of plant food by weight.

B. Application Rates: Determined by soil analysis results.

C. Mix:

1. Nitrogen: 10.
2. Phosphoric Acid: 20.
3. Potash: 10.

D. Top Dress Type: As recommended by local authority.

2.02 SEED

A. Fresh, clean new-crop seed that complies with the tolerance for purity and germination established by Official Seed Analysts of North America.

B. Seeds of Legumes: Inoculated with pure culture of nitrogen-fixing bacteria prepared specifically for legume species in accordance with inoculant manufacturer’s instructions.

C. As directed by local experts such as those part of Oklahoma State University’s Agriculture Extension.

D. Summer Seed: Bermuda.

E. Spring or Fall Seed: Fescue.

F. Winter Protective Seed: Annual ryegrass.

2.03 STRAW MULCH

A. Threshed straw of oats, wheat, barley, or rye, free from (i) seed of noxious weeds or (ii) clean salt hay.


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## 2.04 HYDROSEEDING MULCH

A. Wood Cellulose Fiber Mulch:

1. Specially processed wood fiber containing no growth or germination inhibiting factors.
2. Dyed a suitable color to facilitate inspection of material placement.
3. Manufactured such that after addition and agitation in slurry tanks with water, the material fibers will become uniformly suspended to form homogenous slurry.
4. When hydraulically sprayed on ground, material will allow absorption and percolation of moisture.

## 2.05 NETTING

A. Jute:

1. Heavy-duty, twisted, weighing 1 pound per square yard.
2. Openings Between Strands: Approximately 1 inch square.

B. Matting:

1. Excelsior mat or straw blanket; staples as recommended by matting manufacturer.
2. Manufacturers and Products:
   a. Akzo Industries, Ashville, NC; Curlex mat.
   b. North American Green, Evansville, IN; S150 blanket.

## 2.06 TACKIFIER

A. Derived from natural organic plant sources containing no growth or germination-inhibiting materials.

1. Capable of hydrating in water, and to readily blend with other slurry materials.
2. Wood Cellulose Fiber: Add as tracer, at rate of 150 pounds per acre.
3. Manufacturers and Products:
   a. Chevron Asphalt Co.; CSS 1.
   b. Terra; Tack AR.
   c. J Tack; Reclamare.


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## PART 3 EXECUTION

### 3.01 PREPARATION

A. Grade areas to smooth, even surface with loose, uniformly fine texture.

1. Roll and rake, remove ridges, fill depressions to meet finish grades.
2. Limit such Work to areas to be planted within immediate future.
3. Remove debris, and stones larger than 1-1/2-inch diameter, and other objects that may interfere with planting and maintenance operations.

B. Moisten prepared areas before planting if soil is dry. Water thoroughly and allow surface to dry off before seeding. Do not create muddy soil.

C. Restore prepared areas to specified condition if eroded or otherwise disturbed after preparation and before planting.

### 3.02 FERTILIZER

A. Apply evenly over area in accordance with manufacturer’s instructions. Mix into top 2 inches of topsoil, when applied by broad cast method.

B. Application Rate: Determined by soil analysis results.

### 3.03 SEEDING

A. Start within 2 days of preparation completion.

B. Hydroseed slopes steeper than 3H:1V. Flatter slopes may be mechanically seeded.

C. Mechanical: Broadcast seed in two different directions, compact seeded area with cultipacter or roller.

1. Sow seed at uniform rate of 5 pounds per 1,000 square feet.
2. Use Brillion type seeder.
3. Broadcasting will be allowed only in areas too small to use Brillion type seeder. Where seed is broadcast, increase seeding rate 20 percent.
4. Roll with ring roller to cover seed, and water with fine spray.

D. Hydroseeding:

1. Application Rate: As needed for satisfactory stand of seed mix.
2. Apply on moist soil, only after free surface water has drained away.
3. Prevent drift and displacement of mixture into other areas.
4. Upon application, allow absorption and percolation of moisture into ground.


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5. Mixtures: Seed and fertilizer may be mixed together, apply within 30 minutes of mixing to prevent fertilizer from burning seed.

E. Mulching: Apply uniform cover of wood fiber mulch at rate of 1,500 pounds per acre.

F. Netting: Immediately after mulching, place over mulched areas with slopes steeper than 3:1 in accordance with manufacturer's instructions. Locate strips parallel to slope and completely cover seeded areas.

G. Tackifier: Apply over mulched areas with slopes steeper than 3:1 at rate of 5 gallons per 1,000 square feet in accordance with the manufacturers recommended requirements.

H. Water: Apply with fine spray after mulching to saturate top 4 inches of soil.

3.04 FIELD QUALITY CONTROL

A. 8 weeks after seeding is complete and on written notice from Contractor, Engineer will, within 15 days of receipt, determine if a satisfactory stand has been established.

B. If a satisfactory stand has not been established, Engineer will make another determination after written notice from Contractor following the next growing season.

3.05 PROTECTION

A. Protect from pedestrian traffic by erecting temporary fence around each newly seeded area.

**END OF SECTION**


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# SECTION 33 05 01.09
# POLYVINYL CHLORIDE (PVC) PRESSURE PIPE AND FITTINGS

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American Water Works Association (AWWA):
   a. C110, Ductile-Iron and Gray-Iron Fittings.
   b. C153, Ductile-Iron Compact Fittings, for Water Service.
   c. C605, Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings.
   d. C900, Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 Inches Through 12 Inches (100 mm Through 300 mm), for Water Transmission and Distribution.
   e. C905, Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 Inches through 48 Inches (350 mm through 1,200 mm) for Water Transmission and Distribution.
   f. C907, Injection-Molded Polyvinyl Chloride (PVC) Pressure Fittings, 4 Inches through 12 Inches (100 mm Through 300 mm), for Water, Wastewater, and Reclaimed Water Service.
2. ASTM International (ASTM):
   a. D2241, Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
   b. D2321, Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
   c. D2466, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
   d. D2467, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
   e. D2672, Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement.
   f. D2855, Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.
   g. D3139, Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
3. NSF International (NSF).


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1.02 SUBMITTALS

A. Action Submittals: Drawings showing pipe diameter, pipe class, dimension ratio (DR) and fitting details.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
2. Hydrostatic Testing Plan: Submit at least 15 days prior to testing and at minimum, include the following:
   a. Testing dates.
   b. Piping systems and section(s) to be tested.
   c. Method of isolation.
   d. Method of conveying water from source to system being tested.
   e. Method of disposing of test water.
   f. Calculation of maximum allowable leakage for piping section(s) to be tested.
3. Certification of Calibration: Approved testing laboratory certificate if pressure gauge for hydrostatic test has been previously used. If pressure gauge is new, no certificate is required.
4. Test report documentation.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Solvent Cement: Store in accordance with ASTM D2855.

**PART 2 PRODUCTS**

2.01 MATERIALS

A. Pipe:

1. PVC, conforming to requirements of AWWA C900.
2. DR shall be 25.
3. Pipe to be used for potable water conveyance shall meet the requirements of NSF 61.

B. Joints:

1. As shown on the Drawings.
2. Conform to AWWA C900.

C. Fittings: PVC conforming to AWWA C900, AWWA C905, or AWWA C907.




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D. Service Saddles:

1. Double strap type with minimum strap width of 2 inches.
2. Straps: Type 304 stainless steel.
3. Saddles: Ductile iron, epoxy-coated, 10-mil minimum thickness.
4. Minimum Pressure Rating: 165 psi.

E. Restrained Joints:

1. Provide pipe restraint, where indicated on the Drawings, by system designed specifically for use with PVC pipe using wedges. Do not use systems with set screws, gripper rings, or gripper gaskets.
2. Minimum Pressure Rating: 165 psi.

## PART 3 EXECUTION

### 3.01 INSTALLATION

A. In accordance with AWWA Manual 23.

B. Solvent cement used for joints as recommended by pipe manufacturer.

C. Joints:

1. Rubber Gasketed: In accordance with manufacturer’s written instructions.
2. Solvent Cemented: In accordance with ASTM D2855.
3. Restrained Joint Systems: In accordance with manufacturer’s written instructions.

D. Pipe Bending for Horizontal or Vertical Curves:

1. Bending of pipe barrels larger than 12 inches in diameter is not allowed.
2. Radius of curves shall not exceed 75 percent of manufacturer’s recommended values.
3. Use blocks or braces at pipe joints to ensure axial deflection in gasketed or mechanical joints does not exceed allowable deflection.

E. Maximum Joint Deflection at Mechanical Joint: 75 percent of manufacturer’s recommended values.

F. No deflection is allowed at push-on joints.


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## 3.02 INSPECTION AND HYDROSTATIC TESTING

A. General:

1. Notify Engineer in writing at least 5 days in advance of testing. Perform testing in presence of Engineer.
2. Using water as test medium, all newly installed pipelines must successfully pass hydrostatic leakage test prior to acceptance.
3. Conduct field hydrostatic test on buried piping after trench has been completely backfilled and compacted. Testing may, as approved by Engineer, be done prior to placement of asphaltic concrete or roadway structural section.
4. Contractor may, if field conditions permit and as approved by Engineer, partially backfill trench and leave joints open for inspection and conduct an initial informal service leak test. Final field hydrostatic test shall not, however, be conducted until backfilling has been completed as specified above.
5. Supply of Temporary Water: In accordance with Section 01 50 00, Temporary Facilities and Controls.
6. Dispose of water used in testing in accordance with federal, state, and local requirements.
7. Install temporary thrust blocking or other restraint as necessary to prevent movement of pipe and protect adjacent piping or equipment. Make necessary taps in piping prior to testing.
8. Wait a minimum of 5 days after concrete thrust blocking is installed to perform pressure tests. If high-early strength cement is used for thrust blocking, wait may be reduced to 2 days.
9. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by pressure testing.
10. New Piping Connected to Existing Piping:
    a. Isolate new piping with grooved-end pipe caps, blind flanges, or other means as acceptable to Engineer.
    b. Provide appropriate thrust blocking.

B. Hydrostatic Testing Procedure:

1. Furnish testing equipment, as approved by Engineer, which provides observable and accurate measurements of leakage under specified conditions.
2. Maximum Filling Velocity: 0.25 foot per second calculated based on full area of pipe.
3. Expel air from piping system during filling.
4. Test Pressure: 150 percent of system operating pressure based on pressure as measured at low point of pipeline.


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5. Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.
6. Maintain hydrostatic test pressure continuously for 2 hours minimum, adding make-up water only as necessary to restore test pressure to within 5 psi of specified hydrostatic test pressure.
7. Determine actual leakage by measuring quantity of water necessary to maintain specified test pressure for duration of test.

C. Maximum Allowable Leakage:

$$L = \frac{ND(P)^{1/2}}{7400}$$

where:

L = Allowable leakage, in gallons per hour.
N = Number of joints in tested line.
D = Nominal diameter of pipe, in inches.
P = Average test pressure during leakage test, in pounds per square inch.

**END OF SECTION**


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# SECTION 33 05 01.10
# HIGH-DENSITY POLYETHYLENE (HDPE) PRESSURE PIPE AND FITTINGS

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American Society of Mechanical Engineers (ASME):
   a. Boiler and Pressure Vessel Code, Section IX, Article XXI-XXIV.
   b. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   c. B18.2.1, Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series).
   d. B18.2.2, Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series).
2. American Water Works Association (AWWA):
   a. C906, Polyethylene (PE) Pressure Piping and Fittings, 4 in. through 65 in. for Waterworks.
   b. Manual M55, PE Pipe - Design and Installation.
3. ASTM International (ASTM):
   a. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
   b. A194/A194M, Standard Specification for Carbon Steel, Alloy Steel, and Stainless Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   c. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   d. A307, Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 psi Tensile Strength.
   e. A536, Standard Specification for Ductile Iron Castings.
   f. A563, Standard Specification for Carbon and Alloy Steel Nuts.
   g. D3035, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
   h. D3261, Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
   i. D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.


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j. F714, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter.
k. F2164, Standard Practice for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure.
l. F2620, Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings.

4. Code of Federal Regulations (CFR): Title 49 Part 192.285, Plastic Pipe: Qualifying Persons to Make Joints.
5. NSF International (NSF): 61, Drinking Water System Components - Health Effects.
6. Plastics Pipe Institute (PPI):
   a. Handbook of PE Pipe.
   b. Technical Note 38, Bolt Torque for Polyethylene Flanged Joints.
   c. TR-33, Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe.

## 1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Catalog information confirming pipe, fittings, and other materials conform to requirements of this section.
   b. Drawings of specific connection details.

B. Informational Submittals:

1. Manufacturer’s Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
2. Infrared temperature gun product data.
3. Experience, training record, and certificates of persons to be fusing HDPE pipe.
4. Information on manufacturer and model of machine to be used for fusion of HDPE pipe.
5. Testing Plan:
   a. Submit at least 15 days prior to testing and include the following as a minimum:
      1) Testing dates.
      2) Piping systems and section(s) to be tested.
      3) Method of isolation.
      4) Method of conveying water from source to system being tested.


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6. Certifications of Calibration: Approved testing laboratory certificate if pressure gauge for hydrostatic test has been previously used. If pressure gauge is new, no certificate is required.
7. Test report documentation.
8. Installation Plan following the Plastic Pipe Institute, ASTM F2620, and manufacturer's recommendations. Plan shall include, but not be limited to the following major components:
    a. Pipe and fitting storage.
    b. Pipe and fitting handling equipment.
    c. Proposed means to maintain required temperatures for fusing.
    d. Proposed means to shield fusing area from wind, snow, blowing dust, and rain.
    e. Proposed means to maintain uniform pipe wall temperature prior to fusing.
    f. Temperature Control Plan: Plan shall include means to reduce temperature of pipe to limit stated in Part 3 of this specification.
9. Fusion parameters including recommended limits of criteria recorded by data logger.
10. Fusion report for each joint, including information listed under Article Field Quality Control. Submit joint reports within 24 hours after fusion.
11. Confirmation that thickness and design of stiffening inserts have been approved by pipe and coupling manufacturer and are suitable for use with pipe and coupling. Stiffener shall not buckle under a minimum interior pipe temperature of 40 degrees F when pipe is empty.
12. Gasket manufacturer's table for recommended bolt torque and tightening pattern.

## 1.03 QUALITY ASSURANCE

A. Qualifications:

1. Pipe Manufacturer: Listed with Plastic Pipe Institute.
2. Experienced in fabricating pipe of similar diameters and wall thickness required for the Work.
3. Successful fabrication of at least 1,000 linear feet of 12-inch diameter or larger pipe within past 5-year period.
4. Persons fusing HDPE pipe shall have a current operator qualification training certificate and wallet card showing operator is qualified to operate machine to be used on the Project and have minimum of 1 year of experience with fusing HDPE pipe and have received minimum of 20 hours training for fusing HDPE pipe from pipe supplier or fusing equipment supplier.


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1.04 DELIVERY, STORAGE, AND HANDLING

A. Shipping: Do not cut, kink, or otherwise damage pipe during transportation.

B. Storage and Handling:

1. Pipe interiors are to be inspected and all debris removed prior to storage.
2. Limit stacking of pipe to a height that will not cause excessive deformation of bottom layers of pipes under anticipated temperature conditions.
3. Do not exceed the stacking heights stated in AWWA Manual M55.
4. Where necessary, because of ground conditions, store pipe on wooden sleepers, spaced suitably and of such widths as not to allow deformation of pipe at point of contact with sleeper or between supports.
5. Comply with the requirements of the approved Installation Plan.
6. Keep pipe shaded from direct sunlight prior to fusion and installation in trench.

1.05 CONNECTIONS TO EXISTING PIPE

A. Fusing to Existing Pipe: Comply with manufacturer's or distributor's recommendations based on Site conditions and PPI TR-33.

**PART 2 PRODUCTS**

2.01 MATERIALS

A. Pipe and Fittings:

1. Conform to requirements of AWWA C906.
2. In compliance with NSF 61.
3. Resin:
   a. Potable Water Transmission and Distribution Systems: Polyethylene resin shall meet or exceed requirements of ASTM D3350 for PE 4710 material with cell classification of 445474C, or better. PE 4710 HDPE pipe and fittings shall be manufactured from bimodal resins. Pressure rating shall be based on hydrostatic design stress of 1,000 psi at 73.4 degrees F.
   b. Non-Potable Water Transmission and Distribution Systems: Polyethylene resin shall meet or exceed requirements of ASTM D3350 for:
      1) PE 4710 material manufactured from bimodal resin with cell classification of 445474C, or better. Pressure rating shall be based on hydrostatic design stress of 1,000 psi at 73.4 degrees F.
4. Pressure Rating: 160 and nominal DR of 13.5.


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5. Outside Diameter Basis: IPS.
6. Pipe lengths, fittings, and flanged connections to be joined by thermal butt-fusion shall be of a compatible resin mix for the fusion process.
7. Fittings:
    a. Polyethylene fittings shall have same or higher pressure rating as pipe.
    b. Sizes 12 Inches and Smaller: Molded and manufactured to requirements of ASTM D3261.
    c. Sizes Larger than 12 Inches: Thermal butt-fused fabricated.
    d. Unless noted otherwise, provide fittings with a factory fused 4-foot long spool on each end to facilitate onsite fusion.

B. Backup Rings:

1. Convoluted for Flanged Connections:
    a. ASTM A536, ductile iron.
    b. Complete with one-piece, molded polyethylene flange adapters.
    c. Flanged Connections: Same or greater pressure rating as pipe.
2. Ductile Iron: Shop-coated in accordance with requirements in Section 09 90 00, Painting and Coating.
3. Gaskets: Material, size, and thickness shall be as recommended by gasket manufacturer and in accordance with PPI Technical Note 38. Gasket manufacturer shall provide a table with recommended bolt torque and tightening pattern.

C. Joints: Thermal butt-fusion or electrofusion, except where connecting to unions, valves, and equipment with flanged or threaded connections that may require future disassembly. Use appropriate transition fitting or adapter for all joints that are not thermal butt-fused or electro-fused.

D. Bolts, Nuts, and Washers:

1. Bolt Materials: Type 316 stainless steel, ASTM A193/A193M, Grade B8M hex-head, carbide solution treated and strained hardened.
2. Bolt Fabrication: In accordance with ASME B18.2.1
3. Nut Materials: Type 316 stainless steel, ASTM A194/A194M, Grade 8 hex-head.
4. Nut Fabrication: In accordance with ASME B18.2.2.
5. Washers: Type 316 stainless steel. Same material as bolts in accordance with ASME B18.21.1.
6. Thread Lubricant: Provide bolt manufacturer’s recommended lubricant on bolt threads, nuts, nut face, and around bolt hole.
7. Corrosion Resistance: When used in submerged brine water applications, bolts, nuts, and washers shall be coated in polytetrafluoroethylene (PTFE) applied by fastener manufacturer.


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E. Stiffening Inserts:

1. Stiffening inserts used to provide circumferential inside support of HDPE pipe ends shall be constructed of Type 316 stainless steel per ASTM A240.
2. Thickness of metal stiffening inserts shall be as approved by pipe manufacturer and coupling manufacturer for the specific use.

F. Wall Anchor:

1. Material: Same as HDPE pipe.
2. Internal Diameter: Equal to adjacent pipe.
3. Shear Strength: Equal to or greater than tensile strength of adjacent pipe.
4. Fabrication: Butt fusion. Extrusion bead welding is not allowed.

G. Electrofusion Flex Restraint:

1. Material: HDPE.
2. Method of Attachment: Electrofusion.
3. Designed for restraining movement of HDPE pipe.
4. Manufacturers:
   a. Central Plastics Company.
   b. Industrial Pipe Fittings, IPF-Plasson.

H. Electrofusion Couplings:

1. Material: HDPE.
2. Method of Attachment: Electrofusion.
3. Designed for coupling HDPE pipe.
4. Manufacturers:
   a. Central Plastics Company.
   b. ISCO Industries.

I. Concrete Thrust Blocks: See City of Broken Arrow Standard Construction Specifications and Details, Section 439.

J. Products that restrain HDPE pipe with wedges or clamps are not acceptable.



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## PART 3 EXECUTION

### 3.01 INSTALLATION

A. General:

1. Install polyethylene pipe in conformance with AWWA M55, PPI TR-33, ASTM F2620, and pipe manufacturer's recommendations.
2. Follow all requirements of approved Installation Plan where HDPE is to be installed in ambient temperatures less than 50 degrees F, in hot conditions or in windy conditions.
3. Protect and install pipe in accordance with the Temperature Control Plan when contraction of pipe length may cause damage to or pull out from structures.

B. Joining: Butt-fuse pipes and fittings in accordance with pipe manufacturer's recommendations. Depending on Site conditions, perform butt-fusion joining in or outside of excavated trench.

1. Remove and extract internal fusion bead from pipe.
   a. Verify complete internal fusion bead removal was performed. Accomplish by examination of extracted internal fusion bead or by means of closed-circuit television (CCTV) examination.
   b. Extracted Internal Fusion Bead:
      1) Appearance shall have same double roll back semblance as external fusion bead.
      2) Possess smooth root cut or pipe smoothness and shall be verified by means of closed-circuit television (CCTV) examination.
   c. Removal of internal bead may include pipe wall mass. However, wall mass that is removed shall not exceed 1/10th of pipe wall thickness.
2. If HDPE pipe surface temperature is above 90 degrees F as measured with infrared temperature gun, allow pipe to cool prior to making any connections to flanges, existing pipeline systems, or structures.
3. Connect HDPE pipe to auxiliary equipment such as valves, pumps, tanks, and other piping systems with flanged connections as follows:
   a. Polyethylene flange adapter, thermally butt-fused to end of pipe. Flange "stub ends" are not allowed.
   b. Convoluted backing flange, as specified.
   c. Bolt and nut of sufficient length to show a minimum of three complete threads when joint is made and tightened to manufacturer's standard.
   d. Follow requirements of PPI Technical Note 38 including mandatory 4-hour bolt re-torquing.


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4. Special Precautions at Flanges: Support polyethylene pipe connected to heavy fittings, manholes, and rigid structures in such a manner that no subsequent relative movement between polyethylene pipe at flanged joint and rigid structures is possible.
5. Minimum Long-Term Field Bending Radius: Restricted to limits recommended by AWWA M55, Table 8-2.

C. Placement in Trench:

1. Handle joined pipeline in such a manner that pipe is not damaged by dragging it over sharp and cutting objects.
2. Position slings for handling pipeline away from butt-fused joints.
3. Remove sections of damaged pipe and replace it with undamaged pipe. Damaged pipe is defined as pipe with kinks or gouges exceeding 10 percent of pipe wall thickness.
4. Exercise care when lowering pipe into trench to prevent damage or twisting of pipe.
5. Buried Pipe: Snake pipe from one side of trench to other to allow for thermal and settling movements, and as recommended by pipe manufacturer.
6. At flanges, valves, and connections, excavate out trench bottom sufficiently to ensure clearance between undisturbed trench bottom and flange, valve, or connection.

## 3.02 FIELD QUALITY CONTROL

A. Joint Butt Fusion:

1. Measure and log each joint fusion by an electronic monitoring device (data logger) affixed to fusion machine. Data to be logged shall include the following and shall be capable of being retrieved electronically:
   a. Pipe size, dimensions, and wall thickness.
   b. Machine model and size.
   c. Operator identification.
   d. Job identification number.
   e. Weld number.
   f. Fusion, heating, and drag pressure settings.
   g. Heater plate temperature.
   h. Time stamp showing when weld was performed.
   i. Heating and curing time of weld.
   j. Curing temperature readings and time stamps of readings.
   k. Error messages and warnings for out of range temperature or pressure settings.


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2. In addition to logged items above, the following shall be logged or annotated on report:
    a. Location of joint being fused by pipeline station or by reference to pipe Shop Drawing.
    b. Ambient temperature, wind speed, precipitation, and humidity.
    c. If internal bead was removed.
    d. Environmental actions taken (such as, use of tarps, enclosures, and blankets).
    e. Type of HDPE and manufacturer.

B. Joint Weld Inspection:

1. Visually examine each joint in accordance with the guidelines in ASTM F2620. Remove and replace any joints not meeting the standard.
2. Mechanical Joint Testing:
    a. Pipe Wall Thickness 1-Inch or Less: Test joints in accordance with bend back testing provided in Appendix X4 of ASTM F2620.
    b. Pipe Wall Thickness Greater than 1 Inch: Test joints in accordance with the guided side bend testing in accordance with ASME BPVC, Section IX, Article XXI-XXIV.
    c. Specimens: Cut pipe 12 inches on each side of field made joint. Rejoin ends and proceed with Work.
    d. Test Frequency:
        1) First 1,000 Linear Feet: Two joints selected at random by Engineer.
        2) Each Additional 5,000 Linear Feet: One joint selected at random by Engineer.
        3) Each Test Failure: Two additional joints selected at random by Engineer.

C. Pipeline Hydrostatic Test:

1. General:
    a. Notify Engineer in writing 5 days in advance of testing. Perform testing in presence of Engineer.
    b. Furnish testing equipment and perform tests in manner satisfactory to Engineer. Testing equipment shall provide observable and accurate measurements of initial service leak and allowable make-up water volume under specified conditions.
    c. Test newly installed pipelines.
    d. Isolate new pipelines that are connected to existing pipelines.
    e. Using water as test medium, pipes shall successfully pass a hydrostatic test prior to acceptance.
    f. Conduct field hydrostatic test on buried piping after trench has been completely backfilled. Testing may, as approved by


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Engineer, be done prior to placement of asphaltic concrete or roadway structural section.

g. Contractor may, if field conditions permit and as determined by Engineer, partially backfill trench and leave joints open for inspection and conduct initial service leak test. Final field hydrostatic test shall not be conducted until backfilling has been completed as specified above.
h. Supply of temporary water shall be as stated in Section 01 50 00, Temporary Facilities and Controls.
i. Dispose of water used in testing in accordance with federal, state, and local requirements.

2. Preparation:
   a. Install temporary thrust blocking or other restraint as necessary to prevent movement of pipe and protect adjacent piping or equipment. Make necessary taps in piping prior to testing.
   b. Wait 5 days minimum after concrete thrust blocking or designed thrust collars are installed to perform pressure tests. If high-early strength cement is used for thrust blocking, wait may be reduced to 2 days.
   c. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by pressure testing.
   d. New Piping Connected to Existing Piping: Isolate new piping with grooved-end pipe caps, blind flanges, or other means as acceptable to Engineer.
3. Procedure:
   a. Test pressure shall be 150 percent of system operating pressure based on pressure as measured at lowest point in pipeline.
   b. Maximum filling velocity shall not exceed 0.25 feet per second, calculated based on full area of the pipe.
   c. Expel air from pipe system during filling.
   d. Test procedure shall be in accordance with ASTM F2164.
      1) Initial Expansion Phase: Add water as required to maintain test pressure for 4 hours.
      2) Test Phase: Reduce pressure by 10 psi and start pressure test.
      3) Test is successful if pressure says within 5 percent of initial value for 1 hour.
   e. If test is not completed because of leakage, equipment failure, or other reasons, depressurize test section and allow it to relax for at least 8 hours before retesting.
   f. If there is leakage, repair defective pipe section and repeat hydrostatic test.


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3.03 DISINFECTION

A. Conform to the requirements of Oklahoma Department of Environmental Quality 252:626-19-2, or latest version.

B. Active chlorine concentration shall not exceed 10 percent.

3.04 MANUFACTURER'S SERVICES

A. Provide pipe manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for assistance during pipe joining operations and pipe installation.

**END OF SECTION**


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# SECTION 33 05 13
# MANHOLES

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO): M198, Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
2. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A48/A48M, Standard Specification for Gray Iron Castings.
   c. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   d. A536, Standard Specification for Ductile Iron Castings.
   e. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   f. B139/B139M, Standard Specification for Phosphor Bronze Rod, Bar, and Shapes.
   g. C14, Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe.
   h. C31/C31M, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   i. C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   j. C150/C150M, Standard Specification for Portland Cement.
   k. C192/C192M, Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.
   l. C387/C387M, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
   m. C443, Standard Specification for Joints for Concrete Pipe and Manholes Using Rubber Gaskets.
   n. C478, Standard Specification for Precast Reinforced Concrete Manhole Sections.
   o. C923, Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals.
   p. C990, Standard Specification for Joints in Concrete Pipe, Manholes, and Precast Box Sections using Preformed Flexible Joint Sealants.
   q. C1311, Standard Specification for Solvent Release Sealants.


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r. C1244, Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill.
s. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).
t. D4101, Standard Specification for Propylene Injection and Extrusion Materials.
u. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
v. F594, Standard Specification for Stainless Steel Nuts.

## 1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings including details of construction, reinforcing and joints, anchors, lifting, erection inserts, and other items cast into members.
2. Product Data:
   a. Concrete mix design.
   b. Manhole frame to structure seals.
   c. Manhole frame to structure anchor bolt.
   d. Rubber gaskets and sealants.
   e. External joint wrap.

B. Informational Submittals:

1. Experience Record:
   a. Precast concrete production capabilities.
   b. Evidence of current PCI plant certification.
2. Calculations: Proposed details and design calculations for stresses in precast concrete members for loading conditions including earth pressures and transportation, handling, and erection. Calculations shall be stamped by engineer registered in the same state as the Project.
3. Certificate of Compliance: Certify admixtures and concrete do not contain calcium chloride.
4. Test Reports:
   a. Precast manufacturer’s concrete test cylinders.
   b. Core compression test.
5. Certified load test data for precast manhole steps.
6. Manufacturer’s recommended installation instructions.
7. Field quality control report.


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1.03 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Precast Concrete and Precast Prestressed Concrete: Product of manufacturer with 3 years' experience producing precast concrete products of quality specified.
2. Precast Plant: PCI certified plant with current certification.

**PART 2 PRODUCTS**

2.01 GENERAL

A. Materials of Construction and Service Conditions:

1. Screws, Bolts, or Nuts: Type 304 stainless steel conforming to ASTM F593 and ASTM F594.
2. Gaskets:
   a. Internal and external seals shall be made of materials that have been proven to be resistant to the following exposures and conditions:
      1) Sanitary sewage.
      2) Corrosion or rotting under wet or dry conditions.
      3) Gaseous environment in sanitary sewers and at road surfaces including common levels of ozone, carbon monoxide, and other trace gases at installation site.
      4) Biological environment in soils and sanitary sewers.
      5) Chemical attack by road salts, road oil, and common street spillages or solvents used in street construction or maintenance.
      6) Temperature ranges, variations, and gradients in construction area.
      7) Variations in moisture conditions and humidity.
      8) Fatigue failure caused by a minimum of 30 freeze-thaw cycles per year.
      9) Vibrations because of traffic loading.
      10) Fatigue failure because of repeated variations of tensile, compressive and shear stresses, and repeated elongation and compression. Material shall remain flexible allowing repeated movement.
3. Materials shall be compatible with each other and manhole materials.
4. Designed to provide a 20-year service life.


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B. Structures shall meet requirements of ASTM C478, this specification and the following:

1. Concrete:
   a. Cement: Meet requirements of ASTM C150/C150M.
   b. Compressive Strength:
      1) Minimum 4,000 psi.
      2) Minimum strength shall be confirmed at 7 days by making two standard cylinders per manhole for testing.
2. Reinforcement: Grade 60, unless otherwise specified.
3. Ring: Custom made with openings to meet indicated pipe alignment conditions and invert elevations.
4. Floor: Minimum 6 inches below pipe to provide clearance for grouting channels.
5. Joint:
   a. Form joint contact services with machined castings.
   b. Surfaces shall be parallel with nominal 1/16-inch clearing and tongue equipped with recess for installation of O-ring rubber gasket.
6. Gasket: Meet requirements of ASTM C443.

2.02 PRECAST MANHOLES

A. Riser Sections:

1. Fabricate in accordance with ASTM C478.
2. Diameter: Minimum 48 inches.
3. Wall Thickness: Minimum 4 inches or 1/12 times inside diameter, whichever is greater.
4. Top and bottom surfaces shall be parallel.
5. Joints: Confined O-ring with rubber gaskets meeting ASTM C443.

B. Cone Sections:

1. Eccentric.
2. Same wall thickness and reinforcement as riser section.
3. Top and bottom surfaces shall be parallel.

C. Base Sections and Base Slab:

1. Base slab integral with sidewalls.
2. Fabricate in accordance with ASTM C478.


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D. Manhole Extensions:

1. Concrete grade rings; maximum 6 inches high.
2. Fabricate in accordance with ASTM C478.

E. Joint Seal Manufacturers and Products:

1. Butyl Gaskets:
   a. Hamilton Kent, Sparks, NV; Kent-Seal No. 2.
   b. Henry Company, Houston, TX; Ram-Nek.
   c. Trelleborg Engineered Solutions, Park Hills, MO; NPC Bidco C-56.
2. Confined Plastic or Rubber O-Ring:
   a. As recommended by precasting manufacturer.
   b. Meet requirements of ASTM C443.
3. External Wrap:
   a. Sealing Systems, Inc., Loretto, MN; Gator Wrap.
   b. Henry Company, Houston, TX; RU116 Rubr-Nek External Joint Wrap.
   c. Trelleborg Engineered Solutions, Park Hills, MO; NPC External Joint Wrap.
   d. Cretex Specialty Products, Waukesha, WI; Cretex Wrap.

F. Galvanized Steel Steps:

1. Fabricate from minimum 3/4-inch steel bar meeting ASTM A36/A36M.
2. Minimum Width: 12 inches, center-to-center of legs, drop pattern with 2-inch drop and 2-inch hook on embedment end.
3. Bends: 1-inch radius minimum, 2-inch radius maximum.
4. Embedment: 3-inch minimum and 4-1/2-inch minimum projection from face of concrete at point of embedment to center of step.
5. Galvanize after bending to meet ASTM A123/A123M.
6. Cast in manhole sections by manufacturer.
7. Load Test: Capable of withstanding ASTM C478 vertical and horizontal load tests.

G. Polypropylene Steps:

1. Fabricate from minimum 1/2 inch, Grade 60, steel bar meeting ASTM A615/A615M.
2. Polypropylene encasement shall conform to ASTM D4101.
3. Minimum Width: 13 inches, center-to-center of legs.
4. Embedment: 3-1/2-inch minimum and 4-1/2-inch minimum projection from face of concrete at point of embedment to center of step.


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5. Cast in manhole sections by manufacturer.
6. Load Test: Capable of withstanding ASTM C478 vertical and horizontal load tests.

2.03 CAST-IN-PLACE MANHOLES

A. Concrete: As specified in Section 03 30 00, Cast-in-Place Concrete.

B. Reinforcing Steel: As specified in Section 03 21 00, Steel Reinforcement.

2.04 MANHOLE FRAMES AND COVER

A. Castings:

1. Tough, close-grained gray iron, sound, smooth, clean, free from blisters, blowholes, shrinkage, cold shuts, and defects.
2. Cast Iron: ASTM A48/A48M Class 35B.
3. Ductile Iron: ASTM A536, Grade 60-40-12.
4. Plane or grind bearing surfaces to ensure flat, true surfaces.

B. Cover: True and seat within ring at all points. With the word SEWER in 2-inch raised letters.

1. Where indicated in the plans provide HS-20 rated grate in place of cover.

2.05 MANHOLE FRAME CONNECTION TO STRUCTURE

A. Butyl Sealant:

1. Conform to ASTM C1311, or AASHTO M198 and ASTM C990.
2. Trowelable or cartridge applied.
3. Manufacturers and Products:
   a. Tremco Commercial Sealants and Waterproofing, Beachwood, OH; Tremco Butyl Sealant.
   b. Bostik, Middleton, MA; Chem-Calk 300.
   c. Press-Seal Gasket Company, Fort Wayne, IN; EZ-Stik #3.

B. External Wrap:

1. Meet requirements of ASTM C923.
2. Construct of high quality rubber that will provide flexible watertight seal around joint.
3. Thickness: Minimum 60 mils.
4. Consist of a top and bottom section and be sealed to structure, frame top, and bottom with mastic as applicable.


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5. Length: Extend from manhole frame and extension ring to cone section.
6. Bands: If required, constructed of minimum 16-gauge sheet if channeled, or 5/16-inch diameter if round.
7. Manufacturers and Products:
    a. Sealing Systems, Inc., Loretto, MN; Infi-Shield.
    b. Trelleborg Engineered Systems, Milford, NH; NPC Flexrib Frame-Chimney Seals.
    c. Cretex Specialty Products, Waukesha, WI; X-85 Seal.

C. Internal Wrap or Sealing Membrane:

1. Meet requirements of ASTM C923.
2. Minimum internal thickness of 3/16 inch or as recommended by manufacturer for installation climate.
3. Designed for application and have a demonstrated history of accommodating differential expansion between frame and concrete.
4. Width: Minimum 8 inches.
5. Expansive type wraps shall be fabricated of high quality rubber or urethane.
6. Bands: If required, constructed of minimum 16-gauge sheet if channeled, or 5/16-inch diameter if round.
7. Wrap shall not restrict access to manhole.
8. Manufacturers and Products:
    a. Sealing Systems, Inc., Loretto, MN; Flex-Seal Utility Sealant.
    b. Trelleborg Engineered Systems, Milford, NH; NPC Flexrib Frame-Chimney Seals.
    c. Cretex Specialty Products, Waukesha, WI; Internal Manhole Chimney Seal.

D. Frame to Structure Anchor Bolts:

1. 3/4-inch diameter HAS stainless steel bolts; minimum 6-5/8-inch embedment.
2. Manufacturer and Product: Hilti; HVA Capsules Adhesive Anchoring System.

## 2.06 MORTAR

A. Standard premixed in accordance with ASTM C387/C387M, or proportion one part Portland cement to two parts clean, well-graded sand that will pass a 1/8-inch screen.


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B. Admixtures:

1. May be included; do not exceed the following percentages of weight of cement:
   a. Hydrated Lime: 10 percent.
   b. Diatomaceous Earth or Other Inert Material: 5 percent.

C. Mix Consistency:

1. Tongue-and-Groove Type Joint: Such that mortar will readily adhere to pipe.
2. Confined Groove (Keylock) Joint: Such that excess mortar will be forced out of groove and support is not provided for section being placed.

## 2.07 BACKFILL AROUND AND UNDER MANHOLE

A. Structural fill as specified in Section 31 23 23, Fill and Backfill.

## 2.08 FLEXIBLE JOINTS FOR SEALING PIPES IN MANHOLE

A. Manufacturers and Products:

1. NPC, Inc., Milford, New Hampshire; Kor-N-Seal flexible rubber boot with stainless steel accessories.
2. A-LOK Products, Inc., Tullytown, PA; Z-LOK XP or A-LOK flexible connectors.

## 2.09 SOURCE QUALITY CONTROL

A. Prior to delivery of precast manhole sections to Site, yard permeability tests may be required at point of manufacture. Engineer or Owner will select precast sections not to exceed 5 percent of the total project quantity to test from material which is to be supplied to Project. Test specimens shall be mat tested and meet permeability test requirements of ASTM C14.

B. Concrete Testing: Test two concrete test cylinders for each manhole. Compressive strength shall be tested in accordance with ASTM C31/C31M, ASTM C39/C39M, and ASTM C192/C192M.


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C. Inspection:

1. Material Quality:
   a. Manufacturing process and finished sections shall be subject to inspection and approval by Owner and Engineer.
      1) Inspections may take place at manufacturer's plant, at Site after delivery, or at both.
      2) Sections not meeting requirements of this specification or that are determined to have defects which may affect durability of structure are subject to rejection.
      3) Sections rejected after delivery shall be removed and replaced.
      4) Sections damaged after delivery will be rejected and if already installed shall be repaired to satisfaction of Owner and Engineer.
      5) If structure cannot be repaired it shall be removed and replaced entirely at Contractor's expense.
2. At the time of inspection the sections will be carefully examined for compliance with ASTM C478 and with manufacturer's drawings. Sections will be inspected for general appearance, dimensions, scratch strength, blisters, cracks, roughness, and soundness. Surface shall be dense and close textured.
3. Imperfections may be repaired, subject to approval of Engineer, after demonstration by manufacturer that strong and permanent repairs result.

## PART 3 EXECUTION

### 3.01 GENERAL

A. Prior to installation inspect materials:

1. Sections not meeting requirements of this specification or that are determined to have defects which may affect durability of structure are subject to rejection.
2. Sections damaged after delivery will be rejected and if already installed shall be repaired to satisfaction of Owner and Engineer.
3. Remove and replace structure that cannot be repaired.

B. If needed, dewater excavation during construction and testing operations.

### 3.02 EXCAVATION AND BACKFILL

A. Excavation: As specified in Section 31 23 16, Excavation.

B. Backfill: As specified in Section 31 23 23, Fill and Backfill.


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## 3.03 INSTALLATION OF PRECAST MANHOLES

A. Concrete Base:

1. Precast:
   a. Place on compacted structural fill.
   b. Properly locate, ensure firm bearing throughout, and plumb first section.
2. Cast-in-Place:
   a. Invert: Minimum 8 inches below lowest connecting pipe.
   b. First section of manhole shall be cast in concrete base.

B. Sections:

1. Inspect precast manhole sections to be joined.
2. Clean ends of sections to be joined.
3. Do not use sections with chips or cracks in tongue.
4. Locate precast steps in line with each other to provide continuous vertical ladder.

C. Preformed Plastic Gaskets or Rubber O-Ring:

1. Use only pipe primer furnished by gasket manufacturer.
2. Install gasket material in accordance with manufacturer’s instructions.
3. Completed Manhole: Rigid and watertight.

D. External Joint Wraps: Install in accordance with manufacturer’s instructions.

E. Extensions:

1. Provide on manholes in streets or other locations where change in existing grade may be likely.
2. Install to height not exceeding 12 inches.
3. Lay grade rings in mortar with sides plumb and tops level.
4. Seal joints with mortar as specified for sections and make watertight.

## 3.04 MANHOLE INVERT

A. Construct with smooth transitions to ensure unobstructed flow through manhole. Remove sharp edges or rough sections that tend to obstruct flow.

B. Where full section of pipe is laid through manhole, break out top section and cover exposed edge of pipe completely with mortar. Trowel mortar surfaces smooth.


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## 3.05 MANHOLE FRAMES AND COVERS

A. Install concrete grade rings as required to set covers flush with surface of adjoining pavement or ground surface, unless otherwise shown or directed.

B. Set frames in three equally spaced beads of butyl sealant that run full circumference of frame.

C. Anchor frame to manhole with specified bolts.

D. Install exterior and interior manhole frame to structure seals in accordance with manufacturer's instructions. Seal shall cover grade rings.

## 3.06 CAST-IN-PLACE MANHOLE

A. Concrete: As specified in Section 03 30 00, Cast-in-Place Concrete.

B. Reinforcing Steel: As specified in Section 03 21 00, Steel Reinforcement.

1. Install manhole steps at 16 inches on center, plus or minus 1/4-inch tolerance, and locate to provide a continuous vertical ladder.
2. Do not vary spacing between any two adjacent steps by more than 1/2 inch.
3. Distance between wall of manhole and center of rung, measured at point of embedment, shall be not less than 4 inches or more than 6-1/4 inches.
4. Testing:
    a. Test each step for a horizontal pullout load of 400 pounds with load applied over a width of 3-1/2 inches and centered on rung.
    b. Apply load at a uniform rate until required test load is reached.
    c. Provide suitable hydraulic jacks and gauges to perform test.
    d. Steps will be considered acceptable if they remain solidly embedded after application of test load and if no cracking or fracture of step nor spalling of concrete, masonry, or mortar is evident.
    e. Replace, or reset and retest, steps failing to withstand required load.

## 3.07 MANHOLE PIPING

A. Drop Assembly: See the Drawings for detail of installation requirements.

B. Flexible Joints:

1. Provide in pipe not more than 1-1/2 feet from manhole walls.
2. Where last joint of pipe is between 1-1/2 feet and 6 feet from manhole wall, provide flexible joint in manhole wall.


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C. Stubouts for Future Connections:

1. Provide same type and class of pipe as specified for use in service connection, lateral, main, or trunk sewer construction. Where there are two different classes of pipe at manhole use higher strength pipe.
2. Grout pipe in precast walls or manhole base to provide watertight seal or use flexible joints as specified herein.
3. Maximum Length: 1-1/2 feet outside manhole wall.
4. Construct invert channels as shown. Unless otherwise approved by Engineer, match inside top elevation of service connection pipe to inside top elevation of outlet pipe.
5. Test Plugs:
   a. Install rubber-gasketed plugs in end of stubouts with gasket joints similar to sewer pipe being used.
   b. Plugs shall withstand internal or external pressures without leakage.
   c. Adequately brace plugs against hydrostatic or air test pressures.

D. Permanent Plugs:

1. Clean interior contact surfaces of pipes to be cut off or abandoned as shown, and construct plug as follows:
   a. Pipe 18 Inches or Less in Diameter: Concrete plug in end, minimum 2 feet long.
   b. Pipe 20 Inches and Larger: Concrete plug in end, minimum 4 feet long.
   c. Plugs shall be watertight and capable of withstanding internal and external pressures without leakage.

## 3.08 MANHOLES OVER EXISTING PIPING

A. Maintain flow through existing pipelines at all times.

B. Concrete Pipe: Apply bonding agent on surfaces in contact with concrete.

C. Construct base under existing piping.

D. Construct manhole as detailed on the Drawings.

E. Apply minimum of two complete wraps of hydrophilic waterstop centered on pipe in wall.

F. Place a minimum of 24 inches of concrete around each pipe penetration outside manhole against undisturbed soil or compacted aggregate unless otherwise detailed.



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G. Grout channel through manhole.

H. Saw cut out or demolish existing pipe within new manhole using method approved by Engineer.

I. Protect new concrete or grout for 7 days after placing concrete.

3.09 CONNECTIONS TO EXISTING MANHOLES

A. Core manhole bases and grouting as necessary.

B. Seal pipe in manhole using flexible connector.

C. Regrout to provide smooth flow into and through manholes.

D. Provide diversion facilities and perform work necessary to maintain flow during connection.

3.10 FIELD QUALITY CONTROL

A. Conduct negative air pressure (vacuum) test on all manholes in accordance with ASTM C1244.

B. Hydrostatic Testing:

1. When, in Engineer’s opinion, groundwater table is too low to permit visual detection of infiltration leaks, hydrostatically test all manholes.
2. Procedure: Plug inlets and outlets and fill manhole with water to height determined by Engineer.
3. Manhole may be filled 24 hours prior to time of testing, if desired, to permit normal absorption into pipe walls to take place.
4. Leakage in each manhole shall not exceed 0.1 gallon per hour per foot of head above invert.
5. Repair manholes that do not meet leakage test, or do not meet specified requirements from visual inspection.

**END OF SECTION**


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# SECTION 33 05 16.13
# PRECAST CONCRETE UTILITY STRUCTURE

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO): HB-17, Standard Specifications for Highway Bridges, Division 1 Section 3, Division I Design-Loads (Part A, Part B, Part C).
2. ASTM International (ASTM):
   a. A497/A497M, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
   b. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   c. C387/C387M, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
   d. C478, Standard Specification for Precast Reinforced Concrete Manhole Sections.
   e. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
   f. C858, Standard Specification for Underground Precast Concrete Utility Structures.
   g. D4101, Standard Specification for Propylene Injection and Extrusion Materials.
3. Occupational Safety and Health Administration (OSHA):
   a. 29 CFR 1910.27, Fixed Ladders.
   b. 29 CFR 1926.502, Fall Protection Systems Criteria and Practices.

### 1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Detailed drawings showing complete information for fabrication including, but not limited to:
      1) Member dimensions and cross-sections; location, size, and type of reinforcement, including additional reinforcement.
      2) Layout dimensions and identification of each precast unit.
      3) Welded connections indicated by AWS standard symbols.
      4) Details of connections, joints, accessories, and openings or inserts.
      5) Watertight joint details.


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6) Location and details of anchorage devices.
7) Access door details.
8) Details of ladder.

b. Product Data:
1) Precast concrete items; show materials of construction by ASTM reference and grade.
2) Joint sealants.

B. Informational Submittals:

1. Manufacturer's data for lifting devices for handling and erection.
2. Manufacturer's certification that vault design and manufacture comply with referenced ASTMs (for example, ASTM C857 and ASTM C858).
3. Vault design calculation shall be signed by a structural engineer registered in the State of Oklahoma
4. Manufacturer's laboratory test reports.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Store each unit in a manner that will prevent cracking, distortion, warping, straining and other physical damage, and in a manner to keep marking visible.

B. Lift and support each unit only at designated lifting points and supporting points as shown on Shop Drawings.

**PART 2 PRODUCTS**

2.01 VAULT MANUFACTURERS

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

1. Oldcastle Precast.
2. Jensen Precast.
3. Hanson Pipe and Precast.

2.02 PRECAST CONCRETE VAULTS

A. Design Requirements:

1. In the event of a conflict between or among standards, the more stringent standard shall govern.
2. Comply with ASTM C858, except as modified herein.
3. Reinforcing Steel:
a. Deformed Bars: ASTM A615/A615M, Grade 60.
b. Welded Wire Fabric: ASTM A497/A497M.


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4. Nominal Dimensions: As shown on the Drawings.
5. Construction: Rigid type and behave monolithically.
6. Design Loads: As determined by ASTM C857, and by using Site-specific values below.
    a. Unit Weight of Soil: 120 pcf.
    b. Groundwater Level: Top of structure.
    c. Live Loads: AASHTO HS20-44 truck loading plus impact.
    d. Earth pressure used in design shall be undrained fluid pressure at rest as indicated in General Structural Notes on the Drawings.
    e. Structures shall be designed to avoid flotation with ground water elevation at top of the structure. 1.2 factor of safety shall be used against uplift when utilizing only dead weight of the empty structure as resistance load. 1.5 factor of safety shall be used against uplift when utilizing both dead weight of the empty structure and the weight of soil above the base extensions as resistance loads. Weight of fillets, baffle walls, pump pads, and other equipment shall not be used in the calculation of the structure weight.
    f. The maximum reinforcement ratio allowed is one-half the reinforcement ratio that produces a balanced strain condition.
7. Design shall accommodate additional stresses or loads that may be imposed during factory precasting, transporting, erection, and placement.
8. Precast construction shall be in the form of monolithic walls or horizontal sections. Do not use panel walls.
9. Design and construct walls to be watertight with minimum 6-inch thickness.
10. Blockouts for penetrations shall be as shown on the Drawings.
11. Sealant:
    a. Nonswelling preformed joint sealants to provide a lasting, watertight bond.
    b. Manufacturer and Product: Henry Company; RAM-NEK.
12. Mortar: Comply with ASTM C387/C387M, Type S or use Type I grout as specified in Section 03 62 00, Grouting.

B. Mark each member or element to indicate location in the structure, top surface, and date of fabrication.

C. Vault Floor:

1. Slope of vault floor shall be as shown on the Drawings.
2. Slope may be applied after precasting, using mortar fill as specified in Section 03 30 00, Cast-in-Place Concrete, or Type I grout as specified in Section 03 62 00, Grouting.


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2.03 ACCESSORIES

A. Ladder:

1. Provide vault with galvanized steel ladder. Conform to requirements of Section 05 50 00, Metal Fabrications. Provide with pull-up extension.
2. Meet OSHA 29 CFR 1910.27 and OSHA 29 CFR 1926.502 requirements.

B. Sidewalk Doors and Hatches: HS-20 load rated, spring-assisted, lockable, galvanized steel access door, size as indicated on the Drawings.

C. Pipe Connections to Vault: Flexible joint conforming to requirements of Section 33 05 13, Manholes.

**PART 3 EXECUTION**

3.01 GENERAL

A. Possible Settlement: If subgrade is encountered that may require removal to prevent structure settlement, notify Engineer. Engineer will determine depth of over excavation and means of stabilizing subgrade prior to structure installation.

B. Place 6-inch minimum thickness of imported crushed aggregate material on undisturbed earth or modified subgrade; thoroughly compact with a mechanical vibrating or power tamper. Meet requirements of Article Excavation and Backfill.

3.02 EXCAVATION AND BACKFILL

A. Remove and keep water clear from excavation during construction.

B. Excavation: As specified in Section 31 23 16, Excavation.

C. Backfill: As specified in Section 31 23 23, Fill and Backfill, and Section 31 23 23.15, Trench Backfill.

3.03 INSTALLATION

A. Concrete Base:

1. Place on prepared subgrade.
2. Properly locate, ensure firm bearing throughout, and plumb first section.




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B. Sections:

1. Carefully inspect precast sections to be joined.
2. Thoroughly clean ends of sections to be joined.
3. Do not use sections with chips or cracks.

C. Joints:

1. Fill joints between precast sections per manufacturer's recommendation.
2. Joints shall be watertight to prevent entrance of groundwater.
3. Joint Finish: Dry pack interior of joints to provide smooth finish.

D. Setting Precast Vault: Install vault to elevations shown on the Drawings. Finish grade of structure top shall be even with surrounding finish grade surface, unless noted otherwise on the Drawings.

E. Watertight construction below grade with no open cracks or spalls. Cracking and defective areas of concrete shall be repaired per requirements of Section 03 30 00, Cast-in-Place Concrete, and Section 03 64 23, Epoxy Injection Grouting.

3.04 PIPE CONNECTION TO VAULT

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

B. Grout pipe connections flush with interior and exterior walls.

**END OF SECTION**


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# SECTION 33 32 13
# PACKAGED LIFT STATION

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American Bearing Manufacturers Association (ABMA):
   a. 9, Load Ratings and Fatigue Life for Ball Bearings.
   b. 11, Load Rating and Fatigue Life for Roller Bearings.
2. American Concrete Institute (ACI):
   a. 211.1, Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.
   b. 211.2, Standard Practice for Selecting Proportions for Structural Lightweight Concrete.
   c. 304R, Guide for Measuring, Mixing, Transporting, and Placing Concrete.
   d. 305R, Hot Weather Concreting.
   e. 306R, Cold Weather Concreting.
   f. 309R, Co of Concrete.
   g. 318, Building Code Requirements for Structural Concrete.
   h. 350, Code Requirements for Environmental Engineering Concrete Structures and Commentary.
   i. 517.2R, Accelerated Curing of Concrete at Atmospheric Pressure.
3. American Society of Mechanical Engineers (ASME): B16.1, Gray Iron Pipe Flanges and Flanged Fittings, Class 25, 125, and 150.
4. ASTM International (ASTM):
   a. A48, Standard Specification for Gray Iron Castings.
   b. A576, Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
   c. A36, Specification for Carbon Structural Steel.
   d. A82, Specification for Steel Wire, Plain, for Concrete Reinforcement.
   e. A615, Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   f. C31, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   g. C33, Specification for Concrete Aggregates.
   h. C39, Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   i. C40, Test Method for Organic Impurities in Fine Aggregates for Concrete.


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j. C70, Standard Test Method for Surface Moisture in Fine Aggregate.
k. C117, Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing.
l. C123, Standard Test Method for Lightweight Particles in Aggregate.
m. C136, Test Method for Sieve Analysis of Fine and Coarse Aggregates.
n. C138, Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.
o. C150, Specifications for Portland Cement.
p. C172, Standard Practice for Sampling Freshly Mixed Concrete.
q. C192, Practice for Making and Curing Concrete Test Specimens in the Laboratory.
r. C231, Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
s. C260, Specification for Air-Entraining Admixtures for Concrete.
t. C494, Standard Specification for Chemical Admixtures for Concrete.
u. C566, Test Method for Total Evaporable Moisture content of Aggregate by Drying.
v. C595, Specification for Blended Hydraulic Cements.
w. C617, Standard Practice for Capping Cylindrical Concrete Specimens.
x. C618, Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.
y. C805, Test Method for Rebound Number of Hardened Concrete.
z. C857, Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
aa. C858, Specification for Underground Precast Concrete Utility Structures.
bb. C890, Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures.
cc. C891, Practice for Installation of Underground Precast Concrete Utility Structures.
dd. C913, Specification for Precast Concrete Water and Wastewater Structures.
ee. C920, Specification for Elastomeric Joint Sealants.
ff. C990, Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
gg. C1037, Practice for Inspection of Underground Precast Concrete Utility Structures.
hh. C1064, Standard Test Method for Temperature of Freshly Mixed Concrete.


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ii. C1107, Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink).
jj. C1231, Standard Practice for Use of Unbonded Caps in Determination of Compressive Strength of Hardened Concrete Cylinders.
kk. C1240, Standard Specification for Use of Silica Fume for Use as a Mineral Admixture in Hydraulic-Cement Concrete, Mortar, and Grout.
ll. C1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).
mm. C1293, Standard Test Method for Determination of Length Change of Concrete due to Alkali-Silica Reaction.
nn. C1602, Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.
oo. C1611, Standard Test Method for Slump Flow of Self-Consolidating Concrete.

5. Concrete Reinforcing Steel Institute (CRSI):
   a. Manual of Standard Practice.
   b. Placing Reinforcing Bars.
6. Hydraulic Institute Standards (HIS):
   a. 11.6, Submersible Pump Test.
   b. 14.6, Rotodynamic Pumps for Hydraulic Performance Acceptance Tests.
7. National Electrical Manufacturers Association (NEMA).
8. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code.
   b. 497, Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.
9. National Precast Concrete Association (NPCA): NPCA QC Manual.
10. UL.

## 1.02 DEFINITIONS

A. Terminology pertaining to pumping unit performance and construction shall conform to ratings and nomenclature of Hydraulic Institute Standards.

## 1.03 SUBMITTALS

A. Action Submittals:

1. Make, model, weight, and horsepower of each pump equipment assembly.
2. Complete catalog information, descriptive literature, specifications, and identification of materials of construction, including cable seal details.


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3. Performance data curves showing head, capacity, horsepower demand, and pump efficiency over entire operating range of pump, from shutoff to maximum capacity. Indicate separately head, capacity, horsepower demand, overall efficiency, and minimum submergence required at guarantee point.
4. Power and control wiring diagrams, including terminals and numbers.
5. Motor data, in accordance with the requirements of Section 26 20 00, Low-Voltage AC Induction Motors.
6. Adjustable frequency drive data, in accordance with the requirements of Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.
7. Factory-finish system.
8. L-10 bearing life calculations per ABMA.
9. If required, wiring for motor protection module.
10. Prepackaged, subassembled Lift Station complete with submersible pumps, precast concrete pump chamber with separate valve vault structure, slide rail pump removal system, discharge piping with required supports and fittings, discharge check and plug valves, access hatches, valve vault access ladder, liquid level controls, duplex pump control panel, internal wiring and other required associate options and appurtenances.
11. Drawings indicating dimensions, mechanical and electrical components, complete bill of materials, structural layout and reinforcing per calculations and structural weights.

B. Informational Submittals:

1. Factory and Field Performance Test Reports and Log.
2. Manufacturer’s Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, that factory finish system meets requirements specified herein.
3. Suggested spare parts list to maintain equipment in service for period of 1 year and 5 years. Include list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
4. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
5. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
6. Manufacturer’s Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers’ Field Services.
7. Installation and construction information.


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1.04 QUALITY ASSURANCE

A. Pumps and controls from a single manufacturer; coordinated operating system where adjustable speed drives are required.

B. Precast package lift station manufacturer shall have minimum 10 years' experience producing factory-built packaged Lift Stations and a permanent audited QC program.

C. All electrical materials, devices, and equipment UL listed where applicable; installations per NEC.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Precast concrete units shall be handled and transported in a manner to minimize damage. Lifting devices or holes shall be consistent with industry standards. Lifting shall be accomplished with methods or devices intended for this purpose as indicated on the Shop Drawings. Upon request, the precast concrete producer shall provide documentation on acceptable handling methods for the product.

B. Precast concrete units shall be stored in a manner that will minimize potential damage.

C. Precast concrete units shall be delivered to the Site in accordance with the delivery schedule. Upon delivery to the Job Site, all precast concrete units shall be inspected by the customer's agent for quality and final acceptance.

1.06 WARRANTY

A. Manufacturer's standard equipment warranty applies.

B. Packaged Station Warranty: 1 year from installation from factory completion, whichever occurs first; single-source responsibility by package manufacturer.

1.07 EXTRA MATERIALS

A. Furnish for this set of pumps:

1. One set mechanical seals.
2. One complete set of special tools required to dismantle pump.

B. Concrete Additives and Treatments:

1. Waterproofing.
2. Antimicrobial additives.
3. Damp-proofing.


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C. Joint and Penetration Seal Materials:

1. Sealant.
2. Manhole boots.
3. Water stop couplings.

D. Ladder extensions.

E. Extra materials and special tools for corrosive or abrasive service consider spare impeller and wear rings for each pump.

## PART 2 PRODUCTS

### 2.01 GENERAL

A. The packaged submersible lift station and all system components are furnished by a single supplier. The pumps, valves, and accessories must be standard catalog design, totally warranted by the manufacturer.

B. Submersible Pump:

1. Submersible, vertical shaft, centrifugal nonclog type, for pumping wastewater.
2. Designed for continuous operation under submerged or partially submerged conditions, and intermittent operation when totally dry without damage to pump or motor.
3. Pump and Electrical Driver: Meet requirements for class, group, and division location in accordance with NFPA 70.
4. Where adjustable speed drives are required, furnish a coordinated operating system complete with pump, drive, and speed controller.
5. Pumps furnished under this section to be provided by a single manufacturer.

### 2.02 WET WELL AND VALVE VAULT

A. See Section 33 05 13, Manholes, for wet well manhole materials of construction.

B. Precast structures wall thickness shall be sized by the supplier and appropriate for the installation.

1. Footing and wet well floor shall be designed to account for buoyancy forces.
2. Roof slab shall be able to handle HS-20 traffic rated.
3. Design for wet well manhole shall be sealed by a professional engineer in Oklahoma.


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4. The Horizontal joints between precast sections shall be sealed with a vulcanized butyl rubber joint material conforming to AASHTO M-198.

C. Monolithically precast structures. Wet well alternates shall be approved by the Engineer prior to bid opening.

D. Lift Station Wet Well Dimensions:

1. Shape: Circular.
2. Diameter: 6-foot minimum.
3. Depth: 25 feet maximum. Reference supplements following end of section.
4. Basin Floor: 1H:1V sloped.

E. Valve Vault Dimensions: Size recommended by Manufacturer.

1. Shape: Rectangular.
2. Length: 6 feet, minimum.
3. Width: 6-feet, minimum.
4. Height: As required to maintain burial depth (36 inches of cover).

2.03 SUBMERSIBLE PUMPS

A. See Section 44 42 56.04, Submersible Pumps, for product requirements.

B. Pumps shall be submersible, vertical shaft, centrifugal nonclog type, for wastewater pumping.

C. Designed for continuous operation under submerged or partially submerged conditions, and intermittent operation when totally dry without damage to pump or motor.

D. Pump and Electrical Driver: Meet requirements for class, group, and division location in accordance with NFPA 70.

E. Where adjustable speed drives are required, furnish a coordinated operating system complete with pump, drive, and speed controller.

F. Pumps furnished under this section to be provided by a single manufacturer.

2.04 SUPPLEMENTS

A. Specific requirements are attached to this section as supplements.


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## 2.05 COMPONENTS

A. Equipment consists of pump complete with motor, control system, guide rail, anchoring brackets, base elbow, power cable, and pump lifting cable and control panel and level switches.

B. Lifting Arrangement:

1. Stainless steel chain, 5 feet minimum, and one “grip-eye.”
2. Attach chain permanently to pump and access platform with stainless steel wire rope.
3. “Grip-eye” capable of being threaded over and engaging links of stainless-steel chain so pump and motor may be lifted with “grip-eye” and independent hoist.

C. Sliding Guide Bracket:

1. Integral part of pump unit.
2. Pump unit to be guided by no less than two Type 316 stainless steel guide bars, or equivalent cable system, and pressed tightly against discharge connection elbow with metal-to-metal contact or through use of profile-type gasket, provided gasket is attached to pump’s flange and can be easily accessed for inspection when pump is lifted out of wet well.
3. Pump metal parts that come into contact with guide rail or cable system shall be made of non-sparking materials.

D. Lift Station Access Frame and Cover:

1. Furnish and install aluminum pump access hatch flush with precast cover, H20-ASTM C1802-14- Load Level 4 for accidental traffic load rating with Type 316 stainless steel hardware.
2. Hold open arm to lock cover in 90-degree position, heavy duty stainless hinges.
3. Access frame to be angle style with continuous 1-inch anchor flange and full slab-height skirt to show no exposed concrete when hatch is open Valve Vault Aluminum Access Frame and Cover.
4. Pump access hatch to be supplied with integral safety grating system able to withstand H20-ASTM C1802-14- Load Level 4 for accidental traffic load rating, stainless steel gas shock for ease of operation when opening, and coated with 2 mils to 4 mils thick OSHA type safety orange color.

E. Valve Vault Aluminum Access Frame and Cover: H20 Traffic Rated.

1. Valve vault access hatch to be similar for pump access hatch above.


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F. Vault Ladder:

1. The valve vault shall be supplied with an aluminum (6061-T6) wall-mount access ladder. The ladder shall be fastened to the concrete with Type 316 stainless expansion bolts and shall meet OSHA Standard 1910.27 requirements.
2. The ladder rails and supports shall be all welded aluminum construction. Rails and wall supports shall be solid 3/8-inch by 2-1/2-inch flat stock, and rungs shall be 15/16-inch square with serrated top surface extruded into the rung for slip resistance. The minimum design live load shall be a single concentrated load of 200 pounds.
3. Rung spacing shall be uniform and not exceed 12 inches, the minimum clear length of rungs shall be 18 inches, and the distance from the center line of the rung to the nearest permanent object shall not be less than 7 inches.

G. Motor nameplate horsepower not to be exceeded at head-capacity point on pump curve.

H. Pump motor and sensor cables shall be suitable for submersible pump applications and cable sizing shall conform to NFPA 70 specifications for pump motors. Cables shall be of sufficient length to reach junction boxes without strain or splicing.

I. Motor Protection Module: If required, provide pump with a motor protection module for remote mounting. The Drawings are based on first named submersible pump manufacturer and motor protection module. If pump and motor protection module other than first named manufacturer is provided, provide revised wiring for the motor protection module.

J. Polyvinyl Chloride (PVC) Piping and Fittings:

1. 3-inch PVC piping will be used inside the lift station and valve vault.
2. All PVC pressure piping and fittings for water and wastewater treatment are to be Schedule 80. Corrosion resistant pressure pipe, IPS sizes, for use at temperatures up to and including 140 degrees F. Pressure rating (120 psi to 1,230 psi) varies with schedule, pipe size, and temperature.
3. The material used in the manufacture of the pipe and fittings shall be domestically produced rigid polyvinyl chloride (PVC) compound, Type 1 Grade 1, with a Cell Classification of 12454 as defined in ASTM D1784, trade name designation H707 PVC. This compound shall be gray in color and shall be approved by NSF International for use with potable and non-potable water (NSF 61). All sizes of PVC Schedule 80 pipe and fittings shall be manufactured in strict accordance with the


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requirements of ASTM D1785 for physical dimensions and tolerances, and all performance test requirements of ASTM D1785.

K. Pipe Supports:

1. Piping shall be supported in the valve vault using adjustable stainless steel floor supports, which cradles the pipe/valve flanges.
2. Piping shall be supported in the Lift Station by means of a common Type 304 stainless fabricated angle brace spanning the width of the station and mounted with wall brackets and Type 316 stainless hardware. Both vertical discharge pipes shall be supported from the brace by means of individual Type 316 stainless U-bolts and bolting hardware.
    a. Common pipe support assembly at mid length shall be required when the vertical discharge pipe lengths exceed 10 feet 0 inch.
    b. Common pipe support assemblies at equal spacing shall be required when the vertical discharge pipe lengths exceed 14 feet 0 inch.

L. Wall Penetrations:

1. Mechanical piping shall utilize cast or cored openings with flexible manhole boots. Flexible rubber boots shall consist of EPDM polymer compounds meeting ASTM C923 material performance requirements. Expansion banding and strap shall be Type 304 stainless material and the connection between boot and structure shall utilize an expansion wedge system with Type 304 stainless wedge and hardware components.
2. Electrical conduit penetrations will utilize aluminum electrical couplings assemblies with 2-inch wide minimum water stop, secured to the structure with watertight seal, or cored openings with mechanical rubber seals to fill the annular spacing between electrical conduit and precast wall structure. Mechanical seals shall utilize stainless steel assembly hardware and may be need to be employed when an exterior junction box option is factory mounted to the station.

M. HDPE Piping and Fittings:

1. All HDPE piping and fitting utilized in the Lift Station and/or valve vault shall be DR11, 200 psi, meeting ASTM D3350 cell classification and ASTM F412 thermoplastic piping material designation code. All pipe/fitting joining shall be fusion welded in a clean and climate-controlled environment, with product approved fusion welding equipment. The fusion weld shall be equally as strong as the adjacent joining materials.


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2. HDPE flange back-up ring, shall be ductile iron, with epoxy top coat. Backup ring with HDPE flange will meet class 150-flange requirements. Backup ring to meet ASME/ANSI B16.5 standards for 3-inch to 24-inch HDP size range.
3. Where HDPE pipe assembly shall engage with flange coupling adapters; stainless pipe stiffeners shall be used on the plain end to provide internal circumferential support. Stiffeners shall be Type 304 stainless steel and be supplied with reinforced wedge to provide full ID support.

N. Flange Type Couplings:

1. Flange couplings shall be mounted on each pump base elbows to ensure proper pressure seal while providing a minimum of assembly flexibility. The flange couplings shall be fusion bond epoxy coated and supplied with Type 304 stainless assembly and mounting hardware for harsh and wet environments. The pipe gasket and O-ring seal shall be EPDM.
2. To ensure correct fitting of pipe and couplings, all flange couplings shall be furnished by the pipe supplier and shall be of the pressure rating of at least that of the pipeline in which they are to be installed.

O. Plug Valves:

1. Plug valves shall be of the non-lubricated, quarter-turn, eccentric type with flanged ends and lever operated (up to 4-inch valves) in full conformance with the latest revision of the AWWA C517 Standard.
2. Valves sizes 3 inches shall have a minimum 175 psi pressure rating. Plug Valves shall be round ported for reduced pumping costs and improved flow characteristics. The valves shall have the following minimum full open flow coefficients (Cv): 3 inches = 569.
3. Flange diameter, thickness, and drilling shall conform to ANSI B16.1, Class 125.
4. Valve shaft seals shall be of the self-adjusting U-cup design for reduced maintenance and replaceable without removing the cover from the valve.
5. Valves shall have bodies and covers of ductile iron per ASTM A536 for superior strength. Valve sizes 3 inches shall have body seats of 95 percent welded nickel applied directly to the body and machined to a smooth finish. Sprayed, plated or removable seats are not acceptable. Valves shall have plugs made from ductile iron per ASTM A536 with a vulcanized synthetic rubber seat facing tested per ASTM D429 for all sizes.
6. Valves shall be provided with stainless steel thrust bearings on the upper and lower plug shaft to eliminate plug-to-body contact and ensure long lasting plug-to-seat alignment. Grit seals shall be provided on the upper


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and lower bearing journals to minimize the entrance of grit into the shaft seal and bearing areas.

7. Valves shall be coated internally and externally with 6 mils to 8 mils NSF approved two-part epoxy paint for corrosion protection.

P. Check Valve: A flanged model ball check valve rated for 150 psi at 73 degrees F.

Q. Gasket, Bolts, Nuts:

1. For flange joints, gaskets shall be a minimum of 1/8-inch thick full faced gaskets. Gaskets shall be of composition suitable for exposure to fluids within the pipe. Gaskets shall meet AWWA C110, AWWA C111, and AWWA C115 performance standards.
2. Flange joints shall be bolt assembled utilizing the full faced gasket. Bolting hardware, number, and size, shall conform to the same ANSI standards as the flange. Bolts and nuts shall be Type 304 stainless steel, heavy hex Grade B conforming to ASTM A493/494.

R. Lift Station Vent: A passive station vent shall be supplied using 4-inch Schedule 80 PVC piping and fittings, and a stainless insect screen. The vent will be factory assembled and mounted to the exterior of the station, where the venting will rise above the station, and turn downward (gooseneck), and end with insect screen minimum 3 feet above finish grade.

## 2.06 CONTROL PANEL

A. NEMA 4X enclosure, for outdoor duty.

B. Refer to Section 40 99 90, Package Control Systems, for additional panel requirements. Manufacturer’s standard panel.

C. Free standing, post mounted.

D. Features:

1. Main circuit breaker disconnect interlocked with panel door.
2. Combination circuit breaker type, NEMA rated motor starters.
3. Fused control power transformer, 120V ac.
4. Alternator and pump lead-lag controls.
5. ON/OFF/AUTO switches.
6. Running lights.
7. High level indication.


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8. Normally closed, dry, 5 amps at 120V ac contacts for remote indication of:
   a. High level alarm.
   b. Pump failure (temperature or moisture alarm).
9. Terminal strip for interfacing with external wiring.
10. High temperature indication.
11. Moisture alarm indication.
12. Alarm (high temperature, moisture, or high level) beacon located on top of panel.
13. Lightning protection.
14. Intrinsically safe relays as required for UL validation.
15. Alarm silence button.
16. Document pocket located inside panel with pump and panel operation and maintenance manual, and separate laminated pump curve.
17. 110-volt, duplex GFI outlet, weather-protected, and accessible from outside of panel.
18. Run hour meter.
19. 100 watts minimum, condensation heater with thermostat.
20. UL listing mark.

E. Prewired and factory tested.

F. Mount control switches, indicating lights, and switches on hinged front panel.

G. Single Feed: 480 volts, three-phase.

H. Interior Junction Boxes for Pumps and Level Control Devices:

1. Pump and level control SJO jacketed cables shall be properly supported within the pump station via stainless strain reliefs and hung from stainless equipment hooks positioned in the pump access hatchway. Cable weight will not be transferred to cable entre conduits or wall couplings.
2. The pump station shall be supplied with interior junction boxes for pump power/control and float conductor connections. The pump power/control junction boxes shall be rated NEMA 7 explosion-proof, and shall require one junction box for each pump. The float junction box shall be rated NEMA 4X and constructed of non-metallic durable polypropylene for intrinsically safe float operation, where barrier relays are supplied in the pump control panel. The interior junction boxes shall be positioned together and accessible from the hatchway at grade. Interior conduits and fittings shall be utilized for passage of pump power/control and level control conductors to the junction boxes.


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3. Interior conduits and fittings between the wall-attached electrical couplings and the interior junction boxes will be RGS construction and will be factory mounted. Interior conduit support assembly shall be a fabricated Type 304 stainless steel Unistrut frame with all Type 316 stainless steel fasteners. All final conductor connection in the junction boxes and final float positioning shall be completed onsite by the site electrician.
4. Conduit seal fittings shall be supplied outside of the pump station and prior to the control panel on site by site electrician.

I. Exterior Termination Cabinet:

1. A NEMA 4X, stainless steel, weather-tight pump station exterior termination cabinet shall be factory furnished and mounted to the exterior of the pump station with a minimum of 2-foot clearance between the bottom of the cabinet and the top surface of the pump station. The cabinet will house divided areas for both power/control and low voltage level control. The termination cabinet shall be Type 304 stainless steel with back plate, interior area dividers, power/control/low voltage terminals, continuous door hinge, quarter-turn latch hardware and pad locking hardware. The cabinet size will be 16 inches high by 16 inches wide by 6 inches deep, minimum.
2. The pump power, pump control and float switch conductors shall be connected to suitable power and terminal blocks inside the cabinet. Pump and level control SJO jacketed cables shall be properly supported within the pump station via stainless strain reliefs or other methods, so that cable weight is not transferred to the terminal strips.
3. The exterior termination cabinet shall be mounted to the pump station with a fabricated Type 304 stainless steel Unistrut frame with all Type 316 stainless steel fasteners.
4. Conduits, fittings and seal between the termination cabinet and pump station will be RGS construction and will be factory mounted. Conduits, fittings and seals between the termination cabinet and pump control panel shall be supplied and installed by the site electrician. All final conductor termination and filling of seal fittings, shall be completed onsite by the site electrician.
5. The complete factory mounted termination cabinet will be removed from the station (via station mounting bolts) and shipped separately to the Job Site due to shipping height restrictions, for field reattachment by site electrician.


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## 2.07 ACCESSORIES

A. Level Switches:

1. In accordance with Section 40 99 90, Package Control Systems, component L8 and for:
   a. Low Level: Pump off.
   b. High Level: Pump on.
   c. High High Level: Alarm.

B. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in readily visible location.

C. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications. Coat in accordance with Section 09 90 00, Painting and Coating.

D. Sidewalk Door:

1. Size as shown on the Drawings or if not shown, sized by equipment manufacturer. As specified in Section 05 50 00, Metal Fabrications, with the following additional requirements:
   a. Gasketed and odor tight.
   b. Channel drain is not required.

## 2.08 FACTORY FINISHING

A. Prepare, and prime, and finish coat in accordance with Section 09 90 00, Painting and Coating.

B. Manufacturer’s standard epoxy system for continuous submergence in corrosive water.

## 2.09 SOURCE QUALITY CONTROL

A. Control Panel:

1. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.
2. Factory Tests and Adjustments: Test control panels identical to that furnished.

B. Pump:

1. Factory Performance Test:
   a. In accordance with HIS 11.6, Level B for submersible pump tests.
   b. Include test data sheets curve test results performance test logs.


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2. Conduct on each pump.
3. Perform under actual or approved simulated operating conditions.
    a. Throttle discharge valve to obtain pump data points on curve at 2/3, 1/3, and shutoff conditions.

C. Submersible Motor Functional Test: In accordance with HIS 11.6.

## PART 3 EXECUTION

### 3.01 PLANNING

A. All utilities and owners of surface and subsurface facilities and structures in the area shall be given advance notification of proposed excavation. Every effort shall be made to avoid damage to the facilities of others. If any damage occurs, the owner of the damaged facility shall be notified immediately.

### 3.02 INSTALLATION

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

B. Mount the discharge elbow to the floor of the wet well floor with stainless steel bolts.

C. Connect piping without imposing strain to flanges.

D. No portion of pump shall bear directly on floor of sump.

E. Precast concrete units shall be installed: to the lines and grades shown on the contract documents or otherwise specified; be lifted by suitable lifting devices at points provided by the precast concrete producer; in accordance with applicable industry standards. Upon request, the precast concrete producer shall provide installation instructions and oversight.

F. Where leak resistance is a necessary performance characteristic of the precast concrete unit's end use, joint sealant, pipe-entry connectors, and other penetrations shall be sealed according to manufacturer's requirements to ensure the integrity of the system. Structural leak testing at the joints can only be completed with an exfiltration test after complete backfilling.

### 3.03 FIELD FINISHING

A. Equipment as specified in Section 09 90 00, Painting and Coating.

### 3.04 FIELD QUALITY CONTROL

A. Inspection: Final field elevations and compaction properties shall be verified and documented.


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B. Functional Test: Conduct on each pump.

1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
2. Flow Output: Measured by plant instrumentation and storage volumes.
3. Operating Temperatures: Monitor bearing areas on pump and motor for abnormally high temperatures.
4. Test for continuous 3-hour period.
5. Test Report Requirements: In accordance with Hydraulic Institute Standards for submersible pump tests HIS 14.6 and HIS 11.66.

C. Pump Test:

1. General:
   a. Conduct on each pump provided.
   b. Conduct in accordance with HIS 11.6.
2. Routine Production Tests:
   a. Check impeller, motor rating, and electrical connections for compliance to specification.
   b. Test motor and cable insulation for moisture content and insulation defects.
   c. Prior to submergence, run pump dry to establish correct rotation and mechanical integrity.
   d. Conduct abbreviated three-point operational performance test.
   e. After operational performance test, perform insulation test again.
3. Hydrostatic test.

D. Leakage Test:

1. Structure shall be backfilled as stated above to testing level, unless specifically authorized by Oldcastle’s design engineers.
2. Watertightness Test: The structure shall be tested for water tightness to a minimum of the high-water alarm elevation. Fill tank to the desired level and let stand for 24 hours for absorption, top off liquid to required level and let stand for a 24-hour period. Watertightness shall be defined as loss of liquid level less than 0.05 percent in 24 hours.

## 3.05 MANUFACTURER’S SERVICES

A. See Section 01 43 33, Manufacturers’ Field Services, and Section 01 91 14, Equipment Testing and Facility Startup.


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3.06 SUPPLEMENTS

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

1. Duplex, Submersible Pump.
2. Sanitary Pump No. 1 and Sanitary Pump No. 2 Data Sheet.

**END OF SECTION**




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| Duplex, Submersible Pump | | | | | | |
|---|---|---|---|---|---|---|
| **Submersible Pump Design Criteria:** | | | | | | |
| **Tag Number** | **Flow Rate (gpm)** | **Pressure (feet head)** | **Motor (hp)** | **Motor Speed (rpm)** | **Power (volts/phase)** | **Manufacturer, Model No.** |
| H110-LFT-PMP01<br>&<br>H110-LFT-PMP02 | 80 | 13.5 | 2.2 | 1,735 | 460V/3ph | FLYGT, NP 3085 SH 3~ Adaptive 456 |

| **Wet Well Design Criteria:** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Tag Number** | **Config (sq/rd)** | **Wet Well Size (LxW/dia)** | **(T/RIM) Finished Grade[1] (feet)** | **Inlet Pipe (feet)** | **(LSHH) Water Alarm (feet)** | **(LSH) Pump On (feet)** | **(LSL) Pump Off (feet)** | **Bottom of Sump (feet)** |
| H110-LFT-PMP01<br>&<br>H110-LFT-PMP02 | Round | 6’ | 605.75 +/- | 587.60 | 588.00 | 587.50 | 583.50 | 582.50 |

Note: Finished grade around lift station may vary slightly. Top of Rim elevation shall match yard piping profiles (07-Y-3004).


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## SANITARY PUMP NO. 1 AND SANITARY PUMP NO. 2 DATA SHEET

Tag Numbers: H110-LFT-PMP01 and H110-LFT-PMP02

Pump Name: Sanitary Pump No. 1 and Sanitary Pump No. 2

Manufacturer and Model Number: (1) Flygt NP 3085 SH 3~ Adaptive 456

(2) Or approved equal

### SERVICE CONDITIONS

Liquid Pumped (Material and Percent Solids): Sanitary sewer and composting condensate. > 1% TS.

Pumping Temperature (Fahrenheit): Normal: 70 Max 100 Min 40

Specific Gravity at 60 Degrees F: 1 Viscosity Range: 1 – 1.57

Vapor Pressure at 60 Degrees F: 0.12 pH: 4.5 – 8

Abrasive (Y/N) Y Possible Scale Buildup (Y/N): N

Total suspended solids (mg/L) _____ estimated 0 mg/L to 500 mg/L

Minimum diameter solid pump can pass (inches) 4

Min. NPSH Available (Ft. Absolute): 33.68

### PERFORMANCE REQUIREMENTS

Capacity (US gpm): Rated: 80 Secondary: 80

Total Dynamic Head (Ft): 13.5 Secondary: 16

Min. Rated Pump Hydraulic Efficiency at Rated Capacity (%): _____

Max. Pump Speed at Rated Capacity (rpm): 1,735 Constant (Y/N): Y
Adjustable (Y/N): N

### DESIGN AND MATERIALS

Pump Type: Heavy-Duty Nonclog (Y/N) Y Other: _____

Volute Material: Cast Iron ASTM A48

Pump Casing Material: Cast Iron ASTM A48


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Motor Housing Material: Cast Iron ASTM A48

Wear Rings Case (Y/N): N Material:

Wear Ring Impeller (Y/N): N Material:

Elastomers: Nitrile Rubber

Fasteners: Stainless Steel

Impeller: Type: Double-Shrouded Non-Clog (Y/N): N Other:
Material: Cast Iron ASTM A48

Shaft Material: Carbon Steel, ASTM A576 with stainless steel sleeve or all stainless steel.

Base Elbow: Cast Iron ASTM A48

Double Mechanical Seal (Y/N): Y Bearing Life (Hrs):

**DRIVE MOTOR** (See Section 26 20 00, Low-Voltage AC Induction Motors.)

Horsepower: 2.2 Voltage: 460 Phase: 3 Synchronous Speed (rpm): 1,735

Enclosure: EXP

Other Features:

Moisture Detection Switches (Y/N): Y

Thermal Protection Embedded in Windings (Y/N): Y

**REMARKS:** Submersible pump may exhibit woodchip debris from the composting process and shall be able to pass solids up to 4 inches.


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# SECTION 33 41 01
# STORM DRAIN PIPING

## PART 1 GENERAL

### 1.01 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. M36, Standard Specification for Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains.
   b. M190, Standard Specification for Asphalt- Coated Corrugated Metal Culvert Pipe and Pipe -Arches.
   c. M196, Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains.
   d. M252, Standard Specification for Corrugated Polyethylene Drainage Pipe.
   e. M294, Standard Specification for Corrugated Polyethylene Pipe, 300 – 1500 mm (12-to 60-in). Diameter.
2. American Water Works Association (AWWA):
   a. C104/A21.4, Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
   b. C105/A21.5, Polyethylene Encasement for Ductile-Iron Pipe Systems.
   c. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
   d. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   e. C116/A21.16, Protective Fusion-Bonded Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings.
   f. C150/A21.50, Thickness Design of Ductile Iron Pipe.
   g. C151/A21.51, Ductile-Iron Pipe, Centrifugally Cast.
   h. C153/A21.53, Ductile-Iron Compact Fittings.
3. ASTM International (ASTM):
   a. A746, Standard Specification for Ductile Iron Gravity Sewer Pipe.
   b. C14, Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe.
   c. C76, Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
   d. C150/150M, Standard Specification for Portland Cement.


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e. C311/311M, Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland-Cement Concrete.
f. C361, Standard Specification for Reinforced Concrete Low-Head Pressure Pipe.
g. C425, Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.
h. C443, Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.
i. C497, Standard Test Methods for Concrete Pipe, Concrete Box Sections, Manhole Sections, or Tile.
j. C507, Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe.
k. C595/595M, Standard Specification for Blended Hydraulic Cements.
l. C618, Standard Specification for Coal Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
m. C655, Standard Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe.
n. C700, Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated.
o. C1012/1012M, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
p. D1248, Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.
q. D1784, Standard Classification System and Basis for Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
r. D2412, Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
s. D3034, Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
t. D3212, Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
u. F477, Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
v. F679, Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
w. F794, Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter.
x. F894, Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe.


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1.02 SUBMITTALS

A. Informational Submittals: Manufacturer's Certification of Compliance.

**PART 2 PRODUCTS**

2.01 PIPE AND FITTINGS

A. As specified in the Data Sheets following "End of Section."

**PART 3 EXECUTION**

3.01 INSTALLATION OF PIPE, FITTINGS, AND APPURTENANCES

A. General:

1. Lay pipe up-grade with spigot ends pointing in direction of flow.
2. Excavate bell holes at each joint to permit correct assembly and inspection of entire joint.
3. Pipe invert may deviate from line or grade up to 1/2 inch for line and 1/4 inch for grade, provided that finished pipe line will present a uniform bore, and such variation does not result in a level or reverse sloping invert, or less than minimum slope shown.
4. Bed pipe to form continuous and uniform bearing and support for pipe barrel between joints. Do not rest pipe directly on bell or pipe joint.
5. Prevent entry of foreign material into gasketed joints.
6. Plug or close off pipes that are stubbed off for manhole, concrete structure, or for connection by others, with temporary watertight plugs, unless indicated otherwise.

3.02 PRESSURE TESTING

A. Perform hydrostatic testing as specified in Section 40 80 01, Process Piping Leakage Testing.

3.03 REPAIR AND RETESTING

A. Test and seal individual joints in sections of pipe not meeting pressure test requirements and reperform pressure test. Replace and retest if resealed joints do not pass second hydrostatic test.

B. Following repairs, sections shall be retested as specified.

3.04 PIPE CLEANING

A. Prior to final acceptance and final manhole-to-manhole inspection of the sewer system by Engineer, flush and clean the system. Remove accumulated


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construction debris, rocks, gravel, sand, silt, and other foreign material from the sewer system at or near the closest downstream manhole. Use mechanical rodding or bucketing equipment where flushing does not remove debris.

B. Upon Engineer's final manhole-to-manhole inspection of the sewer system, if foreign matter is still present in the system, reflush and clean the sections and portions of the lines.

3.05 SUPPLEMENTS

A. Data Sheets:

| Number | Title |
|---|---|
| -.03 | Polyvinyl Chloride (PVC) |
| -.05 | Reinforced Concrete |

**END OF SECTION**




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| SECTION 33 41 01.03<br>POLYVINYL CHLORIDE (PVC) | |
|---|---|
| **Item** | **Description** |
| Pipe: 15-inch diameter and under | ASTM D3034: Minimum wall thickness of SDR26 except that the cell classification shall be 12454-B or 12454-C as defined in ASTM D1784. |
| Pipe: 18-inch through 24-inch diameter | ASTM F679: Minimum wall thickness per Table 1 of ASTM F679, except that the cell classification shall be 12454-C as defined in ASTM D1784. |
| Ribbed Profile Pipe: 18-inch through 48-inch diameter | ASTM F794: Minimum stiffness of 46 psi when tested in accordance with ASTM D2412, except that the cell classification shall be 12454-C as defined in ASTM D1784. |
| Joints | ASTM D3212 rubber gasketed. |
| Gaskets | ASTM F477.<br>Lubricants: As approved by manufacturer. |
| Fittings | PVC, gasketed. Provide plug when service piping is not required. |
| Plugs | Removable. Removal shall provide a socket suitable for making a flexible jointed lateral connection or extension. |
| Source Quality Control Testing | In accordance with specified ASTM. |

**END OF SECTION**


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| SECTION 33 41 01.05<br>REINFORCED CONCRETE | |
|---|---|
| **Item** | **Description** |
| Pipe | ASTM C76, Wall B, class as shown. Mark each joint with pipe class. Rotating packer or platform not allowed. |
| Cement | ASTM C150/150M, Type II, or<br>ASTM C150/150M, Type I, with fly ash; maximum 12 percent Tricalcium Aluminate, or<br>ASTM C595/595M, Type IP, with fly ash; Cement: ASTM C150/150M.<br>Minimum 564 pounds per cubic yard without fly ash.<br>Minimum 479 pounds per cubic yard with fly ash. |
| Ratio: Water to Cementitious Materials | Not over 0.49. |
| Fly Ash | ASTM C618, Class C or Class F, Tables 1 and 2 modified as follows:<br>Loss on Ignition: Maximum 3 percent<br>Water Requirement: Maximum 100 percent of control<br>Ratio Percent CaO/Fe2O3: Maximum 1.5<br>or test cement fly ash mix in accordance with ASTM C1012. Mix: Equal to or better than ASTM C150/150M, Type II cement.<br>85 pounds per cubic yard minimum, 160 pounds per cubic yard maximum.<br>Test: ASTM C311/311M and ASTM C618. |
| Joints | ASTM C443 Captive gasket in groove. |
| Rubber Gaskets | ASTM C443. |
| Tee Fittings | Reinforced concrete, rubber gasketed. Provide plug when service piping is not required. |
| Plugs | Removable. Removal shall provide a socket suitable for making a flexible jointed lateral connection or extension. |
| Circumferential Reinforcement | Not closer than 1 inch to inside surface of pipe. Area of outer circular reinforcing cage not less than 75 percent of inner cage. |
| Elliptical Reinforcement | Not allowed. |


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| SECTION 33 41 01.05<br>REINFORCED CONCRETE | |
|---|---|
| **Item** | **Description** |
| Source Quality Control Testing | Load Bearing 0.01-inch Crack, Compressive Strength and Absorption: ASTM C76.<br><br>Load Bearing Ultimate: ASTM C76.<br><br>Permeability: ASTM C497.<br><br>Voids: Longitudinally sawcut one pipe from each 100 lengths of pipe manufactured in half with saw that will not damage the concrete or reinforcing steel. Inspect for voids adjacent to circumferential bars. Voids will be considered continuous if a 1/16-inch diameter pin can be inserted 1/4 inch deep. If voids exist adjacent to more than 10 percent of the circumferential bars, two additional pipes shall be tested. If either of the two pipes fail, the entire 100 lengths will be rejected. |

**END OF SECTION**


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# SECTION 33 44 13.13
# CATCH BASINS

## PART 1 GENERAL

1.01 REFERENCES

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

1. American Welding Society (AWS): Code for Welding in Building Construction.
2. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A48/A48M, Standard Specification for Gray Iron Castings.
   c. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   d. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   e. C387/C387M, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
   f. C478, Standard Specification for Circular Precast Reinforced Concrete Manhole Sections.

## PART 2 PRODUCTS

2.01 CONCRETE

A. Type: Ready-mixed, conforming to ASTM C94/C94M, Alternate 2.

B. Compressive Field Strength: Not less than 2,500 psi at 28 days.

C. Maximum Size of Aggregate: 1-1/2 inch.

D. Slump: Between 2 inches and 4 inches.

E. Assumed Field Strength: 85 percent of strength of laboratory-cured cylinders.

2.02 FORMS

A. Exposed Surfaces: Plywood.

B. Other Surfaces: Steel, matched boards, plywood, or other acceptable material.

1. Trench walls, large rock, and earth are not acceptable form material.


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C. Form vertical surfaces.

D. Provide fillets on re-entrant angles.

2.03 REINFORCING STEEL

A. Conform to ASTM A615/A615M, Grade 60, deformed bars.

2.04 PRECAST UNITS

A. At the option of Contractor, approved precast units may be substituted for cast-in-place units.

B. Conform to ASTM C478 except dimensions shall be as shown. Submit details of proposed units to Engineer for review.

C. Concrete Risers for Extensions: 6 inches high maximum and of same quality as sections.

1. Confirm acceptability of risers with Engineer before installation.

2.05 MORTAR

A. Standard premixed mortar conforming to ASTM C387/C387M, Type S, or proportion one part portland cement to two parts clean, well-graded sand which will pass a 1/8-inch screen.

B. Admixtures may be used if not exceeding the following percentages of weight of cement:

1. Hydrated Lime: 10 percent.
2. Diatomaceous Earth or Other Inert Materials: 5 percent.

C. Consistency of Mortar: As required to readily adhere to concrete.

2.06 FRAMES AND GRATES

A. Frames and Grates for Catch Basins and Storm Drain Inlets: Steel conforming to ASTM A36/A36M.

B. Connections: Welded in accordance with requirements of current Code For Welding in Building Construction of the American Welding Society.

C. Clean and hot-dip galvanized after fabrication.




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2.07 FRAMES AND GRATINGS

A. Frames and Grates for Catch Basins and Storm Drain Inlets: Cast iron conforming to ASTM A48/A48, Class 30.

B. Bearing Surfaces: Clean and provide uniform contact.

C. Castings: Tough, close-grained gray iron, sound, smooth, clean, free from blisters, blowholes, shrinkage, cold shuts, and defects.

## PART 3 EXECUTION

3.01 EXCAVATION AND BACKFILL

A. Excavate as required to accomplish construction. Backfill as specified for adjoining pipe trench.

3.02 CONSTRUCTION OF CATCH BASINS AND INLETS

A. Construct inlets and catch basins at locations shown and in accordance with the Drawings. Construct tight and well-braced forms to dimensions and elevations required. Chamfer form corners.

B. Prior to placing concrete, remove water and debris from forms. Moisten forms just prior to placing concrete. Handle concrete from transporting vehicle to forms in a continuous manner as rapidly as practical without segregation or loss of ingredients. Immediately after placing, compact concrete with mechanical vibrator. Limit duration of vibration to time necessary to produce satisfactory consolidation without causing segregation.

C. Screed top surface of exposed slabs and walls. When initial water has been absorbed, float surfaces with wood float and lightly trowel with steel trowel to smooth finish free from marks or irregularities. Finish exposed edges with steel edging tool. Remove forms and patch defects in concrete with mortar mixed in same proportions as original concrete mix.

D. Use a membrane-forming curing compound to prevent loss of moisture for 7 days. Apply curing compound immediately after removal of forms or finishing of slabs. Protect concrete from damage during curing period.

3.03 PLACING PRECAST UNITS

A. If material in bottom of trench is unsuitable for supporting unit, excavate and backfill to required grade with 3-inch minus, clean, pit-run material. Set units to grade at locations shown.


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3.04 EXTENSIONS

A. Install watertight extensions to height determined by Engineer. Lay risers in mortar with sides plumb and tops to grade. Seal joints with mortar, with interior and exterior troweled smooth. Prevent mortar from drying out and cure by applying a curing compound.

3.05 INSTALLATION OF FRAMES AND GRATES

A. Set frames and grates at elevations indicated or as determined in field and in conformance with the Drawings.

B. Frames may be cast in, or set in mortar.

3.06 CLEANING

A. Upon completion, clean structure of silt, debris, and foreign matter.

**END OF SECTION**


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# SECTION 33 46 00
# SUBSURFACE DRAINAGE

## PART 1 GENERAL

### 1.01 GENERAL

A. This section covers requirements for subsurface drainage piping, cleanouts, silt traps, and pump station sumps used to control shallow groundwater elevations within the Project area.

### 1.02 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. M252, Standard Specification for Corrugated Polyethylene Drainage Pipe.
   b. M294, Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm Diameter.
2. ASTM International (ASTM):
   a. A48/A48M, Standard Specification for Gray Iron Castings.
   b. C387/C387M, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
   c. C478, Standard Specification for Precast Reinforced Concrete Manhole Sections.
   d. D75, Standard Practice for Sampling Aggregates.
   e. D422, Standard Test Method for Particle-Size Analysis of Soils.
   f. D1140, Standard Test Methods for Amount of Material in Soils Finer than No. 200 (75-µm) Sieve.
   g. F405, Standard Specification for Corrugated Polyethylene (PE) Pipe and Fittings.
   h. F449, Standard Practice for Subsurface Installation of Corrugated Polyethylene Pipe for Agricultural Drainage or Water Table Control.
   i. F667, Standard Specification for Large Diameter Corrugated Polyethylene Pipe and Fittings.
3. Natural Resources Conservation Service (NRCS): Conservation Practice Standard 606, Subsurface Drain.

### 1.03 DEFINITIONS

A. Cleanouts: Surface access ports used to access drain lines and constructed of solid corrugated piping.


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B. Drain Lines: Buried perforated pipe providing collection and conveyance of drain water from saturated soils to Drainage Management Unit (DMU).

C. Drainage Management Unit (DMU): An area drained by continuous connected network of drain lines discharging to a single pump station.

D. Granular Drain Material: Granular (sand or gravel) material used as an envelope around drain lines to provide pipe bedding, a permeable drainage zone, and stabilization of base soils to prevent migration of fines into drain lines.

E. Level Check: Inline water control structure used to control hydraulic grade line within subsurface drainage system by inserting or removing adjustable stoplogs.

F. Silt Trap: Manhole installed within drainage system to provide access for removing sediment collected within drain lines.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product Data:
      1) Drain line pipe and fittings.
      2) Drain line installation equipment.
      3) High-pressure water jet cleaning equipment.
      4) Drain line sock; include manufacturer’s recommendation for length of time UV-resistant sock may be left exposed.
   b. Precast Base, Cone, and Top Slab Manhole Sections: Details of construction.
   c. Level Check Box, Stop Logs, Cover, and Pipe Boots: Details of construction.

B. Informational Submittals:

1. Granular Drain Material:
   a. Manufacturer’s Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
   b. Test results from approved commercial testing laboratory before delivering material to Site and at least 10 days before material is required for use.



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2. Surveys:
    a. Survey plan to collect drain line grade QA/QC information, including methods and schedule.
    b. Field Survey:
        1) Information consisting of stationing and ground surface elevation for each drain line prior to installation.
        2) Information consisting of stationing and installed invert elevation of drain pipe for drain line grade QA/QC.
3. Final drain line inspection and cleaning certification of compliance.

## 1.05 QUALITY ASSURANCE

A. Granular Drain Material Source:

1. Sampling:
    a. Conduct sampling of granular drain material source under supervision of Engineer in accordance with ASTM D75.
    b. Samples shall be representative and be clearly marked to show source of the material.
    c. Testing:
        1) In accordance with ASTM D1140 to determine percentage of fines.
        2) In accordance with ASTM D422 to determine gradation of particles larger than No. 200 sieve.
    d. Acceptance:
        1) Based on inspection of source by Engineer.
        2) Certified test results.
    e. Provide additional sampling, testing, and certification for every 500 cubic yards of material and when there is a change in granular drain material.
    f. Upon Engineer’s request, supply supplemental samples of granular drain material to a testing laboratory designated by Owner during installation of drain lines. Owner will bear costs of testing.

## 1.06 DOCUMENTATION

A. Survey Plan:

1. Submit prior to beginning Work.
2. Update on a weekly basis through final drain line inspection and cleaning.


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B. Surveying:

1. At least 10 days prior to installation, provide Engineer with the following information for each drain line:
   a. Field survey ground surface elevations at 250-foot increments.
   b. Calculated cut depth from ground surface to drain line invert elevation.
2. Provide surveyed drain line grades to Engineer no more than 5 days following installation of drain line section.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Drain Sock:

1. Free of tears or other damage. Replace damaged sock.
2. Protect polyethylene drain lines with geotextile sock from UV light while stored onsite, unless geotextile sock is certified UV resistant.
3. UV-resistant Sock Stored Onsite Uncovered:
   a. Mark date of first sunlight exposure for each roll at factory.
   b. Do not allow UV-resistant sock to remain uncovered for more time than recommended by manufacturer.

## PART 2 PRODUCTS

2.01 DRAIN LINES

A. Drain lines shall be perforated, unless otherwise noted on the Drawings.

B. Perforated Drain Lines:

1. Heavy-duty corrugated polyethylene pipe meeting NRCS Conservation Practice Specification 606.
2. Conforming to ASTM F405 for 3-inch to 6-inch diameter pipe.
3. Conforming to ASTM F667 for 8-inch to 15-inch diameter pipe.
4. Water Inlet:
   a. Area of at least 1 square inch per foot of length.
   b. Dimensions of water inlet area shall be measured on a straight specimen with no external forces applied. Make measurements with instruments accurate to 0.01 inch.
   c. Perforations:
      1) Locate at least one perforation in the middle of corrugation so there is a shoulder on each side of perforation.
      2) Pipe 4 Inches to 12 Inches in Diameter:
         a) Slotted perforations shall be no wider than 1/8 inch or no longer than 1-1/4 inches.


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b) Slotted perforations equally spaced along length and circumference of tubing in not less than three rows.

3) Pipe 15 inches in Diameter: Circular perforations will be accepted.

C. Nonperforated Drain Lines:

1. Heavy-duty corrugated polyethylene pipe with smooth interior walls.
2. Conforming to AASHTO M252 for 3-inch to 10-inch pipe.
3. Conforming to AASHTO M294 for 12-inch to 15-inch pipe, Type S.

D. Drain Sock: Provide geotextile fabric material (sock) surrounding perforated drain lines.

E. Drain Line Fittings:

1. Includes cleanouts, elbows, tees, branch connections, snap end caps, and reducing couplers.
2. Conforming to ASTM F405 and ASTM F667 as appropriate.
3. Cleanout snap end cap shall have a metal locating plate attached as shown on the Drawings.
4. Diameter of cleanout fittings shall be as shown on the Drawings.
5. Fittings installed as part of a continuous operation shall be clamp type rather than snap type. Fittings installed after pipe is in place may be either type.

2.02 GRANULAR DRAIN MATERIAL

A. In accordance with Section 31 23 23.15, Trench Backfill.

B. Composed of hard, durable, natural mineral particles free from organic matter, clay balls, soft particles, or other impurities or foreign matter.

C. Material shall conform to the following grading requirements:

| Size or U.S. Standard Sieve | Percent Passing by Dry Weight |
|---|---|
| 3/4" | 95-100 |
| 1/2" | 25-60 |
| No. 4 | 0-20 |
| No. 8 | 0-5 |
| No. 200 | 0-2.0 |


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2.03 TRENCH BACKFILL

A. Above pipe zone shall be in accordance with Section 31 23 23.15, Trench Backfill.

B. Within pipe zone shall be in accordance with Section 31 23 23.15, Trench Backfill.

C. Native backfill free from organic matter and other impurities or foreign matter and free from rocks larger than 3 inches in diameter.

2.04 BASE ROCK

A. In accordance with Section 31 23 23.15, Trench Backfill.

B. Base rock shall be clean 3/4-inch minus crushed granular or crushed rock uniformly graded from coarse to fine and with sufficient fines for proper compaction.

2.05 SILT TRAPS AND PUMP STATION SUMPS

A. Provide manholes to serve as silt traps and pump station sumps in conformance with Section 33 05 13, Manholes.

B. Manhole dimensions shall be as shown on the Drawings.

**PART 3 EXECUTION**

3.01 TRENCH EXCAVATION

A. Trenching Equipment:

1. Automatic laser-guided grade control.
2. Shoe (or boot) that allows granular fill to be placed uniformly around perforated drain lines in a continuous operation during installation.
3. Equipped with specially lengthened shield.
4. Capable of operating at sufficient speed to ensure drain lines can be laid and blinded with granular drain material before groundwater or soil-water slurry moves into trench and into direct contact with drain geotextile sock.

B. In accordance with Section 31 23 16, Excavation.

C. Excavate to lines and grades shown on the Drawings allowing required thickness of granular fill to be placed around drain lines as shown on the Drawings.


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D. Installation of Drain Lines below Water Table: Install with trenching machine specifically designed for fluid soil conditions.

## 3.02 DRAIN LINE INSTALLATION

A. General:

1. No portion of subsurface drainage system in each drainage management unit (DMU) shall be installed until the permanent or temporary pump station in that DMU is installed and operational.
2. Installation of drain lines shall proceed starting from the DMU pump station.

B. Pipe Installation:

1. Handle and install in conformance with ASTM F449.
2. Lay drain lines and appurtenances to lines and grades shown on the Drawings.
3. Take special precautions on hot days to ensure stretch limit is not exceeded and excessive deflection is not caused by premature backfilling.

C. Fitting Installation:

1. Standard connections shall be in conformance with ASTM F449.
2. For nonstandard connections, join drain lines using manufacturer’s printed recommended methods to complete connection.
3. Drain lines that are exposed to make a connection after trench backfilling shall have 4 inches of granular drain material replaced around drain line and connection.
4. Wrap connections and fittings with geotextile sock.

## 3.03 GRANULAR DRAIN MATERIAL INSTALLATION

A. Place granular drain material around perforated drain lines as shown on the Drawings.

B. Place granular drain material around perforated drain lines in a continuous operation during placement of drain lines.

C. Place granular drain material with spreader boxes or other equipment in a manner to minimize segregation.


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## 3.04 TRENCH BACKFILL

A. Trench shall not be left open overnight; plug end of drain lines and backfill trench to prevent animals, sediment, or debris from entering pipe.

B. Perform in a manner that shall minimize settlement.

C. Backfill may be placed automatically by trencher.

D. Where backfill material is placed in drain line trenches mechanically, backfill material shall be pushed onto slope of backfill previously placed and allowed to slide down into trench. Backfill shall not be pushed into trench in such a way as to permit free fall of material until at least 2 feet of cover has been provided over the top of drain line.

E. Place in such a manner to prevent displacement of drain line and granular fill after backfilling.

F. Trench Compaction:

1. After initial backfilling to final grade, a rubber-tired tractor shall be driven a minimum of two passes with tires running parallel on top of trench to facilitate compaction.
2. Additional mechanical backfilling shall be done to leave trench with 4-inch to 6-inch elevated mound on trench.

G. Unless otherwise directed by Engineer, procedures for compaction of trench backfill material shall be accomplished by close of each day’s work.

## 3.05 CLEANING ACCESS INSTALLATION

A. Install inline cleanouts, end-of-line caps, and silt traps and pump station sumps as shown on the Drawings.

B. Install inline cleanout in drain lines longer than 1,000 feet and place cleanouts no further than 1,000 feet apart in drain lines longer than 2,000 feet. Silt traps may be substituted for inline cleanouts.

C. Install end-of-line caps at upstream end of drain lines.

## 3.06 SILT TRAP AND PUMP STATION SUMP INSTALLATION

A. Silt trap and pump station shall be installed in accordance with Section 33 05 13, Manholes.



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B. Base Preparation:

1. Remove loose material from excavation.
2. Place base rock to a compacted depth of not less than 6 inches with top surface at proper elevation.
3. Place precast base section on compacted imported base material.
4. Properly locate, ensure firm bearing throughout, and plumb first section.

C. Placing Precast Manhole Sections:

1. Make joints between precast manhole sections of cement mortar.
2. Place mortar in groove of the lower section of pipe prior to placing next section.
3. Set sections plumb.
4. Fill joints between sections completely with mortar and trowel to a smooth finish.
5. Joints between precast sections shall be watertight.
6. Cut openings in precast manhole sections as required to accommodate inlet and discharge pipes.
7. Cut holes with care and patch with nonshrinking mortar. Bend reinforcement out from the hole insofar as possible so as to reinforce patching.

D. Manhole Inverts: Construct of concrete in accordance with the Drawings. Finished inverts shall be free from sharp edges or rough sections and shall provide a smooth flow.

E. Manhole Frame and Cover: Install in bed of mortar so as to provide a tight, secure joint. Elevation of finished cover shall be as shown on the Drawings.

## 3.07 FIELD QUALITY CONTROL

A. Drain Line Grade:

1. Measure by excavating down to drain every 250 feet and at the beginning and end of each line.
2. Measure drain invert elevation with a survey method accurate to 0.01 foot vertical.
3. Measure for grade at the top of pipe.
4. Drain lines with grades less than 1 percent shall be placed to the design grade within a tolerance of plus or minus 0.1 foot of design invert elevation.
5. Grades of 1 percent or steeper shall be placed to the design grade within a tolerance of plus or minus 0.2 foot of design invert elevation.
6. No reversal in grade of the drain lines shall be permitted.


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B. Drain Line Stretching:

1. Drain lines shall not be stretched more than 5 percent during installation.
2. Measure stretch by measuring the distance across a minimum of 10 corrugations and comparing to manufacturer's standard corrugation dimensions.

## 3.08 FINAL INSPECTION AND CLEANING

A. Preparation:

1. Do not begin jet washing until subsurface drainage work within a DMU is complete.
2. Stage the Work to provide adequate supply of water for jet washing to allow inspection and cleaning of each section of drain line in one continuous operation.
3. Access to drain lines shall be through drain line cleanouts, silt traps, or the pump station sump.

B. High Pressure Jet Washing Equipment:

1. Suitable type and size to perform cleaning specified herein.
2. Cleaning nozzle capable of jet washing 6-inch diameter to 15-inch diameter drain lines in sections up to 1,000 feet long.
3. Capable of negotiating 4-inch diameter cleaning access point.
4. Jet mechanism shall have a forward-piercing jet with trailing side jets that propel mechanism forward.
5. Operating pressures at pump shall not exceed a maximum of 2,300 psi.
6. Operate in accordance with manufacturer's printed instructions, recommendations, and best practice of the trade.

C. Pass high-pressure water jet cleaner through entire length of each drain line no sooner than 10 calendar days after installation of drain line.

D. When drain lines must be jet washed in sections, upstream sections shall be jet washed before connecting section downstream.

E. If tailwater produced is not clear, run jet cleaner through drain line section up to two more passes.

F. Obstructions within drain lines, collapsed drain line sections, or sections outside allowable tolerances for grade that are identified during final inspection and cleaning shall be repaired and corrected to meet these Specifications.


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G. Complete final drain line inspection and cleaning certification of compliance addressing the following items:

1. Dates of work, equipment, and personnel performing work.
2. Locations and descriptions of obstructions, collapsed sections, out-of-grade sections, and actions taken to repair problems.
3. Locations of sections where tailwater did not run clear after three passes.

H. After completing jet washing for a drain line, restore area to a neat and finished appearance.

**END OF SECTION**


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