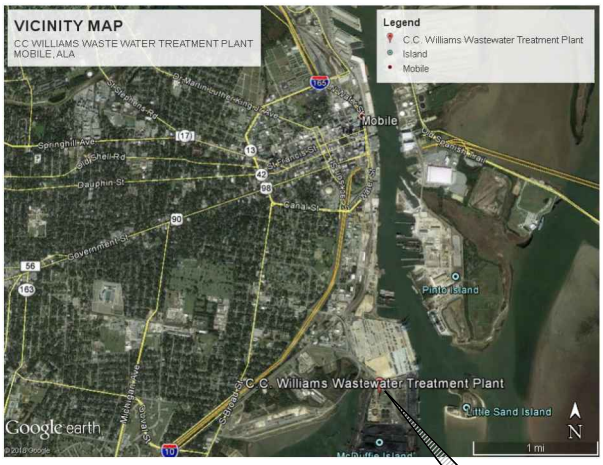
CC WILLIAMS WWTP DEWATERING AND OTHER IMPROVEMENTS

MOBILE AREA WATER & SEWER SYSTEM



PROJECT VICINITY MAP

CC WILLIAMS WWTP

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Sheri N. Weber, Vice Chair
Thomas Zoghby, Secretary-Treasurer
Barabra Drummond
Kenneth W. Nichols
Maria Gonzalez
Raymond L. Bell Jr.

Director:
Bud McCrory

PREPARED FOR THE

MOBILE AREA WATER AND SEWER SYSTEM
MOBILE, ALABAMA

SPECIFICATIONS
VOLUME 2 OF 4

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Jacobs

JACOBS D3226100

MARCH 2021

BID DOCUMENTS

MOBILE AREA WATER AND SEWER SYSTEM

MOBILE, ALABAMA

BIDDING REQUIREMENTS
AND
CONTRACT DOCUMENTS

for the construction of the

CC WILLIAMS WWTP DEWATERING AND OTHER IMPROVEMENTS

****

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JACOBS
Pensacola, FL
March 2021

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END OF SECTION

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SECTION 21 13 13
WET-PIPE SPRINKLER SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

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

1. National Fire Protection Association (NFPA):
   a. 13, Installation of Sprinkler Systems.
   b. 14, Installation of Standpipe and Hose Systems.
   c. 25, Standard For the Inspections, Testing, and Maintenance of Water Based Fire Protection Systems.
   d. 70, National Electrical Code (NEC).
   e. 1963, Standard for Fire Hose Connections.
2. U.S. Code of Federal Regulations (CFR).

1.02 DEFINITIONS

A. High-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure higher than standard 175 psig, but not higher than 300 psig.

B. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175 psig maximum.

C. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply through alarm valve. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device.

D. Abbreviations:

1. American National Taper Pipe Thread (NPT).
2. Authority having jurisdiction (AHJ).
3. Hertz (Hz).
4. Pounds per square inch, gauge (psig).
5. Single-pole, double-throw (SPDT).
6. Volts alternating current (V ac).
7. Volts direct current (V dc).

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1.03 DESIGN REQUIREMENTS

A. Provide design criteria and area densities for the automatic sprinkler systems as indicated on Drawings.

B. Provide sprinkler systems, including bracing, designed and installed in accordance with NFPA 13.

C. Hydraulically design the systems. Submit calculations to verify that, at minimum, densities indicated on Drawings are met.

D. Base hydraulic calculations on water flow tests conducted and recorded at or near the proposed system tie-in point.

E. Contract Drawings are provided for general layout of the sprinkler system. Contractor design responsibility includes determining exact layout and dimensions of the system. Clearly identify deviations from Drawings or Specifications in the Shop Drawing submittal.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Drawings for wet-pipe sprinkler systems; include plans, elevations, sections, details, and attachments to other work.
   b. Product Data: For pipe, fittings, valves, sprinklers and all other attachments and components needed to provide a complete and compliant installation. For electrical/alarm components include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   c. Submit for approval by Owner's loss protection consultant and the fire marshal prior to the start of construction.
   d. Coordination Drawings: Sprinkler systems, drawn to scale, illustrating the coordination of the sprinkler system with:
      1) Domestic water piping.
      2) Compressed air piping.
      3) HVAC hydronic piping and duct work.
      4) Items penetrating finished ceiling, include the following:
         a) Lighting fixtures.
         b) Air outlets and inlets.

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B. Informational Submittals:

1. Qualification Data: Qualified installer, design technician, and professional engineer.
2. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, approved by authorities having jurisdiction, including hydraulic calculations if applicable.
3. Welding certificates.
4. Manufacturer's printed installation instructions.
5. Fire hydrant flow test report.
6. Field test reports and certificates.
7. Field quality control reports.
8. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

C. LEED Submittals:

1. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content and chemical components.

1.05 QUALITY ASSURANCE

A. Comply with the applicable Prevention Code, building codes, and government regulations, and requirements of the Owner's loss protection consultant as identified on Drawings.

B. Provide approvals, permits, and required inspections.

C. Provide materials and equipment UL listed and in compliance with applicable NFPA standards and fire marshal's requirements. Submit documentation that the specific items furnished under this section for this Project conform to such requirements.

D. Welding Qualifications: Refer to NFPA 13 for qualifications and restrictions.

E. Preinstallation Meeting:

1. In accordance with Section 01 31 19, Project Meetings.
2. Convene minimum 1 week prior to commencing work of this section.

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1.06 QUALIFICATIONS

A. Provide layout drawings for fire protection systems prepared by or under the supervision of a NICET Fire Protection Engineering Technician, Level 3 or Level 4, subfield of Fire Protection Engineering Water-Based Systems Layout or as otherwise permitted by State or local Statute. If required by State or local Statute, provide Drawings reviewed and stamped by a registered professional engineer having registration in the State of Alabama or other procedure acceptable the AHJ. Submit a copy of the current certification of the NICET technician and the registered Engineer with the initial submittal.

1.07 PROJECT CONDITIONS

A. Interruption of Existing Sprinkler Service: Do not interrupt sprinkler service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary sprinkler service according to requirements indicated:

1. Notify Owner no fewer than 5 days in advance of proposed interruption of sprinkler service.
2. Do not interrupt sprinkler service without Owner's written permission.

1.08 EXTRA MATERIALS

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

Item	Quantity
Sprinkler Cabinet	One each
Sprinklers	Six of each different size unit
Sprinkler heads Wrench	One per unit

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

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B. Sprinkler system equipment, specialties, accessories, installation, and testing: comply with NFPA 13.

C. Piping Materials: Comply with requirements in “Piping Schedule” located below.

2.02 STEEL PIPE AND FITTINGS

A. Pipe:

1. FM Approved Standard Weight, Galvanized and Black Steel Pipe: ASTM A53/A53M or ASTM A153. Pipe ends may be factory or field formed to match joining method.
2. FM Approved Schedule 30, Galvanized Black Steel Pipe: ASTM A135/A135M or ASTM A795/A795M. Pipe ends may be factory or field formed to match joining method.
3. Do not use lightwall pipe and Schedule 5 pipe.

B. Fittings:

1. Galvanized and Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern. Provide galvanized fittings and couplings:
   a. Where scheduled.
   b. Exterior locations.
2. Flanges:
   a. Cast Iron: ASME B16.1 or AWWA C110, AWWA C111, AWWA C115, 250 psi water service rating, Class 125 dimensions and bolt pattern.
   b. Galvanized and Uncoated Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
3. Grooved-Joint, Steel Pipe Appurtenances:
   a. Galvanized and Uncoated Grooved-End Fittings and Couplings for Steel Piping: UL 213 listed for fire protection service, FM approved, malleable-iron casting or ductile-iron casting; with dimensions matching steel pipe. Standard EPDM gaskets. Rigid type except where flexible type is required for vibration isolation or stress relief.
   b. Manufacturers:
      1) Tyco.
      2) Victaulic Company.
4. Certify fittings, couplings, flanges, and flange adaptors used with thinwall pipe or Schedule 10 pipe by the fitting manufacturer as dimensionally compatible with and fully connectable to the pipe used without field modifications.
5. Welded or segmented fittings are not acceptable.

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2.03 PIPING SCHEDULE

A. Piping Between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends; cast-iron threaded fittings; and threaded or grooved ends; grooved-end fittings; grooved-end pipe couplings; and grooved joints.

B. Standard-pressure, Wet-pipe Sprinkler System , 2 inches and Smaller:

1. Standard-weight black steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Standard-weight galvanized steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
3. Standard-weight black steel pipe with cut or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end pipe couplings for steel piping; and grooved joints.
4. Standard-weight galvanized steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end pipe couplings for steel piping; and grooved joints.
5. Standard-weight black steel pipe with plain ends; steel welding fittings; and welded joints.

C. Standard-pressure, Wet-pipe Sprinkler System 2-1/2 inches to 4 inches:

1. Standard-weight black steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Standard-weight galvanized steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
3. Standard-weight black steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end pipe couplings for steel piping; and grooved joints.
4. Standard-weight galvanized steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end pipe couplings for steel piping; and grooved joints.
5. Standard-weight black steel pipe with plain ends; steel welding fittings; and welded joints.

D. Standard-pressure, Wet-pipe Sprinkler System , 5 inches and Larger:

1. Standard-weight black steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Standard-weight galvanized steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
3. Standard-weight black steel pipe with cut-or roll- grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end pipe couplings for steel piping; and grooved joints.

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4. Standard-weight galvanized steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end pipe couplings for steel piping; and grooved joints.
5. Standard-weight black steel pipe with plain ends; steel welding fittings; and welded joints.
6. Schedule 10 black steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end pipe couplings for steel piping; and grooved joints.

E. High-pressure, Wet-pipe Sprinkler System, NPS 5 inches and Larger:

1. Standard-weight galvanized steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
2. Standard-weight galvanized steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end pipe couplings for steel piping; and grooved joints.
3. Standard-weight black steel pipe with plain ends; steel welding fittings; and welded joints.

2.04 PIPING JOINING MATERIALS

A. Pipe Flange Gasket Materials: AWWA C110/A21.10, rubber, flat face, 1/8 inch (3.2 mm) thick.

1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
2. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.

B. Metal Pipe Flange Bolts and Nuts: ASTM A307 Grade B, galvanized, with galvanized nuts in accordance with ASTM A563 Grade A.

C. Unions: 150 psig galvanized malleable iron, ASTM A197, threaded, ground joint, integral seat.

2.05 VALVES

A. General Requirements:

1. Valves shall be UL listed or FM approved.
2. Minimum Pressure Rating for Standard-Pressure Piping: 175 psig.
3. Minimum Pressure Rating for High-Pressure Piping: 300 psig.
4. Make flanged end and wafer type valves compatible for installation with flanges as specified.

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B. Ball Valves:

1. Standard: UL 1091, except with ball instead of disc.
2. 1-1/2 Inches and Smaller: Bronze body with threaded ends.
3. 2 Inches and 2-1/2 Inches: Bronze body with threaded ends or ductile-iron body with grooved ends.
4. 3 Inches: Ductile-iron body with grooved ends.
5. Manufacturers:
   a. Anvil International, Inc.
   b. Victaulic Company.

C. Iron Butterfly Valves:

1. Standard: UL 1091.
2. Pressure Rating: 175 psig.
3. Body Material: Cast or ductile iron.
4. Stem: Stainless steel.
5. Style: Lug or wafer.
6. End Connections: Grooved.
7. Manufacturers:
   a. Global Safety Products, Inc.
   b. NIBCO INC.
   c. Tyco.
   d. Victaulic Company.

D. Check Valves:

1. Standard: UL 312.
2. Pressure Rating: 300 psig.
3. Type: Swing check or spring assisted swing check.
4. Body Material: Cast or ductile iron.
5. End Connections: Flanged or grooved.
6. Manufacturers:
   a. Kennedy Valve.
   b. Mueller Company.
   c. NIBCO INC.
   d. Tyco.
   e. Victaulic Company.

E. Iron OS&Y Gate Valves:

1. Standard: UL 262.
2. Pressure Rating: 300 psig.
3. Body Material: Cast or ductile iron.

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4. End Connections: Flanged or grooved.
5. Manufacturers:
    a. Kennedy.
    b. Mueller Co.; Water Products Division.
    c. NIBCO INC.
    d. Tyco.
    e. Victaulic Company.

F. Indicating-Type Butterfly Valves:

1. Standard: UL 1091.
2. Pressure Rating: 175 psig minimum.
3. Valves 2 Inches and Smaller:
    a. Valve Type: Ball or butterfly.
    b. Body Material: Bronze.
    c. End Connections: Threaded or grooved.
4. Valves 2-1/2 Inches and Larger:
    a. Valve Type: Butterfly.
    b. Body Material: Cast or ductile iron.
    c. Stem Material: Stainless steel.
    d. End Connections: Flanged, grooved, or wafer.
5. Valve Operation: Weatherproof actuator housing with handwheel and integral dual single-pole, double-throw (SPDT) (Form C) contacts, rated for a minimum of 10 amps at 125/250V ac, 2 amps at 30V dc, 10 mA minimum at 24V dc in tamper-proof cover with mounting and required hardware for attachment to indicated valves visual indicating device.
6. Manufacturers:
    a. Kennedy Valve.
    b. NIBCO INC.
    c. Tyco.
    d. Victaulic Company.

G. NRS Gate Valves:

1. Standard: UL 262.
2. Pressure Rating: 300 psig.
3. Body Material: Cast iron with indicator post flange.
4. Stem: Nonrising.
5. End Connections: Flanged or grooved.
6. Manufacturers:
    a. Kennedy Valve.
    b. Mueller Co.
    c. NIBCO INC.
    d. Tyco.
    e. Victaulic Company.

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H. Indicator Wall Posts:

1. Standard: UL 789.
2. Type: Horizontal for wall mounting.
3. Body Material: Cast iron with extension rod and locking device.
4. Operation: Hand wheel.
5. Manufacturers:
   a. Kennedy Valve.
   b. Mueller Co.
   c. NIBCO INC.
   d. Tyco.
   e. Victaulic Company.

2.06 TRIM AND DRAIN VALVES

A. General:

1. Standard: UL's "Fire Protection Equipment Directory" listing or FM "Approval Guide," listing.
2. Pressure Rating: 175 psig minimum.

B. Angle Valves:

1. Manufacturers:
   a. Fire Protection Products, Inc.
   b. Potter-Roemer.
   c. United Brass Works, Inc.

C. Ball Valves:

1. Manufacturers:
   a. NIBCO INC.
   b. Potter Roemer.
   c. Tyco.
   d. Victaulic Company.

2.07 SPECIALTY VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or FM "Approval Guide" listing.
2. Pressure Rating:
   a. Standard-Pressure Piping Specialty Valves: 175 psig minimum.
   b. High-Pressure Piping Specialty Valves: 300 psig.

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3. Body Material: Cast or ductile iron.
4. Size: Same as connected piping.
5. End Connections: Flanged or grooved.

B. Alarm Valves:

1. Standard: UL 193.
2. Design: Vertical installation.
3. Valve internal components shall be replaceable without removing the valve from the installed position.
4. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gauges, retarding chamber, and fill-line attachment with strainer.
5. Drip Cup Assembly: Pipe drain with check valve to separate from main drain piping.
6. Manufacturers:
   a. Tyco; Series AV.
   b. Victaulic Company; Series 751.
   c. Viking Corporation; Series J-1.

2.08 FIRE DEPARTMENT CONNECTIONS

A. Exposed-Type:

1. Standard: UL 405.
2. Type: Exposed, projecting, for wall mounting.
3. Pressure Rating: 175 psig minimum.
4. Body Material: Corrosion-resistant metal.
5. Inlets: Brass with threaded connections according to NFPA 1963 and matching local fire department requirements; include extension pipe nipples, brass lugged swivel connections, and check devices or clappers. Verify inlet connections with local fire authority.
6. Caps: Brass, lugged type, with gasket and chain.
7. Escutcheon Plate: Round, brass, wall type.
8. Outlet: Back, with pipe threads.
9. Number of Inlets: Two**.**
10. Escutcheon Plate Marking: Similar to “AUTO SPKR.”
11. Finish: Rough brass or bronze.
12. Outlet Size: 4 inches.
13. Manufacturers:
    a. Elkhart Brass Mfg. Company, Inc.
    b. Guardian Fire Equipment, Inc.
    c. Potter-Roemer.
    d. Tyco.

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B. Flush-Type:

1. Standard: UL 405.
2. Type: Flush, for wall mounting.
3. Pressure Rating: 175 psig minimum.
4. Body Material: Corrosion-resistant metal.
5. Inlets: Brass with threads according to NFPA 1963 and matching local fire department sizes and threads. Include extension pipe nipples, brass lugged swivel connections, and check devices or clappers.
6. Caps: Brass, lugged type, with gasket and chain.
7. Escutcheon Plate: Rectangular, brass, wall type.
8. Outlet: With pipe threads.
9. Body Style: Horizontal.
10. Number of Inlets: Two.
11. Outlet Location: Back.
12. Escutcheon Plate Marking: Similar to “AUTO SPKR.”
13. Finish: Rough brass or bronze.
14. Outlet Size: 4 inches.
15. Manufacturers:
    a. Elkhart Brass Mfg. Company, Inc.
    b. Guardian Fire Equipment, Inc.
    c. Potter Roemer.

C. Storz Connection:

1. Standard: UL 405.
2. Type: Storz.
3. Pressure Rating: 175 psig minimum.
4. Body Material: Forged aluminum with.
5. Inlets: 4-inch locking Storz fitting. Verify size with local fire department.
6. Caps: Blind Storz cap with securing cable or chain, forged aluminum with powder coating finish matching inlet fitting.
7. Escutcheon Plate: Square, brass, wall type.
8. Outlet: 4-inch NPT threads.
9. Body Style: 30-degree angle pattern.
10. Number of Inlets: One.
11. Outlet Location: As indicated or as otherwise required for riser configuration.
12. Escutcheon Plate Marking: Similar to “AUTO SPKR.”
13. Finish: Powder coat finish.
14. Outlet Size: 4 inches.
15. Manufacturers:
    a. Guardian Fire Equipment, Inc.
    b. Potter Roemer.

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D. Fire Department Outlet Test Fitting:

1. Brass body and polished brass plate lettered HYDRANT.
2. Polished brass female 4-inch NPT by 2-1/2-inch male hose thread snoots with caps and chains.
3. Two-way hydrant with two outlets and inlet configuration as required for location.
4. Manufacturers:
   a. Elkhart Brass Mfg. Company, Inc.
   b. Guardian Fire Equipment, Inc.
   c. Potter Roemer.
   d. Tyco.

2.09 SPRINKLER SPECIALTY PIPE FITTINGS

A. Branch Outlet Fittings:

1. Standard: UL 213.
2. Pressure Rating: 175 psig minimum.
3. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
4. Type: Mechanical-cross fittings and mechanical-tee.
5. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
6. Size: Dimension to fit on sprinkler main and with outlet connections as required to match connected branch piping.
7. Branch Outlets: Grooved, plain-end pipe, or threaded.
8. Manufacturers:
   a. Tyco.
   b. Victaulic Company.

B. Flow Detection and Test Assemblies:

1. Standard: UL's "Fire Protection Equipment Directory" listing or FM "Approval Guide" listing.
2. Pressure Rating: 175 psig minimum.
3. Body Material: Cast-iron or ductile-iron housing with orifice, sight glass, and integral test valve.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded or grooved.
6. Manufacturers:
   a. Reliable Automatic Sprinkler Co., Inc.
   b. Tyco.
   c. Victaulic Company.

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C. Branch Line Testers:

1. Standard: UL 199.
2. Pressure Rating: 175 psig.
3. Body Material: Brass.
4. Size: Same as connected piping.
5. Inlet: Threaded.
6. Drain Outlet: Threaded and capped.
7. Branch Outlet: Threaded, for sprinkler.
8. Manufacturers:
    a. Elkhart Brass Mfg. Company, Inc.
    b. Potter-Roemer.

D. Sprinkler Inspector's Test Fittings:

1. Standard: UL's "Fire Protection Equipment Directory" listing or FM "Approval Guide" listing.
2. Pressure Rating: 175 psig minimum.
3. Body Material: Cast-bronze, cast-iron, or ductile-iron housing with sight glass.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded or grooved.
6. Manufacturers:
    a. Tyco.
    b. Victaulic Company.
    c. Viking Corporation.

E. Flexible, Sprinkler Hose Fittings:

1. Standard: UL 1474.
2. Type: Flexible braided Type 304 stainless steel flexible tube hose for connection to sprinkler, and with bracket for connection to ceiling grid.
3. Pressure Rating: 175 psig minimum.
4. Size: Same as connected piping, for sprinkler.
5. Manufacturers:
    a. Fivalco Inc.
    b. FlexHead Industries, Inc.
    c. Gateway Tubing, Inc.
    d. Victaulic Company.

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2.10 SPRINKLERS

A. General:

1. Standard: UL's "Fire Protection Equipment Directory" listing or FM "Approval Guide" listing.
2. Pressure Rating
   a. Residential Sprinklers: 175 psig maximum.
   b. Automatic Sprinklers: 175 psig minimum.
   c. High-Pressure Automatic Sprinklers: 300 psig.

B. Sprinkler Schedule

1. Use sprinkler types below for the following applications:
   a. Rooms without Ceilings: Upright sprinklers.
   b. Rooms with Suspended Ceilings: Recessed sprinklers.
   c. Wall Mounting: Sidewall sprinklers.
   d. Spaces Subject to Freezing: Upright, pendent, dry sprinklers; and sidewall, dry sprinklers as indicated.
2. Provide sprinkler types below with finishes indicated.
   a. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
   b. Upright and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

C. Automatic Sprinklers with Heat-Responsive Element:

1. Early-Suppression, Fast-Response Applications: UL 1767.
2. Nonresidential Applications: UL 199.
3. See Drawings for additional information.
4. Sprinkler Finishes:
   a. Chrome plated.
   b. Bronze.
   c. Painted.
5. Special Coatings:
   a. Wax.
   b. Lead.
   c. Corrosion-resistant paint.

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6. Sprinkler Escutcheons:
   a. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
   b. Ceiling Mounting: Chrome-plated steel, two piece, with 1-inch (25-mm) vertical adjustment.
   c. Sidewall Mounting: Chrome-plated steel, one piece, flat.
7. Sprinkler Guards:
   a. Standard: UL 199.
   b. Type: Wire cage with fastening device for attaching to sprinkler.
8. Manufacturers:
   a. Reliable Automatic Sprinkler Co., Inc.
   b. Tyco.
   c. Victaulic Company.
   d. Viking Corporation.

2.11 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Water Motor-operated Alarm:

1. Standard: UL 753.
2. Type: Mechanically operated, with Pelton wheel.
3. Alarm Gong: Cast aluminum with red enamel factory finish.
4. Size: 10-inch (250-mm) diameter.
5. Components: Shaft length, bearings, and sleeve to suit wall construction.
6. Inlet: 3/4 inch.
7. Outlet: 1-inch drain connection.
8. UL listed and FM approved.
9. Manufacturers:
   a. Tyco.
   b. Victaulic Company.
   c. Viking Corporation.

C. Electrically Operated Alarm Bell:

1. Standard: UL 464.
2. Type: Vibrating, metal alarm bell.
3. Size: Minimum 10-inch (250-mm) diameter.
4. Finish: Red enamel factory finish, suitable for outdoor use.
5. UL listed and FM approved.
6. Manufacturers:
   a. Fire-Lite Alarms, Inc.; a Honeywell company.
   b. Notifier; a Honeywell company.
   c. Potter Electric Signal Company.

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D. Water Flow Indicators:

1. Standard: UL 346.
2. Water Flow Detector: Electrically supervised.
3. Components: Provide device with two sets of SPDT (Form C) contacts. Provide minimum switch electrical rating of 10 amps at 125/250V ac, 2 amps at 30V dc resistive, 10 mA at 24V dc.
4. Type: Paddle operated.
5. Pressure Rating: 250 psig.
6. Installation: Horizontal or vertical.
7. UL listed and FM approved.
8. Manufacturers:
    a. Potter Electric Signal Company.
    b. System Sensor; a Honeywell company.
    c. Tyco.
    d. Viking Corporation.

E. Pressure Switches:

1. Standard: UL 346.
2. Type: Electrically supervised water flow switch with retard feature.
3. Components: Provide device with two sets of SPDT (Form C) contacts. Provide minimum switch electrical rating of 10 amps at 125/250V ac, 2 amps at 30V dc resistive, 10 mA at 24V dc.
4. Operation: Rising pressure signals water flow.
5. UL listed and FM approved.
6. Manufacturers:
    a. Potter Electric Signal Company.
    b. System Sensor; a Honeywell company.
    c. Tyco.
    d. Viking Corporation.

F. Valve Supervisory Switches:

1. Standard: UL 346.
2. Type: Electrically supervised.
3. Components: Single unit composed of dual single-pole, double-throw (SPDT) (Form C) contacts, rated for a minimum of 10 amps at 125/250V ac, 2 amps at 30V dc, 10 mA minimum at 24V dc in tamper-proof cover with mounting hardware for attachment to indicated valves.
4. Design: Signals that controlled valve is in other than fully OPEN position.

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5. UL listed and FM Approved.
6. Manufacturers:
    a. ADT Security Services, Inc.
    b. Potter Electric Signal Company.
    c. System Sensor; a Honeywell company.

2.12 MANUAL CONTROL STATIONS

A. Description:

1. UL listed or FM approved.
2. Hydraulic operation, with union, 1/2-inch pipe nipple, and bronze ball valve.
3. Metal enclosure labeled “MANUAL CONTROL STATION”.
4. Cover held closed by breakable strut to prevent accidental opening.

2.13 CONTROL PANELS

A. Description:

1. Single-area, two-area, or single-area cross-zoned control panel as indicated.
2. NEMA ICS 6, Type 1 enclosure with detector, alarm, and solenoid-valve circuitry for operation of deluge valves.
3. Contain power supply, battery charger, standby batteries, field-wiring terminal strip, electrically supervised solenoid valves, and polarized fire alarm bell, lamp test facility, single-pole, double-throw auxiliary alarm contacts, and rectifier.
4. UL listed and FM approved when used with thermal detectors and Class A detector circuit wiring.
5. Electrical Characteristics: 120V ac, 60 Hz, with 24V dc rechargeable batteries.
6. Manual Control Stations: Include metal enclosure labeled “MANUAL CONTROL STATION” and cover held closed by breakable strut to prevent accidental opening.

2.14 PRESSURE GAUGES

A. Description:

1. Standard: UL 393.
2. Dial Size: 3-1/2-inch to 4-1/2-inch (90-mm to 115-mm) diameter.
3. Pressure Gauge Range: 0 psig to 300 psig.
4. Water System Piping Gauge: Include “WATER” or “AIR/WATER” label on dial face.

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5. Air System Piping Gauge: Include retard feature and “AIR” or “AIR/WATER” label on dial face.
6. Manufacturers:
   a. AMETEK; U.S. Gauge Division.
   b. Ashcroft, Inc.
   c. Brecco Corporation.
   d. WIKA Instrument Corporation.

2.15 SLEEVES AND PENETRATIONS FOR PIPING SYSTEMS

A. Sleeves:

1. Walls:
   a. Interior and Exterior Walls: Schedule 40 carbon steel.
   b. Concrete: Cast-iron wall sleeves with integrally cast water stop.
   c. Interior Partitions: 22-gauge (U.S. Standard) minimum galvanized sheet steel.
2. Interior Floor: Schedule 40 carbon steel.
3. Slab on Grade: Cast-iron wall sleeves with integrally cast water stop.
4. Underground (Beneath Foundations, Footings, Grade Beams): Standard weight corrugated steel, bituminous coating inside and outside, with close-fitting bituminous coated plate at each end.

B. Sleeve and Penetration Packing:

1. Modular Wall and Casting Seals: Link-Seal as manufactured by Thunderline Corporation, Flexicraft Pipe Seal. Sleeve and modular wall and casting seal to be furnished together as a single integrated unit.
2. Penetration Packing (With or Without Sleeve) for Interior Walls and Interior Elevated Floors:
   a. UL listed, FM approved materials and sealant systems, by 3M Fire Barrier Wrap/Strip FS-195+.
   b. Flexible elastomeric material unless specified otherwise.
   c. Include additional materials and accessories to meet requirements of manufacturer and this section.
   d. Compatible with penetrated surface.
   e. Hazard Ratings:
      1) Pipes Penetrating Fire Rated Walls, Fire Rated Ceilings, and Fire Rated Floor Slabs (1 hour or greater): Material having maximum flame spread of 25 and maximum smoke develop rating of 50, selected to maintain fire rating of penetrated surface.

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2) Pipes Penetrating Other Interior Walls: Material having maximum smoke develop rating of 50, selected to prevent smoke transmission through penetration.
3) Pipes Penetrating Nonrated Interior Floors: Mineral wool and fire-rated caulk.

PART 3 EXECUTION

3.01 PREPARATION

A. Perform fire hydrant flow test according to NFPA 13 and NFPA 291.

B. Submit test results promptly.

3.02 SERVICE-ENTRANCE PIPING

A. Connect sprinkler piping to water service piping for service entrance to building.

B. Install shutoff valve, check valve, pressure gauge, and drain at connection to water service.

3.03 WATER SUPPLY CONNECTIONS

A. Install shutoff valve, backflow preventer, pressure gauge, drain, and other accessories indicated at connection to water service piping.

3.04 PIPING INSTALLATION

A. Locations and Arrangements:

1. Install piping in accordance with approved Shop Drawings, schematics, and diagrams which indicate general location and arrangement of piping.
2. Deviations from approved piping Shop Drawings require written approval from AHJ. Submit written approval to Engineer before deviating from approved working plans.

B. Piping Standard: Comply with NFPA 13 sprinkler piping installation requirements.

C. Seismic Design Category (SDC) is shown on Structural General Notes on Drawings..

D. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

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E. Install unions adjacent to each valve in pipe 2 inches and smaller.

F. Install “Inspector’s Test Connections” in sprinkler system piping, complete with shutoff valve, sized and located according to NFPA 13.

G. Install sprinkler piping with drains for complete system drainage.

H. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

I. Install automatic drain valve at each check valve for fire department connection, to drain piping between fire department connection and check valve. Install drain piping to and spill over floor drain or to outside building.

J. Install alarm devices in piping systems.

K. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with NFPA 13 requirements for hanger materials.

L. Install pressure gauges on riser or feed main, at each sprinkler test connection, and at top of each standpipe.

1. Include pressure gauges with connection not less than 1/4 inch and with soft metal seated globe valve, arranged to drain pipe between gauge and valve.
2. Install gauges to permit removal, and where not subject to freezing.

M. Fill sprinkler system piping with water.

N. Install sleeves for piping penetrations of walls, ceilings, and floors.

O. Install sleeve seals for piping penetrations of concrete walls and slabs.

P. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.05 JOINT CONSTRUCTION

A. Steel Piping:

1. Pressure-Sealed Joints: Join lightwall steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.
2. Welded Joints: Construct joints according to NFPA 13, using qualified processes and welding operators according to Article Quality Assurance.
   a. Shop-weld pipe joints where welded piping is indicated.
   b. Do not use welded joints for galvanized-steel pipe.

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3. Cut-Grooved and Roll-Grooved Joints:
   a. Cut square-edge groove or roll rounded-edge groove in end of pipe according to NFPA 13.
   b. Install grooved joints in accordance with the manufacturer's latest published installation instructions.
   c. Provide grooved ends clean and free from indentations, projections, and tool marks.
   d. Join steel pipe and grooved-end fittings according to NFPA 13 for steel pipe joints.

B. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.06 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and AHJ.

B. Install listed fire protection shutoff valves supervised open, located to control sources of water supply other than fire department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water supply connection. Install backflow preventers instead of check valves in potable water supply sources.

D. Specialty Valves:

1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
2. Alarm Valves: Include bypass check valve and retarding chamber drain line connection.

E. Specialty Sprinkler Fittings: Install downstream of control valves instead of specified fittings if indicated in approved Shop Drawings.

3.07 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels.

B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.

C. Install sprinklers into flexible, sprinkler hose fittings and install hose into bracket on ceiling grid.

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D. Do not install any sprinklers that have been dropped, damaged, or show a visible loss of fluid. Never install any sprinkler with a cracked bulb.

E. Remove sprinkler bulb protector by hand. Do not use any tools or devices that could damage the bulb.

3.08 FIRE DEPARTMENT CONNECTION INSTALLATION

A. Install wall-type, fire department connection.

B. Install automatic drain valve at each check valve for fire department connection.

3.09 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to NFPA 13 requirements.

B. Identify system components.

3.10 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until leak free.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13.
4. Energize circuits to electrical equipment and devices.
5. Coordinate with fire alarm tests. Operate as required.
6. Coordinate with fire pump tests. Operate as required.
7. Demonstrate that equipment hose threads match local fire department equipment.

B. Sprinkler piping system is defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

1. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13; include “Contractor’s Material and Test Certificate for Aboveground Piping.”

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3.11 MANUFACTURER'S SERVICES

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

1. 2 person-days for installation assistance and inspection.
2. 2 person-days for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
3. 2 person-days for prestartup classroom or Site training.
4. 2 person-days for facility startup.
5. 2 person-days for post-startup training of Owner's personnel.
6. Do not commence training until a detailed lesson plan for each training activity has been accepted by Owner.

3.12 CLEANING

A. Clean dirt and debris from sprinklers.

B. Remove and replace sprinklers with paint other than factory finish.

END OF SECTION

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SECTION 21 24 00
DRY-CHEMICAL FIRE-EXTINGUISHING SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

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

1. American Society of Mechanical Engineers (ASME): B31.1, Power Piping.
2. ASTM International (ASTM):
   a. A53, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   b. A106, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
   c. A197, Standard Specification for Cupola Malleable Iron.
3. National Electrical Manufacturer's Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
4. National Fire Protection Association (NFPA):
   a. 17, Standard for Dry Chemical Extinguishing Systems.
   b. 30, Flammable and Combustible Liquids Code.
   c. 70, National Electrical Code.
   d. 72, National Fire Alarm Code.
   e. 75, Standard for the Protection of Electronic Computer/Data Processing Equipment.
   f. 101, Life Safety Code.
   g. 2001, Standard on Clean Agent Fire Extinguishing Systems.

1.02 DEFINITIONS

A. Protected Area: The area of the building that the dry chemical fire extinguishing system protects.

1.03 PERFORMANCE REQUIREMENTS

A. General: Design a system to detect and suppress by total flooding, fires originating in the protected areas indicated on the Drawings.

B. Fire Detection System:

1. Engineered type suitable for interfacing with the FM-200 suppression system.
2. Concept shall provide an alarm mode on the activation of any one fire detector and a predischarge mode on the activation of any two fire detectors located in the protected area.

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C. Fire Suppression System:

1. System shall discharge the total calculated agent quantity into the protected space in a 10-second time period.
2. System shall provide sufficient FM-200 agent for a concentration of 7 percent by volume at 70 degrees F in the protected area. Adjust calculations as required for:
   a. Multiple protected areas served by a common FM-200 supply.
   b. Suspended ceiling space volume (if required).
   c. Volume of ductwork for HVAC system.

1.04 DESIGN REQUIREMENTS

A. General:

1. System shall include both automatic and manual operation, with control panel, fire detectors, alarm devices, manual discharge stations, abort stations, agent storage containers, piping, nozzles, wiring, conduit, and other auxiliary devices specified herein or required to provide a complete system.
2. System shall conform to the requirements of applicable codes, standards, and authorities including, but not limited to:
   a. National Fire Code; NFPA Nos. 12A, 70, 72, 75, and 2001, including appendages.
   b. Requirements of city, county, or state authorities having jurisdiction.
   c. Requirements of Owner's insurance underwriter, if applicable.
   d. Equipment shall be UL listed and/or Factory Mutual (FM) approved for fire protection.
3. Obtain all permits, arrange all inspections, and perform all systems tests required by the applicable codes and the authorities having jurisdiction.

B. Protected Area Segregation:

1. System shall be based on the protected area enclosure being of sufficient tightness to guard against extinguishing agent exfiltration including, but not limited to, exit doors and windows, piping, and electrical conduit.
2. Area segregation shall require HVAC system supply and return serving the protected space to shut down, and the air duct system motorized dampers to close.

C. Hydraulic Calculations:

1. Base on unbalanced piping principle as defined in NFPA No. 12A and include:
   a. Agent quantity for each nozzle.

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b. Nozzle type and size.
c. Nozzle pressure.
d. Number of agent storage cylinders, cylinder fill weight, and density.
e. Total FM-200 agent weight.
f. Pipe schedule including sizes, length, volume, and percent of agent in pipe after discharge.
g. Discharge time.
h. Pressure at beginning of pipe network.
i. Pressure at beginning and end of each pipe section.
j. Flow rate, density, and pressure drop per pipe section.

D. Pipe Supports: Design and fabrication shall conform to the requirements of ASME B31.1.

E. Discharge Nozzles:

1. Provide sufficient nozzles to assure a uniform agent concentration throughout protected area.
2. Space discharge nozzles as required by applicable codes and manufacturer's criteria.
3. Consider additional nozzles based on area conditions and manufacturer's recommendations.

F. Fire Detectors:

1. Ionization and photoelectric type.
2. Base spacing and installation on guidelines in NFPA 72 recommended practices for ceiling construction and airflow, and on manufacturer's recommendations.

G. Locate manual discharge and abort stations at all exit doors from the protected area.

H. Locate alarm devices within the protected area and above each exit door outside the protected area.

I. Control Panel:

1. Panel Locations: As shown on Drawings.
2. Locate to provide control, supervision, annunciation, and power for the operation of the fire suppression zone and detection circuits.
3. Provide rechargeable battery supply to automatically operate each protected area system including detectors, control panel, manual stations, alarm sounding devices, and auxiliary equipment in the event of a loss of primary power.

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4. Provide a common general alarm circuit for common area signaling.
5. Provide form "C" SPDT dry contacts for general alarm and trouble.
6. Provide a single switch that will silence active signals without affecting subsequent signals.
7. Provide diagnostic indicators to indicate, at a minimum, ac power loss, dc power fault, auxiliary power loss, system common ground fault, and trouble in the common general alarm circuit.
8. Control Circuitry:
    a. Provide each protected area with the following supervised circuits:
        1) Detection: Utilizing cross-zoned or counting zone.
        2) Individually Fused and Silenceable Audible Circuits:
            a) Three required.
            b) Individual diagnostic fault indicators.
            c) Minimum of 24V dc, at 350 mA available power.
            d) Program to operate on alarm, predischarge, and discharge.
        3) Manual Release:
            a) Programmable with the following options:
                (1) Override time delay and abort circuit. Discharge will be immediate.
                (2) Override abort circuit but not the time delay. Discharge occurs at the end of the time delay.
                (3) Not override time delay or abort circuits.
        4) Time Delay:
            a) Field programmable in 1-second intervals from 0 second to 60 seconds.
            b) Have the ability, through the abort circuit, of being recycled and held until the abort switch is released.
            c) Control panel-mounted digital countdown timer.
            d) Illuminated digital display when the system time delay is active and counting down.
        5) Agent Release:
            a) Parallel wired initiators or solenoids, fully supervised.
            b) Wired in a Class A configuration such that a trouble signal will occur if there is a break in the wiring.
            c) System shall function properly if a fire condition occurs with this abnormal condition.
        6) Abort:
            a) Dedicated and supervised.
            b) Actuation shall recycle the time delay to its original setting, and begin counting after the abort station (momentary) pushbutton is released.
        7) Container Low-Pressure: Dedicated and supervised.

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8) Diagnostic Fault Indicators: Detection, alarm audible, predischarge audible, discharge audible, manual release, and abort circuits; discharge circuit wiring; discharge device; relay connection; and low pressure.
9) Area ALARM/DISABLED Switch:
   a) Switch to disable the FM-200 discharge circuit.
   b) Switch shall not interfere with the detection or audible circuits.
   c) Operation of this switch shall cause a distinctive trouble indication for the area involved.
10) Protected Area Control Panel:
   a) Six DPDT and two SPDT auxiliary relays rated at 10 amps at 120V ac/3V dc resistive.
   b) Programmable relays for operation in alarm, predischarge, discharge, or trouble modes.
   c) Programming of relays without the need to relocate wiring.
   d) Means to individually operate relays without the need to put the control panel into alarm condition.
   e) Means to prevent each relay from operating in event of system testing.
11) Capability to transmit a trouble indication from each area.

J. Control System:

1. Actuation of a fire detector in the protected area shall initiate the following control functions:
   a. Light the corresponding suppression zone light on control panel.
   b. Activate alarm.
   c. Shut down HVAC equipment and close motorized air duct dampers serving protected area.
   d. Transmit a signal (close a normally open alarm contact) to the building fire alarm system.
2. Actuation of a second fire detector in the protected area shall initiate the following control functions:
   a. Light the corresponding suppression zone light on control panel.
   b. Activate strobe/horn combination signaling predischarge of FM-200.
   c. Shut down control and electrical equipment in the protected area.
   d. Start preset agent discharge time delay.
   e. Transmit a signal (close a normally open alarm contact) to the building fire alarm system.

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3. If predischarge is not aborted, and time delay expires, system shall discharge and strobe lights shall be activated outside the protected area.
4. Actuation of manual discharge stations shall immediately discharge FM-200 into the protected area and initiate the following control functions:
    a. Light suppression zone light on control panel.
    b. Activate visual and audible alarm devices.
    c. Transmit a signal (close a normally open alarm contact) to the building fire alarm system.
5. Trouble conditions caused by open fire detector, valve actuator circuit wiring, or loss of agent storage container pressure shall initiate the following control functions:
    a. Light the corresponding suppression zone light on control panel.
    b. Light system trouble light.
    c. Sound system trouble signal.
    d. Transmit a signal (close a normally open trouble contact) to the building fire alarm system.
6. Trouble conditions caused by open bell wiring, open battery circuit wiring, silenced alarm sounding devices, or loss of primary power shall initiate the following control functions:
    a. Light system trouble light.
    b. Sound system trouble signal.
    c. Transmit a signal (close a normally open trouble contact) to the building fire alarm system.

K. FM-200 Reserve Supply:

1. Provide a reserve supply of agent and storage containers equal to the main supply.
2. Include required piping, actuating devices, and miscellaneous components to provide a permanently connected reserve system.
3. Reserve containers may have a completely separate set of piping and nozzles, or be connected to the same piping as the main supply.
4. Provide a key operated selector switch to change from the main system to the reserve supply.
5. Provide isolation check valves in discharge piping to prevent loss of agent or injury to personnel in event of system actuation when an agent container is removed.
6. Transfer to Connected Reserve shall be by means of an electrical switch mounted near the control panel.

L. Provide electrical intertie between building fire alarm system, HVAC equipment, and protected area FM-200 control panel as specified in Division 26, Electrical.

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1.05 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Data sheets, catalog cuts, and technical information describing system components and devices to be installed.
   b. Calculations for standby battery power.
   c. Wiring diagrams including elementary, electrical termination, and interconnection diagrams
   d. One-line conduit diagrams showing equipment locations, conduit locations, wire size, number of conductors, equipment mounting and other construction details.
   e. Isometric piping diagrams showing location of agent storage containers, pipe sizes, pipe lengths, and fittings. Key to required piping and nozzle calculations, and cross reference all junctions with calculations.
   f. Complete details on support of agent storage containers.
   g. Anchorage and bracing drawings and catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads provided in Section 01 61 00, Common Product Requirements.

B. Informational Submittals:

1. Experience qualification listing of firm(s) proposed to design and install the system.
2. Design Calculations:
   a. Hydraulic flow from a UL listed computer program, including the manufacturer's name and UL listing for verification.
   b. Include individual pipe lengths and fittings to be used.
   c. Verify that the design concentration of FM-200 is reached within specified time.
3. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing, for loads provided in Section 01 61 00, Common Product Requirements. Submit with Action Submittal for the same item.
4. Test Plan: Submit as specified in Article Field Quality Control, at least 30 days prior to beginning functional testing.
5. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
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.

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1.06 QUALITY ASSURANCE

A. Qualifications: System design and installation shall be by licensed firm(s) having a minimum of 5 years of documented experience in the design, installation, and testing of similar types of suppression systems.

1.07 MAINTENANCE

A. Inspections During Warranty Period:

1. Provide two system inspections, at 6 months and at 12 months, during the 1-year Correction Period.
2. Conduct the inspections in accordance with the manufacturer's guidelines and in compliance with NFPA 2001.
3. Submit documentation to Owner upon completion of each inspection certifying satisfactory system operation.

1.08 EXTRA MATERIALS

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

Item	Quantity
Nozzles	One

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 SYSTEM CONTROL PANEL

A. General: Panel shall contain required system operation lights, reset and silence switches, circuits, relays, a standby battery power and either an enclosed or adjacently mounted battery charger, and all other devices necessary to provide a complete automatic control system.

B. Cabinet:

1. UL listed and FM approved as an alarm-releasing control unit.
2. NEMA 250, Type 1.
3. Surface mounted, 18-gauge steel.
4. Door: Hinged, key lockable.
5. Finish: Manufacturer's standard color.

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C. Standby Battery:

1. Minimum Capacity: 6 Ah.
2. Sized to operate the system for a minimum of 24 hours in supervisory condition and 5 minutes in alarm control condition immediately after the time in supervisory condition.
3. Sealed, gelled electrolyte type, designed for fire alarm service.
4. Supervised to provide a trouble signal on low voltage, open, or shorted cell.

D. Battery Charger:

1. Automatic, solid state, capable of charging batteries from 75 percent to 100 percent of full charge within 24 hours.
2. Voltmeter or other means to display battery condition.
3. Enclosure: Manufacturer's standard.

2.02 FIRE DETECTION BASE AND DEVICES

A. Base:

1. Interchangeable with photoelectric or thermal type detectors.
2. LED that illuminates steadily upon detector sensing a fire condition and with ability to power a remote annunciator that will duplicate LED indication.

B. Detection Devices, General:

1. Equip with a means of securing head to base in a manner that head may not be readily tampered with or removed.
2. UL listed and FM approved.

C. Ionization Type Device:

1. Dual chamber type, utilizing solid state circuitry.
2. Unaffected by RF energy from 1 kHz through 100 MHz or air velocities up to 3,000 fpm.

D. Photoelectric Type Device:

1. Solid state circuitry, pulsed infrared LED light source, and silicon photodiode receiving element.
2. Incorporate means to discriminate between valid fire signals and nonfire signal.

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3. Include a fine stainless steel mesh cover to prevent foreign objects from entering sensing chamber.
4. Dew-proof and unaffected by air velocities up to 3,000 fpm.

2.03 MANUAL DISCHARGE STATION

A. Furnish to provide a means of manually discharging the fire suppression system in case of an emergency.

B. Stainless steel, with keyed red release button.

C. Cover shall include operating instructions and identify discharge station as a FM-200 discharge component.

D. Double-pole switch.

E. UL listed and FM approved.

2.04 DISCHARGE ABORT STATION

A. “Deadman” type requiring constant pressure to transfer one set of normally open and one set of normally closed contacts on each contact block.

B. Digital countdown timer to indicate time remaining until system discharge.

C. Faceplate constructed of stainless steel, with abort button, operating instructions, and identification as a component of the FM-200 system.

D. Rated 6 amps at 120V ac and 1 amp at 120V dc, with ability to override shutdown of HVAC and control equipment.

E. UL listed and FM approved.

2.05 ALARM BELL

A. Vibrating type, approved for use with the control unit provided.

B. Polarized for full supervision, and rated at 24V dc, drawing no more than 0.063 amps.

C. Noise Level: 86 dB to 90 dB at 10 feet.

D. Finish: Baked red enamel.

E. UL listed and FM approved.

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2.06 STROBE LIGHT

A. Rating: 24V dc with amperage draw of 0.033 amp.

B. Lamp protected by a white translucent lens imprinted with the word FM-200 in red letters.

C. Polarized, powered from the control panel.

D. UL listed and FM approved.

2.07 AGENT STORAGE CONTAINERS

A. High-strength alloy steel, equipped with the following:

1. Integral lifting ring.
2. Automatic, remotely operated discharge valve assembly.
3. 0 psi to 600 psi pressure gauge.
4. Electrically supervised valve actuator.
5. Filling valve to allow recharging in place.
6. Supervisory pressure switch to sense loss of agent from the container.
7. Liquid level indicating device, UL listed.

B. Container and Valve: Conform to DOT Specification 4BW500 or 4BA500.

C. Automatic Pressure Relief: On overpressure condition of 810 psi to 1,000 psi.

D. Super pressurized with dry nitrogen to 360 psig at 70 degrees F.

2.08 PIPING

A. In accordance with Section 22 10 01, Plumbing Piping and Accessories:

1. Distribution Piping: Black or galvanized steel, ASTM A53, Grade A, or ASTM 106, Grade A, B, or C.
2. Fittings: Malleable iron, 300-pound class, ASTM A197.

2.09 ELECTRICAL

A. In accordance with Division 26, Electrical.

PART 3 EXECUTION

3.01 DETECTORS

A. Install ionization and photoelectric detectors such that spacing per detector does not exceed 250 square feet.

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B. Do not install detectors closer than 3 feet from air supply diffusers and 1 foot from wall.

C. Conform to NFPA No. 72E, latest edition.

3.02 AGENT STORAGE CONTAINERS

A. Floor mount and securely support to wall with wall brackets.

B. Attach mounting brackets and piping to the structure in a manner capable of withstanding the thrust developed during discharge without displacement.

C. Connect the same size containers to a common manifold.

3.03 CONNECTED RESERVE

A. Provide complete connected reserve supply of FM-200 in agent containers, duplicating those in main supply.

3.04 PIPING

A. Install in accordance with Section 22 10 01, Plumbing Piping and Accessories.

B. Cap pipe ends immediately after installation. Maintain until nozzles are installed.

C. Provide escutcheon plates at all pipe penetrations through walls, floors, and ceilings.

D. Pipe Supports: Install in accordance with ASME B31.1.

3.05 ELECTRICAL

A. Install in accordance with Division 26, Electrical.

3.06 SIGNS

A. In addition to the following, provide as required to comply with NFPA 2001 and the recommendations of the FM-200 equipment manufacturer:

1. Caution:
    a. Provide on all entry doors to FM-200 protected areas.
    b. Wording: Alert personnel that room is protected by FM-200 and all doors must be kept closed in event of fire.

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c. Size: 10 inches by 14 inches by 1/16 inch, constructed of plastic, with black face and yellow letters.

2. Manual Discharge:
   a. Provide adjacent to each manual discharge station.
   b. Identify the manual discharge station as the place where FM-200 can be manually discharged.
   c. Size: 4 inches by 4 inches by 1/16 inch, constructed of plastic, with red face and white letters.
3. Flashing Light:
   a. Provide adjacent to each strobe horn and light.
   b. Explain the presence of the flashing lights.
   c. Size: 7 inches by 4 inches by 1/16 inch, constructed of plastic, with red face and white letters.

3.07 FIELD FINISHING

A. As specified in Section 09 90 00, Painting and Coating.

B. Pipe Labeling:

1. Label with the legend FM-200 EXTINGUISHING AGENT in letters 1 inch high.
2. Maximum Intervals:
   a. Exposed Piping: 12 feet.
   b. Concealed Piping: 20 feet.

3.08 FIELD QUALITY CONTROL

A. General: System functional and performance testing shall be conducted by qualified, trained personnel in accordance with the manufacturer's recommended procedures and NFPA 2001.

B. Test Plan:

1. Prepare a plan of testing to include a step-by-step description of all tests to be performed and the type and location of test apparatus to be employed.
2. Testing shall not be conducted until the Test Plan has been approved.

C. Functional Tests:

1. Perform under supervision of equipment manufacturer and with the Engineer present.
2. All functional testing, including system and equipment interlocks, must be successfully completed at least 5 days prior to beginning performance testing.

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3. Check all containers and distribution piping for proper mounting and installation.
4. Test all electrical wiring for proper connection, continuity, and resistance to ground.
5. Verify that HVAC connections to the area have properly installed dampers, and HVAC equipment will shut down upon a signal from the FM-200 control panel.
6. Test each detector in accordance with the manufacturer's recommended procedures, and record test values.
7. Demonstrate that all system and equipment interlocks, such as door release devices, audible and visual devices, equipment shutdowns, and local and remote alarms function as designed.
8. Test each control panel circuit by inducing a trouble condition into the system.

D. Performance Test:

1. Perform under actual or approved simulated operating conditions to demonstrate that the entire control system functions as designed and intended.
2. Perform under supervision of equipment manufacturer.
3. Demonstrate to the Engineer**,** Owner, and authorities having jurisdiction, operation of all components under simulated fire conditions.
4. Test in accordance with NFPA 2001.
5. Conduct using the Retro-Tec Corp. door fan system, or equivalent, with integrated computer program.
6. Room Pressurization:
   a. Conduct test, at room pressurization in each protected space, to determine the presence of openings that would affect the system concentration levels.
   b. Seal all protected spaces against agent loss or leakage.
   c. Conduct pressurization tests until protected space is shown to be successfully sealed.
7. Test the following circuits:
   a. Automatic actuation.
   b. A.R.M.
   c. Manual actuation.
   d. HVAC and power shutdowns.
   e. Audible and visual alarm devices.
   f. Manual override of abort functions and agent container pressure supervision.
   g. Supervision of all panel circuits, including ac power and battery power supplies.
8. Upon acceptance by Owner, recharge system if required, and place the completed system into normal service.

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3.09 MANUFACTURER'S SERVICES

A. Provide qualified manufacturer's representative(s) for the equipment specified herein at the Job Site and classroom designated by the Owner for the following services:

1. Installation assistance, inspection, and certification of installation.
2. Functional and performance testing assistance.
3. Classroom or Job Site training of Owner's operations and maintenance personnel.

END OF SECTION

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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.
4. Underwriters Laboratories, Inc. (UL).

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. 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.

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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.

1.04 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 Site shall have manufacturer's stamp or label attached, giving name of manufacturer, brand, and description of material.
2. Insulation packages and containers shall be marked "asbestos-free."

PART 2 PRODUCTS

2.01 GENERAL

A. Insulation exterior shall be cleanable, grease-resistant, nonflaking, and nonpeeling.

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

C. Insulation for fittings, flanges, and valves shall be 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, shall be noncombustible.
2. Use no fugitive or corrosive treatments to impart flame resistance.
3. Flame proofing treatments subject to deterioration due to effects of moisture or high humidity are not acceptable.
4. Materials 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 tests conducted in accordance with NFPA 255 methods.

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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.

2.02 PIPE INSULATION

A. Type P1—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.
    c. Rubatex; R-180-FS.

2.03 INSULATION FINISH SYSTEMS

A. Type F1—PVC:

1. Polyvinyl chloride (PVC) jacketing, white, for straight run piping and fitting locations, temperatures to 159 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. Manufacturers and Products:
    a. Armstrong; WB Armaflex finish.
    b. Rubatex; 374, white finish.

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.

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3. Fitting Covers: Material as for aluminum roll jacketing, premolded, one or two piece covers, which includes elbows, tee/valves, end caps, mechanical line couplings, and specialty fittings.
4. 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.

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 foamglass inserts where pipe hangers bear on outside of insulation.

K. Insulation on piping that is to be heat traced shall be installed after installation of heat tape.

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

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

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

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

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

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

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

S. 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.

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

U. 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.

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.

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

B. Potable Hot Water:

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

C. Pipe Hangers:

1. Type P1, 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): 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 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. 1070, Performance Requirements for Water Temperature Limiting Devices.
5. ASTM International (ASTM):
   a. A47/A47M, Standard Specification for Ferritic Malleable Iron Castings.
   b. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   c. A74, Standard Specification for Cast Iron Soil Pipe and Fittings.
   d. A105/A105M, Standard Specification for Carbon Steel Forgings for Piping Applications.
   e. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   f. A179/A179M, Standard Specification for Seamless Cold-Drawn Low-Carbon Steel Heat-Exchanger and Condenser Tubes.
   g. A181/A181M, Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.
   h. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   i. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   j. A197/A197M, Standard Specification for Cupola Malleable Iron.

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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. C1277, Standard Specification for Shielded Couplings Joining Hubless Cast Iron Soil Pipe and Fittings.
ff. C1460, Standard Specification for Shielded Transition Couplings for use with Dissimilar DWV Pipe and Fittings Above Ground.
gg. C1540, Standard Specification for Heavy Duty Shielded Couplings Joining Hubless Cast Iron Soil Pipe and Fittings.
hh. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.

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ii. D1785, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
jj. D2000, Standard Classification System for Rubber Products in Automotive Applications.
kk. D2239, Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.
ll. D2466, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
mm. D2513, Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings.
nn. D2564, Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
oo. D2683, Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
pp. D2855, Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.
qq. D3035, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
rr. D3261, Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
ss. D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
tt. E438, Standard Specification for Glasses in Laboratory Apparatus.
uu. F656, Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings.
vv. F714, Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.
ww. F1412, Standard Specification for Polyolefin Pipe and Fittings for Corrosive Waste Drainage Systems.
xx. F1924, Standard Specification for Plastic Mechanical Fittings for Use on Outside Diameter Controlled Polyethylene Gas Distribution Pipe and Tubing.
yy. 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.

6. 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.

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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. C606, Grooved and Shouldered Joints.
i. C651, Disinfecting Water Mains.

7. Cast Iron Soil Pipe Institute (CISPI):
   a. 301, Standard Specification for Hubless Cast Iron Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
   b. 310, Specification for Couplings for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Strom Drain, Waste, and Vent Piping Applications.
8. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
9. Plumbing and Drainage Institute (PDI): WH 201, Water Hammer Arresters Standard.

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. ICC International Plumbing Code and Local 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.
   b. Anchorage and bracing drawings and data sheets, as required by Section 01 88 15, Anchorage and Bracing.
3. Isometric riser diagrams showing equipment, valves, elevations and fixtures.

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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.

2.02 PIPING

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

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

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2.03 HOSE VALVES AND HYDRANTS

A. HV-1 Hose Valve:

1. Cast bronze globe valve, 3/4-inch size, with NPT screwed ends, union bonnet, rising stem, Teflon disc, hand wheel, and NPT by NST hose thread adapter outlet connection.
2. Rated 150-pound service water pressure, 300-pound WOG.
3. Manufacturers and Products:
   a. Nibco; Catalog No. T-235-Y, Angle No. T-335-Y.
   b. Crane Co.; Catalog No. 7TF, Angle No. 17TF.

B. HV-2 Hose Valve:

1. Cast bronze globe valve, 1-1/2-inch size, with NPT screwed ends, union bonnet, rising stem, Teflon disc, hand wheel, and NPT by NST hose thread adapter outlet connection.
2. Rated 150-pound SWP, 300-WOG.
3. Manufacturers and Products:
   a. Nibco; Catalog No. T-235-Y, Angle No. T-335-Y.
   b. Crane Co.; Catalog No. 7TF, Angle No. 17TF.
   c. Crane Co.; Catalog No. 7TF, Angle No. 17TF.

C. HV-3 Hydrant:

1. Sill faucet with removable T-handle, polished chrome finish, and 3/4-inch inlet and hose connection.
2. Manufacturers and Products:
   a. Chicago; No. 387, with No. E27 vacuum breaker.
   b. Acorn; No. 8121.

2.04 PIPE HANGERS AND SUPPORTS

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

2.05 INSULATION

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

2.06 VALVES

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

B. Gauge Cock Valves 1/8 Inch to 3/8 Inch:

1. Bronze body, hexagon male and female ends, and tee head.
2. Rated for 125-pound SWP.

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3. Manufacturers and Product:
   a. Ernst Gage Co.
   b. Lunkenheimer.

C. Manual Air Vent Valves:

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

D. Pressure Reducing Valve, Natural Gas and Propane, 2 psi to 14-Inch WC:

1. Direct diaphragm, spring controlled cast-iron body, spring aluminum diaphragm and spring case, nitrile disc/diaphragm/O-rings, internal relief, NPT thread ends, 125-psig rated.
2. Size/Rating: Size per Drawings, inlet pressure of 2 psig, outlet pressure set at 13-inch water column or as required by equipment connection.
3. Manufacturer and Product:
   a. Maxitrol; 210D for outdoor equipment.
   b. Maxitrol; R600 for indoor equipment, provide with vent limiter.

E. Point of Use Thermostatic Mixing Valve Assembly:

1. Function: Provide tempered water at 0.5 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 105 degrees F at inlet pressures between 30 psig and 90 psig.
7. Set outlet at 105 degrees F maximum unless otherwise noted.
8. Manufacturers and Products:
   a. Leonard Valve; Model 170-LF.
   b. Watts; LFUSG-B-M2.
   c. Powers; LFe480.

2.07 MISCELLANEOUS PIPING SPECIALTIES

A. Refer to Section 40 27 01, Process Piping Specialties and below.

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B. Strainers for Water Service:

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

C. Vacuum Breakers 2 Inches and Smaller:

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

D. 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 660.
   b. Precision Plumbing Products, Inc.

E. Water Hose:

1. Furnish 2, 50-foot length(s) of 3/4-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. Manufacturers:
   a. Goodyear.
   b. Boston.

F. Hose Nozzles:

1. Furnish 2, 3/4-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. Manufacturers:
   a. Sani-Lav.
   b. Vikan.

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G. Sleeves:

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

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

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

K. Rubber Gaskets: ASTM C564.

2.08 MEASURING DEVICES

A. Thermometers:

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 brass thermowell.
3. Manufacturers and Product:
   a. Trerice Co.; Model A005.
   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.
3. Manufacturers and Products:
   a. Ashcroft; Type 1008.
   b. Marsh; J80.
   c. Marshalltown.

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PART 3 EXECUTION

3.01 GENERAL

A. Install plumbing systems to meet applicable plumbing code.

B. 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.

C. 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.

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

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

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

G. Provide isolation valves and strainers at pressure regulators.

H. Trench Excavation and Backfill: As specified in Section 31 23 16, Excavation, and Section 31 23 23.15, Trench Backfill.

3.02 INSTALLATION

A. Steel Pipe:

1. Ream, clean, and remove burrs and mill scale from piping before making up.
2. Seal joints with pipe joint sealer or Teflon tape.

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B. 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.

C. 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.

D. Water Hammer Arresters:

1. Install in piping systems where shown on Drawings and adjacent to pieces of equipment where quick closing valves are installed.
2. Install at all emergency safety showers and eyewashes.
3. Size and install in accordance with PDI-WH201.
4. 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 WATER SUPPLY PIPING

A. Water supply piping includes potable (W1), hot water (HW), and return hot water (RHW).

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 3 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.

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.

3.04 INSULATION

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

3.05 HANGERS AND SUPPORTS

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

3.06 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.

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B. Where construction joints occur, or 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.

3.07 INTERIM CLEANING

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

3.08 TESTING

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

3.09 CLEANING AND DISINFECTION

A. As specified in Section 33 13 00, Disinfecting of Water Utility Distribution.

3.10 CORROSION PROTECTION

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

3.11 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.

3.12 FIELD FINISHING

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

3.13 PIPING IDENTIFICATION

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

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3.14 SUPPLEMENTS

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

1. Plumbing Piping Data Sheets.

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 10 01.03 CAST IRON SOIL PIPE (CISP) AND FITTINGS		
Item	**Size**	**Description**
Pipe	6" and smaller	Hubless, CISPI 301, service weight, no-hub ends.
	8" and larger	Hub and spigot, ASTM A74, service weight, single hub and spigot.
Joints	6" and smaller	Coupling: Conform to ASTM C564, ASTM C1277 or, ASTM C1540 and CISPI 310. Compression: Neoprene sealing sleeve with 24-gauge Type 304 stainless steel shield and clamp assembly. Joints to dissimilar material shall comply with ASTM C1460.
	8" and larger	Rubber gaskets, ASTM C564.
Fittings	6" and smaller	Conform to ASTM A888 and CISPI 301.
	8" and larger	Conform to ASTM A74.
Coating	All	Bituminous-coated inside and out; marked with manufacturer’s name or trademark and CISPI symbol.

END OF SECTION

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SECTION 22 10 01.12 POLYETHYLENE (PE) PIPE AND FITTINGS— NATURAL GAS SERVICE		
Item	**Size**	**Description**
General	All	Pipe lengths, fittings, and connections to be joined by thermal fusion; shall be same type, grade, and class of polyethylene compound and supplied from same raw material supplier. Pipe tubing and fittings manufactured in accordance with ASTM D2513.
Pipe	1/2" to 4"	ASTM D2513 medium-density polyethylene, maximum allowable hoop stress 1,250 psi at 73.4 degrees F. Polyethylene Resins: Conform to Type PE 2406/2708 or better. Pipe wall thickness shall reflect required SDR* and diameter, as shown in Table 8, ASTM F714. Design Stress Rating: ASTM F1924, 1,250 psi hydrostatic design basis (HDB). Pressure Rating (psi) at 100 degrees F — SDR* 80 — 11.0 Note: Installed outdoors and underground only. Operating pressure for natural gas piping shall be limited to 100 psig or less per 2009 IFGC. Identification: Pipe and fittings shall be yellow in color and shall be marked “ASTM D2513”. *SDR: standard dimension ratio = OD/thickness
Fittings	4" & smaller	Molded Fittings: Conform to PE 2406/2708. Socket Fusion Fittings: Meet requirements of ASTM D2683. Butt Fusion Fittings: Meet requirements of ASTM D3261.

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SECTION 22 10 01.12 POLYETHYLENE (PE) PIPE AND FITTINGS— NATURAL GAS SERVICE		
Item	**Size**	**Description**
Flanges	All	Flanges not permitted underground. Above ground, flanges and bolting shall be part of approved, listed transition fitting.
Risers and Transitions		Conform to ASTM F1973.
Manufacturer		Pipe: JM Eagle UAC 2000 MDPE yellow gas pipe; Driscoplex 6500 series. Risers and Transitions: Georg Fischer Central Plastics.

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. Underwriters Laboratories Inc. (UL).

1.02 SUBMITTALS

A. Action Submittals: Manufacturer's product data.

B. Informational Submittals: 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.

2.02 WATER HEATERS

A. Instantaneous Electric Water Heater:

1. Description: UL listed, tankless with removable cover, replaceable heating element, immersion-type thermostat, replaceable inlet filter, and flow regulator.
2. Capacity: See Plumbing Schedules on Drawings.

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3. Installation: Install per manufacturer recommendations and local building code. Provide all valves, strainers, and appurtenances recommended per manufacturers installation instructions.
4. Manufacturers:
    a. Chronomite Laboratories, Inc.
    b. EEMAX, Inc.
    c. Hubbell, Inc.

B. Gas Water Heating System (Commercial):(20-GWH-01):

1. Description: Complete packaged system including skid-mounted water heater, storage tank, circulation pump, controls, interconnecting piping, fittings, and valves.
    a. Water Heater:
        1) Automatic, gas-fired, instantaneous type with the following features:
            a) Direct vent.
            b) Sealed combustion chamber.
            c) Copper or Cupro-Nickel finned heat exchanger.
            d) Ceramic-lined combustion chamber.
            e) ASME rated for 160 psig working pressure and 180 degrees F temperature.
    b. Regulatory Compliance: AGA, ASME, ASHRAE 90.1, and NSF.
    c. Tank: Steel, glass-lined, 150 psig working pressure.
    d. Insulation: Foam or fiberglass type with minimum R-value per ASHRAE 90.1.
    e. Pressure/Temperature Relief Valve: ASME rated.
    f. Connections: Inlet and outlet with factory-installed dielectric unions and brass drain valve with hose thread.
    g. Burner: Stainless steel, 90 plus percent efficient.
    h. Vent: Direct Vent through wall with a concentric vent.
    i. Controls:
        1) Fully automatic with the following:
            a) Diagnostic controls.
            b) Hot surface ignition control or spark ignition.
            c) Diagnostics control panel.
            d) Flow switch.
            e) Furnish with 110v wall plug.
    j. Guarantee: 5 years.
2. Capacity: See schedule in drawings.
3. Manufacturers:
    a. AO Smith.
    b. Bradford White Corporation.
    c. Lochinvar Corporation.
    d. State Industries, Inc.

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2.03 DOMESTIC WATER EXPANSION TANK

A. Description:

1. Type: Pre-pressurized 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.
8. Anchor tank in accordance with manufacturer's instructions. Provide mounting bracket for wall installation.
9. Capacity: See Plumbing Schedules on Drawings.

B. Manufacturer: AMTROL, Inc.; Model ST.

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. Capacity: See Plumbing Schedules on Drawings.

B. Manufacturers:

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

2.05 ELEVATOR SUMP PUMP SYSTEM

A. Provide centrifugal pumps as specified herein. Refer to drawing for equipment capacity requirements. The manual pump is connected to a control which has the ability to prevent oil from being pumped from the sump. This same control unit will activate an alarm when an oil "film" is detected or when a high-water condition exits. The system will continue to monitor and remove water from the vault even if an oil condition is detected.

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B. Sump pump shall be constructed of class 25 cast iron. The motor housing shall be oil filled to dissipate heat. Air filled motors shall not be considered equal since they do not properly dissipate heat from the motor. All mating parts shall be machined and sealed with a Buna-N O-ring. All fasteners exposed to the liquid shall be stainless steel. The motor shall be protected on the top side with sealed cord entry plate with molded pins to conduct electricity, eliminating the ability of water to enter internally through the cord. The motor shall be protected on the lower side with a unitized ceramic/carbon seal with stainless steel housings and spring or engineered double lip seal with stainless steel springs. The pump shall be furnished with a stainless-steel lift handle.

C. Pump shall be supplied with a multi-conductor 25-foot wall plug power cord capable of continued exposure to the pumped liquid. The power cord shall be sized for the rated full load amps of the pump in accordance with the National Electric Code. The power cable shall not enter the motor housing directly but will conduct electricity to the motor by means of a watertight compression fitting cord plate assembly with molded pins to conduct electricity.

D. Motors shall be oil filled, capacitor start, class B insulated NEMA B design rated for continuous duty. Air filled motors are not considered equal. At maximum load, the winding temperature shall not exceed 135°C unsubmerged. Motors shall have an integral thermal overload switch in the windings for protecting the motor.

E. Provide upper and lower ball bearing shall be required. Both the upper and lower bearing shall be a single ball/race type bearing. Both bearings shall be permanently lubricated by the oil that fills the motor housing. The motor shaft shall be made of 300 or 400 series stainless steel.

F. Furnish a complete control package with that has three probes and a float ball switch. The pump will activate when the middle probe contacts water, and will remain on until the first, longest probe is no longer in contact with water. A high-water alarm is activated when the third or shortest probe contacts water. Furnish with wall plugs to allow for a simple installation of control devices.

G. The system will ignore a small film of oil, however larger volumes of oil will be detected when the alarm probe does not detect water and the float ball activates. The system will continue to operate, removing water, not oil, from the vault even when oil has been detected.

H. The pump shall have a ground continuity check and the motor chamber shall be hi-potted to test for electrical integrity, moisture content and insulation defects.

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I. Manufacturers:

1. Liberty Pump: ELV250
2. SyncroFlo.
3. Grundfos.

2.06 BACKFLOW PREVENTERS

A. Reduced-Pressure Backflow Preventers (3/4 Inch Through 2 Inches):

1. Description:
   a. Regulatory Compliance: AWWA C511, CSA B64.4, FCCHR of USC Section 10, ASSE 1013, 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.
   h. Accessories: Drainline air gap fitting.
2. Sizes: See Plumbing Schedules on Drawings.
3. Manufacturers and Products:
   a. Febco; Model LF 860.
   b. Watts; Model LF 909.

PART 3 EXECUTION

3.01 INSTALLATION

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

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.
2. Piping Systems: Verify that flushing, cleaning, and testing has been completed prior to startup.

END OF SECTION

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SECTION 22 40 00
PLUMBING FIXTURES

PART 1 GENERAL

1.01 REFERENCES

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

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

1.02 SUBMITTALS

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

1.03 REGULATORY REQUIREMENTS

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

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PART 2 PRODUCTS

2.01 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.

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.

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3. Faucet Fittings:
   a. Sinks:
      1) Chicago.
      2) T&S Brass.
   b. Lavatories:
      1) Chicago.
      2) Symmons.
4. Shower Trim:
   a. Symmons.
   b. Powers.
5. Shower Stalls:
   a. Aqua Glass.
   b. Fixture Manufacturers.
6. Stainless Steel Sinks:
   a. Elkay.
   b. Just.
7. Mop Sinks:
   a. Stern-Williams.
   b. Fiat Products Inc.
   c. Fixture Manufacturers.
8. Drinking Fountains and Electric Water Coolers:
   a. Elkay.
   b. Haws.
   c. Western.
9. Wash Fountains:
   a. Bradly.
   b. Acorn.
   c. Intersan.
   d. Willoughby.

C. Emergency Showers and Eyewashes:

1. Haws.
2. Western.
3. Guardian.

D. Drainage Products:

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

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

2.03 GENERAL

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

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

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.

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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. 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.
    e. Mount: Wall mounting can.
    f. Manufacturer and Product: Haws Drinking Faucet Co.; Model H1011.8.
4. EWC-2, Electric Water Cooler (Single Unit):
    a. Finish: Steel baked enamel cabinet, satin finish stainless steel receptor, chrome-plated bubbler.
    b. Valve: Front self-closing push bar with automatic stream regulation.
    c. Trim: Screwdriver stop, strainer, and P-trap with cleanout.
    d. Bottle Filler: Sensor operated with LED lighting
    e. Wall mounted
    f. Cooler: NonCFC, air-cooled.
    g. Manufacturer and Product:
        1) Fixture: Haws Drinking Faucet Co.; Model 1211S.
5. 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. American Standard Companies, Inc.; Lucerne, Model 0355.012.
    b. Faucet: Chicago Faucet Co.; Touchless plug and play infrared detection, EQ-A11A-32ABCP, with 0.5-gpm flow restricter, single supply for tempered water. 120V wall plug transformer and integral mechanical mixing valve.
    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 tempered 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.

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6. LAV-2, 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. American Standard Companies, Inc.; Lucerne, Model 0356.028.02.
   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.
7. MS-1, Mop Sink (Floor Mounted):
   a. Fixture: Stern-Williams Co. Inc.; Model HL-2100-BP; Molded stone, 36 inches by 24 inches by 12 inches deep with stainless steel bumper guard, back panels and chrome-plated brass drain.
   b. Faucet: Chicago Faucet Co.; Model 897-CP, concealed supplies with hose threads, vacuum breaker, and rod support. Faucet mounted 36 inches above finish floor.
   c. Accessories: Stern-Williams Co. Inc.; T-35 hose and T-40 stainless steel mop hanger.
8. S-1, Sink (Counter, Stainless Steel, Single Compartment):
   a. Fixture: 21 inches by 25 inches overall by 8 inches deep, 18-gauge, Type 304 stainless steel, three-hole punch, self-rimming, undercoated, ledge-type. Just Mfg. Co.; Model SL-2125-A-GR.
   b. Faucet: Chicago Faucet Co.; Model 1201 double handle. 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.
   c. Strainer: Just Mfg. Co.; Model J-35, stainless steel crumb-type.
9. S-2, 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 2300-8; single handle with 8-inch cover plate. 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.
   c. Strainer: Just Mfg. Co.; Model J-35, stainless steel crumb-type.

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10. S-3, Sink (Stainless Steel, Single Compartment):
    a. Fixture: 22 inches by 16 inches overall by 10 1/2 inches deep, 14-gauge, Type 304 stainless steel, three-hole punch, Just Mfg. Co.; Model JS-122-T.
    b. Faucet: Just Mfg. Co; JS-47-TGSA.
    c. Strainer: Just Mfg. Co.; Model J-35, stainless steel crumb-type.
11. S-4, (Wall Mount Laundry Tub):
    a. Fixture: Thermoplastic one piece laundry tub with integral wall mounting bracket. Furnish with 1-1/2-inch trap as require.
    b. Faucet: To be furnished with the laundry tub. Faucet to be 4 inch centers with 7-inch swing spout. (For the faucet in the Polymer Room connect both the hot and cold water inlets to cold water only. No hot water available).
    c. Strainer: Just Mfg. Co. Model J-35, stainless steel crumb-type.
12. SH-2, Shower (Trim Only, ADA Compliant):
    a. Showerhead: Sloan Valve Co.; Model AC-11-B-2.5, with 2.5-gpm flow restricter.
    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.
13. SK-1, Sample Sink:
    a. U.S. Standard 18-gauge, ASTM A666, Type 316 stainless steel.
    b. Integral ledge-back sink and rim.
    c. Size: 21 inches long by 15-3/4 inches wide by 10 inches deep interior compartment dimensions.
    d. Undercoated compartment for sound deadening.
    e. Compatible 3-1/2-inch, Type 316 stainless steel strainer body, cup strainer, and 1-1/2-inch tailpiece with removable strainer.
    f. Faucet: Chicago Faucet Co.; Model 350-G8AE29-317XKAB single handle with 8-inch cover plate. Trim: 1-1/2-inch outside diameter, PVC tailpiece and P-trap with cleanout, and 1/2-inch wall supply stop with loose key.
    g. Manufacturers and Products:
        1) Elkay; Model No. DLR252210.
        2) Just Manufacturing; Model No. SL-2225-A-GR-316.

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14. UR-1, Urinal (Flush Valve, Wall-Hung Type, ADA Compliant):
    a. Fixture: Vitreous china, siphon jet action with flushing rim, top spud. American Standard Companies, Inc.; Allbrook 1.0, Model 6541.132.
    b. Trim: Sloan Valve Co.;, Model 186-1 ES-S, 1.0 gallon per flush with 24-volt infrared sensor, Model EL-1500; 24-volt solenoid operator and 120 volt/24 volt, UL listed transformer, Model EL-154.
    c. Carrier: Jay R. Smith Mfg. Co.; Figure 644, commercial floor-mounted type.
15. 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.; G2 8111, 1.28 gallon per flush with battery powered infrared sensor.
    c. Seat: Olsonite Corp.; 10-CC-SS; white open front.
    d. Carrier: Jay R. Smith Mfg. Co.; Model 200/400, commercial type.
16. WC-2, Water Closet (Flush Valve, Wall-Hung Type):
    a. Same as above except provide Sloan Valve Co.; G2 8111, 1.28 gallon per flush with battery powered infrared sensor.

B. Safety Equipment:

1. SSH-1, Safety Shower/Eyewash Combination (All Stainless Steel):
    a. Model: Haws Drinking Faucet Co.; Model 8330.
    b. Shower: Stainless steel deluge.
    c. Eyewash: Stainless steel aerated eye/face wash and stainless steel bowl.
    d. Valve: Stay open.
    e. Support: Freestanding, 1-1/4-inch stainless steel pipe standard, stanchion, and floor flange.
    f. Alarms: Magnetically operated proximity switches.
2. SSH-1, Safety Shower/Eyewash Combination (Frost Free):
    a. Model: Bradley Corporation.; Model S19-310TW.
    b. Shower: Stainless steel deluge.
    c. Eyewash: Stainless steel aerated eye/face wash.
    d. Valve: Stay open.
    e. Support: Thru the wall mounting with stay open valves located in on the warm side of the wall.
    f. Alarms: Magnetically operated proximity switches.

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C. Drainage Products:

1. CO-1, Cleanout (Exterior):
   a. Material: Taper thread, bronze plug, heavy-duty, scoriated cast-iron top.
   b. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 4263.
2. 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.
3. 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.
4. 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.
5. 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.
6. FD-3, Floor Drain (Unfinished Areas, Heavy 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 2233T-U.
7. HD-1, Hub Drain:
   a. Coated cast-iron reducing hub adapter with standard cast-iron hub.
   b. Hub: Two pipe sizes larger than outlet.
8. WCO, Wall Cleanout:
   a. Material: Stainless steel cover and screw.
   b. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 4472.

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

E. Plumbing Specialties:

1. Water Hammer Arresters:
   a. 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.
   b. Manufacturer and Product: Sioux Chief Mfg. Co., Inc.; Series 650 and 660.
2. 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.
3. 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.
4. 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.
5. 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.

PART 3 EXECUTION

3.01 PREPARATION

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

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3.02 INSTALLATION

A. Plumbing Fixtures, Mounting Heights:

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

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

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

D. Safety Equipment:

1. System Shutoff Valves:
   a. Shutoff valves shall give visual indication of position (open or closed).
   b. Shutoff valves shall be lockable valves and locked in open position.
2. Each safety shower, eyewash, combination safety shower/eyewash shall have red safety signoff tag. After completing requirements listed below, Contractor and Owner shall sign red safety signoff tag. Requirements are as follows:
   a. Visually check safety shower/eyewash piping for leaks.
   b. Verify that upon operation, stay-open valves remain open.
   c. Showerheads to be between 82 inches and 96 inches above standing surface.
   d. Shower spray pattern, when valve is full open, shall be a minimum 20 inches in diameter at 60 inches above standing surface.
   e. Water arcs from eyewash spray heads must cross. Test with eyewash gauge; Haws Drinking Faucet Co., Model 9015.
   f. Minimum flow rates for safety showers shall be 20 gpm.
   g. Minimum flow rates for eyewashes shall be 3 gpm.
   h. Tepid water shall be temperature indicated in Section 22 30 00, Plumbing Equipment.

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E. Plumbing Specialties:

1. Shock Arresters:
   a. Install PDI-certified and rated shock arresters, sized and located in accordance with PDI WH-201 and as shown on Drawings.
   b. Install adjacent to equipment wherein quick closing valves are installed.
   c. Install at each emergency safety shower.
   d. Shock arresters to have access panels or to be otherwise accessible.
2. 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.

F. Caulk penetrations of exterior walls with weatherproof sealant as specified.

G. 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.

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. Test safety shower and eyewash units. Water flow must be tested at both showerhead and eyewash/face ring.

1. Shower Flow:
   a. Test with tube-type water gauge (Haws Drinking Faucet Co., Model 9010) and 5-gallon container.
   b. Container shall fill in 10 seconds or less, with a minimum 20-gpm flow.
2. Eyewash Flow:
   a. Test with tube-type water gauge (Haws Drinking Faucet Co., Model 9010) and 1-gallon container.
   b. Container shall fill in 20 seconds or less.
3. Contractor shall log, date, and initial inspection upon passing flow tests.

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D. Verify alarm operation both locally and system wide. Notify security prior to test if alarm is connected system wide.

E. Provide written report indicating date and time, specific tag for units tested, audible and visual alarms, and flow test data.

END OF SECTION

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SECTION 23 05 48
VIBRATION ISOLATION
FOR HVAC PIPING AND EQUIPMENT

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. ASTM International (ASTM):
   a. A36/A36M, Specification for Carbon Structural Steel.
   b. E488, Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements.
3. American Welding Society (AWS): D1.1/D1.1M, Structural Welding Code—Steel.
4. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): Seismic Restraint Manual: Guidelines for Mechanical Systems.
5. Vibration Isolation and Seismic Control Manufacturers Association (VISCMA).

1.02 DEFINITIONS

A. AHJ: Authority Having Jurisdiction.

B. EPDM: Ethylene-Propylene-Diene Monomer.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings, Vibration Isolators:
   a. Include, as a minimum, basic equipment layout, length and width, installed operating weights of equipment to be isolated and distribution of weight at isolation points.
   b. Product Data:
      1) Manufacturer's product data including details of materials, construction, dimensions of individual components, installation details, and finishes.
      2) Schedule of vibration isolator type with location and static and dynamic load on each.

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B. Informational Submittals:

1. Manufacturer's Installation Instructions: Indicate special procedures and setting dimensions.
2. Certifications:
   a. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
   b. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
   c. Welding Certificates: Welding procedures and personnel.

1.04 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M.

B. Isolation materials, flexible connectors, and seismic restraints shall be same manufacturer. Select and certify using published or factory certified data.

PART 2 PRODUCTS

2.01 VIBRATION ISOLATION

A. General:

1. Provide for mechanical piping, ductwork, and equipment as identified by this Specification.
2. Select in accordance with equipment, pipe, or duct weight distribution to produce reasonably uniform deflections.
3. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 30 percent and 60 percent of maximum deflection.

B. Elastomeric Pad:

1. Oil-resistant and water-resistant elastomer or natural rubber waffle pads, arranged in single or multiple layers, molded with a nonslip pattern.
2. Waffle pads bonded each side of minimum 1/4-inch-thick galvanized steel separator plate.
3. Height of waffle ribs shall not exceed 0.7 times width.
4. Maximum Loading: 60 psi.
5. Minimum Single Layer Thickness: 1/4 inch.
6. Separator plate of sufficient stiffness for uniform loading over pad area.

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7. Factory cut to size that matches requirements of supported equipment.
8. Waffle Pad Material: Standard neoprene or Natural rubber**.**
9. Number of Layers: As required to support equipment load; refer to manufacturer's data for load capacities.

C. Spring Hanger:

1. Combination coil spring and elastomeric insert hanger with spring and insert in compression.
2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: 80 percent minimum of compressed height of spring at rated load.
4. Minimum Additional Travel: 50 percent of required deflection at rated load.
5. Lateral Stiffness: 80 percent minimum of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
7. Elastomeric Element:
   a. Molded, oil-resistant rubber or neoprene.
   b. Steel washer reinforced cup to support spring and bushing projecting through bottom of frame.

D. Manufacturers:

1. Mason Industries, Inc.
2. Kinetics Noise Control, Inc.
3. California Dynamics Corp.
4. Isolation Technology, Inc.
5. M.W. Sausse & Co., Inc. (VIBREX).
6. Vibration Eliminator Co., Inc.
7. Vibration Isolation Co., Inc.
8. The VMC Group.

2.02 FLEXIBLE CONNECTORS

A. Flexible Pipe Connectors:

1. Braided Nonferrous: For nonferrous piping systems, provide bronze hose covered with bronze wire braid with copper tube ends or bronze flanged ends, braze-welded to hose.
2. Braided Stainless Steel: For ferrous piping, provide stainless steel hose covered with Type 304 stainless steel wire braid with NPT steel nipples or 150-psi ANSI flanges, welded to hose.

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3. Manufacturers:
    1. Mason Industries, Inc.
    2. General Rubber.
    3. Kinetics Noise Control, Inc.

B. Flexible Duct Connectors: Refer to Section 23 31 13, Metal Ducts and Accessories.

2.03 SHOP/FACTORY FINISHING

A. Manufacturer's standard paint applied to factory-assembled and factory-tested equipment, before shipping.

1. Powder coating on springs and housings.
2. Electro-galvanized hardware.
3. Hot-dip galvanized metal components for exterior use.
4. Baked enamel coat metal components for interior use.

B. Color-code or otherwise mark vibration isolation devices to indicate capacity range.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and equipment to receive vibration isolation devices for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. General:

1. Install products in accordance with manufacturers' written instructions.
2. Connect wiring to isolated equipment with flexible hanging loop.

B. Flexible Connectors: Prior to making piping connections to equipment with operating weights substantially different from installed weights, block up equipment with temporary shims to final height. When full load is applied, adjust isolators to load to allow shim removal.

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3.03 ADJUSTING

A. Vibration Isolation Devices:

1. Adjust isolators after piping systems have been filled and equipment is at operating weight.
2. Adjust isolators to ensure units do not exceed rated operating deflections or bottom out under loading, and are not short circuited by other contacts or bearing points.
3. Adjust leveling devices as required to distribute loading uniformly on isolators. Shim units as required where leveling devices cannot be used to distribute loading properly.

3.04 CLEANING

A. After completing equipment installation, inspect vibration isolation devices. Remove paint splatters and other spots, dirt, and debris.

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. 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.
3. Association of the Nonwoven Fabric Industry (INDA). IST 80.6, Water Resistance (Hydrostatic Pressure).
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. Underwriters' Laboratories, Inc. (UL).

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1.02 DEFINITIONS

A. Cold Air Ductwork: Designed to convey mechanically cooled 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 shall be marked "asbestos-free."

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PART 2 PRODUCTS

2.01 GENERAL

A. Insulation exterior shall be cleanable, grease-resistant, nonflaking, and nonpeeling.

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

C. Insulation for fittings, flanges, and valves shall be 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, shall be noncombustible.
2. Use no 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. Materials 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 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 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.

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3. Water vapor transmission 0.1 perm-inch, or less.
4. Manufacturers and Products:
    a. Armacell; AP Armaflex.
    b. Nomaco; K-Flex LS.
    c. Rubatex; R-180-FS.

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.

B. Type D2—Board:

1. Fiberglass, minimum 2.75 pcf density board, K factor 0.23 maximum at 75 degrees F mean, with factory-applied FSK (foil-scrim-kraft) vapor barrier jacket, for temperatures from 0 degree F to 450 degrees F.
2. Manufacturers and Products:
    a. CertainTeed; CertaPro Commercial Board.
    b. Knauf; Duct Slab.
    c. Owens/Corning Fiberglass; TIW.
    d. Johns Manville; Ductboard.

2.04 INSULATION FINISH SYSTEMS

A. Type F1—PVC:

1. Polyvinyl chloride (PVC) jacketing, white, for straight run piping and fitting locations, temperatures to 159 degrees F.
2. Manufacturers and Products:
    a. Johns Manville; Zeston.
    b. Ceel-Co; 550.

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B. Type F3—Aluminum:

1. Aluminum Roll Jacketing: For straight run piping, wrought aluminum Alloy 3003, 5005, 1100 or 3105 to ASTM B209 with H-14 temper, minimum 0.016-inch thickness, with smooth mill finish.
2. 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, specialty fittings, etc.
4. Manufacturer and Product: RPR Products; INSUL-MATE.

PART 3 EXECUTION

3.01 GENERAL

A. The Contractor is responsible for the correct installation of the insulation specified, including aesthetic as well as mechanical aspects of the Work, shall be of the highest quality consistent with the best practices of the trade.

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

D. 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.

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

F. 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 condensate drain piping insulation at fittings with white vapor barrier coating.

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

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

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

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

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

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

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

N. Placement:

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

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

P. 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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3.03 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.

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

3.05 PIPING INSULATION REQUIREMENTS

A. Condensate Drain:

1. Type P3, 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.

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B. Cooling system condenser water:

1. Type P3, 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. Pipe Hangers:

1. Type P3, Elastomeric: Rigid insulation section with 9-inch-long, 16-gauge galvanized steel saddle.

3.06 DUCTWORK INSULATION REQUIREMENTS

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

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

B. Mechanically Cooled Supply, Return and Outside Air (Exposed to View):

1. Type D2 board.
2. 1-1/2-inch thickness.

C. Air Pressurization unit Outside Air Intake:

1. Type D2, board.
2. 1-1/2-inch thickness.

D. Exhaust Air from conditioned space:

1. Type D2, board.
2. 1-1/2-inch thickness.

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

3.07 INSULATION FINISH REQUIREMENTS

A. Piping Insulation (Exposed to View, Indoors):

1. Type F1, PVC.
2. Type F3, aluminum.

B. Ductwork Insulation (Exposed to View, Indoors): Factory finish.

C. Ductwork Insulation (Outdoor or in Heated only spaces): Type F3. Aluminum.

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D. Piping Insulation (Outdoors): Type F3, aluminum.

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

3.08 FIELD QUALITY CONTROL

A. Insulation installation work shall be of the highest quality consistent with the best practices of the trade including aesthetic as well as mechanical aspects of the Work.

B. 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. 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.
8. National Electrical Manufacturers' Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
9. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code.
   b. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
10. Underwriters Laboratories, Inc. (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. 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.

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J. Abbreviations that may be used in this section:

1. AC: Air Conditioning.
2. ATC: Automatic Temperature Control.
3. BAS: Building Automation System.
4. CMOS: Complementary Metal Oxide Semiconductor.
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. HMI: Human-Machine Interface.
11. HOA: Hand-Off-Auto (Switch).
12. HVAC: Heating, Ventilation, and Air Conditioning.
13. IP: Current (I) - Pressure (P), as in IP transducer.
14. LCD: Liquid Crystal Display.
15. LED: Light Emitting Diode.
16. RAM: Random Access Memory.
17. RTD: Resistance Temperature Detectors.

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.
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. Standalone DDC Control System (STANDALONE DDC):
      1) Microprocessor-based DDC Control System utilizing standalone DDC controllers.
      2) No information sharing between controllers.

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3) User interface at DDC controller.
4) Refer to Section 23 09 23, Direct-Digital Control System for HVAC, for additional requirements.

b. 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**
Dewatering Building	All	STANDALONE DDC & ELECTRIC
Chlorine Building	All	STANDALONE DDC & ELECTRIC

C. Performance Requirements: Design control system and equipment to perform under the following conditions:

1. Temperature, Ambient:
a. Summer maximum 97 DB/82.9 WB degrees F.
b. Winter minimum 22.8 DB degrees F.
c. Based on ASHRAE Handbook Fundamentals weather data for the City of Mobile, AL.
2. Temperature, Indoor:
a. Heated and Ventilated Process Areas: Summer maximum 103 degrees F; winter minimum 50 degrees F.
b. Air-conditioned Non-process Areas: Summer maximum 75 degrees F; Winter minimum 70 degrees F.
c. Air-conditioned electrical rooms: Summer maximum 77 degrees F; Winter minimum 50 degrees F.

D. Refer to Section 01 61 00, Common Product Requirements, for additional environmental performance requirements.

1.04 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.

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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.
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.

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 01, Instrumentation and Control for Process Systems.
9. Operation and maintenance data: In accordance with Section 01 78 23, Operation and Maintenance Data. In addition, include the following detailed information:
    a. Operation and maintenance instructions for control system as furnished and installed, including control of associated mechanical and electrical equipment.
    b. Record of system adjustments and calibration methods.
    c. Performance test results.

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1.05 QUALITY ASSURANCE

A. Materials, devices, appliances, and equipment used shall be indicated as acceptable by established standards of Underwriters Laboratories, Inc. (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. Underwriters Laboratories: 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. Refer to Paragraph, Maintenance.

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. Wireless equipment controllers and auxiliary control devices shall conform to:

1. IEEE 802.15.4 radios to minimize risk of interference and maximize battery life, reliability, and range.
2. Operating range shall be a minimum of 200 feet; open range shall be 2,500 feet (762 m) with less than 2 percent packet error rate to ensure reliable operation.

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3. To maintain robust communication, mesh networking and two-way communications shall be used to optimize the wireless network health.
4. Wireless communication shall be capable of many-to-one sensors per controller to support averaging, monitoring, and multiple zone applications.

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

1.06 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.

1.07 EXTRA MATERIALS

A. Tools:

1. For each building, furnish one complete set of special tools recommended by manufacturer for maintenance, dismantling, or repair of each separate type of equipment item.
2. Furnish toolbox for storage of special tools. Identify purpose by means of stainless steel or solid plastic nametag attached to box.

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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.

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.

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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 Underwriters Laboratories, Inc. (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, 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.

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 Division 26, Electrical, 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. Provide surge suppressors on each power connection, meeting applicable requirements of Section 40 90 01, 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.

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2.07 MICROELECTRONIC CONTROL COMPONENTS

A. Refer to HVAC controls detailed specification, Section 23 09 23, Direct-Digital Control System for HVAC.

2.08 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 tag indicated in this Specification and as shown.
2. Provide adjacent to the following control devices, and for equipment whose function is not readily apparent.
    a. START/STOP switches.
    b. Special purpose devices.
    c. HVAC control panels.

D. Anchor Bolts: Galvanized, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications.

2.09 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.

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PART 3 EXECUTION

3.01 SEQUENCES OF OPERATION

A. Reference Contract Drawings.

3.02 INSTALLATION

A. General:

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

B. 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. Wiring within enclosures shall be neatly bundled and anchored to prevent obstruction to devices and terminals.
    d. Conduit shall be sized to suit the number, type, and size of conductors as specified in Section 26 05 05, Conductors.

C. End-User Accessible Control Components: Mount user adjustable control components (room temperature sensors, etc.) level and in accordance with applicable accessibility requirements of local Building Code.

D. 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.

E. 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.
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, etc.).

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3.03 FIELD QUALITY CONTROL

A. Performance and Functional Testing: 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.

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: Present at Site or classroom as 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 Manufacturer's Certificate of Proper Installation.
   c. 1 person-day for facility startup.

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.

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.

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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 EXTRA MATERIALS

A. HVAC Control Panel (HCP) Spare Lamps: Furnish spare lamps for each type and color of pilot light used, a minimum of one per HCP, stored inside HCP in dummy light sockets secured to back panel surface.

PART 2 PRODUCTS

2.01 HVAC CONTROL PANELS (HCP)

A. Provide at locations shown on 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. Construct each HCP to NEMA 250 rating as indicated in Schedule below**,** except where indicated otherwise:

HVAC Control Panel (HCP) NEMA 250 Construction Schedule

Location	NEMA 250 Type
Dewatering building first floor mezzanine (20-HCP-01)	4X

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HVAC Control Panel (HCP) NEMA 250 Construction Schedule

Location	NEMA 250 Type
Dewatering Building Mechanical room (20-HCP-02 & 03)	4X
Chlorine Building electrical room (50-HCP-01)	12

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

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 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.

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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.

2.02 AUTOMATIC CONTROL VALVES

A. General:

1. Fully proportioning with modulating plugs for equal percentage of linear flow characteristics.
2. Valve Body and Trim: Sufficient to handle system pressure and temperature.
3. Sized for a maximum pressure drop of 3 psi.

B. Valves 1/2 Inch Through 1-1/4 Inches:

1. Constructed with cast brass body and screwed ends.
2. Trim: Removable cage providing valve plug guiding throughout entire travel range.
3. Type 316 stainless steel stem.
4. Removable bonnet, cage, stem, and plug assembly.

C. Valves 1-1/2 Inches and 2 Inches:

1. Constructed with cast brass body and screwed ends.
2. Trim: Removable cage providing valve plug guiding throughout entire travel range.
3. Type 316 stainless steel stem.
4. Removable bonnet, cage, stem, and plug assembly.

D. Valve Actuators:

1. Sufficient power for intended duty.
2. Capable of closing against differential pressures to be encountered.

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3. Constructed and piped to fail to full heating upon loss of control signal.
4. Capable of being sequenced either with other valves where required by sequence of operation.
5. Manufacturers:
    a. Johnson Controls.
    b. Siemens Building Technologies.
    c. Honeywell.
    d. Delta.

2.03 CONTROL DAMPERS

A. General:

1. Specification applies to control dampers, except those specified to be furnished with equipment.
2. Furnish opposed-blade type for proportional action and parallel-blade type for two-position action, except where indicated otherwise.

B. High Performance Control Dampers (MD):

1. Frame: Frame: 5 inches by 1 inch by minimum 0.125 inch (127 mm by 25 mm by minimum 3.2 mm) 6063-T5 extruded aluminum hat-shaped channel, mounting flanges on both sides of frame, reinforced at corners.
2. Blades:
    a. Style: Airfoil-shaped, single-piece.
    b. Orientation: Horizontal or vertical with thrust washers, as indicated on Drawings.
    c. Material: Heavy duty 6063-T5 extruded aluminum.
    d. Width: Nominal 6 inches (152 mm).
3. Bearings: Molded synthetic sleeve, turning in extruded hole in frame.
4. Seals:
    a. Blade Seals: As scheduled on Drawings.
    b. Jamb Seals: As scheduled on Drawings.
5. Linkage: Concealed in frame.
6. Axles:
    a. Minimum 1/2 inch (13 mm) diameter, hex-shaped, mechanically attached to blade.
    b. Material: As scheduled on Drawings.
7. Performance Data: As scheduled on Drawings.
8. Accessories: As scheduled on Drawings.
9. Manufacturers:
    a. Ruskin.
    b. American Warming and Ventilating.
    c. TAMCO.
    d. Greenheck.

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C. Heavy Duty Control Dampers (MD):

1. Frame:
   a. 8 inches by 2 inches by minimum 14 gauge (203 mm by 51 mm by minimum 2 mm) channel.
   b. Bolt Holes: Both flanges.
   c. Material: As scheduled on Drawings.
2. Blades:
   a. Style: Airfoil-shaped, double-skin.
   b. Orientation: Horizontal or vertical with thrust washers, as indicated on Drawings.
   c. Minimum 14 gauge (2 mm) equivalent thickness.
   d. Material: As scheduled on Drawings.
   e. Width: 5 inches to 8 inches (127 mm to 203 mm) maximum.
3. Bearings: Stainless steel sleeve pressed into frame.
4. Seals:
   a. Blade Seals: As scheduled on Drawings.
   b. Jamb Seals: Compressible stainless steel located between blade edge and jamb.
5. Linkage:
   a. Side linkage out of airstream.
   b. Constructed of minimum 10-gauge (3.5-mm) galvanized steel clevis arms with minimum 3/16 inch by 3/4 inch (4.8 mm by 19 mm) plated steel tie bars pivoting on minimum 3/8-inch (9.5-mm) diameter stainless steel pivot pins with lock-type retainers.
6. Axles:
   a. Minimum 3/4 inch (19 m) diameter, hex-shaped, mechanically attached to blade.
   b. Material: As scheduled on Drawings.
7. Performance Data: As scheduled on Drawings.
8. Accessories: As scheduled on Drawings.
9. Manufacturers:
   a. Ruskin.
   b. American Warming and Ventilating.
   c. TAMCO.
   d. Greenheck.

2.04 CONTROL DAMPER OPERATORS

A. General:

1. Drawings and Control Diagrams indicate only one damper motor for each motorized damper (M).

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2. Select actual quantity of motors required to operate each damper in accordance with size of damper provided.
3. Coordinate exact quantity of damper motors with electrical work to ensure that necessary wiring and conduit is provided for installation.
4. Provide operators for motorized dampers and motorized louvers.

B. Electric Damper Operators:

1. Performance: As scheduled on Drawings.
2. Mounting: External side plate.
3. Ample power to overcome friction of damper linkage and air pressure acting on damper blades.
4. Furnished with external adjustable stops to limit stroke.
5. Operators on modulating dampers that are to be sequenced with other control devices shall have full relay type pilot positioner and interconnecting linkage to provide mechanical feedback that will accurately position and control damper.
6. Intake, relief, and exhaust dampers shall close and return dampers shall open on control failure, unless indicated otherwise.
7. Operating Torque:
    a. Provide multiple independent damper sections, each with separate actuator, as needed to provide minimum of 120 percent of operating torque required by damper(s).
    b. Required damper operating torque for actuator sizing calculations shall include friction of damper linkage and 1-inch WC air pressure on damper blades:
        1) Opposed-Blade Dampers: Minimum 5 inch-pounds per square foot of damper area, unless higher values are recommended by damper manufacturer.
        2) Parallel-Blade Dampers: Minimum 7 inch-pounds per square foot of damper area, unless higher values are recommended by damper manufacturer.
8. Manufacturers:
    a. Belimo.
    b. Neptronic.
    c. Siemens Building Technologies.
    d. Johnson Controls.
    e. Honeywell.

2.05 ELECTRIC THERMOSTATS (T)

A. 7-Day programmable Thermostat:

1. Heating and Cooling Stages:
    a. Multi stage cooling and heating electronic control.

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b. Staging delay between each cycle.
c. Visual indication of activation of each stage.

2. Temperature Scale: Furnish 50 to 90 degrees F dial.
3. 7-Day programmable.
4. External adjustments.
5. Operator interface to consist of temperature adjustment, LCD room temperature display, and visual indication of each cooling and heating stage activation.
6. Insulating back, where exterior wall mounting is indicated.
7. Adjustable “dead band” between heating and cooling to be between 4 degrees F and 20 degrees F.
8. Power loss memory for restoration of sequence of operation in event of power loss.
9. Refer to Section 23 09 00, Instrumentation and Control Devices for HVAC, for additional controller operation options.

B. Electric thermostat:

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

2.06 ELECTRONIC SENSORS

A. Temperature (T):

1. General Requirements:
   a. Sensors and transmitters shall be provided, as outlined in input/output summary and sequence of operations.
   b. Wireless space sensors battery life shall be 15 years or greater to minimize the need for battery replacement in typical operating conditions.
   c. To check for proper operation, wireless space temperature sensors shall include a signal strength on the space sensor display.
   d. To allow local troubleshooting without specialized tools, error codes shall be displayed on the digital display. Error codes shall include: not associated, address to 000, improper software configuration, input voltage too high, or general sensor failure. Codes shall be indicated on inside of sensor back cover.
   e. To support use by the physically impaired, the wireless space sensor shall be a minimum font size of 12 points, and the LCD model shall be readable in low light conditions.

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f. Operating range shall be a minimum of 200 feet; open range shall be 2,500 feet (762 m) with less than 2 percent packet error rate to ensure reliable operation.
g. Temperature sensor shall resistance type, and shall be either two-wire 1,000-ohm nickel RTD or two-wire 1,000-ohm platinum RTD.
h. 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
All Others	± 0.75°F

2. Room Temperature Sensors:
   a. Constructed for either surface or wall box mounting.
   b. Nonlocking wire protective guards for room temperature sensors installed in process areas.
   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.
3. Duct Temperature:
   a. Accuracy: Plus or minus 1 degree F.
   b. Range:
      1) Heating: 40 to 140 degrees F.
      2) Cooling: 30 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.

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4. Outdoor Temperature:
    a. Accuracy: Plus or minus 1 degree F.
    b. Range: Minus 40 to 140 degrees F.
    c. Cover: Weathertight, with sealed conduit connection and sun shield.

B. Current Sensors (CS):

1. Fixed Setpoint, Digital Output Current Switch:
    a. Application: Monitoring status of direct drive equipment.
    b. Current-operated solid state relay.
    c. Split core design.
    d. Trip Setpoint: Fixed.
    e. Output: Digital switch.
    f. Sensor Power: Induced from line.
    g. Manufacturer and Product: Veris; Hawkeye 600/800.
2. 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.
3. Adjustable Setpoint, Digital Output, AFD Current Switch:
    a. Application: Monitoring status of belt-drive or direct-drive equipment controlled by an AFD.
    b. Microprocessor-based current-operated solid state relay.
    c. Automatic compensation for AFD frequency and current changes.
    d. Split core design.
    e. Trip Setpoint: Self-calibrating.
    f. Output: Digital switch, with normal and alarm status LED.
    g. Sensor Power: Induced from line.
    h. Manufacturer and Product: Veris; Hawkeye 904.

2.07 VENTILATION MONITORING STATION (20-VMS-XX)

A. Signaling notification alarm panels shall be installed where shown on the drawings and interlocked with the HVAC control panel as shown below to provide ventilation system status and alarm.

1. 20-HCP-01 (20-VMS-XX).

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B. The stations shall be power loop-Feed from 20-HCP-01.

C. Each Panel shall include the following.

1. Green indicating status light with “VENTILATION SYSTEM ACTIVE” sign.
2. Red indicating status light with “WARNING – VENTILATION SYSTEM FAIL” sign.
3. Horn with test push button.

D. Stations shall be wall mounted with Type 316 stainless steel hardware. Mounting fittings shall be provided by the manufacturer.

E. VMS Indicating lights:

1. General: Green and Red indicating lights shall provide a visual indication of the ventilation system status.
2. Required Features:
   a. LED Light: Steady-burn; 60,000 hours.
   b. Lens Color: Red and Green as indicated.
   c. Enclosure: NEMA 4X.
   d. Approvals: UL Listed for Class 1, Div 1, Groups C & D.
   e. Dimensions: 15.63-inch high and 8.82-inch diameter.
   f. Dome guard.
   g. 90 degrees wall mounted bracket.
3. Manufacturer: Provide one of the following:
   a. Federal Signal Corporation.
   b. Larson Electronics, LLC.
   c. Or equal.

F. VMS Horn:

1. General:
   a. Function: Audible alarm suitable for use in a hazardous location and also indoor/outdoor use.
2. Performance:
   a. Temperature, Operating: Minus 54 degrees C to 66 degrees C.
3. Features and ratings:
   a. Hazardous Location: Class I, Div 2, Groups A, B, C, D.
   b. Dimensions: 4.4 inches in height and width, and 4.0 inches in depth, nominal.
   c. Speaker Cone: Polymeric.
   d. Listings: UL, cUL listed, FM, CSA approved.

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4. Enclosure:
    a. Type: Non-metallic polycarbonate light gray.
    b. Rating: NEMA 4X.
    c. Mounting: Surface mount.
5. Manufacturer:
    a. Federal Signal Corporation.
    b. Or equal.

G. VMS Test button: A test button shall be conveniently located in each VMS for the purpose of activating the audible and visual signals in order to validate their operation. The test button shall be a momentary pushbutton switch, is corrosion resistant, suitable for wall mounting and is rated at 120V ac, 60 Hz, three amperes. The test button shall be an Allen-Bradley Company Bulletin 800H, heavy duty pushbuttons factory assembled station or equal.

2.08 STROBE WARNING LIGHTS/AUDIBLE

A. Strobe warning lights shall be installed where shown on Drawings to provide ventilation system status and alarm. General:

1. Function: Warning light and audible alarm suitable for use in a hazardous location and also indoor/outdoor use.
2. Type:
    a. Flashing LED.
    b. Suitable for hazardous locations.
    c. Audible/visible base housing with visual alarm and front mounted.
3. Operating Temperature: minus 58 to 150 degrees F.
4. Performance:
    a. Flash Rate: 60 per minute.
5. Features:
    a. Flashing, super bright LED array.
    b. Lamp Life: 60,000 hours.
    c. Construction:
        1) Aluminum Powder-coated base.
        2) Glass dome with Gasket
    d. Dome guard.
    e. Dome Color: Red, unless otherwise noted.
    f. Mounting: Pipe, unless otherwise noted.
    g. Enclosure Rating: NEMA 4X.
    h. Light Diameter: 6-inches nominal.

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6. Power: Loop-Feed from 20-HCP-01.
7. Hazardous Approvals: Class I, Division 2, Groups A, B, C and D.
8. Manufacturer:
    a. Federal Signal Corporation.
    b. Or equal.

2.09 MISCELLANEOUS DEVICES

A. General:

1. RTD to voltage (0- 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- 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. Flow Element and Switch, Thermal (20-FS-XX):

1. General:
    a. Function: Monitor airflow and provide contact closure at setpoint.
    b. Type: Thermal dispersion flow switch using a heated active RTD and a reference RTD temperature sensor to detect rate of flow as a function of temperature difference between the two sensors.
    c. Double-pole, double-throw “Dry” relay contacts rated at a minimum of five amps.
2. Service:
    a. Ventilation airflow: Air, unless otherwise noted.

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3. Performance:
    a. Setpoint: As noted.
        1) Factory calibration for constant speed systems: The monitoring ventilation alarm shall be activated if the airflow switches read a reduction of the airflow of 15 percent or more from the design airflow showed in the contract documents for every system being monitored.
        2) Accuracy: Greater of plus or minus 5.0 percent of reading or plus or minus 2 sfps (air).
        3) Repeatability: Plus or minus 0.5 percent of reading, at constant temperature and pressure.
        4) Temperature, Operating: Sensor Element: Minus 40 degrees F to plus 350 degrees F.
        5) Pressure, Operating: To 3,500 psig at 70 degrees F, to 2,350 psig at 500 degrees F.
4. Features:
    a. Materials: Type 316 stainless steel, unless otherwise noted.
    b. Temperature Compensation: Via factory calibration.
5. Element Insertion: 2 inches from tip of probe to connection, unless otherwise noted.
6. Electronics:
    a. Location: Integral, unless otherwise noted.
    b. Operating Temperature: Minus 40 degrees F to 140 degrees F.
    c. Calibration Circuit: Built in for field adjustment of setpoint.
7. Signal Interface Contact: Field selectable two SPDT or one DPDT, rated 6 amps at 115V ac, 220V ac or 24V dc. SPDT with separate setpoints.
8. Enclosure:
    a. Type: NEMA 4X.
    b. Enclosure: Type 316 stainless steel, unless otherwise noted.
    c. Approval: Hazardous locations, Class I and Class II, Division 1 and Division 2, Groups B, C, D, E, F, and G.
9. Ancillaries:
    a. Furnish interconnecting cable if remote electronics specified.
        1) Cable Jacket: PVC, unless otherwise noted.
        2) Cable Length: 10 feet, unless otherwise noted.
10. Power: Individually powered; 24V or 120V ac, 60-Hz, from HVAC panel 20-HCP-01 unless otherwise noted.
11. Identifying Tag: Stainless steel.
12. Flow Element shall be applied in the ductwork in the following locations:
    a. 20-MAU-01.
    b. 20-EF-01.
    c. 20-EF-02.
    d. 20-EF-03.

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13. Manufacturer:
    a. Fluid Components, Inc.
    b. Ameritrol, Inc.

D. HVAC System Emergency Shutdown Switch (ESS):

1. Wall-mounted, break-glass type manual pull switches for HVAC system emergency shutdown.
2. Noncoded, single action, single pole.
3. Surface mounting type.
4. Provided with red laminated plastic nameplate with engraved white letters 1/2-inch high reading, “VENTILATION SYSTEM EMERGENCY SHUTOFF SWITCH,” wall mounted directly above each switch.
5. Manufacturers and Products:
    a. Simplex; 2099 Series.
    b. Edwards; 270 Series.

PART 3 EXECUTION

3.01 INSTALLATION

A. Control Dampers:

1. Install at locations indicated on Drawings and in accordance with manufacturer’s instructions.
2. Install square and free from racking with blades running horizontally.
3. Operate opposed blade dampers from a power blade or drive axle.
4. Bracing:
    a. Install for multiple section assemblies to support assembly weight and to hold against system pressure.
    b. Install at every horizontal and vertical mullion.

END OF SECTION

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SECTION 23 09 23
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

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 DEFINITIONS

A. ASCII: ANSI X3.4, Information Systems—Coded Character Sets—7-Bit American National Standard Code for Information Interchange (7-Bit ASCII).

B. Distributed Control: System whereby control processing is decentralized and independent of central computer. Control system is built up of standalone controllers. Single controller failure shall not impact more than one system.

C. Integration:

1. Ability of control system components from different manufacturers to connect together and provide coordinated control via real-time data exchange through common communications data exchange protocol.
2. Integration shall extend to operator's workstation software, which shall support user interaction with control system components.

D. Interoperability: Ability of equipment to communicate mutually.

E. Input/Output (I/O): Connections between computer and sensors and actuators.

F. Human-Machine Interface (HMI): Method by which operator communicates with HVAC Control System. Allows operator to command, monitor, and program control system.

G. Local Area Network (LAN): Network in which devices can communicate directly without going through intervening routers. LANs commonly used by DDC system Suppliers include Ethernet (ISO 8802-3), ARCNET, Echelon LonTalk, and EIA 485.

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H. Network:

1. System of distributed control units that are linked together on communication highway.
2. Allows sharing of point information between control units.
3. Provides central monitoring and control of entire system from any distributed control unit location.
4. Primary networks provide peer-to-peer communications.
5. Secondary networks provide either peer-to-peer, master-slave, or supervised token-passing communications.

I. PID (Proportional, Integral, Derivative) Control Loop: Mathematical calculation used to evaluate control input and determine control output value required to maintain input value at set point. Shall have operator adjustable maximum rate of change, P and D gains, and loop response time delay. Loop shall be self-integrating so no integral constant is required and not be subject to integral windup.

J. Transmission Control Protocol (TCP): Connection-oriented protocol used to convey multiple related messages (e.g., file transfers, Web pages, etc.).

K. Abbreviations that may be used in this section:

1. BIOS: Basic Input Output System.
2. DDC: Direct Digital Control.
3. IBM: International Business Machines, Inc.
4. LCD: Liquid Crystal Display.
5. PC: Personal Computer.
6. PID: Process Instrumentation Diagram.
7. PI: Pressure Indicator.

1.03 QUALITY ASSURANCE

A. Compatibility:

1. System shall have documented history of compatibility by design for minimum of 15 years.
2. Future compatibility shall be supported for no less than 10 years.
3. Compatibility shall be defined as:
   a. Ability to upgrade existing microelectronic controllers to current level of technology, and extend new microelectronic controllers on previously installed network.
   b. Ability for any existing microelectronic controller microprocessor to be connected and directly communicate with new microelectronic controllers without bridges, routers, or protocol converters.

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1.04 SYSTEM PERFORMANCE

A. System shall conform to the following performance standards:

1. Graphic Display:
   a. Minimum of 20 dynamic points.
   b. Current data displayed within 20 seconds of request.
2. Graphic Refresh: System shall update dynamic points with current data within 30 seconds.
3. Object Command:
   a. Maximum time between command of binary object by operator and reaction by device shall be 10 seconds.
   b. Analog objects shall start to adjust within 10 seconds.
4. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 seconds. Select execution times consistent with mechanical process under control.
5. Performance: Programmable Controllers shall be able to execute DDC PID control loops at selectable frequency from at least once every 5 seconds. Controller shall scan and update process value and output generated by this calculation at this same frequency.
6. Reporting Accuracy: Table 1 lists minimum acceptable reporting accuracies for values reported by specified system.

Table 1
Reporting Accuracy

Measured Variable	Reported Accuracy
Space temperature	±0.5°C (±1°F)

PART 2 PRODUCTS

2.01 STANDALONE DDC CONTROL SYSTEM

A. Standalone Custom Controllers:

1. General:
   a. Provide adequate number of controllers to provide performance specified in Article System Performance and as indicated on Drawings.
   b. Microprocessor based to perform control functions or communications, capable of standalone operation, providing control functions without being connected to a network.
   c. Provide touch screen for end user interface at the controller.

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2. Performance:
   a. Set points, controller operating system, and programming shall be resident in EEPROM, within controller.
   b. Capable of executing DDC loops and custom control routines.
   c. DDC loop control programming with editable proportional, integral, and derivative control parameters.
   d. DDC loops shall have editable high and low output limits as well as editable failure output values.
   e. Software control reaction time shall be programmable to be no slower than 5 seconds.
   f. DDC loops shall be programmable to operate at user defined intervals with maximum frequency of 1 second.
   g. Sufficient memory to support its operating system, database, and programming requirements.
3. Environment: Controller hardware shall be suitable for anticipated ambient conditions.
   a. Controller shall be mounted in locking enclosure. Refer to Section 23 09 13, HVAC Controls, Field Components, and Instruments, Article HVAC Control Panels (HCP), for enclosure details.
   b. Controller used in conditioned ambient shall be mounted in dust-proof enclosure and shall be rated for operation at 0 degrees C to 50 degrees C (32 degrees F to 120 degrees F).
4. Clock:
   a. Real time clock that shall remain active during power failure for up to 7 days under normal operating conditions.
   b. When controller is used with higher level system, time clock shall be automatically synchronized with system controller.
5. Software:
   a. Software for controller setup, programming, and editing of database.
   b. In English language.
   c. IBM PC compatible.
   d. PI and PID control loops.
   e. Programming subroutine blocks available to be used in any combination for program modifications.
   f. As a minimum, routines shall include:
      1) Time- or event-based scheduling.
      2) Offline, fill-in-the-blank programming of controller.
      3) Operating and programming error messages and diagnostics.
      4) Database save and restore.
      5) Adaptive optimum start/stop.

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6) Run time totalization.
7) Alarm detection and dial out.
8) Historical Trending: Trend data shall be fully compatible with Microsoft Access and Excel.

g. Documentation: Provide to Owner, before completion of Project:
1) Electronic copy of programming tool software.
2) Electronic copy of control logic program used in controller.
3) User's manual for software operation.
4) Include appropriate cable for interconnection between PC serial port and controller.

6. Diagnostics: Controller shall contain the following diagnostic information:
a. LEDs indicating status of main board, communications Transmit and Receive, and Binary Output on/off.
b. Information regarding failure of analog or change of state of any binary point. Controller must then capture an image of all points at value or state at time of event/alarm. This data must be able to be viewed from a set of screens that are labeled with alarm point, date and time of occurrence, and cause of failure.
c. Self-test procedure for checking communications and verifying functionality of memory and database.
d. Upon detection of communication loss, retransmission shall be attempted.
e. Continuing failure shall cause trouble signal to be annunciated at HCP.

7. External Communication:
a. Allow service tool editing of programming while controller is in total standalone operation.
b. Include Ethernet port for connection to web base network.
c. Include port for connection to portable operator interface device for commissioning, adjustment, diagnosis, upload, download, and editing of data.

8. Portable Operators Terminal.
a. Furnish Portable Operator's Terminal (POT) that shall be capable of accessing system data.
b. Device may be connected directly to any controller for programming, setup, and troubleshooting.
c. Able to display current state of any input/output point connected to controller.
d. Able to modify current state of any output point connected to controller, given appropriate security level.

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e. Capable of displaying controller status, faults, and diagnostics including:
   1) Communications errors.
   2) Controller software versions.
   3) Input/output point alarms.
   4) Controller operating mode.
   5) Operator interface shall allow display, setup, and/or adjustment of:
      a) Viewing alarms.
      b) Monitoring temperatures, operating modes, on/off statuses, and failure conditions.
      c) Temperature setpoints.

9. Electrical:
   a. Power:
      1) On/Off switch inside cabinet.
      2) Each HVAC control panel shall be provided with a dedicated 20A, 120V power feed. Controller Power: 24V, 60 Hz.
      3) On-board isolation transformer or dedicated transformer, rated at minimum of 125 percent of maximum power consumption, and shall be fused or current limiting type.
      4) Battery Backup: Local controller must provide backup of all memory for period of 7 days under normal operating conditions if commercial power to controller is interrupted.
   b. Connections:
      1) Plug-in terminal blocks, in accordance with requirements of Section 23 09 13, HVAC Controls, Field Components, and Instruments, Article HVAC Control Panels (HCP).
      2) Logic card containing active electrical components shall be easily removable from wiring base without use of tools.
      3) Provide quick disconnect interconnection with electrical wiring.
   c. Immunity to Power and Noise:
      1) Controller shall be able to operate at 90 percent to 110 percent of nominal voltage rating and shall perform orderly shutdown below 80 percent nominal voltage.
      2) Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5W at 1 meter (3 feet).
      3) Provide filters, as required to comply with applicable FCC regulations.
   d. Power Loss/Restart:
      1) Tolerant of power failures.
      2) Memory shall be nonvolatile or unit shall hold memory up to 30 days minimum on backup batteries.

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3) When power failure has occurred and power is restored, controller shall restart automatically and without operator intervention.
4) Restart Procedures:
   a) Come online.
   b) Update monitored functions.
   c) Implement special facility startup strategies as required.
5) Resume operation based on current time and status.

10. Input/Output:
    a. Controller shall be configurable using modular Input/Output points to allow for system customization and expansion.
    b. Each controller shall monitor analog inputs and analog outputs, and perform minimum 10 bit A-to-D and 8 bit D-to-A conversion.
    c. Local controller shall receive signals from industry standard sensors and input devices and directly control actuators and control devices.
    d. Controller shall have capability to monitor and control the following types of inputs and outputs:
       1) Analog Inputs:
          a) Current: 4 to 20 mA.
          b) Voltage: 0 to 10 V dc.
          c) Thermistor.
          d) 1,000 Ohm RTD.
       2) Binary Inputs:
          a) Isolated dry contact closure.
          b) Pulse.
       3) Analog Outputs:
          a) Current: 4 to 20 mA.
          b) Voltage: 0 to 10 V dc.
       4) Binary Outputs: 24 V ac, Triac switch.
    e. Output points must be available with manual software and hardware overrides with feedback indication that an output is presently overridden.
    f. Port Isolation:
       1) Individually, electrically isolated to protect against transients, spikes, and power surges.
       2) Optically isolated from each other, controller circuit board, and from power wiring.
       3) Optical isolation either as integral component to controller or as a separate interface device between controller and field wiring.
    g. Quantity of I/O Points: As required to provide equipment function as described in sequences of operation.

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11. Expansion Capability:
    a. Capable of accepting expansion modules for addition of:
        1) Memory.
        2) Input/Output points.
12. Trending:
    a. Minimum of eight user selectable points shall be able to be logged, with a minimum of 24 samples per log.
    b. Start and stop times for each trend log shall be definable or continuous.

PART 3 EXECUTION

3.01 GENERAL

A. Refer to Section 23 09 00, Instrumentation and Control Devices for HVAC, for requirements.

END OF SECTION

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SECTION 23 21 13
HYDRONIC PIPING—GENERAL

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 Petroleum Institute (API): SPEC 5L, Specification for Line Pipe.
3. American Society of Mechanical Engineer's (ASME):
   a. B1.20.1, Pipe Threads General Purpose (Inch).
   b. B16.3, Malleable Iron Threaded Fittings Classes 150 and 300.
   c. B16.4, Gray Iron Threaded Fittings.
   d. B16.5, Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24.
   e. B16.9, Factory-Made Wrought Buttwelding Fittings.
   f. B16.21, Nonmetallic Flat Gaskets for Pipe Flanges.
   g. B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
   h. B16.24, Cast Copper Alloy Pipe Flanges and Flanged Fittings: Class 150, 300, 400, 600, 900, 1500, and 2500.
   i. B31.1, Power Piping.
   j. B31.3, Process Piping.
   k. B31.9, Building Services Piping.
   l. Boiler and Pressure Vessel Code (BPVC), Section I, Rules for Construction of Power Boilers.
4. American Water Works Association (AWWA): C105/A21.5, Polyethylene Encasement for Ductile-Iron Pipe Systems.
5. American Welding Society (AWS):
   a. Brazing Handbook.
   b. Soldering Handbook.
   c. A5.8/A5.8M, Specification for Filler Metals for Brazing and Braze Welding.
   d. D1.1/D1.1M, Structural Welding Code—Steel.
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. A105/A105M, Standard Specification for Carbon Steel Forgings for Piping Applications.

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d. A106/A106M, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
e. A183, Standard Specification for Carbon Steel Track Bolts and Nuts.
f. A197/A197M, Standard Specification for Cupola Malleable Iron.
g. A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
h. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
i. A395/A395M, Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
j. A536, Standard Specification for Ductile Iron Castings.
k. A563, Standard Specification for Carbon and Alloy Steel Nuts.
l. A733, Standard Specification for Welded and Seamless Carbon Steel and Austenitic Stainless Steel Nipples.
m. B32, Standard Specification for Solder Metal.
n. B88, Standard Specification for Seamless Copper Water Tube.
o. B813, Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube.
p. D2000, Standard Classification System for Rubber Products in Automotive Applications.
q. D2672, Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement.
r. F402, Standard Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings.

7. Copper Development Association (CDA): Copper Tube Handbook.
8. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS):
   a. SP-25, Standard Marking System for Valves, Fittings, Flanges and Unions.
   b. SP-95, Swage (d) Nipples and Bull Plugs.
   c. SP-97, Integrally Reinforced Forged Branch Outlet Fittings—Socket Welding, Threaded, and Buttwelding Ends.
9. NSF International (NSF).
10. Underwriters Laboratories (UL).

1.02 DEFINITIONS

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

1. ID: Inside Diameter.
2. WOG: Water, Oil, Gas.

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1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Coordination Drawings: Provide 1/4-scale drawings of piping layout, showing relationship between piping and other trades.
   b. Name of system.
   c. Pipe: ASTM number, grade if known, type, wall thickness, and material.
   d. Fittings: ASTM number, grade if known, class, type, wall thickness, and material.
   e. Joint type.
   f. Flanges: ASTM number, grade, class, type, and material.
   g. Bolt and nut material.
   h. Thread joint sealant material.
   i. Flange gasket material and rating.
   j. Unions: ASTM number, type, material, and rating.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services.
2. Piping Certificates:
   a. Material certificates shall include dimensions, heat numbers, chemical analysis, and tensile test results for pipe shipped to Site.
3. Field test reports; test pressure and media for each piping system.
4. Cleaning:
   a. Piping system flushing procedures.
   b. Piping system cleaning method.

1.04 QUALITY ASSURANCE

A. Regulatory Requirements: Piping materials, products and installation shall comply with ASME B31.9, ASME B31.1, and local codes.

B. Manufacturer, pressure class, size, and heat code of each fitting and flange shall be permanently identified on its body in accordance with MSS SP-25.

1.05 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01 61 00, Common Product Requirements.

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B. Piping:

1. Free of scale.
2. Install plastic end caps/plugs on each end of pipe.
3. Maintain end caps/plugs through shipping, storage, and handling to prevent pipe end damage, and to eliminate dirt and construction debris from accumulating inside of pipe.
   a. Flanges: Securely attach metal, hardboard, or wood protectors over entire gasket surface.
   b. Threaded or Socket Welding Ends: Fit with metal, wood, or plastic plugs or caps.
   c. Linings and Coatings: Prevent excessive drying.
   d. Cold Weather Storage: Locate products to prevent coating from freezing to ground.
   e. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.

C. Storage:

1. Where possible, store materials inside and protect from weather.
2. Where necessary to store outside, elevate above grade and enclose with durable, waterproof wrapping.

PART 2 PRODUCTS

2.01 MATERIALS

A. Piping and Fittings:

1. Refer to Pipe Data Sheet on Section 40 27 00.10, Polyvinyl Chloride (PVC) Pipe and Fittings Data Sheet.
2. Refer to Pipe Data Sheet on Section 40 27 00.13, Copper and Copper Alloy Pipe, Tubing and Fittings Data Sheet.
3. In accordance with ASME B31.9 and ASME B31.1, as applicable.
4. Unless otherwise indicated, fittings and accessories connected to pipe shall be of same material as pipe.
5. Bullhead tees are not permitted.

B. Piping System Cleaner:

1. Detergent cleaning compound similar to Nalco 2567.
2. Suitable for removal of organic soil, hydrocarbons, flux, pipe mill varnish, pipe compounds, iron oxide, and like deleterious substances, with or without inhibitor.
3. Suitable for system metals without deleterious effects.
4. Cleaner shall not contain phosphate.

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2.02 COMPONENTS

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

B. Insulation: In accordance with Section 23 07 00, HVAC Insulation.

C. Hydronic Specialties: In accordance with Section 23 21 14, Hydronic Specialties.

D. Valves: Gate, globe, check, ball, and butterfly valves as specified in Section 40 27 02, Process Valves and Operators.

2.03 ACCESSORIES

A. Vent and Drain Valves:

1. Pipeline, 2-Inch Diameter and Smaller: 1/2-inch vent, 1-inch drain, unless shown otherwise.
2. Pipeline, 2-1/2-Inch Diameter and Larger: 3/4-inch vent, 1-inch drain, unless shown otherwise.

B. Wells and Tappings:

1. Pipeline, 2-Inch Diameter and Smaller: Use piping tee fitting.
2. Pipeline, 2-1/2-Inch Diameter and Larger: Use threadolets or sockolets.

C. Leak Plates:

1. Locate leak plate at mid-point of pipe passing through wall.
2. See Section 40 27 01, Process Piping Specialties, for link seal.

D. Threaded Joint Sealants:

1. Nontoxic, chemically inert, nonhardening rated for minus 50 degrees F to plus 500 degrees F, bearing UL, AGA, and NSF approvals.
2. Teflon tapes are not allowed.

E. Flange Gaskets:

1. Asbestos free and suitable for pressure temperatures and fluid of piping system.
2. Nonmetallic gaskets in accordance with ASME B16.21.

F. Corrosion Protection Coatings: Refer to Section 09 90 00, Painting and Coating, for details of coating requirements.

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2.04 VALVES

A. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

B. If valve applications are not indicated on Drawings, use the following:

1. Water Shutoff Service:
   a. NPS 2-1/2 and Smaller: Ball valve.
   b. NPS 3 and Larger: Butterfly valve.
2. Throttling Service:
   a. All Sizes: Globe valve.
3. Pump Discharge:
   a. All Sizes: Silent check valve.
4. General Service Backflow Prevention:
   a. All Sizes: Horizontal swing check valve.
5. Vents and Drain Service:
   a. NPS 2 and Smaller: Ball valve.

2.05 MANUFACTURERS

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

1. American Valve, Inc.
2. Conbraco Industries, Inc.
3. Milwaukee Valve Company.
4. NIBCO INC.
5. Crane Valves.
6. Tyco Valves & Controls.
7. Bray Controls.

2.06 BALL VALVES

A. NPS 2 Inches and Smaller:

1. Two or Three Piece Bronze Body, Full Port, Stainless Steel Trim, Blowout Proof Stem, Vented Ball:
   a. Standard: MSS SP-110.
   b. Rating: 150 psig SWP/600 psig CWP.
   c. Construction: Bronze body, PTFE seat, stainless steel ball and stem.
   d. Actuator Type: Lockable lever handle.
   e. Ends: Threaded or solder.
   f. Service: Suitable for water, glycol and compressed air with “WOG” indicated on valve body.

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B. NPS 2-1/2 to 4 Inches:

1. Two or Three Piece Bronze Body, Full Port, Stainless Steel Trim, Blowout Proof Stem, Vented Ball:
   a. Standard: MSS SP-110.
   b. Rating: 150 psig SWP/400 psig CWP.
   c. Construction: Bronze body, PTFE seat, stainless steel ball and stem.
   d. Actuator Type: Lockable lever handle.
   e. Ends: Threaded or solder.
   f. Service: Suitable for water, glycol and compressed air with "WOG" indicated on valve body.

2.07 BUTTERFLY VALVES

A. NPS 3 Inches and Larger:

1. Class 150, High Performance Butterfly Valve, Carbon Steel Body, Stainless Steel Disc and Stem:
   a. Standard: MSS SP-68.
   b. Rating: 285 psig at 100 degrees F.
   c. Construction: Carbon steel lug body with SS disc and stem, PTFE seat.
   d. Actuator Type: Lockable lever handle sizes NPS 6 and less. Gear operator for NPS 8 and greater.
   e. Ends: Lug body per ASME B16.5.
   f. Service: Suitable for bi-directional end-of-line service (dead end) at full rated pressure without the need of a downstream flange.

2.08 SWING CHECK VALVES

A. NPS 2 Inches and Smaller:

1. Class 125, Bronze Body, Horizontal Swing, Y-Pattern:
   a. Standard: MSS SP-80, Type 3.
   b. Rating: 200 psig CWP.
   c. Construction: ASTM B62 bronze body with bronze disc and trim.
   d. Ends: Threaded per ASME B1.20.1.

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B. NPS 2-1/2 Inches and Larger:

1. Class 125, Iron Body, Horizontal Swing, Bolted Bonnet:
   a. Standard: MSS SP-71, Type I.
   b. Rating: 200 psig CWP.
   c. Construction: ASTM A126, gray iron body with bronze disc and trim.
   d. Ends: Flanged per ASME B16.1.

2.09 LIFT CHECK VALVES

A. NPS 1-1/2 Inches and Smaller:

1. Class 125, Iron or Bronze Body, Inline, Spring-Assisted Center-Guided Lift Check (Silent Check):
   a. Standard: MSS SP-125.
   b. Rating: 200 psig CWP.
   c. Construction: ASTM A126 cast iron or ASTM B62 bronze body with bronze disc and trim.
   d. Ends: Threaded per ASME B1.20.1 or wafer style body.

B. NPS 2 Inches and Larger:

1. Class 125, Iron Body, Inline, Spring-Assisted Center-Guided Lift Check (Silent Check):
   a. Standard: MSS SP-125.
   b. Rating: 200 psig CWP.
   c. Construction: ASTM A126, cast iron body with bronze disc and trim.
   d. Ends: Flanged per ASME B16.1.

2.10 GATE VALVES

A. NPS 2 Inches and Smaller Water Service:

1. Class 125, Bronze Body, Screw-in Bonnet, Rising Stem, Solid Wedge:
   a. Standard: MSS SP-80, Type 2.
   b. Rating: 200 psig CWP.
   c. Construction: ASTM B62 bronze body with bronze trim and integral seat.
   d. Actuator Type: Steel or iron handwheel.
   e. Ends: Threaded per ASME B1.20.1.

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B. NPS 2-1/2 Inches and Larger Water Service:

1. Class 125, Iron Body, Bolted Bonnet, Outside Screw and Yoke, Solid Wedge:
   a. Standard: MSS SP-70, Type I.
   b. Rating: 200 psig CWP.
   c. Construction: ASTM A126 gray iron body with bronze trim.
   d. Actuator Type: Steel or iron handwheel.
   e. Ends: Flanged per ASME B16.1.

2.11 GLOBE VALVES

A. NPS 2 Inches and Smaller Water Service:

1. Class 125, Bronze Body, Screw-in Bonnet, Integral Seat:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
   c. Construction: ASTM B62, bronze body with bronze trim.
   d. Actuator Type: Steel or iron handwheel.
   e. Ends: Threaded.

B. NPS 2-1/2 Inches and Larger Water Service:

1. Class 125, Iron Body, Bolted Bonnet:
   a. Standard: MSS SP-85, Type I.
   b. Rating: 200 psig CWP.
   c. Construction: ASTM A126, gray iron body with bronze trim.
   d. Actuator Type: Steel or iron handwheel.
   e. Ends: Flanged per ASME B16.1.

2.07 FINISHES

A. Factory prepare, prime, and finish coat in accordance with Pipe Data Sheet(s) and Piping Schedule.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify size, material, joint types, elevation, horizontal location, and pipe service of pipelines to be connected to new equipment or existing pipe.

B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

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3.02 PREPARATION

A. Notify JACOBS at least 2 weeks prior to field fabrication of pipe or fittings.

B. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.

C. Damaged Coatings and Linings: Repair using original coating and lining materials in accordance with manufacturer's instructions.

D. Refer to Piping Schedule and Section 09 90 00, Painting and Coating, for additional requirements.

3.03 INSTALLATION

A. In accordance with ASME B31.9 and ASME B31.1, and these Specifications.

B. General:

1. Install piping to allow adequate service space for equipment.
2. Install vertical piping plumb.
3. Where interferences develop in field, offset or reroute piping as required to clear such interferences.
4. Install valves, control valves and piping specialties, including items furnished by others, as specified and detailed.
5. Make connections to equipment installed by others where that equipment requires piping services indicated in this section.
6. Pitch horizontal mains up at 1 inch per 40 feet in direction of flow.
7. Provide straight lengths of pipe upstream and downstream of flow measuring devices as required for accurate flow measurement.
8. Use copper piping (non combustible) for any areas above a lay in ceiling that creates and air plenum.
9. Use PVC piping where piping is not in plenum space.

C. Piping Expansion: Provide anchors, expansion joints, swing joints and expansion loops so piping may expand and contract without damage to itself, equipment, or building.

D. Aboveground Piping:

1. Group piping wherever practical at common elevations.
2. Install piping to conserve building space and to not interfere with use of space and other work.
3. Run piping parallel to building or column lines and perpendicular to floor, unless shown otherwise.

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4. Install piping at such heights not to obstruct any portion of window, doorway, stairway, or passageway.
5. Install piping so no load or movement in excess of that stipulated by equipment manufacturer will be imposed upon equipment connection.
6. Piping Clearance (unless otherwise shown):
    a. Over Walkway and Stairs: Minimum of 7 feet 6 inches, measured from walking surface or stair tread to lowest extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
    b. Between Equipment or Equipment Piping and Adjacent Piping: Minimum 3 feet, measured from equipment extremity and extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
    c. From Adjacent Work: Minimum 2 inches from nearest extremity of completed piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
    d. Do not route piping in front of or to interfere with access ways, ladders, stairs, platforms, walkways, openings, doors, or windows.
7. Do not route piping over, around, in front of, in back of, or below electrical equipment including controls, panels, switches, terminals, boxes, or other similar electrical work.

E. PVC Pipe Systems:

1. Cut, makeup, and install in accordance with pipe manufacturer's recommendations.
2. Offset: As recommended by manufacturer for maximum temperature variation between time of solvent welding and final use.
3. Do not install pipe when temperature is below 40 degrees F or above 90 degrees F when exposed to direct sunlight.
4. Shield ends to be joined from direct sunlight prior to and during laying operation.
5. Use strap wrenches only for tightening threaded plastic joints. Do not over tighten fittings.

F. Fittings:

1. Mitered ells, welded branch connections, notched tees and "orange peel" reducers are not allowed.
2. Unless specifically indicated, reducing flanges and reducing bushings are not allowed, except reducing bushings may be used for air vents and instrumentation connections.

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3. Unless otherwise indicated, for upfeed risers use top or top 45-degree connection to main, and for downfeed risers use side or bottom 45-degree connection to main.
4. Do not use mechanically formed tee fittings.

G. Joints:

1. General:
   a. Refer to Piping Data Sheet(s) for acceptable joint methods for each piping system.
   b. Make piping joints in accordance with ASME B31.9 and ASME B31.1, and these Specifications.
2. Preparation:
   a. Ream ends of pipes and tubes and remove burrs.
   b. Bevel plain ends of steel pipe.
   c. Remove scale, slag, dirt and debris from inside and outside of pipe and fittings before assembly.
3. Threaded Joints:
   a. Thread pipe with tapered pipe threads in accordance with ASME B1.20.1.
   b. Cut threads full and clean using sharp dies.
   c. Cut threads so no more than three threads remain exposed after joint is made.
   d. Ream threaded pipe ends to remove burrs and restore full ID.
   e. Apply thread sealants to cleaned male threads.
   f. Assemble joint to appropriate depth and remove excess pipe joint compound from tightened joint.
4. Flanged Joints:
   a. Clean flange surfaces and align flange surfaces parallel.
   b. Select appropriate gasket material, size, type and thickness for service application.
   c. Bolt holes of gaskets shall be cut slightly larger than bolt diameter and gasket ID shall be slightly larger than flange ID.
   d. Position gasket concentrically so compression is equally distributed over entire gasket surface.
   e. Lubricate bolts and run nuts down by hand.
   f. Tighten nuts in proper sequence so gasket is compressed evenly, and to torque specified by bolt manufacturer.
   g. Retorque bolts 12 to 24 hours after startup.
5. Welded Joints: Construct joints in accordance with ASME B31.1 and ASME B31.9, using qualified processes and welding operators according to Article Quality Assurance.

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6. Solvent Welded Joints:
    a. Comply with ASTM F402 for safe handling practices of cleaners, primers, and solvent cements.
    b. Clean and dry joining surfaces by wiping with clean cloth and applying primer.

H. Unions and Flanges:

1. Provide at each equipment connection or instrumentation connection to facilitate installation and removal without cutting of piping.
2. Install at each automatic control valve and at each piping specialty or piece of equipment that requires tube pull or removal for maintenance, repair, or replacement.
3. If required, provide additional unions or flanges in order to facilitate removal of piping sections that interfere with tube pulls or equipment removal.
4. Required for line sizes 1 inch and larger.
5. Not required on copper piping with soldered joints for 1/2-inch and 3/4-inch line sizes.
6. Where valve is located at piece of equipment, provide flange or union connection on equipment side of valve.
7. Concealed unions or flanges are not allowed.

I. Vents and Drains:

1. Vents and drains that are required for completed piping system may or may not be shown on Drawings.
2. Install vents and drains throughout piping systems to permit complete venting and drainage of entire system.
3. Install drains on low points of pipelines at low point locations.
4. Install vents on high points of pipelines at high point locations.
5. If vent is not in accessible location, extend air vent piping to nearest code acceptable drain location with vent valve located at nearest accessible location to pipe.

J. Pipe Size Changes:

1. For proper air venting, use eccentric fittings (top of pipe straight) for changes in horizontal pipe sizes with fittings.
2. Concentric fittings may be used for changes in vertical pipe sizes.
3. Where size of pipe segment is not indicated, pipe segment size shall be equal to largest pipe segment to which it is connected. Transition to smaller size shall occur on side of fitting where smaller size is indicated.

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K. Piping Branch Connections:

1. Refer to Piping Data Sheet(s) for branch connection applications.
2. Do not install branch connections smaller than 1/2-inch nominal pipe size, including instrument connections, unless shown otherwise.
3. Threaded taps in pipe barrel are unacceptable.
4. Materials of branch connections shall match material of piping.

L. Terminal Equipment Connections:

1. Use minimum of three elbows in each pipeline to terminal equipment to provide flexibility for expansion and contraction of piping systems.
2. Main branches and runouts to terminal equipment may be made at top, side, or bottom of main provided there are drain valves located for complete system drainage, and manual air vents are located as described in these Specifications.
3. Size for supply and return piping connections shall be same as for equipment connections.
4. Install control valves in accessible locations close to connected equipment.
5. Install bypass piping with globe valves around control valve. If multiple, parallel control valves are installed, only one bypass is required.
6. Install ports for pressure and temperature gauges at coil inlet connections.

M. Hangers and Supports: Refer to Section 40 05 15, Piping Support Systems, for materials and methods of piping support systems.

N. Insulation: In accordance with Section 23 07 00, HVAC Insulation.

3.04 APPLICATION

A. Piping and Fittings:

1. Refer to Piping Schedule, Section 40 27 00, Process Piping—General.
2. When piping of lower pressure connects to piping of higher pressure, requirements of Piping Data Sheet for higher pressure rating prevails up to and including first isolation valve in line carrying the lower pressure, unless otherwise shown.

B. Valves: In accordance with Section 40 27 02, Process Valves and Operators.

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3.05 FIELD FINISHING

A. Notify JACOBS at least 3 days prior to start of surface preparation or coating application work.

B. Accessories:

1. Above Ground: Accessories include, but are not limited to, pipe hangers, supports, expansion joints, pipe guides, flexible couplings, vent and drain valves, and fasteners.

3.06 FIELD QUALITY CONTROL

A. Pressure Leakage Testing: In accordance with Section 40 80 01, Process Piping Leakage Testing.

3.07 CLEANING

A. Piping System:

1. General: Internally clean piping systems before they are used, except conduct pressure test before cleaning.
2. System Flush:
   a. Flush piping systems with water thoroughly, for 15 minutes or longer, as required to ensure removal of dirt and foreign matter from piping system.
   b. Bypass pumps and equipment, and remove strainers from strainer bodies.
   c. Provide temporary piping or hose to bypass coils, control valves, other factory cleaned equipment, and any component which may be damaged, unless acceptable means of protection are provided and subsequent inspection of hide-out areas takes place.
   d. Sectionalize system to obtain minimum velocity of 6 feet per second.
   e. Provide temporary piping to connect dead-end supply and return headers as necessary.
   f. Flush bottoms of risers.
3. System Cleaning:
   a. After initial flushing of system, use portable pumping apparatus for continuous 24-hour, minimum, circulation of cold water detergent.
   b. Add cleaner to closed systems at concentrations as recommended by cleaner manufacturer.
   c. Flush detergent clear with continuous draining and raw water fill for additional 12 hours or until cleaner is removed from system.

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d. Inspect, remove sludge, and flush low points with clean water after cleaning process is completed.
e. Replace strainers and reconnect permanent pumping apparatus and bypassed apparatus.
f. Drain cleaning water to sanitary sewer.

3.08 PIPE DATA SHEETS

A. Polyvinyl Chloride Pipe and Fittings Data Sheet, and Section 40 27 00.10, Polyvinyl Chloride (PVC) Pipe and Fittings Data Sheet.

END OF SECTION

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SECTION 23 21 14
HYDRONIC SPECIALTIES

PART 1 GENERAL

1.01 REFERENCES

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

1. American National Standards Institute (ANSI).
2. American Society of Mechanical Engineers (ASME).
   a. B15.1, Safety Standard for Mechanical Standard Transmission Apparatus.
   b. B40.100 Pressure Gauges and Gauge Instruments.
   c. B40.200, Thermometers, Direct Reading and Remote Reading.
   d. BPVC Section VIII, Rule for Construction of Pressure Vessels.
3. National Electrical Manufacturers Association (NEMA).
4. Occupational Safety and Health Act (OSHA).

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
2. Provide for products specified, as follows:
   a. Identify as referenced in Contract Documents.
   b. Manufacturer’s name and model number.
   c. Descriptive specifications, literature and drawings.
   d. Dimensions and weights.
   e. Pump Curves:
      1) Performance Curves Indicating:
         a) Relationship of flow rate to static pressure for various pump speeds.
         b) Brake horsepower curves.
         c) Acceptable selection range.
         d) Static pressure, capacity, horsepower demand and overall efficiency required at the duty point.
   f. Capacities and ratings.
   g. Construction materials.
   h. Pump type, size, drive arrangement, and bearings.
   i. Impeller type, diameter.
   j. Motor data.

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k. Power and control wiring diagrams, including terminals and numbers.
l. Vibration isolation.
m. Factory finish system.
n. Color selection charts where applicable.

3. Where submitted equipment results in change to piping and equipment configuration shown on Drawings, submit detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement to equipment furnished.

B. Informational Submittals:

1. Recommended procedures for protection and handling of equipment and materials prior to installation.
2. Manufacturer's installation instructions.
3. Test reports.
4. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data; including as-built version of equipment schedules.

1.03 EXTRA MATERIALS

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

Item	Quantity
Pressure gauge	Two in appropriate range
Temperature gauge	Two in appropriate range
Special tools required to maintain or dismantle	One complete set

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Some specific equipment requirements are listed in Equipment Schedules. Refer to Drawings.

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2.02 EQUIPMENT

A. Expansion Tank:

1. Heavy-duty butyl rubber diaphragm type.
2. Steel tank designed and constructed per ASME Section VIII, Division 1 rated for 240 degrees F working temperature and 125 psi working pressure.
3. Performance and Capacities: Refer to Equipment Schedule.
4. Manufacturers and Product:
    a. Amtrol; Extrol AX Diaphragm Series.
    b. ITT/Bell & Gossett; D Series, Diaphragm.
    c. Taco; CX Diaphragm Series.

B. Pot Feeder: Bypass Filter feeder for injecting chemical treatment into closed loop systems. Install as shown in drawings.

1. Working Pressure: 125 psi.
2. Cast-iron or steel body.
3. Quick opening cap with O-ring seal.
4. Funnel or large opening on top for easy chemical addition.
5. Bag filters rated at 20 micron and 5 micron. Install one 20 micron filter at the time of installation with one spare 20 micron and two spare 10 micron filters to be turned over to the owner.
6. Furnish with balance valve to limit the flow to approximately 5.0 GPM.
7. Manufacturers and Products:
    a. Neptune; Model DBF, 5-gallon capacity.
    b. J. L. Wingert; Model DB.

C. Flowmeter:

1. Cast-iron wafer type orifice plate.
2. Pressure taps equipped with EPT check valves and gasketed caps.
3. Rated for maximum working pressure of 250 psi and maximum operating temperature of 250 degrees F.
4. Machined and calibrated orifice plate.
5. Nameplate giving flow rates and differential pressures.
6. Manufactures and Products:
    a. ITT/Bell & Gossett; Series OP Circuit Sensor.
    b. Flowset; Series H.

D. Automatic Flow Control Valve:

1. In-line automatic flow controller.
2. Plus or minus 5 percent accuracy over a 3-pound to 40-pound differential range.

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3. 400-pound rated ball valve for shutoff service.
4. Pressure/temperature test port with cap retainer.
5. Flow rate set at factory.
6. Permanently marked to show direction of flow and flow rate.
7. In-line strainer, complete with in-line stainless steel strainer basket and blowdown/drain valve.
8. Manufacturers:
    a. AutoFlow.
    b. Griswold.

E. Pressure and Temperature Test Plug:

1. Brass body.
2. 1/4-inch NPT.
3. Removable threaded brass protective cap.
4. Dual Nordel core rated for 200 degrees F.
5. Manufacturers and Products:
    a. Sisco; Model BNO.
    b. MG Piping Products; Model PT.
    c. Peterson Equipment Co.; Pete's Plugs.

F. Bimetallic Industrial Thermometer:

1. Precision calibrated bimetallic sensing element.
2. Silicone dampened coil.
3. Adjustable angle type with swivel union connection.
4. 3–inch diameter face.
5. Hermetically sealed stainless steel case.
6. Stem:
    a. Stainless steel.
    b. Length as recommended by manufacturer for pipe or duct size and insulation thickness at installed thermometer location.
7. Weatherproof case when thermometer will be located in exterior location.
8. Double strength glass window.
9. External recalibrator.
10. Fahrenheit and Celsius scales.
11. When installed in piping, install with thermowell furnished by same manufacturer as thermometer.
12. Maximum 2 degrees per scale division for Fahrenheit scale, maximum 1 degree per scale division of Celsius scale.
13. Accurate to plus or minus 1 percent of full scale in accordance with ASME B40.200.
14. Condenser water System range: 0 degrees F to 200 degrees F and minus 20 degrees C to 95 degrees C.

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15. Manufacturers and Products:
    a. H. O. Trerice; Series B8.
    b. Weksler Glass Thermometer Company.
    c. Ashcroft.

G. Pressure Gauge:

1. Bourdon tube sensing element.
2. Range:
    a. 0 psig to 150 psig.
    b. Indelibly mark ranges with black figures on a white background.
3. Connection: 0.25-inch male NPT.
4. Case:
    a. Painted steel, stainless steel, fiberglass reinforced polypropylene, or aluminum.
    b. Weatherproof case when gauge will be located in exterior location.
5. Wetted Parts: Bronze, brass, stainless steel, or monel.
6. Ring: Stainless steel or fiberglass reinforced polypropylene.
7. Window: Acrylic or glass.
8. Dial Face:
    a. 4-inch diameter, minimum.
    b. White with black figures.
9. Accuracy: Plus or minus 1 percent of full scale in accordance with ASME B40.100.
10. Temperature Rating: 250 degrees F, minimum.
11. Manufacturers:
    a. H. O. Trerice.
    b. Ashcroft.
    c. Weksler.

H. Automatic Air Vent: Brass body with nonferrous internals.

1. Manufacturers and Products: For 150 psig maximum operating pressure and 240 degrees F maximum operating temperature.
    a. ITT/Hoffman Specialty; No. 78.
    b. ITT/Bell & Gossett; No. 87.
2. Manufacturers and Products: For 35 psig maximum working pressure and 230 degrees F maximum operating temperature.
    a. ITT/Hoffman Specialty; No. 79.
    b. ITT/Bell & Gossett; No. 67.

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I. Strainers:

1. Y-type.
2. Body: Class 125 cast iron.
3. 2 Inches and Smaller: Screwed ends and screwed face cap.
4. 2-1/2 Inches and Larger: Flanged ends with bolted end cover and blowdown connection.
5. Screen:
   a. Type 316 stainless steel.
   b. Free Area: Minimum of 2-1/2 times inlet area with 3/16-inch perforations.
6. Manufacturers:
   a. Armstrong.
   b. Keckley.
   c. Spirax Sarco.

J. Suction Diffuser:

1. To be furnished by pump manufacturer.
2. Body: 175 psig working pressure, cast iron.
3. Inlet straightening vanes with length no less than 2-1/2 times pump suction diameter.
4. Stainless steel combination diffuser-strainer-orifice cylinder with total free area equal to or greater than five times the cross-sectional area of pump suction; designed to withstand pressure differential equal to pump shutoff head.
5. Disposable 16-mesh startup strainer.
6. Permanent magnet located in flow stream, removable for cleaning.
7. Adjustable foot support designed to carry weight of suction piping.
8. Blowdown tapping in bottom, gauge tapping in side.
9. Manufacturers and Products:
   a. ITT/Bell & Gossett; Suction Diffuser.
   b. Taco; SD.

K. Piping Flexible Connectors:

1. Spherical connector.
2. Twin sphere.
3. Precision molded of multiple layers of Kevlar cord and EPDM cover.
4. Rated 175 psi at 200 degrees F.
5. 2 Inches and Smaller: Threaded union end connections.
6. 2-1/2 Inches and Larger: Steel or cast-iron flanges.
7. Manufacturers and Products:
   a. Mason; Safeflex.
   b. Metraflex; Metrasphere.

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L. Dielectric Isolators:

1. Isolators:
   a. Glass fiber reinforced nylon insulating bushings where size reduction is required.
   b. Two insulating bushing in oversized couplings where size reduction is not required.
2. Unions: Nylon insulated metal unions.
3. Insulating Sets:
   a. Combination sleeve, washer, and full-face neoprene gasket flange at flange joints.
   b. Drill flange holes oversize and use standard size bolts, with double insulation on bolts so each bolt is insulated from both flanges.
4. Temperature Rating: 210 degrees F.

M. Centrifugal-Action Separator:

1. Vortex type.
2. Performance: 98 percent removal of 74 microns and larger, with significant particle removal.
3. Purge outlet shall be male NPT 3/4 inch.
4. Purge of separated solids accomplish automatically with a 3/4-inch timer activated motorized ball valve.
5. Inlet and outlet shall be male NPT 1-1/2 inches.
6. Maximum pressure loss of 10 psi.
7. Material: Stainless steel.
8. Clamp-on support legs.

N. Automatic Glycol Feed System:

1. General:
   a. Monitor hydronic system pressure. When hydronic system pressure drops below a set pressure indicating loss of fluid, feed system shall pump treated glycol solution into hydronic system as required to bring hydronic system pressure back to pressure setpoint.
   b. System shall be fully automatic with one pump for each hydronic loop served, controls, glycol tank, stand and all other devices as required for a complete and functional stand alone system.
2. Single loop system.
3. Tank:
   a. Industrial grade polyethylene storage tank with cover.
   b. Size: 17 gallon, minimum.

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4. Pump: One for each hydronic system served, each rated at minimum 1.3 gpm at 100 psi.
5. Drain valve.
6. Y-type strainer at each pump inlet and check valve at each pump outlet.
7. Pump isolation valves.
8. Pressure gauge for each hydronic system served.
9. Pressure Relief Valve:
    a. Provide with recirculation piping for each hydronic system served.
    b. Relief Pressure: 30 psi.
10. Controls:
    a. NEMA 4X control panel enclosure.
    b. Factory prewired.
    c. Low tank level cutoff switch that prevents pump operation when tank level is low with audible low level alarm and silence switch with dry contact for low tank level alarm.
    d. Adjustable pressure switch for each hydronic system served. Cut in, cut out, and pressure differential as required for system to function effectively at system pressure specified.
    e. Main power switch and ON light.
    f. HAND/OFF/AUTO switch for each pump.
    g. Low level alarm indicating light.
11. Single point power connection plug in type.
12. Voltage: 115 volt, 60 Hz.
13. Manufacturers:
    a. Axiom.
    b. Neptune.
    c. J. L. Wingert.
    d. Or equal.

O. Glycol Fluid:

1. 20 percent solution of propylene glycol and water, with corrosion inhibitors.
2. Dilution water per manufacturer’s recommendations.
3. Manufacturers and Products:
    a. DOW; Dowfrost HD.
    b. STA-Clean Products; STA-Clean Antifreeze.

P. Hydronic Pumps, In-Line Mounted:

1. Centrifugal type.
2. Resiliently mounted horizontal or vertical motor.
3. Cast-iron pump casing fitted with companion flanges for line mounting.
4. Gauge tappings.

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5. Cast-iron construction.
6. Mechanical shaft seal.
7. Rating: 175 psig working pressure.
8. Performance and Capacities: Refer to Equipment Schedule.
9. Manufacturers and Products:
    a. Bell & Gossett.
    b. Taco.
    c. Paco.
    d. Memphis.

2.03 MOTORS

A. General:

1. Pump 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 shall not operate into service factor.

B. Motor requirements shall be as follows, unless designated otherwise on Equipment Schedule:

1. Horsepower, Voltage, and Phase: As scheduled.
2. Enclosure: As scheduled.
3. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
4. Winding Thermal Protection: None.
5. Space Heater: None.
6. Number of Speeds: Single.
7. Number of Windings: One.
8. Motor Efficiency: Premium efficient.
9. Shaft Type: Solid, carbon steel.
10. Oil-lubricated ball bearings.
11. Mounting: As required for pump arrangement.
12. Service Factor: 1.15.

2.04 FLOW CONTROL VALVE

A. General: Provide a control valve complete, regulating valve, isolation valves, flexible hoses and unions as required for installation.

B. Valve shall be sized to control between 4 and 57 psi differential.

C. Constructed with cast brass body and screwed ends.

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D. Trim: Removable cage providing valve plug guiding throughout entire travel range.

E. Type 316 stainless steel stem, removable bonnet, cage, stem, and plug assembly, inlet and outlet isolation valves and differential pressure ports for measuring the flow thru the valve.

F. Furnish with a minimum 18-inch flame retardant flexible hose that is approved for use in a plenum space.

G. Valves 1/2 Inch to 2 Inches:

1. Constructed with cast brass body and screwed ends.
2. Trim: Removable cage providing valve plug guiding throughout entire travel range.
3. Type 316 stainless steel stem.
4. Return side: Isolator union ball valve with combination pressure/temperature test valve and manual air vent.
5. Supply side: Pressure/temperature test valve, manual air vent and drain valve

H. Manufacturers:

1. Griswold Hosekit.
2. AutoFlow.
3. Or equal.

2.05 NATURAL GAS BOILER

A. Provide hot water heating boiler complete with firing equipment, combustion chamber, insulation with steel jacket, safety and operating controls, integral electrical wiring and other appurtenances, to make the boiler a complete, self-contained, fully-automatic unit, ready for service upon completion of utility connections. Commercial boilers less than 300,000 Btuh must have an Annual Fuel Utilization Efficiency (AFUE) of at least 90 percent.

B. Packaged, modulating, sealed combustion, power-vented, high-efficiency gas-fired boiler(s) with stainless steel fire-tube heat exchangers that use outside air for combustion (direct vent). Boiler(s) shall have an AHRI gross output at 100 percent fire rate. Refer to drawing for boiler capacity and firing rate. Boiler shall be 95 percent AFUE, minimum DOE efficient as required by National Energy Conservation Act or ASHRAE 90.1 - IP or have a minimum thermal efficiency of 96 percent. Units shall have an independent laboratory rating of <20 ppm for Oxides of Nitrogen (NOx) to meet the requirements of South Coast Air Quality Management District in Southern California and the requirements of Texas Commission on Environmental Quality. Boiler shall be capable of full modulation firing with a turn down of up to 10 to 1.

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C. Boiler(s) to conform to Section IV of the ASME BPVC. Provide with working pressure of 80 psig water as listed on the rating label. Boiler and controls to comply with applicable regulations and shall be fully factory packaged.

D. Boiler heat exchanger shall be fire-tube with stainless steel heat exchanger. The boiler must have corrosion-resistant condensate collector to capture condensate from both the vent system and heat exchanger.

E. The combustion chamber will be sealed and located at the top which will be of counter flow design to assure that sediment and any lime that might form will fall to the bottom away from the crown sheet area. Boiler must be capable of using outside air piped directly to boiler for combustion. Inlet and termination of these pipes must be connected to either through-the-roof or sidewall terminations as recommended by the manufacturer.

F. Burner shall be premix combustion type, made with stainless steel and a woven metal fiber outer covering to provide a wide range of modulating firing rates. Boiler shall be equipped with a variable speed blower system capable of modulating the boiler firing rate.

G. Boiler shall be equipped with a device capable of controlling the air/fuel ratio through a 10 to 1 turndown ratio with smooth operation. Control system shall have an electronic display for boiler set-up, boiler status, and boiler diagnostics. Furnish with a Boiler powered ECM circulator to provide primary water circulation through the boiler when in operation. Provide with a wall mounting bracket to support boiler on wall or strut framing.

H. All controls shall be factory-furnished and tested. Boiler Control to be UL 353 Listed. As a minimum include the following:

1. High limit temperature control with manual reset (190 degrees F maximum allowable boiler water temperature).
2. Combination pressure-temperature gauge. Gauge dial clearly marked and easy to read.
3. ASME-certified pressure relief valve set to relieve at 80 psig.
4. Flue gas, outlet water temperature, and return water temperature sensors.
5. Low water protection with manual reset.
6. Built-in freeze protection.
7. Built-in BACnet communication.
8. Ability to power and control circulator pump.
9. Flue gas, outlet water temperature, and return water temperature sensors.

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10. LCD display and button interface.
11. Alarm contact that triggers during manual lockout, flame failure, high temperature limit and low water cut off.
12. Remote modulation capable of interfacing with Building Automation.

I. Manufacturers:

1. Weil-McLain Model EVG.
2. Lochinvar.
3. Or equal.

2.06 BOILER FLUE

A. Boiler Stack:

1. UL listed, Type AL-29 or as recommended by the boiler manufacturer.
2. Stainless steel inner and outer jacket.
3. Provide a concentric vent where vent penetrates wall or roof assembly.
4. Insulating thimble.
5. Tee section with drain where stack is offset.
6. Manufacturer's standard fittings as required.

B. Manufacturers and Product:

1. Selkirk; Metalbestos.
2. Van Packer.

2.07 ACCESSORIES

A. Equipment Identification Plates: Furnish 16-gauge stainless steel identification plate securely mounted on each separate equipment component in a readily visible location. Plate shall bear 1/4-inch high die-stamped block type black enamel filled equipment identification number and letters indicated in this Specification.

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

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.

2.08 FINISHES

A. Manufacturers' standard.

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PART 3 EXECUTION

3.01 EQUIPMENT INSTALLATION

A. Expansion Tank:

1. Secure tank to structure.
2. Charge to required system pressure.

B. Balancing Devices:

1. Install balancing devices with unrestricted flow and straight pipe for four pipe diameters up and downstream.
2. Install well tappings and fittings for control sensors furnished by controls Supplier.
3. Provide pressure and temperature test plugs at the following locations, unless pressure gauges and thermometers are provided:
   a. Inlet and outlet to hydronic coils.
   b. Both sides of pumps.
   c. Both sides of control valves.
   d. Both sides of heat exchangers.
   e. Expansion tanks.

C. Air Vents:

1. Automatic Air Vents:
   a. Install at air separators.
   b. With 3/4-inch shutoff valve with 1/2-inch Type L copper drain line to nearest receptor.
2. Manual Air Vents: Install at high side of coils and at high points of condenser water piping system

D. Centrifugal-Action Separator:

1. Install as indicated on Drawings.
2. Secure to structure.

E. Valves:

1. Locate and orient so handles are readily accessible.
2. Orient stems vertically in horizontal runs of pipe having centerline elevations 4.5 feet or less above finished floor, unless otherwise noted.
3. Orient stems horizontally in horizontal runs of pipe having centerline elevations above 4.5 feet above finished floor, unless otherwise noted.

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F. Strainers:

1. Install on upstream side of automatic valves, pressure-reducing valves, suction side of pumps, and elsewhere as indicated.
2. Where installed in equipment rooms, provide valved blowout connection piped to nearest drain.
3. Where installed at pump mains, provide 16-gauge bronze start-up strainer. Remove start-up strainer after system flush and prior to balancing.
4. Remove and clean system strainers after 24 hours of operation and after 30 days of operation.

G. Suction Diffusers: Provide 16-gauge bronze startup strainer. Remove startup strainer after system flush and prior to balancing.

H. Flexible Connectors: Install at pumps, chillers, air-handling units, equipment on vibration isolators, and at building seismic joints.

I. Dielectric Isolators: Install where incompatible piping materials, except for bronze valves and strainers, come into contact with each other.

J. Automatic Glycol Feed Systems:

1. Install in compliance with manufacturer's written instructions.
2. Coordinate with other trades as required for power and control wiring.
3. Install with access as required for normal operation and as required to service parts.

K. Glycol Fluid:

1. Fill the following hydronic systems: Condenser water.
2. After hydronic systems have been completely filled with specified glycol solution, provide full tank of glycol solution specified.

L. In-Line Mounted Pumps separately from piping.

M. Thermometer:

1. Install in strict accordance with manufacturer's recommendations.
2. Install in location that allows easy access for reading thermometer in safe fashion.
3. When located in piping install with a thermowell and heat transfer gel.

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N. Pressure Gauge:

1. Install in strict accordance with manufacturer's recommendations.
2. Install in location that allows easy access for reading gauge in safe fashion.

O. Boiler:

1. Install in accordance with manufacturer's recommendations.
2. Pipe drains and relief valve discharges to floor drain, terminating with an elbow discharging downward.
3. Flush out boiler and connecting piping prior to initial fill.
4. Provide seismic restraints for the boiler utilizing lateral and vertical motion limiters described in SMACNA "Seismic Restraint Manual: Guidelines for Mechanical Systems."

P. Boiler Stack and Breeching:

1. Assemble individual sections of stack together to provide a completely supported stack.
2. Follow manufacturer's drawings and directions for installation of stack.
3. Gas Vent Stack: Install in accordance with manufacturer's recommendations and requirements of NFPA 54.

3.02 ACCESS AND CLEARANCE CONSIDERATIONS

A. Obstructions: Drawings do not attempt to show exact details of piping. Anticipate and work around obstructions.

B. Cover piping installed across aisles or other main access walkways with a protective checkered plate steel ramp, pitched a maximum of 2:12 to allow safe wheeled or foot traffic, and paint with a prime coat and two finish coats of Safety Yellow. Support ramp from floor and do not rest ramp directly on pipe.

C. Install specialties with suitable access clearances for maintenance or removal of replaceable components. Provide necessary couplings or flanges to maintain or remove specialties without removing connecting appurtenances.

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D. Do not install water piping immediately over or within a 3-foot horizontal clearance of any electrical panel, motor starter, or environmental control panel (ECP). Where piping is located within these zones, install piping inside a PVC conduit or shield electrical device to protect it from direct water access.

E. Provide an alternate safe means of access where equipment requiring periodic maintenance cannot be reached by walkways because of substitution of equipment or interference with ductwork, piping, or other mechanical conflicts resulting from construction. These may include:

1. Overhead platform with stairway or ladder access and safety railings or handholds.
2. Walk-through duct plenums with hinged access doors.
3. Other means as necessary to meet OSHA standards for safe maintenance procedures.

3.03 CLEANING AND ADJUSTING

A. Cleanup:

1. Thoroughly clean parts of the installation and remove refuse material at completion of the Work.
2. Lubricate motors and bearings in accordance with manufacturer's service manuals prior to equipment startup.

END OF SECTION

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SECTION 23 25 00
HVAC WATER TREATMENT

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. D859, Standard Test Method for Silica in Water.
   b. D1066, Standard Practice for Sampling Steam.
   c. D1067, Standard Test Methods for Acidity or Alkalinity of Water.
   d. D1068, Standard Test Methods for Iron in Water.
   e. D1126, Standard Test Method for Hardness in Water.
   f. D3370, Standard Practices for Sampling Water from Closed Conduits.
2. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
3. National Fire Protection Association (NFPA): 70, National Electrical Code.
4. Underwriters Laboratories (UL): 486A-486B, Standard for Safety for Wire Connectors.

1.02 SYSTEM DESCRIPTION

A. Design Requirements: Engineer, design, fabricate, program, shop assemble, shop test, provide documentation, deliver, field test, and provide startup assistance for HVAC Water Treatment Systems, as required by this Specification.

B. Performance Requirements:

1. Maintain water treatment for HVAC systems that controls corrosion and buildup of scale and biological or organic growth for maximum efficiency of installed equipment without posing hazard to operating personnel or environment.
2. Base chemical treatment performance requirements as follows:
   a. Quality of water available at Site.
   b. HVAC system equipment material characteristics and functional performance characteristics.
   c. Operating personnel capabilities.
   d. Requirements and guidelines of authorities having jurisdiction.

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1.03 SUBMITTALS

A. Action Submittals:

1. Detailed equipment assemblies indicating dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: Detailed power and control wiring; differentiate between manufacturer-installed and field-installed wiring.
3. Manufacturer's literature including rated capacities and furnished products listed below:
   a. Pumps.
   b. Chemical solution tanks.
   c. Spill Containment Basin.
   d. Control equipment and devices.
   e. Test equipment.
   f. Chemicals.
   g. Blowdown control solenoid valves.
   h. Chemical usages, based on addition rate per gallon of treated water.

B. Informational Submittals:

1. Shipping, installed, and operating weights.
2. Water Analysis: Copy of water analysis to illustrate water quality available at Site.
3. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
4. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.05 MAINTENANCE SERVICE

A. Maintenance Service Contract:

1. Provide chemicals and service program for maintaining optimum conditions in the HVAC condenser water system, for inhibiting corrosion, scale, and organic growths.
2. Provide service for the following systems, piping and equipment: Cooling, condenser water piping and Cooling Towers.

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3. Contract Duration:
   a. Provide services and chemicals for a period of 1 year from date of Substantial Completion.
   b. Not less than 12 service calls and written status reports.
4. Provide the following services as a minimum:
   a. Initial water analysis and recommendations.
   b. Direct flushing, cleaning, pretreatment, training, debugging, startup assistance, and acceptance testing operations.
   c. Direct and perform chemical limit control, in accordance with these specifications.
   d. Periodic field service and consultation.
   e. Customer report charts and log sheets.
   f. Laboratory technical assistance.
   g. Analyses and reports of chemical items concerning safety and compliance with government regulations.
5. Additional Specific Tests:
   a. Open Loop Condenser Water Systems:
      1) Perform monthly tests of cooling tower water for Legionella pneumophila and submit reports stating Legionella bacteria count per millimeter.
      2) Conduct tests in a certified laboratory and not by a technician in the field.
   b. Automatic Chemical Feed Systems:
      1) Perform two separate water analyses to prove automatic chemical feed systems are maintaining water quality within performance requirements specified.
      2) Conduct the first water analysis test after successful HVAC Water Treatment System startup and acceptance.
      3) Perform analyses at least 60 days apart.
      4) Provide written reports of water analysis.

1.06 EXTRA MATERIALS

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

Item	Quantity
Chemicals	Quantity equal to 25 percent of amount initially installed
Log Forms	One year supply of preprinted water treatment test log forms

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. Nalco Chemical Co.
2. Ampion Corp.
3. ANCO, A Division of Chem-Aqua, Inc.
4. Cleaver-Brooks.
5. Barclay Chemical Co., Water Management, Inc.
6. Betz Dearborn, Inc.
7. Calgon Corp., ECC International.
8. Diversey Water Technologies, Inc.
9. DuBois Chemicals, Inc., DuBois USA Subsidiary.
10. Fluids Pumps & Controllers, Inc.
11. Harmsco Industrial Filters.
12. Metro Group, Inc., Metropolitan Refining Div.
13. Selick & Bird, Inc.
14. Stewart-Hall, Div. of the Rectorseal Corp.
15. Trane Boland Services, Water Treatment.
16. Watcon, Inc.

2.02 MATERIALS

A. Furnish chemicals recommended by water treatment system manufacturer that are compatible with piping system components and connected equipment.

B. System Cleaning Compounds:

1. Alkaline phosphate or nonphosphate detergent/surfactant/specific to remove organic soil, hydrocarbons, flux, pipe mill varnish, pipe compounds, iron oxide, and like deleterious substances.
2. Suitable for system wetted metals without deleterious effects.
3. Refer to Section 23 21 13, Hydronic Piping, for flushing and cleaning procedures.

2.03 CLOSED-LOOP HYDRONIC SYSTEM TREATMENT

A. System Description: Chemical corrosion treatment system for closed-loop hydronic systems.

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B. Application:

1. Closed Condenser Water Systems:
   a. Chemical Type: Glycol freeze and corrosion inhibitor.
   b. Chemical Quantity: 50 gallons.
   c. Dosing Method: Automatic, via glycol water makeup system.

C. Chemicals:

1. General:
   a. Maintain inhibitor residual as determined by water treatment laboratory, taking into consideration residual and temperature effect on pump mechanical seals.
   b. pH Control: Include adequate buffer in inhibitor formulation to maintain pH range of 8.0 to 10.5.
   c. Will not cause or enhance bacteria/corrosion problems or mechanical seal failure because of excessive total dissolved solids.
   d. Suitable for makeup water quality and rate.

2. Glycol Freeze and Corrosion Inhibitor:
   a. Formulated for hydronic piping system freeze protection and corrosion prevention.
   b. 30% Propylene glycol
   c. Formulated for use as a heat transfer fluid.
   d. Product:
      1) Glycol, technical grade (not automotive formula), inhibited with 1.75 percent dipotassium phosphate.
      2) Type: Propylene glycol.
      3) Dyed red in color, for easy identification.
   e. Manufacturers:
      1) Dow Chemical.
      2) Union Carbide.
3. Antiscale/pH Control/Corrosion Inhibitor/Conductivity Enhancer:
   a. Contains sequestering agent to reduce deposits and adjust pH, corrosion inhibitors, and conductivity enhancers.
   b. Sodium nitrite/borate, molybdate-based inhibitor or other approved proprietary compound.

D. Performance:

1. Maintain system essentially free of scale, corrosion, and fouling.
2. pH Control: Include adequate buffer in inhibitor formulation to maintain pH range of 8.0 to 10.5.

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3. Protect various wetted, coupled, materials of construction including ferrous, and red and yellow metals.
4. Corrosion rate of following metals not to exceed specified mills per year penetration; ferrous, 0-2; brass, 0-1; copper, 0-1.
5. Inhibitor stable at equipment skin surface temperatures and bulk water temperatures of, respectively, not less than 121 degrees C (250 degrees F) and 52 degrees C (125 degrees F).
6. Heat exchanger fouling and capacity reduction not to exceed that allowed by fouling factor of 0.0005.

2.04 OPEN HYDRONIC SYSTEM TREATMENT (PROVIDED BY EQUIPMENT MANUFACTURER AS SCHEDULED)

A. System Description:

1. General: System described below is general in nature. Some variations may occur based on specific system manufacturer selected.
   a. Chemical corrosion treatment system for open hydronic systems.
   b. Refer to Article, Components, for equipment description and requirements.
2. Cooling Tower System:
   a. Conductivity controller samples system water when activated by pump and operates solenoid blowdown valve.
   b. Pumps sequestering agent and corrosion inhibitor from solution tank into condenser water supply to tower. Use agitator as required.
   c. Intermittently feeds biocide to condenser water to achieve a toxic level of the chemical to kill the organism present.
   d. Changes biocides periodically to avoid chemical immunity.
   e. Automatically feeds chemical with electronic solid-state controllers.
   f. Deactivates solution pump and signal alarm by a liquid-level switch in each solution tank on low chemicals.

B. Application:

1. Cooling Tower System:
   a. Chemical Type: Sequestering agents and Biocide.
   b. Dosing Method: Automatic via chemical feeding system.
   c. Filtration: Full stream water Centrifugal Separator.

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C. Chemicals:

1. General:
   a. Maintain inhibitor residual as determined by water treatment laboratory, taking into consideration residual and temperature effect on pump mechanical seals.
   b. Will not cause or enhance bacteria/corrosion problems or mechanical seal failure because of excessive total dissolved solids.
2. Sequestering Agent: Inhibits scaling, corrosion inhibitor, and biocide nonoxidizing.
3. Biocide: Chlorine release agents or microbiocides.

D. Performance: Maintain system essentially free of scale, corrosion and total suspended solids.

E. Positive-Displacement Diaphragm Pump:

1. Simplex, self-priming, rated for intended chemical with 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Thermoplastic construction.
4. Fully enclosed, continuous-duty, 120-volt, 60-Hz, single-phase motor.
5. Built-in relief valve.

F. Positive-Displacement Piston Pump:

1. Metal and thermoplastic construction.
2. Fully enclosed, continuous-duty, 120-volt, 60-Hz, single-phase motor.
3. Built-in relief valve.

G. Chemical Solution Tanks:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with graduated markings.
2. Removable molded fiberglass cover with recess for mounting pump, agitator, and liquid-level switch.
3. Capacity: 15 gallons (57 L).

H. Agitator:

1. Direct drive, 1,750 rpm, mounted on tank with angle adjustment.
2. Fully enclosed, continuous-duty, 120-volt, 60-Hz, single-phase motor.
3. Stainless-steel clamp and motor mount with stainless-steel shaft and propeller.

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I. Packaged Conductivity Controller: Solid-state circuitry, 5 percent accuracy, linear dial adjustment, built-in calibration switch, on-off switch and light, control-function light, output to control circuit, and recorder.

J. Solenoid Valves: Thermoplastic body, 150-pound pressure rating, and general-purpose solenoid enclosure with 120-volt, continuous-duty coil.

K. Chemical Tubing: Schedule 80, CPVC with solvent-cement joints or polypropylene tubing with heat fusion joints.

L. Plastic Ball Valves: Rigid CPVC body, locking handle, integral union ends, and polytetrafluoroethylene seats and seals.

2.05 ACCESSORIES

A. Water Test Kit: Manufacturer recommended equipment and chemicals, in a carrying case, for testing pH, total dissolved solids, dissolved oxygen, biocount, chloride, total alkalinity, and calcium hardness.

B. Spill Containment Basin.

C. Corrosion Test Coupon Assembly:

1. Complete with housing, holder, piping, valves, and mild steel and copper coupons.
2. Coupon Holder: Type 316 stainless steel.
3. Locate copper coupon downstream from mild steel coupon in the test coupon assembly.
4. Two point-station rack.

PART 3 EXECUTION

3.01 PREPARATION

A. Water Analysis: Perform analysis of supply water to determine type and quantities of chemical treatment needed to maintain water quality specified in Paragraph, Performance Requirements.

B. System Cleaning and Flush:

1. Perform system clean and flush in accordance with water treatment system manufacturer’s requirements.
2. Refer to Section 23 21 13, Hydronic Piping, for additional requirements.

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3.02 INSTALLATION

A. Install treatment equipment level and plumb.

B. Connections:

1. Piping installation requirements are specified in other Division 23, Heating, Ventilating, and Air Conditioning sections.
2. Drawings indicate general arrangement of piping, fittings, and specialties.
3. Install piping adjacent to equipment to allow service and maintenance.

C. Electrical:

1. Confirm applicable electrical requirements in Division 26, Electrical sections for connecting electrical equipment.
2. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

3.03 FIELD QUALITY CONTROL

A. Test chemical feed piping as follows:

1. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
2. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
3. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
4. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for 4 hours. Leaks and loss in test pressure constitute defects.
5. Repair leaks and defects with new materials and retest piping until satisfactory results are obtained.
6. Provide test reports, including required corrective action.

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3.04 MANUFACTURER'S SERVICES

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

1. 1 person-day for installation assistance and inspection.
2. 1 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.

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

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

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

1.02 DEFINITIONS

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

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

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

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

1.03 SUBMITTALS

A. Action Submittals:

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

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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) Sealing materials.
      c) Dampers; include leakage, pressure drop, and maximum back pressure data.
      d) Duct-mounted access panels and doors.
      e) Sheet metal fasteners.

B. Informational Submittals:

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

1.04 QUALITY ASSURANCE

A. Industry Standards:

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

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

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

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

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

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

1. Specifically approved in writing by Engineer.
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.

PART 2 PRODUCTS

2.01 SCHEDULES

A. Ductwork Schedule: Refer to Drawings.

2.02 GENERAL

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

B. Internally Lined Ductwork: Duct sizes indicated for internally lined ducts are the clear inside dimensions, and shall be increased in both dimensions by twice the thickness of the liner.

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

D. Ductwork Interior Surfaces:

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

2.03 SHEET METAL MATERIALS

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

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

C. Aluminum Ductwork:

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

D. 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 shall comply with SMACNA manual, unless specified otherwise.

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.

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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.

2.05 DUCTWORK FASTENERS

A. General:

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

B. Self-Drilling Screws:

1. Aluminum Ductwork System:
   a. Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated Type 410 stainless steel, complete with bonded metal and fiber washer for dielectric separation.
   b. Manufacturers:
      1) DB Building Fasteners Inc., Santa Fe Springs, CA.
      2) Clark Craft Fasteners, Tonawanda, NY.
2. Stainless Steel Ductwork System:
   a. Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated Marutex® stainless steel with strength of Type 410 stainless steel and corrosion resistance of Type 304 stainless steel Type 410 stainless steel.
   b. Manufacturers:
      1) DB Building Fasteners Inc., Santa Fe Springs, CA.
      2) Clark Craft Fasteners, Tonawanda, NY.

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2.06 DUCTWORK PRESSURE CLASS

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

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

2.07 RECTANGULAR DUCTWORK

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

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

2.08 RECTANGULAR DUCTWORK FITTINGS

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

B. Elbows:

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

2.09 RECTANGULAR DUCTWORK BRANCH CONNECTIONS

A. Branch duct connections to rectangular duct mains shall be made using factory fabricated fittings with spot welded tap to main duct connections.

2.10 RECTANGULAR DUCTWORK INSULATION LINER (APPLY TO PLENUMS)

A. Location: Provide ductwork with internal insulation liner where indicated on Drawings or in Ductwork Schedule.

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B. Material:

1. Fiberglass, nominal 1.5 pcf density liner, K factor 0.25 maximum at 75 degrees F mean.
2. Black composite coating on surface exposed to airstream to prevent erosion of glass fibers, for temperatures to 250 degrees F.
3. Liquid water repellency rating not less than 4.0 when tested in accordance with INDA IST 80.6.
4. Potential heat value not exceeding 3,500 Btu per hour per pound when tested in accordance with NFPA 259 and meeting classification of "Limited Combustible" as defined by NFPA 90A.
5. Maximum rated velocity not less than 6,000 fpm when tested in accordance with ASTM C1071.
6. Resistant to microbial growth using a "no growth criteria" when tested in accordance with ASTM C1139.
7. Manufacturers and Products:
   a. CertainTeed; Toughgard.
   b. JohnsManville; Linacoustic RC.
   c. Knauf; Duct Liner M.

C. Thickness: Minimum 1 inch(es) or greater thickness where indicated on Drawings or Ductwork Schedule.

D. R-Value: Minimum 6 hours foot squared degrees F per Btu or greater, where indicated on Drawings or Ductwork Schedule.

E. Liner Adhesive: In accordance with NFPA 90A and ASTM C916.

F. Mechanical Fasteners:

1. Same material as ductwork, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct.
2. Provide fasteners that do not damage liner when applied as recommended by manufacturer, that do not cause leakage in duct, and will indefinitely sustain 50-pound tensile dead load test perpendicular to duct wall.
3. Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
4. Adhesive for Attachment of Mechanical Fasteners: In accordance with Fire Hazard Classification of duct liner system.

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G. Liner Application:

1. Ductwork liner shall be applied at time of ductwork manufacture in an approved sheet metal workshop.
2. Adhere single layer of indicated thickness of duct liner with 90 percent coverage of adhesive at liner contact surface area. Multiple layers of insulation to achieve indicated thickness is prohibited.
3. Apply coat of adhesive to liner facing in direction of airflow not receiving metal nosing.
4. Butt transverse joints without gaps and coat joint with adhesive.
5. Fold and compress liner in corners of rectangular ducts or cut and fit to assure butted edge overlapping.
6. Longitudinal Joints:
   a. Shall not occur except at corners of ducts, unless size of duct and standard liner product dimensions make longitudinal joints necessary.
   b. Apply adhesive coating on longitudinal seams in ducts exceeding 2,500 fpm air velocity.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely around perimeter, at 3 inches from transverse joints, and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing airstream with metal nosing that are either channel or “Z” profile or are integrally formed from duct wall at the following locations:
   a. Fan discharge.
   b. Intervals of lined duct preceding unlined duct.
   c. Upstream edges of transverse joints in ducts.
9. Seal insulation edges.
10. Repair abrasions or tears with mastic.

2.11 DUCTWORK HANGERS AND SUPPORTS

A. General:

1. Ductwork support system shall be designed and provided by HVAC contractor in accordance with SMACNA Manual referenced for type of duct system being installed.
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.

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

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

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.

2.12 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.

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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.

2.13 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 either Amerlock 10 or Ventlock No. 100 latches, and Ventlock Series No. 100 hinges.
4. Fabricated of same material as ductwork.

B. Round Spin-in Type Access Doors:

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

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C. Manufacturers:

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

2.14 MANUAL DAMPERS

A. Butterfly Manual Dampers:

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:
   a. Accessible Ductwork: Ventlok.
   b. Accessible Insulated Ductwork: Ventlok.
   c. Concealed Ductwork: Ventlok.

B. Manual Opposed-Blade Balancing Dampers:

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

2.15 BACK DRAFT DAMPERS

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

B. Aluminum, Counterbalanced, Standard Duty:

1. Fabrication:
   a. Frame: 2 inches by minimum 0.06 inch (51 mm by minimum 1.5 mm), 6063-T5 extruded aluminum channel with front flange and rear flange and mitered corners.

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b. Blades:
   1) Style: Single piece, overlap frame.
   2) Action: Parallel.
   3) Material: Minimum 0.025-inch (0.6 mm) 6063-T5 formed aluminum.
   4) Width: Maximum 6 inches (152 mm).
c. Bearings: Corrosion-resistant, long-life, synthetic, formed as single piece with axles.
d. Blade Seals: Extruded vinyl, mechanically attached to blade edge.
e. Linkage: Concealed in frame.
f. Axles: Corrosion-resistant, long-life, synthetic, locked to blade and formed as single piece with bearings.
g. Counterbalances: Adjustable zinc plated steel weights mechanically attached to blade enabling damper to operate over wide range of pressures.
h. Mounting:
   1) Suitable for mounting in vertical, horizontal airflow up, and horizontal airflow down positions.
   2) Configured for positions as shown on Drawings.
i. Finish: Mill aluminum.

2. Performance Data:
   a. Temperature Rating: Withstand minus 40 degrees to 200 degrees F (minus 40 degrees to 93 degrees C).
   b. Maximum Back Pressure: 2-inch WC (500 Pa).
   c. Maximum Spot Air Velocity: 1,000 fpm (5 mps).
   d. Operation of Blades:
      1) Start to Open: 0.01-inch WC (0.002 kPa).
      2) Fully Open: 0.06-inch WC (0.01 kPa).
   e. Pressure Drop: Maximum 0.04-inch WC (0.01 kPa) at 1,000 fpm (305 mpm) through 24-inch by 24-inch (610 mm by 610 mm) damper.
3. Manufacturers and Products:
   a. Ruskin; Model CBD2.
   b. Greenheck; Series 160, 360, 460.

2.16 FIRE, FIRE/SMOKE, SMOKE DAMPERS (If required for the project)

A. Duct Mounted Fire Dampers in Fire Walls with Rating of 2 Hours or Less:

1. NFPA 90A rated for 1-1/2-hour service.
2. Blades, frame, and mounting angles same material as ductwork.
3. Accordion style folded blades or air foil type blades for multiblade dampers.
4. 165 degrees F fusible link.
5. Approved for installation with 2-hour fire rating.

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6. Rated, manufactured, tested, and approved in accordance with UL 555.
7. Blades out of airstream when open (Style B).
8. Furnish with sleeved frame for duct connections.
9. Furnish dynamic and horizontal mounted dampers with springs for proper closure.
10. Corrosive Service Dampers: Type 316 stainless steel.
11. Manufacturers:
    a. Nailor Industries.
    b. Ruskin.

B. Combination Fire/Smoke Dampers:

1. General:
    a. UL Listed according to UL 555S.
    b. UL Listed for 1-1/2 hour rating according to UL 555.
    c. As part of UL qualification, smoke dampers shall have demonstrated capacity to operate (to open and close) under HVAC system operating conditions, with pressures up to 4-inch WC in closed position, and 2,000-fpm air velocity in open position.
2. Fusible Link: Replaceable, 165 degrees F.
3. Bearings: Stainless steel sleeve turning in extruded hole in frame. Galvanized bearings are not acceptable.
4. Controlled Closure: Heat-actuated release device to prevent duct and HVAC component damage. Instantaneous damper closure is unacceptable.
5. Leakage Class: In accordance with UL 555S Class I (4 cfm per square foot at 1-inch WC).
6. Frame and Blades: 16-gauge galvanized steel.
7. Mounting Sleeve: Factory installed, 18-gauge galvanized steel, length to suit wall or floor application.
8. Manufacturer and Product: Ruskin; FSD Series.

C. Smoke Dampers:

1. General:
    a. UL Listed according to UL 555S.
    b. As part of UL qualification, smoke dampers shall have demonstrated capacity to operate (to open and close) under HVAC system operating conditions, with pressures up to 4-inch WC in closed position, and 2,000-fpm air velocity in open position.
2. Bearings: Stainless steel sleeve turning in extruded hole in frame. Galvanized bearings are not acceptable.
3. Controlled Closure: Heat-actuated release device to prevent duct and HVAC component damage. Instantaneous damper closure is unacceptable.

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4. Leakage Class Class I (4 CFM per square foot at 1-inch WC).
5. Frame and Blades: 16-gauge galvanized steel.
6. Mounting Sleeve: Factory installed, 18-gauge galvanized steel, length to suit wall or floor application.
7. Manufacturer and Product: Ruskin; SD Series.

2.17 CONTROL DAMPERS

A. Refer Section 23 09 13, HVAC Controls, Field Components, and Instruments, for requirements.

2.18 EXTERNAL DUCT INSULATION

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

2.19 MISCELLANEOUS ACCESSORIES

A. 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.

B. 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.

PART 3 EXECUTION

3.01 GENERAL INSTALLATION

A. Miscellaneous:

1. Install sheet metal ductwork and flexible ductwork in accordance with SMACNA Manual, NFPA 90A, and NFPA 90B.

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

B. Ductwork Location:

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

C. Penetrations:

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

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D. Coordination with Other Trades:

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

3.02 RECTANGULAR DUCTWORK

A. General:

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

B. Low Pressure Taps:

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

C. Fittings:

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

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3. Mechanical Joint Option:
   a. Construct transverse joints with Ductmate 25/35 duct connector systems, Ductmate W.D.C.I. Heavy/Lite duct connector systems, or Ductlok J/E duct connector system. Slip-on duct flange connectors shall have integral sealant pocket with permanently flexible sealant.
   b. When using Ductmate W.D.C.I. Heavy/Lite system, construct ductwork in accordance 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 DUCTWORK HANGERS AND SUPPORTS

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

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

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

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

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

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

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

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

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3.04 FLEXIBLE CONNECTIONS

A. Flexible Collars and Connections:

1. Use between fans and ducts.
2. For round ducts, securely fasten flexible connections by zinc-coated steel clinch-type draw bands.
3. For rectangular ducts, lock flexible connections to metal collars.

3.05 DAMPERS

A. General:

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

B. Manual Dampers:

1. Provide balancing dampers for grilles and diffusers as indicated on Drawings in branch duct as near main as possible.
2. Add or remove balancing dampers as requested by air balancing firm for necessary control of air.

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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D. Fire Dampers:

1. At ceiling grille and diffuser fire dampers, provide thermal blankets where required by local authorities.
2. Install 1-1/2-hour rated, unless otherwise indicated, at locations shown and in accordance with SMACNA Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems.

3.06 ACCESS DOORS

A. Ductwork: Install access doors in ductwork, in accordance with manufacturer's instructions, at each:

1. Duct mounted fire damper.
2. Duct mounted smoke or ionization detector.
3. Motorized damper.
4. Turning vane.
5. Volume damper.
6. Automatic damper.
7. Temperature controller.

3.07 EXTERNAL DUCT INSULATION

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

3.08 MISCELLANEOUS ACCESSORIES

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

B. 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.

3.09 DUCT SEALING

A. Seal duct seams and joints as follows: As indicated on Ductwork Schedule.

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.

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3.10 BALANCING OF AIR SYSTEMS

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

3.11 PROTECTION OF INSTALLED WORK

A. Open ends of installed ductwork systems shall be covered to prevent dust, foreign objects and water from entering ductwork.

B. Ductwork systems shall not be used for air conveyance until adequate air filtration devices are installed in air handling equipment, to prevent ingress of construction dust.

3.12 CLEANING

A. Ductwork shall be cleaned of rust, dust, and debris, both internally and externally, before placing in operation.

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

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

END OF SECTION

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SECTION 23 31 16.16
THERMOSET FIBERGLASS-REINFORCED PLASTIC 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-D, Laboratory Methods of Testing Dampers for Rating.
2. American National Standards Institute (ANSI).
3. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250).
   b. B16.5, Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24.
   c. B18.22.1, Plain Washers.
4. 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 and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   c. C582, Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion Resistant Equipment.
   d. D3982, Standard Specification for Contact Molded “Fiberglass” (Glass Fiber Reinforced Thermosetting Resin) Duct and Hoods.
   e. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
5. Sheet Metal and Air Conditioning Contractors’ National Association, Inc., (SMACNA): Thermoset FRP Duct Construction Manual.

1.02 SUBMITTALS

A. Action Submittals:

1. Duct:
   a. Statement of resins and reinforcing proposed for use.
   b. Pressure, vacuum, and temperature rating of duct.
   c. Duct wall thickness calculations for ductwork with support spacing greater than 10 feet.
   d. Dimensions of subassemblies to be shipped.

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e. Manufacturer's data and descriptive literature for duct accessories.
f. Drawings showing layout, support, and joint details.
g. Stamped and signed structural engineering design calculations.
h. Information, details, and requirements for installation and support of duct and torque values for flange bolting.
i. Name of manufacturer.

2. Supports:
   a. Location plan.
   b. Type and details.
   c. Materials of construction.
   d. Stamped and signed structural engineering design calculations for special supports.
3. Expansion Joints/Flexible Connectors:
   a. Type and model.
   b. Materials of construction.
   c. Force required for expansion/contraction.
   d. Name of manufacturer.
4. Butterfly Dampers and Blast Gates:
   a. Statement of resins and reinforcing proposed for use.
   b. Pressure, vacuum, and temperature rating.
   c. Materials of construction.
   d. Total weight including operator.
   e. Drawings showing overall dimensions and connection size.
   f. Type and model.
   g. Name of manufacturer.
5. Equipment anchorage and support drawings and/or cut sheets indicating size, material, spacing, embedment and edge distances of anchors and other relevant information. Drawings should reflect the results of the calculations submitted below.

B. Informational Submittals:

1. Qualifications:
   a. Fabricator: List of references substantiating experience.
   b. Installer: Manufacturer's certification that installer is qualified for installation work.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
3. Manufacturer's factory inspection report.
4. Manufacturer's installation instructions.
5. Detailed information on structural, mechanical, electrical, or other modifications necessary to adapt the arrangement or details shown to the ductwork installation.

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6. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
7. Size and anchorage calculations stamped by an Engineer licensed in the State of Tennessee. Anchorage, bracing and support design criteria and calculations shall conform to the manufacturer's requirements and any other referenced standards. Anchor calculations shall indicate edge distance, embedment, concrete thickness and strength, and other conditions assumed in the design calculations. All assumed field conditions shall be verified by the Contractor prior to installation of the anchors and bracing.

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Fabricator: Minimum 5 years' experience.
2. Installer: Minimum 5 years' experience.
3. Joint Installer: Manufacturer certified.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Shipping:

1. Do not ship ducting by nesting small diameter components inside larger diameter components.
2. Protect flanged sections by bolting to wooden blinds 2 inches greater than outside diameter of flange.
3. For nonflanged components, use either rigid plugs inside ends to prevent deflection or protect with wooden boxes.
4. Crate materials whenever practical prior to shipment.
5. Firmly fasten and pad components shipped to prevent shifting or flexing of components while in transit.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Temperature: Make field joints only when ambient temperature is above 55 degrees F and below 100 degrees F.

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PART 2 PRODUCTS

2.01 MATERIALS

A. Resin:

1. Resin System: Premium corrosion-resistant, fire-retardant vinylester, or other qualified thermosetting resin. Resin to be selected by fabricator, subject to approval of Engineer, and suitable for intended service with no fillers or thixotropic agents.
2. Liner Resin: Premium grade and corrosion resistant.
3. Structural wall resin may be of different chemical resistance, subject to conditions of service and approval of Engineer.
4. Flame Spread Index: ASTM E84, less than 25; fire retardant additives used only in structural layer.
5. Add ultraviolet absorbers to surfacing resin to improve weather resistance.
6. Color: Use no dyes, pigments, or colorants. Exterior gel coat shall be Owner selected.

B. Reinforcement:

1. Veil: Chemical surfacing mat, Type C (chemical) glass, 10 mils thick with finish and binder compatible with lay-up resin.
2. Corrosion Barrier: Resin-rich interior surface of nominal 100 mils to 120 mils thick, using chopped strand mat backing the veil. Use no additive in corrosion barrier.
3. Chopped Strand Mat: Type E glass, minimum 1-1/2 ounces per square foot, with silane finish and styrene soluble binder.
4. Continuous Roving for Chopper Gun Spray-Up: Type E glass.
5. Woven Roving: Type E glass, nominal 24 ounces per square yard, 4 by 5 weave, with silane type finish.
6. Continuous Roving for Filament Winding: Type E glass with silane type finish.

C. Fasteners:

1. Bolts: ASTM A193/A193M, Type 316 stainless steel, ANSI coarse thread series, Grade B 8M hex head.
2. Nuts: ASTM A194/A194M, Type 316 stainless steel, Grade 8M.
3. Washers: ASME B18.22.1, flat, Type 316 stainless steel.

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2.02 DUCTWORK

A. Design Requirements:

1. Conform to ASTM D3982.
2. Duct manufacturer's design for round section, including duct wall thickness and stiffeners.
3. All wall thickness calculations shall use the structural layers only and exclude corrosion barriers and liners.
4. Take into account expansion from seasonal temperature variations.
5. Ducts shall have the minimum wall thicknesses as shown in the following table for support spacing of up to 10 feet:

Duct Diameter	Minimum Wall Thickness
Up to 12"	0.22"
>12" up to 20"	0.29"
>20" up to 36"	0.37"
>36" up to 48"	0.41"

6. Duct minimum wall thickness for support spacing greater than 10 feet shall be increased from the minimum provided herein to accommodate the increased span. The increase shall be based solely upon the change in span length with all other factors, including the mechanical properties, held constant and shall be in accordance with ASTM D3982 Article 6.2.3.

B. Service Conditions:

1. System Maximum Pressure: 7 inches of water column.
2. System Maximum Vacuum: 2 inches of water column.
3. Location: Outside as shown on Drawings.
4. Ambient Temperature: Minus 20 degrees F to 110 degrees F.
5. Wind and Snow Loads: As shown on structural Drawings.

2.03 FABRICATION

A. Physical Properties: Meet or exceed requirements of ASTM D3982 and ASTM C582.

B. Squareness of ends, fittings, elbows, and butt joints shall meet or exceed requirements of ASTM D3982.

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C. Butt joints shall only be permitted in duct sections that are accessible for inside overlay. Internal overlay to consist of two layers of 1-1/2 ounce per square foot of fiberglass mat followed by one layer of surfacing veil, as a minimum.

D. Bell and spigot joints shall be permitted in round sections 16 inches in diameter and smaller where access for internal overlay is not possible. The joints must have a minimum of 3 inches of overlap and utilize an exterior bonding joint. All exposed structural laminate on the duct interior must be sealed with resin prior to the closure of the joint.

E. Flanged joints:

1. Keep use of flanges to a minimum; butt joints with required inside overlay are preferred method of joining sections of duct.
2. Flanges for Duct to Duct Connections and Duct Wall Thicknesses: ASTM D3982, rated for specified pressure and vacuum.
3. Flange dimensions and bolt patterns for flanges that connect to equipment, flexible connections, existing FRP and new metal ductwork shall match the opposing connection flange.

F. Furnish gussets on flanged nozzles from ducts.

G. Back Face of Flanges: Spot-faced, flat and parallel to flange face, and of sufficient diameter to accept ANSI metal washer under bolt head or nut.

H. Laminate:

1. Reinforce inner surface of ducts with resin-rich surfacing veil 10 mils thick to 20 mils thick.
2. Construct interior layer of resin reinforced with at least two plies of chopped strand mat; thickness at least 100 mils.
3. Glass content of combined inner surface and interior layer shall be 27 percent plus or minus 5 percent.

I. Duct and Fittings:

1. Type: Contact molded or filament wound, meeting requirements of ASTM D3982.
2. Joints: Butt wrapped with inside overlay, flanged or bell sand spigot except flanged at connections to expansion joints, or mechanical equipment.
3. Fittings: Plain end or flanged, manufacturer’s standard sizes.
4. Gaskets: 1/8-inch thick Hypalon or Viton full-face gaskets of 40 to 50 durometer.

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J. Manufacturers:

1. Spunstrand.
2. Belco.
3. Daniel Company.
4. ECS Environmental.

K. Supports:

1. Supports for FRP ductwork shall be provided per Section 40 05 15, Piping Support Systems, and as described herein.
2. Connections to structural framing to not introduce twisting, torsion, or lateral bending in the framing members. Provide supplementary steel as required.
3. Maximum Duct Deflection: 1/2 inch.
4. Support Spacing:
   a. 24 Inch Diameter and Larger: 20 feet, maximum.
   b. 20 Inch Diameter and Smaller: 15 feet, maximum.

L. Marking:

1. Identify each duct component with fabricator's name, resin, minimum thickness, and date of manufacture.
2. Use permanent marking. Seal decals and labels into laminate exterior with resin.
3. For piece marking used for installation, use oil-based paint for easy removal.

M. Cure products to at least 90 percent of minimum Barcol hardness specified by resin manufacturer.

N. Expansion Joints/Flexible Connections:

1. Provide where indicated on Drawings or as recommended by manufacturer for proper duct installation.
2. Type: W-design configuration with integral flanges suitable for service with FRP duct.
3. Material: EPDM.
4. Backing Rings: 3/8-inch thick, 2 inches wide, Type 316 stainless steel.
5. Drilling Pattern: Match adjacent ductwork or equipment connection.
6. Length: 12 inches, flange-to-flange.
7. Extension: 0.5 inches.
8. Compression: 2.0 inches.

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9. Lateral Offset: 1.0 inch.
10. Thickness: 1/4 inch, minimum.
11. Manufacturer and Product:
    a. Holz Rubber Company, Inc.; Style 945.
    b. Or equal.

O. Butterfly Dampers:

1. Dampers:
    a. Single-blade type, complete with channel-type frame, close-fitting axle, and bearings.
    b. Same inside diameter as connecting ductwork.
    c. Axles not less than 3/4 inch in diameter and shall be continuous through damper.
    d. When used for isolation service, shall be furnished with blade seal and shaft seal.
    e. When used for balancing only, shall be furnished with full circumference molded in blade stop.
    f. Isolation dampers shall have maximum leakage rate of 5.2 cubic feet per minute per square foot of damper area, at a differential pressure of 30 inches WC. Dampers used to isolate the fans and odor control systems (or where otherwise noted in the Contract Drawings) are to be 100 percent bubble tight at the odor control fans pressure rating.
    g. Dampers shall be designed so that all parts including shaft, blade, bearings, compression seal, handle, and operator may be disassembled for maintenance and repair using simple hand tools. A list of spare parts and instruction on how to replace dampers shall be made readily available by the manufacturer as part of an operation and maintenance manual.
2. Operators:
    a. Sizes 18 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 18 Inches:
        1) Hand-wheel driven worm gear operators mounted to FRP stand-off plate made integral to damper body.
        2) Worm gear operators shall be sized for the pressure rating and torque required to rotate the blade from opening to closed positions.

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3) Dampers located at an elevation greater than 6 feet above the floor, shall be provided with chain wheel operators. Chain wheel sprockets along with anti-gagging chain guides and corrosion resistant chain link of appropriate lengths shall be coupled with worm gear operators of the type previously specified. Worm gear operator shaft diameters shall be sized large enough to withstand pull forces of 300 pounds.
4) Axle lock with no larger than 5-degree increments.
5) Provide locking bolt.

3. Design Requirements:
   a. Each damper shall be designed for the following conditions:
      1) Air Temperature Range: Minus 20 degrees F to 110 degrees F.
      2) Differential Pressure: 20-inch WC.
4. Materials:
   a. FRP materials for dampers shall be same resin as used in ductwork.
   b. Requirements for flame spread and smoke development shall be same as required for ductwork.
5. Construction:
   a. Frames: Fiberglass reinforced plastic with resin as described herein.
   b. Blades: Fiberglass reinforced plastic with resin as described herein. Unitary construction having a calculated percent deflection of L/360. Damper blades shall be of the single laminate design with corrosion liners applied to both sides and any external stiffeners. All stiffeners shall be integral to the blade. The use of coring material shall not be allowed to thicken the blade.
   c. Axles: Continuous Type 316 stainless steel with nuts, bolts, and washers encapsulated in FRP. Axle to extend 6 inches beyond frame.
   d. Shaft seal shall be located at the penetration of the fiberglass body. The shaft seals shall be designed to permit external access for easy adjustment and/or replacement of packing material without having to remove the damper from the duct line. Shaft seal assemblies shall contain no metal parts.
   e. Bearings: Molded PTFE sleeve type and require no lubrication.
   f. Blade Stops: FRP with resin as described herein.
   g. Blade Seals: Neoprene.
   h. Shaft Seals: Neoprene.
   i. Flanges: As specified to match ductwork flanges.
6. Manufacturers and Products:
   a. Balancing dampers: Belco; Model 201.
   b. Isolation dampers: Belco; Model 203.

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P. Blast Gate Dampers:

1. Fabricate from duct construction materials, with finished grade thickness not less than 0.375 inch.
2. Finish gate's smooth surfaces and edges with accurate fit to the gate receiver.
3. Size gates for not more than 50 pounds.
4. Trim excess material to minimize surface area.
5. Provide a 100 percent seal gate receiver cover plate and loop ring to protect the grooves in the receiver. Provide with corrosion-resistant hardware.
6. Cover plate to be installed when the gate is removed.
7. The gate receiver section may be fabricated as part of the duct or be fitted with bell ends for field bonding.
8. Provide nylon blade position locking bolts bonded to the gate opening.

Q. Vibration Isolation:

1. Provide at each support location and where contact with ductwork is made.
2. Supports shall be configured to allow for vibration isolation material thickness.
3. Materials: Minimum 3/16 inch thickness EPDM bonded to support structure. Material shall not be bonded to ductwork.

2.04 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 shall 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.

C. Coordinate support locations with layout and joints.

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3.02 INSTALLATION

A. Ductwork:

1. Cut, fit, and install in accordance with duct manufacturer's recommendations. The SMACNA manual may be used for guidance, but duct manufacturer's recommendations shall take precedence.
2. Seal cut edges with compatible resin.
3. Ductwork shall be free of vibration when in operation. Vibration isolation devices shall be provided and installed by Contractor.
4. Install plumb and straight and in proper alignment.
5. Provide for expansion and contraction of ductwork and fittings.
6. Anti-seize thread compound shall be applied to all nuts and bolts.
7. Flange bolts shall be tightened to torque values specified by manufacturer. Install flat washer under each nut and bolt head.

B. Field Joints:

1. Provide material in kit form; one kit for one joint.
2. Make joints only when ambient temperature is above 55 degrees F and below 100 degrees F.
3. Finish each field joint with gel coat system matching that of adjacent ductwork.
4. Made by manufacturer certified installer.

C. Dampers: Unless otherwise necessary for proper operation of damper, axles shall be installed in horizontal position.

3.03 DUCTWORK HANGERS AND SUPPORTS

A. Install ductwork with support systems in accordance with manufacturer's recommendations, unless otherwise noted.

B. Penetrating fasteners of any type, such as Tek screws, rivets, etc., are not permitted for hanging ductwork.

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

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

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

F. Support vertical ducts at maximum interval of 15 feet and at each floor.

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

H. In new constructions, install concrete insert prior to placing concrete.

3.04 EXPANSION JOINTS/FLEXIBLE CONNECTIONS

A. Flexible Collars and Connections:

1. Provide at the inlet and outlet of each fan.
2. Provide as necessary to accommodate thermal expansion.
3. Provide as indicated on Drawings and recommended by duct manufacturer.

B. Install such that flexible molded boot is not concave or otherwise twisted or deformed during normal operating conditions.

3.05 DAMPERS

A. General:

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

B. Blast Gate Dampers:

1. Install with gate in horizontal position.
2. Provide sufficient clearance to allow gate removal.

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3.06 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. Leaks shall be corrected and duct retested until no further leaks appear.

3.07 MANUFACTURER'S SERVICES

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

1. 2 person-days for installation assistance, including pre-installation training of Contractor personnel in joint assembly, and inspection.
2. 2 person-days for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.

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

3.08 ADJUSTING

A. After duct leakage testing, provide complete air balancing of entire system as described in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

3.09 CLEANING

A. Blow ductwork clean using system fans; purged continuously for not less than 48 hours at a flow rate not less than design flow rate. If required, system fan shall be throttled on inlet side to prevent motor overload. Temporary screen shall be installed on system fan inlet to protect fan from entering debris.

B. Dampers shall be smooth, clean, and free of dirt when installed.

END OF SECTION

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SECTION 23 34 00
HVAC FANS

PART 1 GENERAL

1.01 REFERENCES

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

1. Acoustical Society of America (ASA): S2.19, Mechanical Vibration—Balance Quality Requirements of Rigid Rotors—Part 1, Determination of Permissible Residual Unbalance.
2. Air Movement and Control Association International (AMCA):
   a. 99, Standards Handbook.
   b. 201, Fans and Systems.
   c. 203, Field Performance Measurement of Fan Systems.
   d. 204, Balance Quality and Vibration Levels for Fans.
   e. 210, Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.
   f. 300, Reverberant Room Method for Sound Testing of Fans.
   g. 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
3. American Bearing Manufacturers Association (ABMA): 9, Load Ratings and Fatigue Life for Ball Bearings.
4. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
5. ASTM International (ASTM):
   a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
   b. D2247, Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity.
   c. D2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
   d. D3363, Standard Test Method for Film Hardness by Pencil Test.
   e. D4167, Standard Specification for Fiber-Reinforced Plastic Fans and Blowers.
   f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
6. National Electrical Manufacturers Association (NEMA).
7. National Fire Protection Association (NFPA): 45, Standard on Fire Protection for Laboratories Using Chemicals.
8. Occupational Safety and Health Act (OSHA).

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9. Society for Protective Coatings (SSPC):
    a. SP 3, Power Tool Cleaning.
    b. SP 5, White Metal Blast Cleaning.
    c. SP 6, Commercial Blast Cleaning.
    d. SP 10, Near-White Blast Cleaning.
10. Underwriters Laboratories Inc. (UL): 507, Safety Standard for Electric Fans.

1.02 DEFINITIONS

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

1. AC: Alternating Current.
2. CISD: Chemical Industry, Severe-Duty.
3. dB: Decibel.
4. DWDI: Double Width, Double Inlet.
5. FRP: Fiberglass Reinforced Plastic.
6. hp: Horsepower.
7. ODP: Open Drip Proof.
8. SWSI: Single Width, Single Inlet.
9. TEFC: Totally Enclosed, Fan Cooled.

1.03 SUBMITTALS

A. Action Submittals:

1. Provide following for specified products:
    a. Manufacturer’s name and model number.
    b. Descriptive specifications, literature, and drawings.
    c. Dimensions and weights.
    d. Fan sound power level data (reference 10 to power minus 12 watts) at design operating point.
    e. 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).
            d) Static pressure, capacity, horsepower demand and overall efficiency required at duty point, including drive losses.
    f. Capacities and ratings.
    g. Construction materials.
    h. Fan type, size, class, drive arrangement, discharge, rotation, and bearings.

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i. Wheel type, diameter, maximum revolutions per minute for fan class, operating revolutions per minute, and tip speed.
j. Power and control wiring diagrams, including terminals and numbers.

2. "Or Equal" Equipment:
   a. Where submitted equipment results in change to fan inlet or outlet ductwork configuration shown on Drawings, submit system effect factor calculations indicating increased static pressure requirements as described in AMCA 201.
   b. Where submitted equipment results in change to ductwork and equipment configuration shown on Drawings, submit detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement to equipment furnished.

B. Informational Submittals:

1. Recommended procedures for protection and handling of products prior to installation.
2. Manufacturer's installation instructions.
3. Manufacturer's Certificate of Compliance for the following: Motors specified to be premium efficient type.
4. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
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, and special tools:

Item	Quantity
Special tools required to maintain or dismantle	One complete set for each different size unit

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PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Some specific equipment requirements are listed in Equipment Schedule. Refer to Drawings.

2.02 GENERAL

A. Spark Resistant Construction: Fans required to be spark resistant shall comply with requirements of AMCA 99-0401.

B. Operating Limits: Fans designated to meet a specified fan class shall comply with requirements of AMCA 99-2408.

C. Acoustical Levels: Equipment selections shall produce sound power levels in each octave band no greater than shown in Equipment Schedule.

D. Fan Drives:

1. Drive assembly shall be sized for a minimum 140 percent of fan motor horsepower rating.
2. Sheaves: Capable of providing 150 percent of motor horsepower.
3. 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.
4. Fan Shafts: First critical speed of at least 125 percent of fan maximum operating speed.
5. Provide speed test openings at shaft locations.
6. 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. Furnish motors for V-belt drives with adjustable rails or bases.
7. Weather Cover: For outdoor applications, factory fabricated drive assembly of same material as fan housing, unless specified otherwise.

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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.
4. Fiberglass Parts: Finished in accordance with Paragraph Fiberglass Material.

2.03 CABINET FAN (50-EF-06)

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.

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D. Shaft, Bearings, Drive:

1. Shafts: Turned, ground and polished carbon steel.
2. Bearings: Grease lubricated, precision antifriction ball, sealed type.
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: Provide as scheduled in Equipment Schedule.

G. Manufacturers and Products:

1. Loren Cook; Gemini Series.
2. Greenheck; SP Series.
3. ACME; Model VQ Series.
4. Twin City; T.

2.04 INLINE FAN, CENTRIFUGAL, SQUARE (20-EF-08 & 09)

A. General:

1. Factory-assembled, centrifugal, inline fan, square housing configuration; including housing, fan wheel, drive assembly, motor and accessories.
2. Bearing AMCA Certified Ratings Seal for sound and air performance.

B. Housing:

1. Construction: All aluminum.
2. Integral duct collars.
3. Removable side panels, for ease of service.
4. Field convertible for side air discharge configuration.
5. Predrilled universal mounting brackets for vertical or horizontal installation.
6. Inlets: Aerodynamic aluminum venturi.
7. Corrosion-resistant fasteners.
8. Drive and bearings separated from air stream by enclosure.

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C. Wheel:

1. Centrifugal backward inclined, 100 percent aluminum construction.
2. Precision machined cast aluminum hub.
3. Die-formed airfoil or backward inclined blades.
4. Matched to inlet venturi.
5. Attached to fan shaft with split taper lock bushing.

D. Shaft, Bearings, Drive:

1. Shafts:
   a. Turned, ground and polished carbon steel.
   b. Keyed for sheave installation.
2. Bearings:
   a. Grease lubricated, precision antifriction ball, self-aligning, pillow block style, relubricatable or sealed type.
   b. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
3. Drives:
   a. In accordance with Paragraph Fan Drives.
   b. Factory set to specified fan revolutions per minute.
   c. Type: Direct.

E. Accessories: Provide as scheduled in Equipment Schedule.

F. Manufacturers and Products:

1. Aerovent; Model SCDD (Direct).
2. Loren Cook; Model SQND (Direct).
3. Or “Equal”.

2.05 WALL FAN, PROPELLER, HEAVY DUTY (20-SF-1 & 2)

A. General: Factory-assembled wall propeller fan; including housing, propeller, drive assembly, motor and accessories.

B. Housings:

1. Material: Type 316 stainless steel.
2. Panel:
   a. Minimum 14-gauge sheet metal construction.
   b. Integral formed venturi orifice.
   c. Continuously welded corners.
   d. Bolted to frame.

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3. Frame:
   a. Minimum 14-gauge metal construction.
   b. Continuously welded joints.
   c. Reinforced motor baseplate.

C. Propeller:

1. Cast aluminum construction
2. Hub keyed and mechanically locked to shaft.

D. Shaft, Bearings, Drive:

1. Shafts:
   a. Turned, ground, and polished carbon steel.
   b. Keyed for sheave installation.
2. Bearings:
   a. Grease lubricated, precision antifriction ball, self-aligning, sealed pillow block style.
   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. In accordance with Paragraph Fan Drives.
   b. Factory set to specified fan revolutions per minute.
   c. Type: Direct.

E. Filters: Provide filter housing and intake hood as required.

F. Accessories: Provide as scheduled in Equipment Schedule.

G. Manufacturers and Products:

1. Aerovent; DDP (Direct).
2. Cook; Model AVAD (Direct).
3. Or “Equal”.

2.06 ROOF FAN, FIBERGLASS CENTRIFUGAL UPBLAST (20-EF-01, 02, 03, 04, 05 06, 07 & 50-EF-1, 2, 3, 4 & 5)

A. General:

1. Factory-assembled centrifugal upblast fiberglass roof fan; including housing, fan wheel, drive assembly, motor, and accessories.
2. Fiberglass Construction: In accordance ASTM D4167.
3. Suitable to convey air at temperatures up to 150 degrees F.
4. Bearing AMCA Certified Ratings Seal for sound and air performance.

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B. Fiberglass Material:

1. Construction: Resin reinforced fiber cloth and mat.
2. Resin:
   a. Vinyl ester thermosetting resin.
   b. No fillers or thixotropic agents.
   c. Premium grade and corrosion resistant.
   d. Structural wall resin may be of different chemical resistance, subject to conditions of service and approval by Engineer.
   e. Flame Spread Index:
      1) ASTM E84, less than 25; fire retardant additives used only in structural layer.
      2) Structural wall resin shall contain a minimum of 3 percent antimony trioxide to achieve required flame spread index.
   f. Add ultraviolet absorbers to surfacing resin to improve weather resistance.
   g. Color:
      1) Use no dyes, pigments, or colorants , except in exterior gel coat.
      2) Exterior gel coat shall be white.
3. Reinforcement:
   a. Veil: Chemical surfacing mat, Type C (chemical) glass veil.
   b. Chopped Strand Mat: Type E glass, minimum 1-1/2 ounces per square foot, with silane finish and styrene soluble binder.
   c. Continuous Roving for Chopper Gun Spray-Up: Type E glass.
   d. Woven Roving: Type E glass, nominal 24 ounces per square yard, 4 by 5 weave, with silane type finish.
4. Laminate:
   a. Inner Surface (Veil):
      1) Resin rich, veil reinforced, 10 mils to 20 mils thick.
      2) Use no additives.
      3) Finish and binder compatible with lay-up resin.
      4) Reinforcement Content: Not more than 20 percent.
   b. Interior (Corrosion) Layer:
      1) Resin rich, at least two plies of chopped strand mat, nominal 100 mils to 120 mils thick.
      2) Use no additives.
      3) Construct interior layer of resin reinforced with at least two plies of chopped strand mat backing the veil.
      4) Reinforcement Content: 25 plus or minus 5 percent.

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c. Exterior (Structural) Layer:
   1) Resin with mat, cloth, woven roving or chopped strand glass reinforcement.
   2) Enough resin present to prevent surface fiber show.
   3) Exterior surface relatively smooth, with no exposed fibers or sharp projections.
d. Outer Surface (Gel Coat):
   1) Resin rich.
   2) 10 mils to 20 mils thick.
e. Wall Thickness: As required for equipment structural integrity, but no less than 3/16 inch.

C. Housing:

1. Windband: FRP construction, finished with smooth edge.
2. Top Cap: FRP construction, with motor access via quick release latches.
3. Motor completely sealed from exhaust air stream.
4. Motor cooling via air breather tubes.
5. Integral conduit chase for wiring, vinyl coated flexible metal.
6. Drain trough at lowest point of housing.
7. Fan Inlet:
   a. Aerodynamic inlet venturi, FRP construction.
   b. Match wheel inlet shroud.
8. Hardware: Type 316 stainless steel.

D. Wheel:

1. Aluminum construction, fully welded, epoxy coated.
2. Backward inclined centrifugal, nonoverloading type.
3. Machined, cast aluminum hub.
4. Matched to housing inlet venturi.

E. Shaft, Bearings, Drive:

1. Shaft:
   a. Turned, ground, and polished Type 316 stainless steel.
   b. Keyed for sheave installation.
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: Direct.

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F. Accessories: Provide as scheduled on Equipment Schedule.

G. Manufacturers and Products:

1. Aerovent; Model AWA.
2. Or equal.

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.

2.08 ACCESSORIES

A. Equipment Identification Plates: Furnish 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 on Drawings.

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

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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: Unless noted otherwise, each fan wheel shall be statically and dynamically balanced to ASA S2.19 Grade G6.3.

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. Scroll Drains: Pipe drain connection through running trap to floor drain.

D. Labeling:

1. Label fans in accordance with Article Accessories.
2. Mark exhaust fans serving fume hoods with arrows to indicate proper direction of rotation, in accordance with NFPA 45.

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E. Service Access: Locate units to provide access spaces required for motor, drive, bearing servicing, and fan shaft removal.

F. 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.

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3.03 MANUFACTURER'S SERVICES

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

1. 1 person-day for installation assistance and inspection.
2. 1 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
3. 1 person-day for facility startup.

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

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.

3.05 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

B. On completion of installation, internally clean fans according to manufacturers' written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

END OF SECTION

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SECTION 23 37 00
AIR OUTLETS AND INLETS

PART 1 GENERAL

1.01 REFERENCES

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

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 880, Air Terminals.
2. ASTM International (ASTM): C636/C636M, Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels.
3. UL.

1.02 DEFINITIONS

A. NC: Noise Criteria; background sound rating method for indoor sound.

B. WC: Water column.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Manufacturer's data and descriptive literature for products specified.
   b. Furnish the following information for each type of diffuser, register, and grille furnished.
      1) NC sound data.
      2) Static pressure loss data.
      3) Throw data.

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Refer to Drawings.

2.02 CEILING DIFFUSERS

A. Perforated Face Diffusers (CD1-X):

1. Construction: Refer to Equipment Schedule.
2. Removable core section with deflector vanes.

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3. Removable perforated faceplate.
4. Performance: Refer to Equipment Schedule.
5. Manufacturers and Products:
    a. Krueger; Model 56604 (aluminum).
    b. Carnes; Type SLAB (aluminum).
    c. Titus; Model PAS-AA (aluminum).

2.03 SUPPLY GRILLES AND REGISTERS

A. Supply Grilles and Registers (SG1-X):

1. Construction: Refer to Equipment Schedule.
2. Adjustable front horizontal and rear vertical vanes on 3/4-inch centers.
3. Continuous sponge rubber gasket at face flange.
4. 1-inch minimum flat rectangular frame.
5. Performance: Refer to Equipment Schedule.Manufacturers and Products:
    a. Krueger; 880/5880 Series.
    b. Titus; 300 Series.

2.04 RETURN, EXHAUST AND TRANSFER GRILLES AND REGISTERS

A. Exhaust Grilles (EG1-X):

1. Construction: As follows:
    a. Material: Aluminum.
    b. Finish: Aluminum.
    c. RR and ER Register Accessories:
        1) Gang-operated opposed-blade volume control damper.
        2) Material to match grille.
2. Fixed horizontal louvers set at 35 degrees to 45 degrees.
3. 1-inch minimum flat, rectangular frame.
4. Manufacturers and Products:
    a. Krueger; S80/S580H Series.
    b. Carnes; Type RAAAH.
    c. Titus; 350 Series.

B. Perforated Ceiling Return, Exhaust and Transfer Grilles and Registers (RG2-X):

1. Construction: Refer to Equipment Schedule.
2. Removable perforated faceplate.
3. Size to fit into standard lay-in tee-bar ceiling.

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4. Round neck.
5. Manufacturers and Products:
    a. Krueger; Model 6500 Series.
    b. Carnes; Type SLRB (aluminum).
    c. Titus; Model PAR-AA(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 and applicable building code.

END OF SECTION

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SECTION 23 60 00
CENTRAL COOLING 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):
   a. 365, Performance Rating of Commercial and Industrial Unitary Air-Conditioning Condensing Units.
   b. 370, Sound Performance Rating of Large Air-Cooled Outdoor Refrigerating and Air-Conditioning Equipment.
   c. 550/590, Performance Rating of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapor Compression Cycle.
   d. 560, Absorption Water Chilling and Water Heating Packages.
2. American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE):
   a. 15, Safety Standard for Refrigeration Systems.
   b. 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
3. American Society of Mechanical Engineers (ASME): BPVC Section VIII, Rules for Construction of Pressure Vessels.
4. ASTM International (ASTM):
   a. B68/B68M, Standard Specification for Seamless Copper Tube, Bright Annealed.
   b. B75/B75M, Standard Specification for Seamless Copper Tube.
   c. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
   d. B280, Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
   e. D523, Standard Test Method for Specular Gloss.
   f. D870, Standard Practice for Testing Water Resistance of Coatings Using Water Immersion.
   g. D2247, Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity.
   h. D2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
   i. D3359, Standard Test Methods for Measuring Adhesion by Tape Test.
   j. D3363, Standard Test Method for Film Hardness by Pencil Test.
   k. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.

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5. Cooling Tower Institute (CTI):
    a. ATC-105, Acceptance Test Code for Water Cooling Towers.
    b. STD-201, Standard for Thermal Performance Certification of Evaporative Heat Rejection Equipment.
    c. Cooling Tower Manual.
6. FM Global (FM).
7. Hydraulic Institute Standards (HIS).
8. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
9. National Electrical Manufacturers' Association (NEMA):
    a. MG 1, Motors and Generators.
    b. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
10. National Fire Protection Association (NFPA):
    a. 70, National Electrical Code (NEC).
    b. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
    c. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
11. Nationally Recognized Testing Laboratory (NRTL).
12. Occupational Safety and Health Act (OSHA).
13. Underwriters Laboratories Inc. (UL):
    a. 674, Standard for Safety Electric Motors and Generators for Use in Hazardous (Classified) Locations.
    b. 1995, Standard for Safety Heating and Cooling Equipment.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Complete specifications, descriptive drawings, catalog cuts, and descriptive literature including make, model, dimensions, weight of equipment, and electrical schematics for all equipment specified.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
2. Manufacturer's installation instructions.
3. Recommended procedures for protection and handling of materials prior to installation.
4. Manufacturers' service reports.

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5. Detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement or details shown to equipment furnished.
6. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
7. Field test results.
8. List of recommended spare parts for equipment.

1.03 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Cooling Tower Certification: In accordance with CTI STD-201 for each cooling tower furnished.

PART 2 PRODUCTS

2.01 CLOSED CIRCUIT COOLING TOWER, AXIAL FAN

A. General:

1. One fan per cell.
2. Factory assembled.
3. Casing, structure, collection basing and distribution basing of type stainless steel.
4. Propeller fan and drive assembly.
5. Cross-flow, induced draft design.
6. Vertical air discharge.
7. Fill material, drift eliminators, framing, and associated hardware.
8. In conformance with CTI Standards and CTI Manual.
9. Suitable for application requiring equipment anchorage to resist wind loads per application and applicable code.

B. Fan Drive Assembly:

1. Heavy duty, axial flow, with aluminum alloy blades.
2. Statically and dynamically balanced.
3. Grease packed ball bearings with moisture-proof seal designed for L10 life of 40,000 hours.
4. Variable frequency drive.
5. Furnish moving parts with OSHA guards.
6. Vibration isolated.

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C. Vibration Switch: Unit shall be provided with a cutout switch, operating on 120V ac feed, to protect the fan and drive assembly from damage in the event of excess vibration. Vibration switch shall be DPDT. Switch shall be wired into the shut-down circuit of the fan.

D. Water Distribution System: Spray nozzles shall be zero-maintenance precision molded ABS with large 1-1/4-inch orifice threaded into branch piping with internal sludge ring to eliminate clogging. Spray header, branches and riser shall be schedule 40 Polyvinyl Chloride (PVC) for corrosion resistant.

E. Heat Transfer Media: Heat transfer coil shall be elliptical tubes of prime surface steel, encased in steel framework with entire assembly hot dip-galvanized after fabrication. The coil assembly shall be designed with sloping tubes for liquid drainage and air pressure tested for 390 psig air under water. Coil shall be in compliance with ASME/ANSI B31.5.

F. Drift Eliminators: Drift eliminators shall be constructed entirely of polyvinyl Chloride (PVC) in easily handle sections. Design shall incorporate three changes in air direction and limit the water carryover to a maximum of 0.001 percent of the recirculating water rate. Drift eliminators shall be self-extinguishing, have a flame spread of less than 25 under ASTM E84, and shall be resistant to rot, decay and biological attack.

G. Cold Water Basin: Type stainless steel construction.

H. Air Intake Louvers: The air inlet louver screens shall be constructed from UV inhibited Polyvinyl Chloride (PVC) and incorporate a framed interlocking design that allows for easy removal of louver screens for access to the entire basin area for maintenance. The louver screens shall have a minimum of two changes in air direction and shall be of a non-planar design to prevent splash-out and block direct sunlight and debris from entering the basin. Air inlet louvers shall be self- extinguishing, have a flame spread of less than 25 under ASTM E84, and shall be resistant to rot, decay and biological attack.

I. Make Up Float Valve Assembly: Make up float valve assembly shall be a mechanical brass valve with an adjustable plastic float.

J. Bleed-off: Unit shall have waste water bleed line with a manual adjustable valve provided.

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K. Pump: Unit shall have EISA close-coupled centrifugal pump with mechanical seal. The pump shall be installed in a vertical position so that water will drain from the pump when the cold-water basin is emptied. Pump motor shall be totally enclosed with protective canopy for outdoor operation.

L. Provide a 2-position electronically controlled isolation butterfly valve to isolate the tower when it is not in operation. Valve shall be controlled by the tower control panel and the valve shall be capable of being manually overridden.

M. Accessories: Provide as scheduled in equipment schedule.

N. Motors:

1. Variable speed, inverted duty type.
2. Service factor 1.15.
3. TEFC motor.
4. Weep holes and drain plugs for moisture removal.
5. Sealed winding insulation.
6. Screens over air openings.
7. Ground terminal in conduit box.
8. Motor Junction Boxes:
    a. Connected to grounding system with 3/8-inch machine screws.
    b. Prepare baseplate for grounding in two opposite corners by drilling two holes in 10-3/4-inch centers and tapping for 1/2-inch 13 NC thread.

O. Capacity: Refer to equipment schedules on drawings for sizing information.

P. Factory furnish a cooling tower control panel. The panel shall be suitable for single point power connection and shall provide power and controls. Panel shall be stainless steel NEMA 4X with a hinged and lockable door and securely mounted and wired to the cooling tower. Panel shall be configured to provide adequate cooling for the internal equipment. The panel shall include the following equipment or features and shall meet the requirements of Section 40 99 90, Package Control Systems:

1. Integral main circuit breaker rated at 65,000A.
2. Surge suppression device (SPD) on the incoming 480V power feed.
3. Variable Speed Drive shall be compatible with Section 26 29 23, Low Voltage Adjustable Frequency Drive. Adjust drive size as required for cabinet heat. The AFD shall be sized at a minimum of 1.15 times the motor nameplate FLA. Each AFD shall include a minimum of a 5 percent input line reactor.

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4. Contactor for all heaters.
5. 120V panel heater.
6. Furnish a digital control system to provide stand alone control capability for the entire cooling tower system. Controller shall be BACnet compatible and shall communicate with the HVAC control panel. Controller shall control all functions of the tower after receiving an enable signal provided by the HVAC control system. The tower controls shall monitor the leaving water temperature of the tower and shall adjust the fan speed as required to maintain the leaving water temperature.
7. 480V-120V step down transformer to provide control power as well as a 120-volt circuit and a duplex weather tight electrical outlet. Coordinate the requirements of the water treatment system with the control panel. Provide additional electrical outlets as required for the water treatment system.
8. Provide a 24-volt transformer for low voltage controls.
9. Solid state temperature controller with LCD/LED display. Controller shall be suitable for controlling the starting/stopping of the basin circulation pump based on fluid temperature.
10. Pump starter.
11. Pilot lights. All lights shall be push-to test type.
12. Status contacts.
13. Basin heater controls.
14. Integrated valve control circuit that shall control the motorized isolation valve when the tower is not in service.
15. Furnish with a cabinet mounted NEMA 4X air conditioner. AC unit shall operate off of power from within the cabinet and shall be sized to maintain the cabinet at a maximum of 80 degrees F when the ambient temperature is 100 degrees F. Furnish each cooler with a filter that will filter the outside air (condensing air) to prevent the build up of contaminants on the condensing coil. Filter shall be rated at 10-micron size. Furnish 2 filters per cooler.
16. UL listed.

Q. Manufacturers and Products:

1. Marley Cooling Technologies.
2. Baltimore Air Coil.
3. Evapco.

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2.02 ACCESSORIES

A. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

B. Equipment Identification Plates: Furnish 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 as shown.

C. Anchor Bolts: Factory furnished.

2.03 SOURCE QUALITY CONTROL

A. Cooling Tower Factory Test:

1. Monitor and record ampere draw for each electric motor at specified conditions.
2. Check controls for proper function and sequence.

B. Premium Efficiency Motors: Test in accordance with NEMA MG 1-12.53a and IEEE 112, Test Method B.

PART 3 EXECUTION

3.01 INSTALLATION

A. Cooling Tower:

1. Install on steel support members in accordance with manufacturer's recommendations.
2. Pipe overflow and manual drain piping to catch basin.
3. Inspect tower circuit piping and controls.
4. Perform operating checks on operating and safety controls.
5. Calibrate integral control devices and thermostats.

3.02 FIELD QUALITY CONTROL

A. Functional Tests: Conduct on each cooling tower assisted by manufacturer's representative as follows:

1. Alignment: Prior to facility startup, test complete assemblies for correct rotation, proper alignment and connection, quiet operation, and satisfactory specified performance.

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B. Performance Test: Conduct on each cooling tower assisted by manufacturer's representative.

1. Perform under actual or approved simulated operating conditions.
2. Test for continuous 3-hour period without malfunction.
3. Perform with Engineer present.
4. Test Log: Upon completion of test, record and report results.
5. Adjust, realign, or modify units and retest if necessary.

C. Cooling Tower Acceptance Test: In accordance with CTI ATC-105.

3.03 MANUFACTURER'S SERVICES

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

1. 2 person-days for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
2. 1 person-day for prestartup classroom or Site training.

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 77 00
AIR HANDLING UNITS

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): 410, Forced-Circulation Air-Cooling and Air-Heating Coils.
2. Air Movement and Control Association International, Inc. (AMCA):
   a. 201, Fans and Systems.
   b. 203, Field Performance Measurement of Fan Systems.
   c. 204, Balance Quality and Vibration Levels for Fans.
   d. 300, Reverberant Room Method for Sound Testing of Fans.
   e. 301, Methods for Calculating Fan Sound Ratings From Laboratory Test Data.
   f. 99-0401, Classifications for Spark Resistant Construction.
   g. 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):
   a. 15, Safety Standard for Refrigeration Systems.
   b. 52.1, Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
   c. 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
   d. 62.1, Ventilation for Acceptable Indoor Air Quality.
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. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
6. CSA America (CSA):
   a. B149.1, Natural Gas and Propane Installation Code.
   b. Z83.4, Non-Recirculating Direct Gas-Fired Industrial Air Heaters.
   c. Z83.18, Recirculating Direct Gas-Fired Industrial Air Heaters.

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7. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 841, Standard for Petroleum and Chemical Industry - Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 370 kW (500 hp).
8. International Standards Organization (ISO): 9001, Quality Management Systems – Requirements.
9. National Electrical Manufacturers Association (NEMA).
10. National Fire Protection Association (NFPA):
    a. 54, National Fuel Gas Code.
    b. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
    c. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
11. Occupational Safety and Health Act (OSHA).
12. Society of 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.
13. Underwriters Laboratories Inc. (UL):
    a. 181, Standard for Safety Factory-Made Air Ducts and Connectors.
    b. 723, Standard for Safety Test for Surface Burning Characteristics of Building Materials.

1.02 DEFINITIONS

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

1. ac: alternating current.
2. AFD: Adjustable Frequency Drive.
3. AHU: Air Handling Unit.
4. cfm: cubic feet per minute.
5. dB: Decibel.
6. DX: Direct Expansion.
7. DWDI: Double Width, Double Inlet.
8. ETL: ETL Testing Laboratories, Inc.
9. FM: Factory Mutual Insurance.
10. fpm: feet per minute.
11. hp: Horsepower.
12. MAU: Make-Up Air Unit.
13. NRC: Noise Reduction Coefficient.
14. OD: Outside Diameter.
15. ODP: Open Drip Proof.
16. O&M: Operations and Maintenance.
17. psi: pounds per square inch.

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18. PVC: Polyvinyl Chloride.
19. rpm: revolutions per minute.
20. SWSI: Single Width, Single Inlet.
21. TEFC: Totally Enclosed, Fan Cooled.
22. UV: Ultra Violet.
23. VFD: Variable Frequency Drive.
24. WC: Water Column.

1.03 SUBMITTALS

A. Action Submittals:

1. Provide Shop Drawings for products specified, including, as a minimum:
    a. Unit identification as referenced in Contract Documents.
    b. Manufacturer's name and model number.
    c. Descriptive specifications, literature, and drawings.
    d. Dimensions and weights for unit, including fully assembled and shipping sections.
    e. Acoustics: Fan sound power level data (ref. 10 to power minus 12 Watts) at design operating point, based on AMCA 300 for unit discharge, inlet and casing.
    f. Fans:
        1) Type, size, quantity, class, drive arrangement, discharge, rotation and bearings.
        2) Wheel type, diameter, rpm, and tip speed.
        3) 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 safe operating rpm).
            d) Static pressure, capacity, horsepower demand and overall efficiency required at the duty point, including drive losses.
    g. Unit capacities and ratings, including airflow and static pressure summary.
    h. Power and control wiring diagrams, including terminals and numbers.

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2. "Or Equal" Equipment:
    a. Where submitted equipment results in change to fan inlet or outlet ductwork configuration shown on drawings, submit system effect factor calculations indicating increased static pressure requirements as described in AMCA 201.
    b. Where submitted equipment results in change to ductwork and equipment configuration shown on drawings, submit detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement or details shown to equipment furnished.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance.
2. Sample copy of guarantee.
3. Sample copy of lifetime guarantee for corrosion.
4. Recommended procedures for protection and handling of products prior to installation.
5. Manufacturer's installation instructions, including component spacing requirements.
6. Operation and Maintenance Data:
    a. In conformance with Section 01 78 23, Operation and Maintenance Data.
    b. Include as-built version of equipment schedules.

1.04 QUALITY ASSURANCE

A. Fans: Licensed to bear AMCA seal for air flow and sound performance.

B. Manufacturer's Qualifications:

1. The make-up unit manufacturer shall have been successfully manufacturing air handling units for a period of no less than 5 years.
2. Manufacturer's qualifications are subject to review by the Owner/Engineer to determine acceptance.

C. Fan Performance:

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.
3. Motor shall not operate into motor service factor in any listed case.
4. Accommodate drive efficiency in motor selection according to manufacturer's published recommendation, or according to AMCA 203, Appendix L.

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D. Thermal Insulation: Shall meet the erosion requirements of UL 181 facing the air stream and fire hazard classification of 25/50 (per ASTM E84 and UL 723).

E. Units with Fuel Gas Heating Sections:

1. Conform to CSA Z83.18 and CSA Z83.4 and provide evidence that air handler has been tested as a system and found in compliance with these standards by an independent national testing laboratory.
2. Conform to NFPA 90A.
3. Conform to the NFPA 54.
4. Conform to required or specified insurance specifications (FM, IRI, etc.) for the gas manifold construction.
5. For gas fired units, provide a current sensor on the supply fan motor. When current is outside current sensor limits, the natural gas supply is to be shut down.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Air handling unit manufacturer shall coordinate with the Contractor as to the requirements for proper delivery, storage, and handling of the air handling unit and its components required in this Specification to ensure that the unit is properly cared for prior to final installation.

1.06 EXTRA MATERIALS

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

Item	Quantity
V Belts	One complete set per unit
Special tools required to maintain or dismantle	Onecomplete set

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Refer to Drawings.

2.02 OPERATING LIMITS

A. Fans designated to meet a specified Fan Class shall comply with requirements of AMCA 99-2408.

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2.03 ACOUSTICAL LEVELS

A. Equipment selections shall produce sound power levels in each octave band no greater than shown in fan equipment schedule.

B. Perform noise tests in accordance with AMCA 300.

2.04 FAN DRIVES

A. Furnish multiple drive belts.

B. Drive assembly shall be sized for a minimum 150 percent of fan motor horsepower rating.

C. Motors for V-belt drives shall be furnished with adjustable rails or bases.

D. Unless otherwise noted, furnish belt-driven fans with cast iron or flanged steel fixed sheaves.

E. Motors: Fixed-pitch sheaves required.

F. Drive Adjustment:

1. 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.
2. Provide trial and final sheaves, as well as drive belts, as required.

G. Weather Cover: For outdoor applications, factory fabricated drive assembly of same material as fan housing, unless specified otherwise.

H. Belt and Shaft Guards:

1. Easily removable and to enclose entire drive assembly, meeting federal, OSHA and State of Tennessee requirements.
2. Guard faces of expanded metal having minimum 60 percent free area for ventilation.
3. Bright yellow finish.

I. Provide speed test openings at shaft locations.

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2.05 FINISHES

A. Carbon Steel Parts: Factory finished as follows, unless indicated otherwise.

1. Parts cleaned and chemically pretreated with a phosphatizing process.
2. Alkyd enamel primer.
3. Air-dry enamel topcoat.

B. Aluminum Parts: Finished smooth and left unpainted, unless stated otherwise.

C. Stainless Steel Parts: Finished smooth and left unpainted.

2.06 MAKE-UP AIR UNITS—INDUSTRIAL (50-MAU-1 & 2)

A. General:

1. Custom air handling unit, constructed by assembly of factory-fabricated components such as fan units, motor and drive assembly, heat transfer devices, dampers, plenums, filters, condensate pans, heating units, control devices and accessories.
2. Required unit components as indicated on plans and equipment schedule.
3. Assembly shall be a complete and fully functioning system with all components and accessories as specified.
4. Fan Air and Sound Performance: Tested and rated in accordance with AMCA and guaranteed by manufacturer.

B. Unit Casing:

1. General:
   a. Fully enclosed housing, 2-inch thermo-composite construction.
   b. No galvanized steel material on any part of the unit internal or external.
   c. Lifting lugs and unit support frames, factory installed, to facilitate installation.
   d. For double wall units, distance between inner and outer panels as required to accommodate insulation thickness specified in Paragraph, Insulation. Double wall units are required, unless noted otherwise.
2. Panel Arrangement: Panels mechanically fastened together forming a self-framing housing with no additional structural support required.
3. Material: 2-inch thermo-composite construction.

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4. Joints:
    a. Joints between exterior panels and structural frames shall have seals and gaskets with appropriate material type for air seal and acoustical break.
    b. Seams caulked and sealed for an airtight unit.
    c. Fully through-bolted section to section joints.
5. Insulation: foam insulation.
6. Access Doors:
    a. Oversized access doors insulated.
    b. Sized and located to provide easy access to unit internal components.
    c. Hinged, latched, and gasketed to provide a weatherproof seal.
    d. Provide doors on both side(s) of each unit.
    e. Latches:
        1) "Ventlok" style noncorrosive alloy latches operable from inside and outside of unit.
        2) For access doors configured to open against unit operating pressure, provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement.
7. Casing Performance:
    a. Air Leakage: Maximum of 0.5 cfm per square foot of cabinet area at 5-inch WC static pressure.
    b. Panel Deflection: For modules under negative pressure located on the suction side of the fan, maximum permissible panel deflection shall not exceed 1/200th of panel length, when subject to 8-inch WC differential pressure.

C. Drain Pans:

1. IAQ style drain pans, complying with requirements of ASHRAE 62.1.
2. Formed sections of minimum 16-gauge (0.0625 in.) Type 304 stainless steel.
3. Triple pitched for complete drainage, with no standing water in unit.
4. Double Wall Construction:
    a. Space between walls filled with foam insulation.
    b. Sealed moisture tight.
    c. Welded corners.
5. Drain Connections:
    a. Type 304 stainless steel, male pipe thread.
    b. Both ends of pan.
    c. Extended to exterior of unit cabinet.
    d. Connection centerline shall be a minimum of 3 inches above base rail. Drain connections that protrude from the base rail are not acceptable.

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D. Unit Base:

1. Full perimeter base frame.
2. Minimum10-gauge (0.135 in.) epoxy coated structural steel construction, with C channel cross support members, on close centers.
3. All joints fully welded.
4. Fitted with lifting lugs at corner of unit.
5. Attached to unit at factory, unless noted otherwise for field assembly.

E. Supply Fan Section:

1. General:
   a. Supply air section with fan assembly, consisting of housing (where applicable), wheel, fan shaft, bearings, motor, disconnect switch, drive assembly, support structure, and accessories.
   b. Casing constructed in accordance with Article Unit Casing.
   c. Suitable to convey air at temperatures up to 250 degrees F.
   d. Fan Performance: AMCA 99-2408 class rating corresponding to the static pressure at which the fan is designed to operate.
   e. Fan Assemblies: Statically and dynamically balanced, designed for continuous operation at maximum rated fan speed and motor horsepower.
2. Centrifugal Fan Housing:
   a. Material: Type 304 stainless steel construction:
      1) Formed and reinforced sheet metal panels, curved scroll configuration with shaped cutoff, continuous seam welding and side angle reinforcement.
      2) Flanged and drilled outlet to permit duct connection.
      3) Spun-formed aerodynamic bell mouth inlet.
      4) Access doors or panels to allow entry to internal parts and components.
      5) Base:
         a) All-welded heavy-gauge metal.
         b) Fan and motor mounted on common base.
         c) Motor Mount: Adjustable slide mount.
   b. Plug Fans: Fabricate without fan scroll and volute housing.
   c. Hardware: Type 316 stainless steel.
3. Fan Wheel:
   a. Centrifugal, one-piece.
   b. Backward Inclined Fans:
      1) Nonoverloading performance characteristics.
      2) Backward inclined blades, heavy gauge metal construction, continuously welded to backplate and curved inlet flange.

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4. Fan Shaft, Bearings, Drive:
    a. Shafts:
        1) Turned, ground, and polished carbon steel.
        2) Ends drilled and countersunk for tachometer readings.
        3) Keyed for sheave installation.
        4) Coated with lubricating oil.
    b. Bearings:
        1) Grease lubricated, precision anti-friction ball, self-aligning type.
        2) Mounted in cast iron pillow block housing.
        3) Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
    c. Drives:
        1) In accordance with Article Fan Drives.
        2) Factory set to specified fan revolutions per minute.
        3) Type: Belt.
        4) Arrangement: 3.
5. Internal Vibration Isolation:
    a. Fan/Motor Base: Isolate base from unit casing with open spring isolators with 2-inch deflection.
    b. Flexible Connectors: Install flexible neoprene coated canvas ducts between fan and unit casing to ensure complete isolation.

F. Gas Heat Section, Indirect Fired:

1. General:
    a. Indirect-fired fuel gas heating section, fuel type as scheduled.
    b. Casing constructed in accordance with Article Unit Casing.
    c. Entire assembly approved and labelled by ETL or other nationally recognized certification agency, for both sea level and high altitude areas.
    d. Approved for operation down to minus 20 degrees F ambient air.
    e. Visual burner inspection port in unit casing.
    f. Insulation in burner section covered by a heat-reflective Type 304 stainless steel liner.
    g. For gas fired units, provide a current sensor on the supply fan motor. When current is outside current sensor limits, the natural gas supply is to be shut down.
2. Pipe Chase:
    a. Piping and piping mounted controls located in pipe chase.
    b. Chase construction and insulation as for unit.
    c. Internal to unit casing.
    d. Adequately sized access door(s) for installation and maintenance of piping.

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3. Gas Pipe Train:
    a. FM and IRI code approved.
    b. Housed within unit cabinet.
    c. Pipe Train Components:
        1) Flow control valve.
        2) Fail-safe shut off valve(s).
        3) Main and pilot gas pressure regulators.
        4) Manual shut off valves.
        5) Electric pilot valve.
    d. Operating gas pressure, at unit(s) manifold: As scheduled.
4. Heat Exchanger:
    a. Primary drum and multitube secondary assembly constructed of titanium Type 409 stainless steel with multiplane metal turbulators.
    b. Floating stress relieved design.
    c. Condensate drain connection.
5. Burner:
    a. Blow through positive pressure type.
    b. Intermittent pilot ignition system.
    c. Housed within unit cabinet.
    d. Turndown: Minimum 20 to 1.
    e. Atmospheric burners or burners requiring power assisted venting are not acceptable.
    f. Unit(s) incorporating discharge air control and wherever specified, shall include 15:1 turndown for all inputs.
6. Venting:
    a. Installation and venting provisions in accordance with CSA B149.1 and NFPA 54, and local authorities having jurisdiction.
    b. Venting arrangement approved by a nationally recognized certification agency.
    c. Double acting barometric damper.
7. Electrical/Controls:
    a. Flame Surveillance: solid state programmed flame relay complete with flame rod.
    b. Air proving switch.
    c. Control interlocks.
    d. Panelboard: Electrical/control components housed in Unit Main Control Panel; refer to Paragraph Unit Electrical and Controls Panelboard, NEMA Type 4X enclosure, mounted on the outside of unit.
8. For gas fired units, provide a current sensor on the supply fan motor. When current is outside current sensor limits, the natural gas supply is to be shut down.

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G. Unit Access:

1. Unit access to allow improved access to air handling internal components.
2. Casing constructed in accordance with Article Unit Casing.
3. Double wall, hinged, removable access doors on both side(s) of unit.

H. Filters:

1. General:
   a. Air filtration section, complete with filter media and filter racks.
   b. Casing constructed in accordance with Article Unit Casing.
   c. Access doors on one or both side(s) of unit.
   d. Maximum 500 fpm face velocity across filters.
2. Frame and Filter Assembly:
   a. Suitable for space indicated.
      1) MERV 8 Prefilter efficiency per ASHRAE 52.2.
      2) MERV 8 Final filter efficiency per ASHRAE 52.2.
      3) Minimum 30 percent Dust Spot Efficiency and 90 percent average arrestance in accordance with ASHRAE 52.
   b. Permanent reusable, side-loading aluminum holding frame, retainer, and sealer frame.
   c. Filter blank-offs to prevent air bypass around filters, same material as frame.
   d. For 100 percent make-up air application, each individual filter to include minimum 18-gauge aluminum full perimeter frame on each individual filter for later strength if filter becomes damp.
3. Accessories:
   a. Filter Pressure Gauge:
      1) Each filter bank shall be furnished with Magnehelic filter gauge (Dwyer Series 2000).
      2) Adjustable signal flag.
4. Manufacturers:
   a. Farr.
   b. Flanders.
   c. Tri-Dim.
   d. American Air Filter.

I. Outside Air Intake:

1. Weather Hood: Fabricated from same material as unit casing.
2. Louver: Drainable type, S-shaped rainproof blades, spaced 2 inches maximum.
3. 1/2-inch mesh aluminum bird screen on inside face of louver.

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J. Control Dampers:

1. Internally mounted ultra-low leak dampers.
2. Parallel blade action.
3. Construction:
   a. Extruded aluminum blades.
   b. Aluminum frame, U-shaped Aluminum sections securely screwed or welded to unit chassis.
   c. Vinyl blade seals, stainless steel jam seals.
   d. Type 304 stainless steel linkage, shafts, and hardware.
   e. Type 304 stainless steel sleeve bearings.
4. Performance: Leakage rate shall not exceed 5 cfm per square foot at 1 inch-WC and 9 cfm per square foot at 4-inch WC.

K. Unit Electrical and Controls:

1. General:
   a. Electrical and control components shall meet requirements of Division 26 Electrical.
   b. All electrical and controls components and assemblies UL or ETL listed and labeled.
   c. Factory wired units shall bear an ETL or UL label with all necessary identification marks, electrical data, and cautions, as required by NEC.
   d. Provide as-built wiring diagrams and schematics for electrical and control systems, secured to inside of control panel door, or enclosed in plastic jackets placed inside control panel.
   e. For additional requirements, refer to Specification paragraphs for individual sections and components, and Section 23 09 00, Instrumentation and Control Devices for HVAC.
2. Main Power Connection: Provide single point power connection to unit, serving both primary unit voltage and unit control voltage.

L. Accessories: Provide where scheduled in Equipment Schedule.

M. Manufacturers:

1. Annex Air.
2. Or equal.

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2.07 MAKE-UP AIR UNITS—INDUSTRIAL (20-MAU-1)

A. General:

1. Custom air handling unit, constructed by assembly of factory-fabricated components such as fan units, motor and drive assembly, heat transfer devices, dampers, plenums, filters, condensate pans, heating units, control devices and accessories.
2. Required unit components as indicated on plans and equipment schedule.
3. Assembly shall be a complete and fully functioning system with all components and accessories as specified.
4. Fan Air and Sound Performance: Tested and rated in accordance with AMCA and guaranteed by manufacturer.

B. Unit Casing:

1. General:
   a. Fully enclosed housing, 2-inch thermo-composite construction.
   b. No galvanized steel material on any part of the unit internal or external.
   c. Lifting lugs and unit support frames, factory installed, to facilitate installation.
   d. For double wall units, distance between inner and outer panels as required to accommodate insulation thickness specified in Paragraph, Insulation. Double wall units are required, unless noted otherwise.
2. Panel Arrangement: Panels mechanically fastened together forming a self-framing housing with no additional structural support required.
3. Material: 2-inch thermo-composite construction.
4. Joints:
   a. Joints between exterior panels and structural frames shall have seals and gaskets with appropriate material type for air seal and acoustical break.
   b. Seams caulked and sealed for an airtight unit.
   c. Fully through-bolted section to section joints.
5. Insulation: foam insulation.
6. Access Doors:
   a. Oversized access doors insulated.
   b. Sized and located to provide easy access to unit internal components.
   c. Hinged, latched, and gasketed to provide a weatherproof seal.

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d. Provide doors on both side(s) of each unit.
e. Latches:
    1) "Ventlok" style noncorrosive alloy latches operable from inside and outside of unit.
    2) For access doors configured to open against unit operating pressure, provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement.

7. Casing Performance:
    a. Air Leakage: Maximum of 0.5 cfm per square foot of cabinet area at 5-inch WC static pressure.
    b. Panel Deflection: For modules under negative pressure located on the suction side of the fan, maximum permissible panel deflection shall not exceed 1/200th of panel length, when subject to 8-inch WC differential pressure.

C. Drain Pans:

1. IAQ style drain pans, complying with requirements of ASHRAE 62.1.
2. Formed sections of minimum 16-gauge (0.0625 in.) Type 304 stainless steel.
3. Triple pitched for complete drainage, with no standing water in unit.
4. Double Wall Construction:
    a. Space between walls filled with foam insulation.
    b. Sealed moisture tight.
    c. Welded corners.
5. Drain Connections:
    a. Type 304 stainless steel, male pipe thread.
    b. Both ends of pan.
    c. Extended to exterior of unit cabinet.
    d. Connection centerline shall be a minimum of 3 inches above base rail. Drain connections that protrude from the base rail are not acceptable.

D. Unit Base:

1. Full perimeter base frame.
2. Minimum10-gauge (0.135 in.) epoxy coated structural steel construction, with C channel cross support members, on close centers.
3. All joints fully welded.
4. Fitted with lifting lugs at corner of unit.

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5. Attached to unit at factory, unless noted otherwise for field assembly.
6. A factory furnished curb assembly shall be of stainless steel provided by the factory for field assembly and installation as part of the unit. The curb shall include a duct adapter(s) for supply air. The installing contractor shall be responsible for coordinating with roofing contractor to ensure curb unit is properly flashed to provide protection against weather/moisture penetration. Contractor shall provide and install appropriate insulation for the curb assembly.

E. Supply Fan Section:

1. General:
   a. Supply air section with fan assembly, consisting of housing (where applicable), wheel, fan shaft, bearings, motor, disconnect switch, drive assembly, support structure, and accessories.
   b. Casing constructed in accordance with Article Unit Casing.
   c. Suitable to convey air at temperatures up to 250 degrees F.
   d. Fan Performance: AMCA 99-2408 class rating corresponding to the static pressure at which the fan is designed to operate.
   e. Fan Assemblies: Statically and dynamically balanced, designed for continuous operation at maximum rated fan speed and motor horsepower.
2. Centrifugal Fan Housing:
   a. Material: Type 304 stainless steel construction:
      1) Formed and reinforced sheet metal panels, curved scroll configuration with shaped cutoff, continuous seam welding and side angle reinforcement.
      2) Flanged and drilled outlet to permit duct connection.
      3) Spun-formed aerodynamic bell mouth inlet.
      4) Access doors or panels to allow entry to internal parts and components.
      5) Base:
         a) All-welded heavy-gauge metal.
         b) Fan and motor mounted on common base.
         c) Motor Mount: Adjustable slide mount.
   b. Plug Fans: Fabricate without fan scroll and volute housing.
   c. Hardware: Type 316 stainless steel.
3. Fan Wheel:
   a. Centrifugal, one-piece.
   b. Backward Inclined Fans:
      1) Nonoverloading performance characteristics.
      2) Backward inclined blades, heavy gauge metal construction, continuously welded to backplate and curved inlet flange.

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4. Fan Shaft, Bearings, Drive:
    a. Shafts:
        1) Turned, ground, and polished carbon steel.
        2) Ends drilled and countersunk for tachometer readings.
        3) Keyed for sheave installation.
        4) Coated with lubricating oil.
    b. Bearings:
        1) Grease lubricated, precision anti-friction ball, self-aligning type.
        2) Mounted in cast iron pillow block housing.
        3) Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
    c. Drives:
        1) In accordance with Article Fan Drives.
        2) Factory set to specified fan revolutions per minute.
        3) Type: Belt.
        4) Arrangement: 3.
5. Internal Vibration Isolation:
    a. Fan/Motor Base: Isolate base from unit casing with open spring isolators with 2-inch deflection.
    b. Flexible Connectors: Install flexible neoprene coated canvas ducts between fan and unit casing to ensure complete isolation.

F. Gas Heat Section, Direct Fired:

1. General:
    a. Direct-fired fuel gas heating section, fuel type as scheduled.
    b. Casing constructed in accordance with Article Unit Casing.
    c. Entire assembly approved and labelled by ETL or other nationally recognized certification agency, for both sea level and high altitude areas.
2. Pipe Chase:
    a. Piping and piping mounted controls located in pipe chase.
    b. Chase construction and insulation as for unit.
    c. Internal to unit casing.
    d. Adequately sized access door(s) for installation and maintenance of piping.
3. Gas Pipe Train:
    a. FM and IRI code approved.
    b. Housed within unit cabinet.
    c. Pipe Train Components:
        1) Flow control valve.
        2) Fail-safe shut off valve(s).
        3) Main and pilot gas pressure regulators.

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4) Manual shut off valves.
5) Electric pilot valve.

d. Operating gas pressure, at unit(s) manifold: As scheduled.

G. Direct Gas-Fired Burner:

1. Unit shall be factory assembled, piped and wired. Direct gas-fired system will be 92 percent efficient while supplying a burner that is capable of providing 25:1 turndown. Unit will utilize a draw through design and incorporate adjustable burner baffles plates for filed adjustments. Unit will have a direct spark ignition system.
2. Burner construction shall consist of a cast aluminum burner manifold and 400 series stainless steel mixing plates. No air from the inside space shall be allowed to pass across the burner at any time. Flame sensing shall be provided by a flame rod or ultra-violet scanner. A flame safeguard display shall be included. Burner control shall have a digital coded fault indicator capable of storing the last five faults.
3. Shall be equipped for operation on natural gas with a maximum rated inlet gas pressure of 2 psi or as indicated in drawings. An External Gas pressure regulator shall be provided by the factory if required.
4. Burner control options to include the following, discharge temperature with room override.
   a. Shall include the following safety controls:
   b. Manual Reset, High Limit Switch: Main gas valve closes if high-limit temperature is exceeded.
   c. Dual safety shutoff valves shall be that do not exceed 120V ac control signals.
   d. High and low Gas Pressure Switch(s) with visual indication.
   e. Proof of close valves(s) shall be included.
   f. Visual indication: Clear visual signal demonstrating the position of the main gas safety shutoff valves.

H. Unit Access:

1. Unit access to allow improved access to air handling internal components.
2. Casing constructed in accordance with Article Unit Casing.
3. Double wall, hinged, removable access doors on both side(s) of unit.

I. Filters:

1. General:
   a. Air filtration section, complete with filter media and filter racks.
   b. Casing constructed in accordance with Article Unit Casing.
   c. Access doors on one or both side(s) of unit.
   d. Maximum 500 fpm face velocity across filters.

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2. Frame and Filter Assembly:
    a. Suitable for space indicated.
        1) MERV 8 Prefilter efficiency per ASHRAE 52.2.
        2) 22-inch deep bag filter assembly. Filters will not be installed at this time but provide frames for filter installation. Provide complete from and all necessary clips and similar holding devices.
        3) Minimum 30 percent Dust Spot Efficiency and 90 percent average arrestance in accordance with ASHRAE 52.
    b. Permanent reusable, side-loading aluminum holding frame, retainer, and sealer frame.
    c. Filter blank-offs to prevent air bypass around filters, same material as frame.
    d. For 100 percent make-up air application, each individual filter to include minimum 18-gauge aluminum full perimeter frame on each individual filter for later strength if filter becomes damp.
3. Accessories:
    a. Filter Pressure Gauge:
        1) Each filter bank shall be furnished with Magnehelic filter gauge (Dwyer Series 2000).
        2) Adjustable signal flag.
4. Manufacturers:
    a. Farr.
    b. Flanders.
    c. Tri-Dim.
    d. American Air Filter.

J. Outside Air Intake:

1. Weather Hood: Fabricated from same material as unit casing.
2. Louver: Drainable type, S-shaped rainproof blades, spaced 2 inches maximum.
3. 1/2-inch mesh aluminum bird screen on inside face of louver.

K. Control Dampers:

1. Internally mounted ultra-low leak dampers.
2. Parallel blade action.
3. Construction:
    a. Extruded aluminum blades.
    b. Aluminum frame, U-shaped Aluminum sections securely screwed or welded to unit chassis.
    c. Vinyl blade seals, stainless steel jam seals.
    d. Type 304 stainless steel linkage, shafts, and hardware.
    e. Type 304 stainless steel sleeve bearings.

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4. Performance: Leakage rate shall not exceed 5 cfm per square foot at 1 inch-WC and 9 cfm per square foot at 4-inch WC.

L. Unit Electrical and Controls:

1. General:
   a. Electrical and control components shall meet requirements of Division 26 Electrical.
   b. All electrical and controls components and assemblies UL or ETL listed and labeled.
   c. Factory wired units shall bear an ETL or UL label with all necessary identification marks, electrical data, and cautions, as required by NEC.
   d. Provide as-built wiring diagrams and schematics for electrical and control systems, secured to inside of control panel door, or enclosed in plastic jackets placed inside control panel.
   e. For additional requirements, refer to Specification paragraphs for individual sections and components, and Section 23 09 00, Instrumentation and Control Devices for HVAC.
2. Main Power Connection: Provide single point power connection to unit, serving both primary unit voltage and unit control voltage.
3. The unit shall be constructed so that it can function as a stand-alone heating and cooling system controlled by factory-supplied remote panel, thermostats and sensors.
   a. Remote panel shall be NEMA 4 panel for mounting indoors. Panel shall include the following as a minimum:
      1) LED/LCD display to display the leaving air temperature and the room air temperature.
      2) Burner on indication light.
      3) Filter alarm indication light
      4) Fault alarm Indication light.
      5) Ability to adjust the room temperature up/down.
      6) Remote room temperature sensor/bulb to be connected thru the remote-control panel. Sensor shall be suitable for a Class 1 Division 2 corrosive environment. Refer to Drawings.
4. Unit shall incorporate a Network interface controller with integral LCD screen that provides text readouts of status, operating settings and alarm conditions. Network interface controller shall have a built-in keypad to permit operator to access read-out screens and change settings without the use of ancillary equipment, devices or software. DDC controllers that require the use of equipment or software that is not factory-installed in the unit are not acceptable. Alarm readouts consisting of flashing light codes are not acceptable.

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5. Operating protocol: The Network interface controller shall be supplied with a protocol card for BACnet MSTP for monitoring of the unit's status.
6. Sensors to be provided with the unit:
    a. Room / Space Temperature Sensors.
    b. Heating Inlet Air Sensor.
    c. Dirty Filter Sensor.

M. Accessories: Provide where scheduled in Equipment Schedule.

N. Manufacturers:

1. Annex Air.
2. Or equal.

2.08 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. Provide IEEE 841 motor, unless noted otherwise.
3. Motors for fans specified for use with variable frequency drives shall be inverter duty type.
4. Fan motors shall not operate into service factor in any case.

B. Motor requirements shall be as follows unless designated otherwise on fan 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.

2.09 CORROSION PROTECTION

A. General:

1. Factory applied corrosion protection coating for application to unit components and accessories, where in required by this section.

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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: For all coating systems, parts to be coated shall be cleaned as follows:
    a. Immerse parts in heated cleaning solution to remove lubricants, machining oils, and residual factory contamination.
    b. Follow with immersion in potable water bath to neutralize and remove cleaning solution.
    c. Chemical Pretreatment: Immerse parts in heated chemical solution, iron phosphate for steel, clear/yellow chromate for aluminum.

B. Air-Dry Epoxy:

1. Material: Two-part catalyzed epoxy.
2. Surface Preparation: Clean surface to SSPC SP 3.
3. Application: Standard air-pressurized spray equipment.
4. Curing: Air dry.
5. Finished Thickness: 4-mil to 6-mil dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
    a. Salt Spray Test: Minimum 1,500-hour duration, ASTM B117 test method.
    b. Pencil Hardness: H-2H, ASTM D3363 test method.
    c. UV Resistance: UV inhibited life of minimum 10 years when exposed to sun in State of Florida.
    d. Service Temperature: Maximum 150 degrees F, continuous.

2.10 ACCESSORIES

A. Equipment Identification Plates: Furnish 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 as shown.

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

2.11 SOURCE QUALITY CONTROL

A. Factory Tests and Adjustments Test equipment actually furnished.

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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. Manufacturer's Tests:

1. Electrical Circuits:
   a. Tested and checked as to proper function.
   b. Perform dielectric strength test.

D. Balancing: Completed fan assemblies shall be dynamically balanced to minimum grade of G 6.3 per AMCA 204 at design operating speed.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install units level and plumb.

B. Secure roof-mounted units to rood curbs with Type 316 stainless steel hardware.

C. Inspect internal casing insulation, seal all exposed edges, and butt joints with mastic to ensure insulation will not be loosened during operation.

D. All condensate drain connections piped and trapped separately for proper drainage.

E. Labeling: In accordance with Article Accessories.

F. Service Access: Locate units to provide access spaces required for filter changing; motor, drive, and bearing servicing; and fan shaft and coil removal.

G. Equipment Restraints:

1. Restrain equipment against seismic forces as required by Code.
2. Restrain equipment against wind loads as required by Code.
3. Seismic Restraint Snubbers:
   a. Rubber-faced, securely anchored to floor or structure.
   b. 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. Isolate sheet metal duct connections from all noninternally spring-isolated fan units or other rotating equipment.
2. Install ductwork adjacent to fans so as to allow proper service and maintenance.
3. Pipe drain pan connection through trap running to floor drain.

3.02 FIELD QUALITY CONTROL

A. Functional Tests:

1. Verify shipping blocking and bracing are removed.
2. Verify unit 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 rpm.
   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 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate non-sealed bearings prior to startup.

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D. Air 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.

3.04 CLEANING

A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

3.05 MANUFACTURER'S SERVICES

A. Lifetime warranty against corrosion.

B. Provide manufacturer's representative at site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified component, subsystem, equipment, or system.

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

1. 2 person-days for installation assistance and inspection.
2. 2 person-days for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
3. 1 person-day for facility startup.

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.

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10. National Electrical Manufacturers Association (NEMA).
11. National Fire Protection Association (NFPA): 255, Standard Method of Test of Surface Burning Characteristics of Building Materials
12. Underwriters Laboratories Inc. (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. 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.
   b. Manufacturer’s standard finish color selection for enclosure finishes.
   c. 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 cooling performance data at design operating conditions.
   d. Air Pressurization Unit: Documentation that media filter modules are UL rated Class 1.

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B. Informational Submittals:

1. Manufacturer's documentation that media filter modules rated UL Class 1.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services, air-conditioning units, and motors.
3. Detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement or details shown to equipment furnished.
4. Sample copy of guarantee.
5. Test reports.
6. 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. Cooling Equipment: Minimum operating efficiencies, defined as EER, as specified in ASHRAE 90.1.

B. Units shall be certified by UL and CSA, and shall be UL or ETL listed and labeled.

C. Cooling performance rated in accordance with AHRI testing procedures.

D. 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 EXTRA MATERIALS

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

Item	Quantity
Fan Belts	One complete set for each belt-driven fan.
Filters	One complete set per unit.
Filter (Filter Housing 20-FH-01)	Two complete sets per unit. One set installed into service and the second set turned over to the owner.

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

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.

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2.02 EQUIPMENT SCHEDULES

A. Refer to Drawings.

2.03 PACKAGED INDOOR WATER-SOURCE HEAT PUMP UNITS-ABOVE CEILING (20-WSHP-04 THRU 20-WSHP-11)

A. General:

1. Factory assembled, packaged indoor water-source heat pump unit.
2. Contained within unit enclosure shall be factory wiring, piping, controls, compressor, and holding charge of R-410A refrigerant.
3. Factory run-tested in both heating and cooling modes with full water flow.
4. Unit capable of starting with 40 degrees F entering air temperature and 40 degrees F entering water temperature in heating mode with AHRI water and airflow rates.
5. Unit Configuration: Packaged, above ceiling, horizontal.

B. Unit Cabinet:

1. Fabricated from G-90 galvanized steel, phosphatized, and coated with baked enamel finish.
2. Insulated sheet metal panel separating fan compartment from compressor compartment.
3. Removable access panels providing full access to compressor, and control and fan sections.
4. Separate openings and knockouts for entrance of line voltage, condensate piping, and low voltage control wiring.
5. Water connections and electrical knockouts located so as to not interfere with serviceability of unit.
6. Interior insulated with 1-inch thick, 1.5-pound per cubic foot density, coated glass fiber insulation, attached with adhesive material.
7. Fiberglass insulation exposed edges tucked under flanges to prevent introduction of glass fibers into airstream.
8. Ducted Units: Provide duct flanges for connection of supply and return ductwork, and filter racks.

C. Evaporator Fan:

1. Double-inlet, double-width, forward-curved fan.
2. Direct-drive or belt-drive as standard with unit.
3. Motor: Totally enclosed and permanently lubricated, with integral overload protection.

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D. Compressor:

1. Fully hermetic reciprocating or scroll type.
2. Equipped with oil system, operating oil charge, and motor.
3. Internal overload and over-temperature protection.
4. Motor shall be NEMA rated, Class F, suitable for operation in a refrigerant atmosphere.
5. Reciprocating compressors shall be equipped with crankcase heaters.
6. Scroll compressors shall have high discharge gas temperature protection.
7. Compressor assembly shall be installed on rubber vibration isolators.

E. Refrigerant to Air Coil:

1. Constructed of aluminum, fins mechanically bonded to internally enhanced seamless copper tubes, with galvanized steel tube sheets.
2. Condensate Drain Pan: Plastic, extending full length of air coil, insulated, with primary and secondary drain fittings, minimum 3/4-inch copper drain tube, extending outside unit casing.
3. Coat entire coil with anticorrosion protective coating, as scheduled in Equipment Schedule and in accordance with Article Factory Dip-Applied Protective Coating.

F. Water to Refrigerant Coil:

1. Co-axial tube-within-a-tube or shell-and-tube water-cooled type.
2. Supply and return water connections with female NPT copper fittings located outside cabinet for connection to flexible hoses.
3. Suitable for Propylene glycol 30%.

G. Refrigeration Components:

1. Brass liquid line and suction line service valves with service gauge port connections.
2. Accumulator.

H. Controls:

1. Factory selected, assembled, and tested.
2. Refer to Drawings for required capacity and voltage requirements. As a clarification there will be no neutral leg available for.
3. Unit shall be furnished with a BACnet communication card to interface with the building automation system. Furnish a wall mounted premium quality thermostat that is compatible with the unit control systems.

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4. Refrigerant Metering:
    a. Reverse flow bypass metering device with internal check valves.
    b. Heating mode metering device.
5. Control box within unit cabinet containing 24-volt transformer, 24-volt activated two-pole or three-pole compressor contactor, low voltage terminal junction block.
6. Time delay restart to prevent compressor reverse rotation on single-phase scroll compressors.
7. Automatic restart on power failure.
8. Safety lockout if any outdoor unit safety is open.
9. Start capacitor and relay (single-phase units without scroll compressors).
10. Safeties:
    a. Reversing valve shall be energized in cooling mode, with "fail-safe" to heating mode.
    b. Circuit-breaker protected control circuit.
    c. High condensing temperature protection.
    d. Compressor motor current and temperature overload protection.
    e. High refrigerant pressure relief.
    f. Low voltage protection.
    g. High voltage protection.
    h. Unit shutdown on high or low refrigerant pressures. Low-pressure switch shall not be monitored for first 90 seconds after compressor start command to prevent nuisance safety trips.
    i. Unit shutdown on low water temperature.
    j. Water coil freeze protection (selectable for water or antifreeze).
    k. Air coil freeze protection (check filter switch).
    l. Condensate overflow shutdown.
    m. Automatic intelligent reset. Unit shall automatically reset 5 minutes after trip if fault has cleared. Should fault reoccur three times sequentially then permanent lockout will occur.
    n. Ability to defeat time delays for servicing.
    o. Selectable 24-volt or pilot duty dry contact alarm output.
    p. 24-volt output to cycle a motorized water valve with compressor contactor.

I. Filters:

1. Rack mounted.
2. One-inch thick strainer type with pleated nonwoven fabric media.
3. Rated at 30 percent efficiency and 90 percent average arrestance in accordance with ASHRAE 52.2.
4. Manufacturer and Product: Farr; 30/30.

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J. Accessories: Provide as scheduled in Equipment Schedule.

K. Manufacturers and Products:

1. Carrier; 50 RVC/RHC.
2. Climatemaster; TR Series.
3. Florida Heat Pump; EC and LV Series.
4. Water Furnace; Versatec and Envision.

2.04 WATER SOURCE HEAT PUMP-FLOOR MOUNT (20-WSHP-01,02,03)

A. General Description:

1. Self-contained unit shall include compressors, evaporator coils, filters, supply fans, reheat coil, and unit controls.
2. Unit shall be factory assembled and tested including and run testing of the supply fans and factory wired electrical system. Run test report shall be supplied with the unit.
3. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
4. Unit components shall be labeled, including pipe stub-outs, refrigeration system components and electrical and controls components.
5. Installation, Operation and Maintenance manual shall be supplied within the unit.
6. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's access door.
7. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's access door.
8. R-410A refrigerant.
9. ECM driven direct drive backward curved plenum supply fans.
10. Double sloped stainless-steel drain pans.
11. Hinged access doors with lockable handles.
12. Variable capacity compressor with 10-100% capacity.
13. Factory installed acoustic insulation in the compressorized section.

B. Construction:

1. Unit shall be provided with a horizontal intake, have a draw-through supply fan configuration and discharge air vertically.
2. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.

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3. Unit insulation shall have a minimum thermal resistance R-value of 6.25. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D1929-11 for a minimum flash ignition temperature of 610°F.
4. Unit construction shall 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.
5. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Sealing shall be included between panels and between access doors and openings to reduce air leakage. Refrigerant piping and electrical wiring through cabinet panels shall include sealing to reduce air leakage.
6. Access to filters, compressors, cooling coil, reheat coil, condensers, supply fans and electrical, and controls components shall be through hinged access doors.
7. Access doors shall be flush mounted to cabinetry, with stainless steel removable pin hinges and zinc cast lockable handles. Units shall include a 304 stainless steel sloped drain pan. Drain pan connection shall be available on the right (left) side of the air handling section of the unit.
8. Cooling coils shall be mechanically supported above the drain pan by multiple supports that allow drain pan cleaning and coil removal.
9. Interior ceiling, floor, service doors, fan inlet cone, damper rack, and filter rack in the air stream are spray coated with a two-part polyurethane, heat baked coating. The coils, coil casings, condensate drain pans, damper blades and gears, fan wheel, fan motor, and compressor cabinet are not coated. Option is intended for use in coastal saltwater conditions under the stress of heat, salt, sand and wind and is applicable to all corrosive environments where a polyurethane coating is acceptable. Coating withstands at least 2,500 hours when tested under ASTM B 117-95 requirements.
10. Unit shall include an exterior corrosion protection which shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects when tested in a salt spray and fog atmosphere in accordance with ASTM B117-95 test procedure.
11. Unit shall include a 5-inch forklift base.

C. Electrical:

1. Unit shall be provided with an integrated control panel.
2. Unit shall be provided with standard power block for connecting power to the unit.

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3. Control circuit transformer and wiring shall provide 24V ac control voltage from the line voltage to the unit.
4. Unit shall have a 5kAIC SCCR.

D. Supply Fans:

1. Unit shall include direct drive, unhoused, backward curved, plenum supply fans.
2. Fan and motor assembly shall be dynamically balanced.
3. Motors shall be a high efficiency electronically commutated motor (ECM).
4. Supply air shall discharge vertically-up from the unit.
5. Blower and motor assembly shall be mounted on rubber isolators.

E. Cooling Coil:

1. Evaporator Coil:
   a. Coil shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.
   b. Coil shall be hydrogen or helium leak tested.
   c. Coil shall be furnished with factory installed thermostatic expansion valves. The sensing bulbs shall be field installed on the suction line immediately outside the cabinet.
   d. Coils shall have a flexible, epoxy polymer e-coat uniformly applied to all coil surface areas without material bridging between fins. Humidity and water immersion resistance shall be up to a minimum 1,000 hours each (ASTM D2247-92 and ASTM D870-92). Corrosion durability shall be confirmed through testing, with coating capable of withstanding at least 10,000 hours of salt spray per ASTM B117-90. Coated coils shall receive a spray-applied, UV-resistant polyurethane topcoat to prevent UV degradation of the e-coat. Coating shall carry a 5 year warranty, from the date of original equipment shipment from the factory. Instructions coil cleaning, maintenance, and recording keeping must be followed. Refer to the unit Installation, Operation and Maintenance Manual.

F. Refrigeration System:

1. Unit shall be factory charged with R-410A refrigerant.
2. Compressors shall be R-410A scroll type with thermal overload protection and independently circuited.
3. Unit shall include a variable capacity scroll compressor which shall be capable of modulation from 10-100 percent of its rated capacity.

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4. Compressor shall carry a 5 year non-prorated warranty, from the date of original equipment shipment from the factory.
5. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged compressor access doors shall be fabricated of double wall, rigid polyurethane foam insulated panels to prevent the transmission of noise outside the cabinet.
6. Compressors shall be isolated from unit with the compressor manufacturer's recommended rubber vibration isolators, to reduce any transmission of noise from the compressor into the building area.
7. Unit shall be equipped with thermostatic expansion valve type refrigerant flow control.
8. Unit shall be configured as a water-source condensing unit.
9. Unit shall be configured as a water-source heat pump. Unit shall be equipped with an automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low pressure sides, factory installed liquid line heat pump filter drier, reversing valve and thermostatic expansion valves on the indoor coil. Reversing valve shall energize during the cooling mode of operation.
10. Modulating hot gas reheat shall be provided on the lead refrigeration circuit. Refrigeration circuit shall be provided with hot gas reheat coil, modulating valves, receiver tank, electronic controller, supply air temperature sensor and a dehumidification control signal terminal which allow the unit to have a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space.
11. Each refrigeration circuit shall be equipped with suction and discharge compressor isolation valves.

G. Condensers

1. Water-cooled condensing section shall contain coaxial tube-in-tube heat exchangers. Heat exchanger shall be circuited in a counter flow arrangement to the refrigerant system. Tubes shall be cupronickel. Field piping connections shall be external to the self-contained unit. Connections shall be labeled, extend beyond the unit casing and be factory sealed to prevent condensation in the panel assembly. Maximum operating pressure on the water side of the condenser shall be 300 psi.
2. Unit shall include factory installed head pressure control module and each heat exchanger shall include factory installed head pressure control valve which modulates the condenser water flow based on head pressure and allows cooling operation below 65°F condenser water temperature.

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3. Coils shall have a flexible, epoxy polymer e-coat uniformly applied to all coil surface areas without material bridging between fins. Humidity and water immersion resistance shall be up to a minimum 1,000 hours each (ASTM D2247-92 and ASTM D870-92). Corrosion durability shall be confirmed through testing, with coating capable of withstanding at least 10,000 hours of salt spray per ASTM B117-90. Coated coils shall receive a spray-applied, UV-resistant polyurethane topcoat to prevent UV degradation of the e-coat. Coating shall carry a 5 year warranty, from the date of original equipment shipment from the factory. Instructions coil cleaning, maintenance, and recording keeping must be followed. Refer to the unit Installation, Operation and Maintenance Manual.

H. Filters

1. Unit shall include 2 inch thick, pleated panel filters with an ASHRAE MERV rating of 8, in a prefilter box upstream of the cooling coil.
2. For 20-WSHP-01 the unit shall not have filters in the unit. All filters will be external to the unit.
3. Unit shall include a clogged filter switch.
4. Unit shall include factory installed Magnehelic gauge measuring the pressure drop across the filter rack.

I. Controls:

1. Furnish a factory mounted controller that is BACnet communication port compatible with MS/TP with an LCD/LED display that can be used for unit set up and monitoring.
2. Provide a wired thermostat shipped loose that allows for display of room temperature and humidity as well as certain status and setpoints.
3. Factory Installed and Factory Provided Controller:
    a. Unit controller shall be capable of controlling all features and options of the unit. Controller shall be factory installed in the unit controls compartment and factory tested.
    b. Controller shall be capable of standalone operation with unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling available without dependence on a building management system.
    c. Controller shall have an onboard clock and calendar functions that allow for occupancy scheduling.
    d. Controller shall include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.
    e. Constant Volume Controller.

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4. Unit shall modulate cooling with constant airflow to meet space temperature cooling loads.
5. With modulating hot gas reheat, unit shall modulate cooling and hot gas reheat as efficiently as possible, to meet space humidity loads and prevent supply air temperature swings and overcooling of the space.
6. Unit shall modulate heating with constant airflow to meet space temperature heating loads. Staged heating capacity shall modulate based on space temperature.
7. Unit shall modulate heating with constant airflow to meet space temperature heating loads. Modulating heating capacity shall modulate based on supply air temperature.
8. Supply air temperature sensor and space temperature sensor with temperature setpoint reset and unoccupied override shall be furnished with the unit for field installation.

J. Accessories: Unit shall be provided with a low voltage safety shutdown terminal block for field installation of a smoke detector which shuts off the unit's control circuit.

K. Manufacturers and Products:

1. Aaon; SB.
2. Or Equal.

2.05 FILTER HOUSING (20-FH-01)

A. Side access filter housings are designed to accommodate ASHRAE rated filters as indicated in equipment schedules. Factory assembled flanged units suitable for installation in a duct. Housings accommodate filters of different types and efficiencies. Filters are easily serviced through quick-opening hinged access doors. Factory-gasketed filters, channels, and doors ensure positive sealing. Housings shall be rated for minus 6.0-inch w.g. to plus 6.0-inch w.g. The leakage rate is less than 0.5 percent of airflow at 6.0-inch w.g. internal static pressure. Refer to Extra Materials section on number of filters to provide.

B. Housings shall include filter tracks for filters as identified in the filter schedule. Housings shall be constructed of 16-gauge stainless steel type 304 with upstream and downstream outwardly turned flanges. Filter tracks are extruded aluminum. All filter tracks shall be gasketed with replaceable polypropylene pile air seals. Access doors shall be sealed with neoprene gasketing on the perimeter. Gasketing also seals the filter edge to the door.

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C. Filters shall be as follows:

1. Pre-filter: 24-inch by 24-inch by 24-inch thick filter that is 100 percent synthetic non-woven, media rated at 500 FPM that achieves a MERV 8 rating (AAF PREpleat or equal).
2. Carbon Filter: 24-inch by 24-inch by 11.5-inch thick with gaskets. Filter shall be constructed of a pleated media with highly activity carbon particles bonded into a matrix of carbon granulate embedded between two non-woven synthetic layers (AAF VariSorb XL or equal).
3. Final filter bag style: 24-inch by 24-inch by 22-inch media that is rated for 500 FPM that achieves a MERV 13 rating. Media shall be injection molded into a support frame that creates and air tight seal. Pocket shall be tapered for better holding capacity (AAF DriPAK NX or equal).

D. Manufacturers and Products:

1. AAF/Flanders; SureSeal.
2. Camfil-Farr.

2.06 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: Use one of the following materials:

1. Epoxy Modified Phenolic. Straight phenolic materials are not acceptable.
2. Epoxy or epoxy urethane.
3. Polyelastomer: Complex chain linked polyelastomer material.

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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.
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: Coil finish shall meet or exceed the following criteria:

1. Salt Spray Test: In accordance with ASTM B117, minimum 3,000-hour duration, with no fin corrosion or degradation.
2. Thermal Efficiency: Loss no greater than 1 percent after coating application.
3. 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. Bronzglow; Husky.
2. Aero-Marine Engineering Inc.; Technicoat 10-1.
3. AST ElectroFin Inc; ElectroFin.

2.07 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.

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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.

2.08 ACCESSORIES

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

B. Equipment Identification Plates: Furnish 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 tag indicated in this Specification and as shown on Drawings.

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.

2.09 SOURCE QUALITY CONTROL

A. Factory Tests:

1. Direct expansion coils leak tested underwater with 200-psig air. Pressure tested to 450 psig.

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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. Isolate sheet metal duct connections from portions of unit not internally spring-isolated from fans, or other vibrating or rotating equipment.

C. Inspect internal casing insulation, seal exposed edges, and butt joints with mastic to ensure insulation will not be loosened during operation.

D. 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.

E. 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. 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).

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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.
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.

C. Coils shall be cleaned with environmentally friendly coil cleaners. The use of chemicals that can impact or contaminate the environment shall not be permitted.

END OF SECTION

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SECTION 23 82 00
TERMINAL HEATING AND COOLING UNITS

PART 1 GENERAL

1.01 REFERENCES

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

1. Air Moving and Conditioning Association (AMCA): 300, Reverberant Room Method for Sound Testing of Fans.
2. American Gas Association (AGA).
3. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): 90.1 IP/SI, Energy Standard for Buildings, Except Low-Rise Residential Buildings.
4. ASTM International (ASTM):
   a. A106/A106M, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
   b. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
5. Canadian Gas Association (CGA).
6. Electrical Test Laboratories (ETL).
7. National Electrical Manufacturer's Association (NEMA).
8. National Fire Protection Association (NFPA):
   a. 54, National Fuel Gas Code.
   b. 70, National Electrical Code (NEC).
   c. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
9. Sheet Metal and Air Conditioning Contractors' National Assoc., Inc. (SMACNA): Ducted Electric Heat Guide for Air Handling Systems.
10. UL: Product Directories.

1.02 DEFINITIONS

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

1. AC: Alternating Current.
2. CISD: Chemical Industry, Severe-Duty.
3. dB: Decibel.
4. DWDI: Double Width, Double Inlet.
5. FRP: Fiberglass Reinforced Plastic.
6. hp: Horsepower.
7. ODP: Open Drip Proof.
8. PSC: Permanent Split Capacitor.
9. SWSI: Single Width, Single Inlet.

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10. TEFC: Totally Enclosed, Fan Cooled.
11. UV: Ultraviolet.
12. XP: Explosion Proof.

1.03 SUBMITTALS

A. Action Submittals:

1. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature which shall include make, model, dimensions, weight of equipment, and electrical schematics for products specified.
2. Manufacturer's standard finish color selection for cabinet finishes.
3. Performance data, including sound power level data (reference 10 to minus 12 power watts) at design operating point, shall be based on AMCA 300.

B. Informational Submittals:

1. Manufacturer's test reports for the following: Electric space heater.
2. Recommended procedures for protection and handling of equipment and materials prior to installation.
3. Detailed information on structural, mechanical, electrical, or other modifications necessary to adapt the arrangement or details shown to the equipment furnished.
4. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data. Include as-built version of equipment schedules.

1.04 QUALITY ASSURANCE

A. Heating Equipment: Minimum operating efficiencies, specified in Chapter 6 of ASHRAE 90.1 IP/SI and the State of Tennessee Energy Code.

PART 2 PRODUCTS

2.01 EQUIPMENT

A. Equipment Schedules: Refer to Drawings.

2.02 UNIT HEATER, GAS, PROPELLER FAN

A. Characteristics:

1. Factory assembled, wired and test fired.
2. Dynamically balanced, direct drive, propeller type fan.

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3. UL listed.
4. AGA or CGA certified.
5. Minimum 80 percent efficient.
6. Steel cabinet with baked enamel or powder coated finish.
7. Designed for ceiling suspension.
8. Sealed flue product collection chamber.
9. Totally enclosed motors with thermal overload protection and vibration isolation.
10. Motor contactor.
11. Horizontal discharge with adjustable face louvers.
12. Horizontal and vertical vent outlets.
13. External gas connection.
14. Solid state ignition; a match lit pilot is not acceptable.
15. Described by manufacturer in published literature as commercial or industrial grade.

B. Controls:

1. Fan and limit safety controls.
2. Combustion air pressure switch.
3. 24-volt control transformer.

C. Accessories and Features: Provide as scheduled in Equipment Schedule.

D. Manufacturers:

1. Reznor.
2. Modine.
3. Trane.

2.03 UNIT HEATER, ELECTRIC, SUSPENDED

A. Characteristics:

1. Factory assembled including casing, heater elements, fan wheel, drive assembly, motor, controls and accessories.
2. UL listed.
3. Meet requirements of National Electrical Code.
4. Three phase heaters shall have balanced phases.
5. Casing:
   a. Heavy gauge steel casing.
   b. Baked enamel finish.
   c. Individual adjustable discharge louvers.
   d. Protective air inlet louvers or fan guards.

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6. Heating elements shall be one of the following types:
   a. Aluminum finned, copper clad, steel sheath.
   b. High mass, all steel tubular finned type, copper brazed, in fixed element banks.
   c. Nickel-chromium wire elements enclosed in powder filled aluminum coated steel tubes with permanently fused fins.
   d. Steel tubes with nickel chromium resistance wire embedded in a dielectric with steel fins crimped and brazed to the tube.
   e. Corrosion-resistant steel fins brazed to tubular heating elements.
7. Fan and Motor:
   a. Totally enclosed motor.
   b. Direct drive fan.
   c. Sealed bearings. Permanently lubricated.
8. Controls:
   a. Thermal overload protection with automatic reset.
   b. Controls, transformers, and contactors shall be factory assembled, except wall mounted thermostats when indicated.

B. Accessories and Features: Provide as scheduled in Equipment Schedule.

C. Manufacturers and Products:

1. Trane; Type UHCA.
2. Markel; Type HF.
3. Or equal.

2.04 GAS VENT STACKS

A. Characteristics:

1. Suitable for gas-fired unit heaters.
2. UL listed Type B double wall, insulated gas vent pipe with rain cap.
3. Stainless steel inner and outer jacket.
4. Insulating thimble.
5. Pier section with cleanout where stack is offset.
6. Manufacturer’s standard fittings as required.

B. Manufacturers and Products:

1. Selkirk; Metalbestos.
2. Van Packer.

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2.05 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.

2.06 ACCESSORIES

A. Equipment Identification Plates: Furnish 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.

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

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2.07 SOURCE QUALITY CONTROL

A. Functional Test:

1. Perform manufacturer's standard factory test on equipment.
2. Test equipment furnished.
3. Motor Test: See Section 26 20 00, Low-Voltage AC Induction Motors.
4. Equipment with Electric Resistance Heating Coils: Test with 2,000-volt dielectric test.

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Install in strict compliance with manufacturer's instructions. Maintain clearances around unit as listed in manufacturer's recommendations.

B. Electric Unit Heaters, All Types:

1. Bottom of unit shall be a minimum of 8 feet above finish floor, unless indicated otherwise.
2. Heater shall be permanently mounted in position indicated with a fixed power supply.
3. Install so obstructions do not block heater air inlet or outlet.

C. Gas-Fired Units:

1. Install in accordance with manufacturer's recommendations.
2. Mount bottom of unit at 8 feet above floor, except where noted otherwise on Drawings or schedule.

D. Gas Vent Stacks:

1. Install in accordance with manufacturer's recommendations.
2. Install in accordance with requirements of NFPA 54.

3.02 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified equipment.

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 comprehensive short circuit, protective device coordination, and arc flash study 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 prior to Engineer reviewing any major electrical Shop Drawings.

B. Provide lightning protection system design for the structures per Section 26 41 00, Facility Lightning Protection.

C. Provide anchorage and bracing design drawings, calculations, and related information where required under Section 01 88 15, Anchorage and Bracing.

D. Provide seismic certification per requirements of Section 01 45 33, Special Inspection, Observation, and Testing, where required in that section for electrical equipment listed.

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1.04 TELEPHONE SERVICE DIVISION OF RESPONSIBILITY

A. All new phone lines shall originate from the business rack located within the Server Room. The Contractor shall be responsible for providing all conduit and CAT 6 cables from the business rack to each of the telephone receptacles shown and to the elevator control panel.

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 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.

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.

1.07 ENVIRONMENTAL CONDITIONS

A. The following areas are classified hazardous Class I, Division 1, Group D, because of the potential for occurrence of hazardous concentrations of combustible gases, and for exposure to corrosive environment. Use materials and methods required for such areas.

1. Inside wet well containing wastewater.
2. Existing Sludge Heating Building – Digester Gas Processing Room.

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3. Existing Enclosed Aeration Basin.
4. Plant Drain Pump Station.

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. Enclosed, belowgrade valve and metering vaults with closed piping systems containing wastewater.

C. The following areas are classified nonhazardous, wet, and corrosive. Use materials and methods required for such areas.

1. Inside of dewatering wet well.
2. Chlorine and SO2 Building – Chlorine Storage Room.
3. Chlorine and SO2 Building – Chlorine Feed Room.
4. Chlorine and SO2 Building – SO2 Storage Room.
5. Chlorine and SO2 Building – SO2 Feed Room.

D. The following areas are classified nonhazardous and wet. Use materials and methods required for such areas.

1. Outdoor abovegrade areas not covered above.
2. Belowgrade vaults.
3. New Dewatering and Controls Building – All Process Rooms.
4. Existing Secondary Digester Building – Lower Level (Unclassified By Owner added ventilation system).
5. Existing Dewatering Bldg. – All Process Rooms.
6. Existing Blower Building – All Process Rooms.

E. The following areas are classified as indoor and dry:

1. Existing Administration Building.
2. New Dewatering and Controls Building – Non-Process Rooms.
3. Sludge Heating Building – Heat Exchanger/Electrical Room.
4. Existing Blower Building – Electrical Room.
5. Existing Reactor Control Building.
6. Existing Generator Building – Electrical Room and Generator Room.
7. Existing Maintenance Building.
8. Existing Headworks Electrical Building.
9. Existing Secondary Digester Building - Upper Level (Unclassified By Owner added ventilation system).
10. Existing Dewatering Building – Electrical Room.
11. New Chlorine and SO2 Building – Fire Riser Room, Electrical Room, Vestibule, and Toilet.

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F. The following areas are not classified. Use dust-tight and oil-tight NEMA 12 materials and methods.

1. Areas not covered above.

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.

2.02 EQUIPMENT FINISH

A. Manufacturer's standard finish color, except where specific color is indicated. If manufacturer has no standard color, finish equipment in accordance with gray color finish as approved by Engineer.

2.03 NAMEPLATES

A. Material: Laminated plastic.

B. Attachment Screws:

1. Stainless steel.
2. Adhesive: Single-part, room temperature vulcanizing adhesive suitable for the environment and materials installed. Use adhesive on NEMA 4 or NEMA 4X enclosures only.

C. Color: White, engraved to a black 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.

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.

B. Check approximate locations of light fixtures, switches, electrical outlets, equipment, and other electrical system components shown on 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.

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.

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. Drawings show each homerun circuit to be provided.

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B. Homerun circuits shown on 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 do not exceed 40 percent fill.
   e. Changes shall be documented on 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 do not exceed 40 percent fill.
   d. Changes shall be documented on record drawings.
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 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 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.

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3.04 NAMEPLATES, SIGNS, AND LABELS

A. Arc Flash Protection Warning Signs:

1. Field mark switchgear, switchboards, motor control centers, and panelboards to warn qualified persons of potential arc-flash hazards. Locate marking so to be clearly visible to persons before working on energized equipment.
2. Use arc flash hazard boundary, energy level, PPE level and description, shock hazard, bolted fault current, and equipment name from study required in Section 26 05 70, Electrical Systems Analysis as basis for warning signs.

B. Available Fault Current Signs:

1. Install label on service equipment to indicate the maximum available fault current at the equipment. Labels shall be of sufficient durability for the environment in which the equipment is installed. Labels shall include the following information:
   a. Equipment name or identification.
   b. Available fault current at the equipment.
   c. Date the fault current calculations were performed.
2. Use bolted fault current and equipment name from study required in Section 26 05 70, Electrical Systems Analysis, as basis for the label.
3. Where existing electrical systems are modified, completely remove existing fault current labels if present, and install new labels in accordance with the above requirements.

C. Multiple Power Supply Sign: Install permanent plaque or directory at each service disconnect location denoting other services, feeders, and branch circuits supplying the building, and the area served by each.

D. Equipment Nameplates:

1. Provide a nameplate to label electrical equipment including switchgear, switchboards, motor control centers, panelboards, motor starters, transformers, terminal junction boxes, disconnect switches, switches and control stations.
2. Switchgear, motor control center, transformer, and terminal junction box nameplates shall include equipment designation.
3. Disconnect switch, starter, and control station nameplates shall include name and number of equipment powered or controlled by that device.
4. Switchboard and panelboard nameplates shall include equipment designation, service voltage, and phases.

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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 CLEANING AND TOUCHUP PAINTING

A. Cleaning: Throughout the Work, clean interior and exterior of devices and equipment by removing debris and vacuuming.

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.

3.07 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.

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. Underwriters Laboratories, Inc. (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.

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f. 810, Standard for Capacitors.
g. 943, Standard for Ground-Fault Circuit-Interrupters.
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.

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.

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3. Voltage Ratings: 120, 240, 277, 480, 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. All new 480V equipment shall include a minimum short circuit rating of 65,000A. All new 208/120V or 240/120V equipment shall include a minimum short circuit rating of 22,000A.
2. Series Connected Ratings: Do not apply series connected short circuit ratings, except where specifically shown. Where shown, provide UL listed series ratings for the specific breaker/breaker and fuse/breaker combinations.

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. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker specified above with ground fault sensor and rated to trip on 30-mA ground fault (UL-listed for equipment ground fault protection).

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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.

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.

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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.

I. The submittal for all fused and non-fused switches shall include a table that includes the following information:

1. Equipment tag number of each disconnect switch.
2. Amperage rating of each disconnect switch.
3. Indicate if the disconnect switch is fused or non-fused. If fused, include the fuse rating required.
4. Indicate the enclosure type provided with each disconnect switch.
5. Indicate the physical dimensions required for the disconnect switch.

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. Auxiliary Contact:

1. Operation: Make before power contacts make and break before power contacts break.
2. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.

E. Enclosures: See Article Enclosures.

F. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

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G. The submittal for all fused and non-fused switches shall include a table that includes the following information:

1. Equipment tag number of each disconnect switch.
2. Amperage rating of each disconnect switch.
3. Indicate if the disconnect switch is fused or non-fused. If fused, include the fuse rating required.
4. Indicate the enclosure type provided with each disconnect switch.
5. Indicate the physical dimensions required for the disconnect switch.

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.
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.

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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.

D. Pushbutton Color:

1. ON or START: Black.
2. OFF or STOP: Red.

E. Pushbutton and selector switch lockable in OFF position where indicated.

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.

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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.

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 as shown.
2. Field convertible from ON delay to OFF delay and vice versa.

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D. Latching Attachment: Mechanical latch, having unlatching coil and coil clearing contacts.

E. Manufacturers and Products:

1. Eaton/Cutler-Hammer; D26 Type M.
2. General Electric Co.; Type CR120A.
3. 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 Drawings.

G. Manufacturers and Products:

1. Square D Co.; Type XO.
2. Eaton/Cutler-Hammer; Type D26MR.
3. 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.

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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 MAGNETIC CONTACTOR

A. UL listed.

B. Electrically operated, electrically held.

C. Main Contacts:

1. Power driven in one direction with mechanical spring dropout.
2. Silver alloy with wiping action and arc quenchers.
3. Continuous-duty, rated 30 amperes or as shown.
4. Poles: As shown.

D. Control: As shown.

E. Auxiliary Contacts: Quantity as shown, rated 7200VA make, 720VA break, at 600V, A600 per NEMA ICS 5.

F. Enclosures: See Article Enclosures.

G. Manufacturers and Products:

1. Eaton/Cutler-Hammer; Class A201.
2. General Electric Co.; CR 353.
3. Square D Co.; Class 8910.

2.12 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.

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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.

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.

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.

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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 24 volts dc, nominal, with not more than 250 volts available under fault conditions.

C. Contact Rating: 5 amps, 250 volts 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.

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 Underwriters Laboratories, Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.

B. Firestop System:

1. Formulated for use in through-penetration firestopping around cables, conduit, pipes, and duct penetrations through fire-rated walls and floors.
2. Fill, Void, or Cavity Material: 3M Brand Fire Barrier Caulk CP25, Putty 303, Wrap/Strip FS195, Composite Sheet CS195 and Penetration Sealing Systems 7902 and 7904 Series.

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3. Two-Part, Foamed-In-Place, Silicone Sealant: Dow Corning Corp. Fire Stop Foam, General Electric Co. Pensil 851.
4. Fire Stop Devices: See Section 26 05 33, Raceway and Boxes, for raceway and cable fittings.

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	Unfinished	Industrial Use	12
Indoor and Outdoor	Any	Wet	4
Indoor and Outdoor	Any	Denoted "WP"	3R
Indoor and Outdoor	Any	Wet and Corrosive	4X 316 Stainless Steel
Indoor and Outdoor	Any	Wet, Dust or Oil	13
Indoor and Outdoor	Any	Hazardous Gas	7
Indoor and Outdoor	Any	Hazardous Dust	9

PART 3 EXECUTION

3.01 GENERAL

A. Install equipment in accordance with manufacturer's recommendations.

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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.
5. Aluminum Railings: Devices mounted on aluminum railing shall use aluminum framing channel.

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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 2000 Volts or Less for the Distribution of Electrical Energy.

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d. WC 71, Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy.
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. Underwriters Laboratories Inc. (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. Manufactured Wire Systems:
   a. Product data.
   b. Rating information.
   c. Dimensional drawings.
   d. Special fittings.

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3. 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) Power and control conductor, and control and instrumentation cable installations in ductbanks.
      4) 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.
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. 120-Volt and 277-Volt Lighting, 10 AWG and Smaller: Solid copper.
2. 120-Volt Receptacle Circuits, 10 AWG and Smaller: Solid copper.
3. All Other Circuits: Stranded copper.

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C. Insulation: Type THHN/THWN-2, except for sizes No. 6 and larger, with XHHW-2 insulation.

D. Direct Burial and Aerial Conductors and Cables:

1. Type USE/RHH/RHW insulation, UL 854 listed, or Type RHW-2/USE-2.
2. Conform to physical and minimum thickness requirements of NEMA WC 70.

E. Flexible Cords and Cables:

1. Type SOW-A/50 with ethylene propylene rubber insulation in accordance with UL 62.
2. Conform to physical and minimum thickness requirements of NEMA WC 70.

2.02 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: Copper, 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 12-1/2 percent minimum overlap.
10. Jacket: Extruded polyvinyl chloride (PVC) compound applied in accordance with NEMA WC 71 or NEMA WC 74.

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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. Pirelli Wire and Cable.
    c. General Cable.
    d. 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.

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

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No. of Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
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.
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 3 4	0.42 0.45 0.49	45
10	10	2 3 4	0.54 0.58 0.63	60
8	10	3 4	0.66 0.75	60

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Conductor Size	Minimum Ground Wire Size	No. of Current Carrying Conductors	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
6	8	3 4	0.74 0.88	60
4	6	3 4	0.88 1.04	60 80
2	6	3 4	1.01 1.16	80
1	6	3 4	1.10 1.25	80
1/0	6	3 4	1.22 1.35	80
2/0	4	3 4	1.32 1.53	80
3/0	4	3 4	1.40 1.60	80
4/0	4	3 4	1.56 1.78	80 110

5. Manufacturers:
   a. Okonite Co.
   b. Southwire.

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.

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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.

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.

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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 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

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Conductor Size	Minimum Ground Wire Size (AWG)	No. of Insulated Conductors	Max. Outside Diameter (Inches)	Minimum Jacket Thickness (Mils)
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.

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.

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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.
   b. Manufacturers and Products:
      1) Raychem; Type D-SCE or 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.

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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.
   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.

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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.
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.
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.

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D. Elbow Connector Systems:

1. Molded, peroxide-cured, EPDM-insulated, Class 15 kV, 95 kV BIL, 200A, 15,000A rms nonload-break elbows 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. Junctions: Class 15 kV, 95 kV BIL two-way, and 200A, nonload-break, having EPDM rubber body mounted on adjustable bracket.
6. Mounting Plates: Two-way, ASTM A167 stainless steel, complete with universal mounting brackets, grounding lugs and two parking stands.
7. Manufacturers:
   a. Cooper Industries.
   b. Elastimold.

E. 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.

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D. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.

E. Manufacturers:

1. Ideal Co.
2. Polywater, Inc.
3. Cable Grip Co.

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 and aluminum 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 One Hot Leg Other Hot Leg	White Black Red
208Y/120 Volts, Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Black Red Blue
240/120 Volts, Three-Phase, Four-Wire, Delta, Center Tap, Ground on Single-Phase	Grounded Neutral Phase A High (wild) Leg Phase C	White Black Orange Blue
480Y/277 Volts, Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Brown Orange 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 Appearing in Circuit Schedules: Identify using circuit schedule designations.

C. Circuits Not Appearing in Circuit Schedules:

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

D. Method:

1. Conductors 3 AWG and Smaller: Identify with sleeves or heat bond markers.
2. Cables and Conductors 2 AWG and Larger:
   a. Identify with marker plates or tie-on cable marker tags.
   b. Attach with nylon tie cord.
3. 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 riser pole 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. 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 at splices in manholes, handholes, vaults, cable trays, and other indicated locations.

B. Install arc and fireproofing tape on 15 kV cables at splices 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).

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product data for the following:
      1) Exothermic weld connectors.
      2) Mechanical connectors.
      3) Compression connectors.
      4) 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 the 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-clad.

B. Diameter: Minimum 3/4 inch.

C. Length: 10 feet and segmented to allow additional lengths of ground rod to be added if required.

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:
   a. Erico Products, Inc.; Cadweld and Cadweld Exolon.
   b. Thermoweld.

B. Compression Type:

1. Compress-deforming 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 antiseizing compound and sealed.
5. Manufacturers:
   a. Burndy Corp.; Hyground Irreversible Compression.
   b. Thomas and Betts Co.
   c. ILSCO.

C. Mechanical Type: Split-bolt, saddle, or cone screw type; copper alloy material.

1. Manufacturers:
   a. Burndy Corp.
   b. Thomas and Betts Co.

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2.04 GROUNDING WELLS

A. Ground rod box complete with cast-iron riser ring and traffic cover marked "GROUND ROD".

B. Manufacturers and Products:

1. Christy Co.; No. G5.
2. Lightning and Grounding Systems, Inc.; I-R Series.

PART 3 EXECUTION

3.01 GENERAL

A. Grounding: In compliance with NFPA 70 and IEEE C2.

B. Ground electrical service neutral at service entrance equipment with grounding electrode conductor to grounding electrode system.

C. Ground 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.

3.02 WIRE CONNECTIONS

A. Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.

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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.

E. Circuits 20 Amps or Above: Tap motor frame or equipment housing. Install solderless terminal with minimum 5/16-inch diameter bolt.

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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 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.

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B. Bond neutrals of substation transformers to substation grounding grid and system grounding network.

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. Telecommunications Industry Association (TIA): 569B, Commercial Building Standard for Telecommunications Pathways and Spaces.
4. National Electrical Contractor's Association, Inc. (NECA): Installation standards.
5. 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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6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
7. Underwriters Laboratories Inc. (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 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. PVC Schedule 40 conduit.
   b. PVC Schedule 80 conduit.
   c. PVC-coated rigid conduit, submittal to include copy of manufacturer's warranty.
   d. Stainless steel rigid conduit.
   e. Flexible metal, liquid-tight conduit.
   f. Flexible, nonmetallic, liquid-tight conduit.
   g. Flexible metal, nonliquid-tight conduit.
   h. Conduit fittings.
   i. Wireways.
   j. Device boxes for use in hazardous areas.
   k. Junction and pull boxes used at or below grade.
   l. Large junction and pull boxes.
   m. Terminal junction boxes.

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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. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.
6. 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. Seismic 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. 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 Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

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PART 2 PRODUCTS

2.01 CONDUIT AND TUBING

A. Stainless Steel Rigid Conduit (SSRC):

1. ANSI C80.1, UL6A, ASTM A-312/SA-312.
2. Fittings: Threaded type.
3. Type 316 stainless steel. Schedule 40.

B. Rigid Aluminum Conduit:

1. Meet requirements of NEMA C80.5 and UL 6A.
2. Material: Type 6063, copper-free aluminum alloy.

C. 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.

D. Flexible Metal, Liquid-Tight Conduit:

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

E. Flexible Metal, Nonliquid-Tight Conduit:

1. Meet requirements of UL 1.
2. Material: Galvanized steel.

F. Flexible, Nonmetallic, Liquid-Tight Conduit:

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

G. Innerduct:

1. Resistant to spread of fire, per requirements of UL 2024.
2. Smooth or corrugated HDPE.
3. Textile Manufacturer: Maxcell.

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2.02 FITTINGS

A. Rigid Stainless Steel Conduit:

1. General:
   a. Meet requirements of UL 514B.
   b. Type: Threaded, Type 316 stainless steel. Set screw fittings not permitted.
2. Insulated Bushing:
   a. Material: Type 316 stainless steel, with integral insulated throat, rated for 150 degrees C.
   b. Manufacturer: Calbrite.
3. Grounding Bushing:
   a. Material: Type 316 stainless steel with integral insulated throat, rated for 150 degrees, with solderless lugs.
   b. Manufacturer: Calbrite.
4. Conduit Hub:
   a. Material: Type 316 stainless steel, with insulated throat.
   b. UL listed for use in wet locations.
   c. Manufacturers: Calbrite.
5. Conduit Bodies:
   a. Material: Type 316 stainless steel.
   b. Manufacturer: Calbrite.
6. Couplings: As supplied by conduit manufacturer.
7. Conduit Sealing Fitting:
   a. Material: Type 316 stainless steel.
   b. Manufacturer: Calbrite.
8. Drain Seal:
   a. Material: Type 316 stainless steel.
   b. Manufacturer: Calbrite.
9. Drain/Breather Fitting:
   a. Material: Type 316 stainless steel.
   b. Manufacturer: Calbrite.
10. Expansion Fitting:
    a. Material: Type 316 stainless steel.
    b. Manufacturer: Calbrite.
11. Cable Sealing Fittings:
    a. To form watertight nonslip cord or cable connection to conduit.
    b. Bushing: Neoprene at connector entry.
    c. Material: Type 316 stainless steel.
    d. Manufacturer: Calbrite.

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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 EYM-AL.
      2) Crouse-Hinds; Type EYS-SA or 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. PVC Conduit and Tubing:

1. Meet requirements of NEMA TC 3.
2. Type: PVC, slip-on.

D. 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.

E. Flexible Metal, Nonliquid-Tight Conduit:

1. Meet requirements of UL 514B.
2. Body: Galvanized steel or malleable iron.
3. Throat: Nylon insulated.
4. 1-1/4-Inch Conduit and Smaller: One screw body.
5. 1-1/2-Inch Conduit and Larger: Two screw body.
6. Manufacturer and Product: Appleton; Series 7400.

F. Flexible, Nonmetallic, Liquid-Tight Conduit:

1. Meet requirements of UL 514B.
2. Type: High strength plastic body, complete with lock nut, O-ring, threaded ferrule, sealing ring, and compression nut.
3. Body/compression nut (gland) design to ensure high mechanical pullout strength and watertight seal.
4. Manufacturers and Products:
    a. Carlon; Type LT.
    b. O-Z/Gedney; Type 4Q-P.
    c. Thomas & Betts; Series 6300.

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G. 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 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.

H. 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.

2.03 OUTLET AND DEVICE BOXES

A. Cast Stainless Steel:

1. Material:
   a. Box: Cast, Type 316 stainless steel.
   b. Cover: Gasketed, weatherproof, cast stainless steel with stainless steel screws.
2. Hubs: Threaded.
3. Lugs: Cast mounting.
4. Manufacturers: Calbrite.

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.

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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. Nonmetallic:

1. Box: PVC.
2. Cover: PVC, weatherproof, with stainless steel screws.
3. Manufacturer and Product: Carlon; Type FS or Type FD, with Type E98 or Type E96 covers.

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:

1. NEMA 250, Type 4.
2. Box: Cast malleable iron, or ferrous metal, electrogalvanized finished, with drilled and tapped conduit entrances and exterior mounting lugs.
3. Cover: Hinged with screws.
4. Gasket: Neoprene.
5. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
6. Manufacturers and Products, Surface Mounted Nonhinged Type:
   a. Crouse-Hinds; Series W.
   b. O-Z/Gedney; Series Y.
7. Manufacturer and Product, Surface Mounted, Hinged Type: O-Z/Gedney; Series YW.
8. Manufacturers and Products, Recessed Type:
   a. Crouse-Hinds; Type WJBF.
   b. O-Z/Gedney; Series YR.

D. 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.

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4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers and Products:
    a. Crouse-Hinds; Type EJB.
    b. Appleton; Type AJBEW.

E. Large Cast Aluminum Box:

1. NEMA 250 Type 4.
2. Box: Cast copper-free aluminum, with drilled and tapped conduit entrances and exterior mounting lugs.
3. Cover: Nonhinged.
4. Gasket: Neoprene.
5. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
6. Manufacturers and Products, Surface Mounted Type:
    a. Crouse-Hinds; Series W-SA.
    b. O-Z/Gedney; Series YS-A, YL-A.
    c. Killark.

F. 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 screws.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers:
    a. Hoffman Engineering Co.
    b. Robroy Industries.
    c. Wiegman.

G. 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.

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H. 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.
4. Manufacturers and Products:
   a. Christy, Concrete Products, Inc.; B1017BOX.
   b. Utility Vault Co.; 3030 SB.

2.05 TELEPHONE TERMINAL CABINET

A. Material: Code-gauge galvanized steel box with hinged doors and 3/4-inch fire-resistant plywood backboard, meeting requirements of telephone service provider.

B. Finish: Provide gray finish as approved by Engineer.

C. Minimum Size: 18 inches high by 18 inches wide by 6 inches deep.

2.06 TELEPHONE AND DATA OUTLET

A. Provide outlet boxes and cover plates meeting requirements of TIA 569B.

2.07 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.

2.08 METAL WIREWAYS

A. Meet requirements of UL 870.

B. Type: Aluminum-enclosed, lay-in type.

C. Cover: Hinged with friction latch.

D. Rating: NEMA 4X.

E. Finish: Rust inhibiting phosphatizing primer and gray baked enamel.

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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.

2.09 PRECAST MANHOLES AND HANDHOLES

A. Concrete Strength: Minimum, 3,000 psi 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.

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.

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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.

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: Cast, on upper side, in integral letters, minimum 2 inches in height, appropriate titles:
    a. Above 600 Volts: ELECTRIC HV.
    b. 600 Volts and Below: ELECTRIC LV.
    c. TELEPHONE.
    d. ANALOG.
    e. DISCRETE.

I. Handhole Frames and Covers:

1. Material: Steel, hot-dipped galvanized.
2. Cover Type: Solid, bolt-on, of nonskid design.
3. Cover Loading: AASHTO H-20.
4. Cover Designation: Burn by welder, on upper side in integral letters, minimum 2 inches in height, appropriate titles:
    a. 600 Volts and Below: ELECTRIC LV.
    b. TELEPHONE.
    c. ANALOG.
    d. DISCRETE.

J. Hardware: Stainless steel.

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K. Furnish knockout for ground rod in each handhole and manhole.

L. Manufacturers:

1. Utility Vault Co.
2. Penn-Cast Products, Inc.
3. Concrete Conduit Co.
4. Associated Concrete Products, Inc.
5. Pipe, Inc.

2.10 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.
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, nonferrous metal.
   b. Shape: Round.
   c. Raceway Designation: Pressure stamped, embossed, or engraved.
   d. Tags relying on adhesives or taped-on markers not permitted.
2. Warning Tape:
   a. Material: Polyethylene, 4-mil gauge with detectable strip.
   b. Color: Red.
   c. Width: Minimum 6 inches.
   d. Designation: Warning on tape that electric circuit is located below tape.
   e. Identifying Letters: Minimum 1-inch-high permanent black lettering imprinted continuously over entire length.
   f. Manufacturers and Products:
      1) Panduit; Type HTDU.
      2) Reef Industries; Terra Tape.

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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. Raceway Coating: Clean and paint in accordance with Section 09 90 00, Painting and Coating.

D. 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.

E. 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.

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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.

N. Install watertight fittings in outdoor, underground, or wet locations.

O. Paint threads and cut ends, before assembly of fittings, conduit 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. Install conduits for fiber optic cables, telephone cables, and Category 6 data cables in strict conformance with the requirements of TIA 569B.

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3.02 REUSE OF EXISTING CONDUITS

A. Where 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.

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.

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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:

1. Non-AFD and Non-AC Circuits: Rigid aluminum.
2. AFD and Analog Control Circuits: Rigid Stainless Steel.

C. Interior, Exposed:

1. Non-AFD and Non-AC Circuits: Rigid aluminum.
2. AFD and Analog Control Circuits: Rigid Stainless Steel.

D. Interior, Concealed (Not Embedded in Concrete):

1. AFD and Analog Control Circuits: Rigid Stainless Steel.
2. Non-AFD and Non-Analog Control Circuits: PVC Schedule 40.

E. Aboveground, Embedded in Concrete Walls, Ceilings, or Floors:

1. AFD and Analog Control Circuits: Rigid Stainless Steel.
2. Non-AFD and Non-Analog Control Circuits: PVC Schedule 40.

F. Direct Earth Burial:

1. PVC Schedule 80 for ac circuits.
2. Stainless steel for AFD and Analog Control circuits.

G. Concrete-Encased Ductbank:

1. AFD and Analog Control Circuits: Rigid Stainless Steel.
2. Non-AFD and Non-Analog Control Circuits: PVC Schedule 40.

H. Under Slabs-On-Grade:

1. AFD and Analog Control Circuits: Rigid Stainless Steel.
2. Non-AFD and Non-Analog Control Circuits: PVC Schedule 40.

I. Transition from Underground or Concrete Embedded to Exposed: Rigid stainless steel conduit.

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J. Under Equipment Mounting Pads:

1. AFD and Analog Control Circuits: Rigid Stainless Steel.
2. Non-AFD and Non-Analog Control Circuits: PVC Schedule 40.

K. Exterior Light Pole Foundations: Rigid stainless steel conduit.

L. Corrosive Areas:

1. AFD and Analog Control Circuits: Rigid Stainless Steel.
2. Non-AFD and Non-Analog Control Circuits: PVC Schedule 40.

M. Hazardous Gas Areas:

1. AFD and Analog Control Circuits: Rigid Stainless Steel.
2. Non-AFD and Non-Analog Control Circuits: PVC Schedule 40.

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, nonmetallic or flexible metal liquid-tight.
4. Dry Areas: Flexible, metallic liquid-tight.
5. Hazardous Areas: Flexible coupling suitable for Class I, Division 1 and 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.

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C. Fire-Rated Walls, Floors, or Ceilings: Firestop openings around penetrations to maintain fire-resistance rating as specified in Section 26 05 04, Basic Electrical Materials and Methods.

D. Apply heat shrinkable tubing or single layer of wraparound duct band 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.
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.
4. Corrosive-Sensitive Areas:
    a. Seal conduit passing through chlorine and SO2 room walls.
    b. Seal conduit entering equipment panel boards and field panels containing electronic equipment.
5. Existing or Precast Wall (Underground): Core drill wall and install watertight entrance seal device.
6. 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.

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7. 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 8 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 25 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. Nonmetallic Conduit: Nonmetallic.

D. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:

1. Wood: Wood screws.
2. Hollow Masonry Units: Toggle bolts.
3. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.
4. Steelwork: Machine screws.
5. Location/Type of Hardware:
    a. Dry, Noncorrosive Areas: Stainless steel.
    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.

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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 stainless 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.

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.

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B. Adapters:

1. PVC to Metallic Fittings: PVC terminal type.
2. PVC to Rigid Metal Conduit: PVC female adapter.

C. Belled-End Conduit: Bevel unbelled end of joint prior to joining.

3.11 WIREWAYS

A. Install in accordance with manufacturer's instructions.

B. Locate with cover on accessible vertical face of wireway, unless otherwise shown.

C. Applications:

1. Metal wireway in indoor dry locations.
2. Nonmetallic wireway in indoor wet, outdoor, and corrosive locations.

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 Type 316 stainless steel Myers hubs, maintaining enclosure integrity.
2. Metallic Conduit: Provide ground terminal for connection to maintain continuity of ground system.

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.

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2. Aluminum and Stainless Steel 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. Flexible Metal Conduit: Provide two screw type, insulated, malleable iron connectors.
4. Flexible, Nonmetallic Conduit: Provide nonmetallic, liquid-tight strain relief connectors.
5. PVC Schedule 40 Conduit: Provide PVC terminal adapter with lock nut, except where threaded hubs required above.

D. Motor Control Center, Switchgear, 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.

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.

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H. Transition from Underground to Exposed: Stainless 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. Metallic Raceway Coating: At couplings and joints, apply wraparound duct band with one-half tape width overlap to obtain two complete layers.

K. Provide expansion fittings that allow minimum of 4 inches of movement in vertical conduit runs from underground where exposed conduit will be fastened to or will enter building or structure.

L. Provide expansion/deflection fittings in conduit runs that exit building or structure belowgrade. Conduit from building wall to fitting shall be PVC-coated rigid steel.

M. Concrete Encasement:

1. As specified in Section 03 30 00, Cast-in-Place Concrete.
2. Concrete Color: Red.

N. Backfill: As specified in Section 31 23 23.15, Trench Backfill. 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.

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.

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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 stainless steel 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.
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.

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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. Switch, Motor Starting: 48 inches above floor, unless otherwise indicated on 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.

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. Wood: Wood screws.
   b. Concrete or Brick: Bolts and expansion shields.
   c. Hollow Masonry Units: Toggle bolts.
   d. Steelwork: Machine screws.

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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.

C. Mounting Hardware:

1. Noncorrosive Dry Areas: Stainless steel.
2. Noncorrosive Wet Areas: Stainless steel.
3. Corrosive Areas: Stainless steel.

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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. Wood: Wood screws.
   b. Concrete or Brick: Bolts and expansion shields.
   c. Hollow Masonry Units: Toggle bolts.
   d. 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 Engineer'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 TERMINAL CABINET

A. Install with top of cabinet 6 feet above floor.

B. Door Opening: 120 degrees, minimum.

3.18 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.

3.19 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.

3.20 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.

3.21 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 noncorrosive wire 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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3.22 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 CD of final studies including all engineering software input files, output reports, and libraries.

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1.03 QUALITY ASSURANCE

A. Short circuit, protective device coordination, and arc flash studies shall be prepared by a licensed professional electrical engineer registered in the State of Alabama.

1.04 SEQUENCING AND SCHEDULING

A. Initial complete short circuit study shall be submitted, reviewed, and approved before Engineer will review any Shop Drawings for any major electrical equipment.

B. Initial complete protective device coordination and arc flash studies shall be submitted within 30 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 30 days before energizing electrical equipment. The final short circuit, coordination, and arc flash studies must be approved before the Contractor will be permitted to energize any of the new 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 Drawings.

B. Perform studies using one of the following electrical engineering software packages:

1. SKM Power Tools for Windows.
2. ETAP.
3. Paladin.
4. Easy Power.

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C. Perform complete fault calculations for each existing and proposed source combination. The fault calculations shall be performed under each of the various scenarios as outlined below:

1. Scenario #1: Normal utility power being utilized to operate the facility loads. Note that there are currently five (5) different electrical load centers located throughout the Williams WWTP. Each of these load centers includes provisions for the downstream plant loads to be fed from either the normal utility source OR from the back-up generator that is located in close proximity to the associated electrical load center.
2. Scenario #2: The back-up generator being utilized to operate the facility loads. Note that there are currently five (5) different electrical load centers located throughout the Williams WWTP. Each of these load centers includes provisions for the downstream plant loads to be fed from either the normal utility source OR from the back-up generator that is located in close proximity to the associated electrical load center.

D. Utilize proposed and existing load data for study obtained from Contract Documents, provided by Engineer, and obtained from extensive field investigation of system configuration, wiring information, and equipment. The Owner will make all existing documentation of the Williams WWTP available to the Contractor for his use in the development of the specified studies. However, all the information required to perform the specified studies will not be contained within the existing documentation made available for Contractor's use. Therefore, the Contractor will be required to perform extensive field investigations to obtain any information that is not available from the Owner, Engineer, or the existing documentation of this facility. Furthermore, the Contractor shall also be aware that the available documentation that the Owner does have of this existing facility is only design documents, but not "As-Built" documents. Therefore, the accuracy of any of the documentation that will be made available to the Contractor will need to be field verified by the Contractor. All labor, materials, equipment, and incidental items required to obtain any information necessary to perform the specified studies shall be provided by the Contractor as part of his Bid.

E. Existing System and Equipment:

1. Extent of existing system to be included in study is all of the existing system and equipment that is shown to remain as well as all new electrical equipment. Note that there will be five (5) different electrical load centers located throughout the Williams WWTP at the completion of this Project. The load centers will be located within each of the following structures:
   a. Existing Blower Building.
   b. Existing Dewatering Building.

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c. Existing Generator Building.
d. Existing Headworks Electrical Building.
e. New Dewatering Building.

All new and existing electrical equipment that is fed from the Alabama Power's 13.2KV overhead line shall be included in the analysis performed by the Contractor. The Contractor shall note that there is an existing 13.2KV overhead line that is owned by MAWSS which shall be included within the analysis performed by the Contactor. Additionally, there are also five (5) different electrical load centers that shall be included as part of the studies to be performed by the Contractor. The analysis to be performed by the Contractor shall commence at the connection point with Alabama Power's 13.2KV overhead line and shall extend down to the existing motor loads, panelboards, and vendor control panels that will be distributed throughout the Williams WWTP.

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.
5. Analysis performed shall include the Contractor obtaining the fault current ratings of all the existing electrical equipment that will remain.

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.
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 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.

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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.

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 or switchboard.
3. Unit substation primary and secondary terminals.
4. Low-voltage switchgear and switchboards.
5. Automatic and manual transfer switches.
6. Motor control centers.
7. Standby generators.
8. Branch circuit panelboards.
9. Future load contributions as shown on one-line diagrams.

D. Provide bolted line-to-ground fault current study for areas as defined for three-phase bolted fault short circuit study.

E. Provide bolted line-to-line fault current study for areas as defined for three-phase bolted fault short circuit study.

F. 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.

G. 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.

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2. Short Circuit Data (for each source combination):
    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.

H. Written Summary:

1. Scope of studies performed.
2. Explanation of bus and branch numbering system.
3. Prevailing conditions.
4. Selected equipment deficiencies.
5. Results of short circuit study.
6. Comments or suggestions.

I. Suggest changes and additions to equipment rating and/or characteristics.

J. Notify Engineer in writing of existing circuit protective devices improperly rated for new fault conditions.

K. Revise data for “as-installed” condition.

1.07 PROTECTIVE DEVICE COORDINATION STUDY

A. General:

1. Prepare in accordance with IEEE 242.
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.

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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.
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.

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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.

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: For each major part of electrical power system, determine the following:

1. Flash hazard protection boundary.
2. Limited approach boundary.
3. Restricted approach boundary.
4. Incident energy level.
5. Glove class required.

D. Produce arc flash warning labels that list items in Paragraph Base Calculation and the following additional items.

1. Bus name.
2. Bus voltage.

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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.
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 40 cal/cm2. 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.

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PART 2 PRODUCTS

2.01 PERMANENT MARKING OF ARC FLASH HAZARD BOUNDARY

A. The Contractor shall be responsible painting the floor, or providing other permanent markings, that will clearly indicate to the plant operators the limits of the arc flash hazard boundary around all of the electrical equipment, both new and existing, installed throughout the Williams WWTP.

2.02 ARC FLASH WARNING LABELS

A. Arc flash warning labels printed in color on thermally bonded adhesive backed, UV- 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.

3.02 SUPPLEMENTS

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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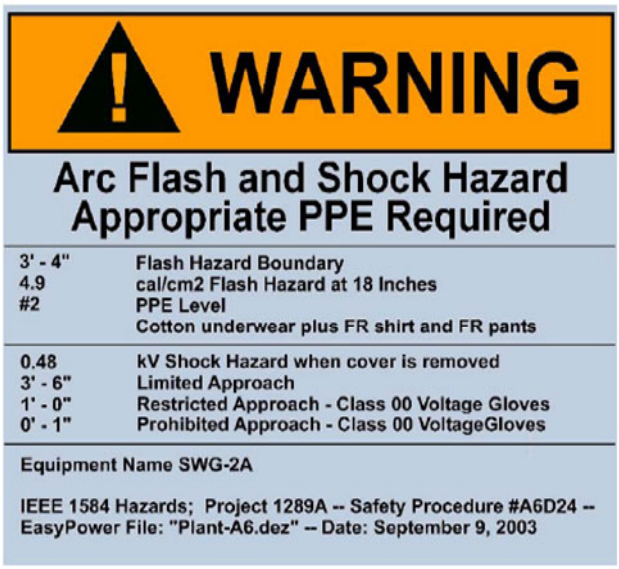

Figure 1
Example Arc Flash Label

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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 (2300V 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, 3200 Vdc and below) Power Circuit Breaker Switchgear.
j. C37.20.2, Standard for Metal-Clad Switchgear.
k. C37.20.3, Standard for Metal-Enclosed Interrupter Switchgear.
l. C37.23, Standard for Metal-Enclosed Bus.
m. 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 through 46 kV.
   c. S-97-682, Standard for Utility Shielded Power Cables Rated 5 through 46 kV.
4. 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.
5. InterNational Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Equipment and Systems.
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: Prior to initial energization of electrical distribution equipment; include the following:
   a. Owner's representative sign-off form for complete and accurate arc flash labeling and proper protective device settings for equipment to be energized.
   b. Staged sequence of initial energization of electrical equipment.
   c. Lock-Out-Tag-Out plan for each stage of the progressive energization.
   d. 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: At completion of Performance Demonstration Test, submit final hardcopy printout and electronic files on compact disc of as-left setpoints, programs, and device configuration files for:
   a. Protective relays.
   b. Intelligent overload relays.
   c. Adjustable frequency drives.
   d. Power metering devices.
   e. Uninterruptible power supplies.
   f. 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 Engineer prior to de-energization.
2. Minimized to avoid extended period of interruption to the operating plant equipment.

C. Notify Engineer 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. Set, test, and calibrate protective relays, circuit breakers, fuses, power monitoring meters, and other applicable devices in accordance with values established by short circuit, coordination, and arc flash harmonics studies as specified in Section 26 05 70, Electrical Systems Analysis.

E. Adjust mechanisms and moving parts of equipment for free mechanical movement.

F. Adjust and set electromechanical electronic relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

G. Verify nameplate data for conformance to Contract Documents and approved Submittals.

H. Realign equipment not properly aligned and correct unlevelness.

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

J. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench/screw driver to manufacturer's recommendations, or as otherwise specified in NETA ATS.

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

L. Provide proper lubrication of applicable moving parts.

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M. Inform Engineer of working clearances not in accordance with NFPA 70.

N. 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.

O. 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.

P. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents or approved Submittals.

Q. 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.

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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 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 SWITCHGEAR ASSEMBLIES

A. Visual and Mechanical Inspection:

1. Insulator damage and contaminated surfaces.
2. Proper barrier and shutter installation and operation.
3. Proper operation of indicating devices.
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 or OPEN position.
    b. Opening attempt of door when device is in ON or CLOSED position.
8. Check nameplates for proper identification of:
    a. Equipment title and tag number with latest one-line diagram.
    b. Pushbutton.
    c. Control switch.
    d. Pilot light.
    e. Control relay.
    f. Circuit breaker.
    g. Indicating meter.
9. Verify fuse and circuit breaker ratings, sizes, and types conform to those specified.

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10. Check bus and cable connections for high resistance by calibrated torque wrench and thermographic survey applied to bolted joints.
    a. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
    b. Thermographic survey temperature gradient of 2 degrees C or less.
11. 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.
12. Verify performance of each control device and feature.
13. Control Wiring:
    a. Compare wiring to local and remote control and protective devices with elementary diagrams.
    b. Proper conductor lacing and bundling.
    c. Proper conductor identification.
    d. Proper conductor lugs and connections.
14. Exercise active components.
15. Perform phasing check on double-ended equipment 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. Each phase of each bus section.
    c. Phase-to-phase and phase-to-ground for 1 minute.
    d. With breakers open.
    e. With breakers closed.
    f. Control wiring except that connected to solid state components.
    g. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Overpotential Tests:
    a. Applied ac or dc voltage and test procedure in accordance with IEEE C37.20.1. Alternatively use NETA ATS, Table 100.2.
    b. Each phase of each bus section.
    c. Phase-to-phase and phase-to-ground for 1 minute.
    d. Test results evaluated on a pass/fail basis.
3. Current Injection Tests:
    a. For entire current circuit in each section.
    b. Secondary injection for current flow of 1 ampere.
    c. Test current at each device.

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4. Control Wiring:
    a. Apply secondary voltage to control power and potential circuits.
    b. Check voltage levels at each point on terminal boards and each device terminal.
5. Operational Test:
    a. Initiate control devices.
    b. Check proper operation of control system in each section.

3.04 PANELBOARDS

A. Visual and Mechanical Inspection: Include the following inspections and related work:

1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.
2. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer's instruction manual.
3. Check panelboard mounting, area clearances, and alignment and fit of components.
4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
5. Perform visual and mechanical inspection for overcurrent protective devices.

B. Electrical Tests: Include the following items performed in accordance with manufacturer's instruction:

1. Insulation Resistance Tests:
    a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
    b. Each phase of each bus section.
    c. Phase-to-phase and phase-to-ground for 1 minute.
    d. With breakers open.
    e. With breakers closed.
    f. Control wiring except that connected to solid state components.
    g. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Ground continuity test ground bus to system ground.

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3.05 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.

3.06 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.

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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.
   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.

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3.07 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect each individual exposed power cable No. 4 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. 4 and Larger:

1. Insulation Resistance Tests:
   a. Utilize 1,000-volt 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.
2. Continuity test by ohmmeter method to ensure proper cable connections.

C. Low-voltage cable tests may be performed by installer in lieu of independent testing firm.

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3.08 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 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.
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.

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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.

3.09 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.
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 electrical and mechanical interlocking system operation and sequencing.

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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 deviation of 50 percent or more from adjacent poles or similar switches.

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 1,000-volt dc megohmmeter for 480-volt and 600-volt circuit breakers and 500-volt dc megohmmeter for 240-volt circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
   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.

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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 LOW VOLTAGE POWER CIRCUIT BREAKERS

A. Visual and Mechanical Inspection:

1. Proper mounting, cell fit, and element alignment.
2. Proper operation of racking interlocks.
3. Check for damaged arc chutes.
4. Proper contact condition.
5. Bolt torque level in accordance with NETA ATS, Table 100.12.
6. Perform mechanical operational and contact alignment tests in accordance with manufacturer's instructions.
7. Check operation of closing and tripping functions of trip devices by activating ground fault relays, undervoltage shunt relays, and other auxiliary protective devices.
8. Verify primary and secondary contact wipe, gap setting, and other dimensions vital to breaker operation are correct.
9. Check charging motor, motor brushes, associated mechanism, and limit switches for proper operation and condition.
10. Check operation of electrically operated breakers in accordance with manufacturer's instructions.
11. Check for adequate lubrication on contact, moving, and sliding surfaces.

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B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 1,000-volt 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.
   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 characteristic when adjusted to setting sheet parameters shall be within manufacturer's published time-current tolerance band.

3.12 PROTECTIVE RELAYS

A. Visual and Mechanical Inspection:

1. Visually check each relay for:
   a. Tight cover gasket and proper seal.
   b. Unbroken cover glass.
   c. Condition of spiral spring and contacts.
   d. Disc clearance.
   e. Condition of case shorting contacts if present.
2. Mechanically check each relay for:
   a. Freedom of movement.
   b. Proper travel and alignment.
3. Verify each relay:
   a. Complies with Contract Documents, approved Submittal, and application.
   b. Is set in accordance with recommended settings from Coordination Study.

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B. Electrical Tests:

1. Insulation resistance test on each circuit to frame, except for solid state devices.
2. Test on nominal recommended setting for:
   a. Pickup parameters on each operating element.
   b. Timing at three points on time-current curve.
   c. Pickup target and seal-in units.
   d. Special tests as required to check operation of restraint, directional, and other elements in accordance with manufacturer's instruction manual.
3. Phase angle and magnitude contribution tests on differential and directional relays after energization to vectorially verify proper polarity and connections.
4. Current Injection Tests:
   a. For entire current circuit in each section.
   b. Secondary injection for current flow of 1 ampere.
   c. Test current at each device.

3.13 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Visually check current, potential, and control transformers for:
   a. Cracked insulation.
   b. Broken leads or defective wiring.
   c. Proper connections.
   d. Adequate clearances between primary and secondary circuit wiring.
2. Verify Mechanically:
   a. Grounding and shorting connections have good contact.
   b. Withdrawal mechanism and grounding operation, when applicable, operate properly.
3. Verify proper primary and secondary fuse sizes for potential transformers.

B. Electrical Tests:

1. Current Transformer Tests:
   a. Insulation resistance test of transformer and wiring-to-ground at 1,000 volts dc for 30 seconds.
   b. Polarity test.
   c. Ratio and accuracy test.

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2. Potential Transformer Tests:
    a. Insulation resistance test at test voltages in accordance with NETA ATS, Table 100.9, for 1 minute on:
        1) Winding-to-winding.
        2) Winding-to-ground.
    b. Polarity test to verify polarity marks or H1-X1 relationship as applicable.
    c. Ratio and accuracy test.
3. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 100.5.

3.14 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.

3.15 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Equipment and circuit grounds in motor control center, panelboard, and switchgear assemblies for proper connection and tightness.
2. Ground bus connections in motor control center, panelboard, and switchgear assemblies for proper termination and tightness.
3. Effective transformer core and equipment grounding.
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 5 ohm(s).

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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 0.50 ohm.

3.16 AC INDUCTION MOTORS

A. General: Inspection and testing limited to motors rated 5 horsepower 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.
        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.

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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.

3.17 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 or OPEN position.
    b. Opening attempt of door when device is in ON or CLOSED position.
8. Check key interlocking systems for:
    a. Key captivity when device is in ON or CLOSED position.
    b. Key removal when device is in OFF or OPEN 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 and the applicable control diagrams for each motor starter or VFD.
    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 calibrated torque wrench applied to bolted joints and thermographic survey:
    a. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
    b. Thermographic survey temperature gradient of 2 degrees C, or less per NETA ATS, Table 100.18.
13. 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.
14. Verify performance of each control device and feature furnished as part of motor control center.
15. 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.
16. Exercise active components.
17. Inspect contactors for:
    a. Correct mechanical operations.
    b. Correct contact gap, wipe, alignment, and pressure.
    c. Correct torque of connections.
18. Compare overload heater rating with full-load current for proper size.
19. Compare motor protector and circuit breaker with motor characteristics for proper size.
20. 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.

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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.
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 1,000 volts 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.

3.18 MANUAL TRANSFER SWITCHES

A. Visual and Mechanical Inspection:

1. Check doors and panels for proper interlocking.
2. Check connections for high resistance by calibrated torque wrench applied to bolted joints.
3. Check positive mechanical and electrical interlock between normal and alternate sources.
4. Check for proper operation:
   a. Manual transfer function switch.
   b. Transfer switch under load and nonload conditions.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1, for each phase with switch CLOSED in both source positions.
   b. Phase-to-phase and phase-to-ground for 1 minute.
   c. Test values in accordance with manufacturer's published data.
2. Contact Resistance Test:
   a. Contact resistance in microhms across each switch blade for both source positions.
   b. Investigate values exceeding 500 micro-ohms.
   c. Investigate values deviating from adjacent pole by more than 50 percent.
3. Perform manual transfer tests by:
   a. Simulating loss of normal power and transferring load to back-up source.
   b. Return of normal power and transferring load to normal source.

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3.19 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.

3.20 LOW VOLTAGE SURGE ARRESTORS

A. Visual and Mechanical Inspection:

1. Adequate clearances between arrestors and enclosures.
2. Ground connections to ground bus.

B. Electrical Tests:

1. Varistor Type Arrestors:
   a. Clamping voltage test.
   b. Rated RMS voltage test.
   c. Rated dc voltage test.
   d. Varistor arrestor test values in accordance with IEEE C62.33, Section 4.4 and Section 4.9.

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3.21 STANDBY GENERATOR SYSTEMS

A. Visual and Mechanical Inspection:

1. Proper grounding.
2. Blockage of ventilating passageways.
3. Proper operation of jack water heaters.
4. Integrity of engine cooling and fuel supply systems.
5. Excessive mechanical and electrical noise.
6. Overheating of engine or generator.
7. Proper installation of vibration isolators.
8. Proper cooling liquid type and level.
9. Operate engine-generator and check for:
    a. Excessive mechanical and electrical noise.
    b. Overheating.
    c. Correct rotation.
    d. Check resistance temperature detectors or generator inherent thermal protectors for functionability and proper operation.
    e. Excessive vibration.
10. Verify voltage regulator and governor operation will cause unit speed and output voltage to stabilize at proper values within reasonable length of time.
11. Proper operation of meters and instruments.
12. Compare generator nameplate rating and connection with one-line diagram or approved Submittal.
13. Verify engine-generator operation with adjustable frequency drives energized and operating under normal load conditions.

B. Electrical and Mechanical Tests:

1. Cold start test by interrupting normal power source with test load consisting of connected building load to verify:
    a. Transfer switch operation.
    b. Automatic starting operation.
    c. Operating ability of engine-generator.
    d. Overcurrent devices capability to withstand inrush currents.
2. Phase rotation tests.
3. Test engine protective shutdown features for:
    a. Low oil pressure.
    b. Overtemperature.
    c. Overspeed.

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4. Load bank test with resistors for each load step. Record voltage, frequency, load current, oil pressure, and engine coolant temperature at 15-minute intervals:
    a. 25 percent applied load for 30 minutes.
    b. 50 percent applied load for 30 minutes.
    c. 75 percent applied load for 30 minutes.
    d. 100 percent applied load for 3 hours.
    e. Load test results to demonstrate ability of unit to deliver rated load for test period.
5. One-Step Rated kW Load Pickup Test:
    a. Perform test immediately after performing load bank test.
    b. Apply rated load, minus largest rated hp motor, to generator.
    c. Start largest rated horsepower motor and record voltage drop for 20 cycles minimum with high-speed chart recorder or digital storage oscilloscope.
    d. Compare voltage drop with maximum allowable voltage dip for specified starting situation.

3.22 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. Oil-Filled, Padmounted Transformer.
2. Low voltage switchgear.
3. Low voltage motor control center.
4. Panelboard.
5. Adjustable Frequency Drive (AFD).

B. Provide thermographic survey of feeder conductors No. 4 and larger terminating at:

1. Motors rated 50 hp and larger.
2. Low voltage disconnect switches.
3. Manual Transfer switches.
4. Engine-generators.
5. Panelboard.
6. Motor Control Center.
7. Low voltage switchgear.
8. Vendor Control Panel.
9. Oil-Filled, Padmounted Transformer.

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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 12 02
OIL-FILLED PAD MOUNTED TRANSFORMERS

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): D3487, Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus.
2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
   b. C57.12.00, Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.
   c. C57.12.22, Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers with High-Voltage Bushings, 2,500 kVA and Smaller.
   d. C57.12.26, Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers for Use with Separable Insulated High Voltage Connectors.
   e. C57.12.28, Switchgear and Transformers—Pad-Mounted Equipment, Enclosure Integrity.
   f. C57.12.90, Standard Test Code for Liquid Immersed Distribution, Power, and Regulating Transformers.
   g. C57.106, Guide for Acceptance and Maintenance of Insulating Oil in Equipment.
   h. C62.11, Metal-Oxide Surge Arresters for Alternating-Current Power Circuits (>1 kV).
3. National Electrical Manufacturers Association (NEMA):
   a. TR 1, Transformers, Regulators, Reactors.
   b. TP 1, Guide for Determining Energy Efficiency for Distribution Transformers.
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. UL.
6. United States Department of Energy: Code of Federal Regulations, Final Rule 10 CPR Part 431 DOE 2016 efficiency.

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1.02 SUBMITTALS

A. Action Submittals:

1. Descriptive information.
2. Dimensional drawings.
3. Transformer nameplate data, including efficiency.
4. Schematic and connection diagrams.
5. 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. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
3. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
4. Factory test reports.

1.03 QUALITY ASSURANCE

A. Design, test, and assemble in accordance with applicable standards of NEMA TR 1, IEEE C57.12.00, IEEE C57.12.22, IEEE C57.12.26, and IEEE C57.12.90.

1.04 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage and deliver prior to 90 percent Project completion the following spare parts, special tools, and materials:

1. One quart of paint to match color and quality of equipment final shop finish.
2. One spare fuse links for each replaceable fuse size.
3. Pentahead socket for 1/2-inch socket drive.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Eaton.

B. Square D Co.

C. General Electric.

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2.02 GENERAL

A. Integral Unit: Compartmental type unit consisting of transformer, oil-filled tank, and high and low voltage terminating compartments, assembled on a common structural base.

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

2.03 TRANSFORMER

A. kVA Rating: 1500KVA.

B. Primary Voltage: 13.2 kV line-to-line, three-phase, 60-Hz.

C. Secondary Voltage: 480 volts, three-phase, three-wire, 60 Hz.

D. BIL Rating:

1. 95 kV BIL for 15 kV insulation class transformers.
2. 30 kV BIL for secondary.

E. Temperature Rise: 65 degrees C above 30 degrees average ambient with maximum ambient not to exceed 40 degrees C.

F. Impedance:

1. 1.35 percent minimum for transformers rated 150 kVA and less.
2. 3.0 percent minimum for transformers rated 225, 300, and 500 kVA.
3. 6.0 percent for transformers rated 750 kVA and above.

G. Efficiency: Meet or exceed DOE 2016 efficiency requirements.

H. Dielectric Coolant: Fully biodegradable, nontoxic, and nonbio-accumulating fluid, qualifying as “less flammable” per NEC 450.23; Factory Mutual Approved or UL Classified.

I. Primary Taps:

1. Full capacity, two 2-1/2 percent below and two 2-1/2 percent above, rated voltage.
2. Externally operated no-load tap changer.
3. Provisions for locking handle in any position.

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J. Coil Conductors: Copper windings.

K. Wye-wye transformers wound on five-legged or triplex cores.

L. Sound Level: In accordance with manufacturer's standards.

2.04 ENCLOSURE

A. In accordance with IEEE C57.12.28 requirements.

B. Welded carbon steel transformer tank, with cooling panels when required, and lifting eyes.

C. 12-gauge sheet steel terminal compartment enclosure having no exposed screws, bolts, or other fasteners that are externally removable.

D. Color: Provide gray finish as approved by Engineer.

2.05 TERMINAL COMPARTMENTS

A. General: IEEE C57.12.28, enclosed high and low voltage compartments side by side, separated by steel barrier, bolted to transformer tank.

1. Doors:
    a. Individual, full-height, air-filled.
    b. Low voltage door with three-point latching mechanism, vault type handle, and single padlocking provision.
    c. High voltage door fastenings inaccessible until low voltage door has been opened.
    d. Door Bolts: Penta-head type.
    e. Lift-off, stainless steel hinges and door stops.
    f. Removable front sill to facilitate rolling or skidding over conduit stubs.
    g. Recessed lock pocket, with steel door release bolt adjacent to secondary compartment door handle.

B. High Voltage Compartment:

1. Deadfront in accordance with IEEE C57.12.26 type construction.
2. Protective fuses.
3. High voltage bushings.
4. Transformer grounding pad.
5. Surge arresters with barriers.
6. Radial feed, two position sectionalizing load-break switch.

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C. Low Voltage Compartment:

1. Livefront in accordance with IEEE C57.12.26 type construction.
2. Low voltage bushings.
3. Grounding pad.
4. Stainless steel equipment nameplate.
5. Liquid level gauge.
6. 1-inch upper filter press and filling plug.
7. Drain valve with sampling device.
8. Dial type thermometer.
9. Pressure relief valve.
10. Pressure relief device, self-resealing with indicator.
11. Pressure-vacuum gauge.
12. Mounting provision for current and potential transformers.
13. Nameplate.

2.06 BUSHINGS

A. High Voltage:

1. Deadfront Termination:
   a. Universal bushing well rated at 15 kV in accordance with IEEE 386.
   b. Bushings externally clamped and front removable.
   c. Rated for 200 amperes continuous, 95 kV BIL.
   d. Standoff brackets located adjacent to bushings.
   e. Insulated Standoff Bushings: Class 15 kV, 95 kV BIL, 200 and 600 amperes, complete with EPDM rubber body, stainless steel eyebolt with brass pressure foot, and stainless steel base bracket.

B. Low Voltage:

1. Molded epoxy bushing clamped to tank with 8 hole spade type terminals.
2. Rated 150 percent of continuous full-load current, 30 kV BIL, 600 volts.
3. Internally connected neutral extending to neutral bushing.

2.07 HIGH VOLTAGE SWITCHING

A. Internal, oil-immersed, gang-operated load-break, manually operated switches.

B. Hot stick operated handle located in high voltage compartment.

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C. Capable of operating at full-load current.

D. Feed Switch: Two-position, ON/OFF radial.

2.08 HIGH VOLTAGE PROTECTION

A. Combination Oil-Immersed Bayonet Expulsion and Current Limiting Fuses:

1. Accessibility:
   a. Bayonet expulsion fuse accessible through primary compartment.
   b. Current-limiting fuse accessible through tank handhole.
2. Expulsion Fuse for Low Current Faults: Interrupting capacity of 1,800 amperes rms asymmetrical.
3. Current Limiting for High Current Faults: Interrupting capacity of 50,000 amperes rms symmetrical.
4. Bayonet fuse externally replaceable with hot stick.

2.09 TANK GROUNDING PADS

A. High and Low Voltage Compartments:

1. Connected together with bare No. 2/0 stranded copper conductors.
2. Wye-wye high and low voltage neutrals internally connected with link and brought out to insulated low voltage bushing externally grounded to tank.
3. Low voltage neutral connected to externally mounted insulating bushing in low voltage compartment and grounded to tank with removable strap.

2.10 TAP CHANGER WARNING SIGN

A. Red laminated plastic, engraved to white core.

B. Engrave to Read: DO NOT OPERATE WHEN TRANSFORMER ENERGIZED.

C. Mount above tap changer handle.

2.11 FACTORY TESTS

A. Production tests in accordance with IEEE C57.12.90 and IEEE C57.12.00, Section 8 and Table 16.

B. Dielectric test in accordance with IEEE C57.12.26.

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PART 3 EXECUTION

3.01 GENERAL

A. Secure to mounting pads with anchor bolts.

B. Install plumb and longitudinally in alignment with pad or adjacent building wall.

C. Ground neutrals and enclosures in accordance with applicable codes.

3.02 ADJUSTMENTS

A. Adjust voltage taps to obtain rated output voltage under normal operating load conditions.

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 50 hp and larger.
    e. Multispeed load classification (for example, variable torque).
    f. Adjustable frequency drive motor load classification (for example, variable torque) and minimum allowable motor speed for that load classification.
    g. Guaranteed minimum full load efficiency and power factor.

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4. Enclosure type and mounting (such as, horizontal, vertical).
5. Dimensions and total weight.
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.
15. Anchorage and bracing data sheets and drawings 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. 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. General Electric.
2. Baldor.
3. U.S. Electrical Motors.

2.02 GENERAL

A. For multiple units of the same type of equipment, furnish identical motors and accessories of a single manufacturer.

B. In order to obtain single source responsibility, use a single supplier to provide drive motor, its driven equipment, and specified motor accessories.

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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): Driven equipment brake horsepower at any head capacity point on pump curve not to exceed motor nameplate horsepower rating, excluding service factor. The use of inverter ready motors for any application in which the motors speed shall be varied will not be accepted. Any application in which the motors speed shall be varied shall require the use of inverter duty rated motors without exception.

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: Unless otherwise indicated in motor-driven equipment specification:

Voltage Rating		
Size	**Voltage**	**Phase**
1/4 hp and smaller	115	1
1/3 hp through 400 hp	460	3
450 hp and larger	4,000	3

C. Suitable for full voltage starting.

D. 100 hp and larger also suitable for reduced voltage starting with 65 percent or 80 percent voltage tap settings on reduced inrush motor starters.

E. 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.

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2.08 INSULATION SYSTEMS

A. Single-Phase, Fractional Horsepower Motors: Manufacturer's standard winding insulation system.

B. Motors Rated Over 600 Volts: VPI windings in accordance with NEMA MG 1.

C. 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 DIR motors.

D. Motors With Form-Wound Coils: Locked coil bracing system in accordance with NEMA C50.41.

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 C and 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. Submersible: In accordance with Article Special Motors.

E. 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
Above 600	All sizes	200

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 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. Above 400 hp: Regreasable antifriction bearings in labyrinth sealed end bells with removable grease relief plugs.
4. 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.
5. 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 whose motor data sheets and/or control diagrams indicate thermostats are to be provided.
   b. Bi-metal disk or rod type thermostats embedded in stator windings.
   c. Automatic reset contacts rated 120 volts ac, 5 amps minimum, opening on excessive temperature. (Provide manual reset at motor controller.)
   d. Leads extending to separate terminal box for motors 100 hp and larger.

C. Space Heaters:

1. Provide winding space heaters with leads wired out to separate condulet or terminal box.
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.

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.

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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.
6. Provide forced ventilation where speed ratio is greater than published range for motor provided.
7. When installed in Division 1 hazardous (classified) location, provide motor identified by manufacturer as suitable use with a variable speed drive in a Division 1 location.

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8. 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.
9. Shaft Grounding Device, Motors Larger than 25 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. Manufacturers:
        1) Grounding Brush: Sohre Turbomachinery, Inc.
        2) Grounding Ring: EST-Aegis.

G. Submersible Pump Motor:

1. Manufacturers:
    a. Reliance Electric.
    b. Xylem Flygt Corp.
    c. KSB.
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
10.1 through 50	85	82
50.1 through 100	87	82
Over 100	89	82

3. Insulation System: Manufacturer's standard Class B or Class F.
4. Motor capable of running dry continuously.
5. Enclosure:
    a. Hermetically sealed, watertight, for continuous submergence up to 65-foot depth.
    b. Listed to meet UL 674 and NFPA 70 requirements for Class I, Division 1, Group D hazardous atmosphere.
    c. Seals: Tandem mechanical.
6. Bearing and Lubrication:
    a. Permanently sealed and lubricated, replaceable antifriction guide and thrust bearings.
    b. Minimum 15,000 hours L-10 bearing life.

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7. Inrush kVA/horsepower no greater than NEMA MG 1 and NFPA 70, Code F.
8. Winding Thermal Protection:
   a. Thermal sensor and switch assembly, one each phase, embedded in stator windings and wired in series.
   b. Switches normally closed, open upon excessive winding temperature, and automatically reclose when temperature has cooled to safe operating level.
   c. Switch contacts rated 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. Winding thermal protection and moisture detection specified above may be monitored by single device providing two independent 120V ac contacts, one closing and one opening on malfunction.
11. 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. Vibration (balance).
5. 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 12-11.
3. Efficiency and power factor by Test Method F, IEEE 112, Forms F-1, F-2, and F-3.
4. 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 for motors larger than 50 hp.

B. Manufacturer's Certificate of Proper Installation.

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): C57.96, Guide for Loading Dry Type Transformers.
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. Underwriters Laboratories, Inc. (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.
5. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

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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 volt, 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. Provide dry-type transformers in accordance with this section, including transformers installed in other equipment specified in Section 26 32 13.13, Diesel Engine Generator Set. All dry-type transformers provided throughout the entire project shall be from the same manufacturer for standardization of parts and equipment.

B. UL 1561, NEMA ST 20, unless otherwise indicated.

C. Dry-type, self-cooled, two-winding, with copper windings.

D. Units larger than 5 kVA suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

E. Efficiency: Meet or exceed DOE 2016 efficiency requirements.

F. 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.

G. Overload capability: Short-term overload per IEEE C57.96.

H. Wall Bracket: For single-phase units, 15 kVA to 37-1/2 kVA, and for three-phase units, 15 kVA to 30 kVA.

I. Vibration Isolators:

1. Rated for transformer’s weight.
2. Isolation Efficiency: 99 percent, at fundamental frequency of sound emitted by transformer.

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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.

J. Manufacturers:

1. Square D Co.
2. Eaton/Cutler-Hammer.
3. General Electric.

2.02 MINI-POWER CENTER (06MPZ-1 AND 06MPZ-2)

A. General: Transformer, primary, and secondary main circuit breakers, and secondary panelboard section enclosed in NEMA 250, Type 3R, 316 stainless steel enclosure.

B. Transformer:

1. Insulation Class and Temperature Rise: Manufacturer's standard.
2. Efficiency: Manufacturer's standard (DOE 2016 efficiency).
3. Core and Coil: Encapsulated.
4. Full capacity, 5 percent voltage taps, two below normal voltage.
5. KVA Rating: 10KVA.
6. Primary Voltage: 480, single-phase.
7. Secondary Voltage: 240/120 volts, single-phase, three-wire.
8. Primary Main Breaker Rating: 40A.
9. Secondary Main Breaker Rating: 60A.

C. Panelboard: Full, UL 489, short-circuit current rated.

1. Type: Thermal-magnetic, quick-make, quick-break, indicating, with noninterchangeable molded case circuit breakers.
2. Number and Breaker Ampere Ratings: Refer to the Drawings for the Panel Schedule of each MPZ.

2.03 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.

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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: Four 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: 4.5 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.

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 23 00
LOW-VOLTAGE SWITCHGEAR

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): C37.50, Switchgear—Low-Voltage AC Power Circuit Breakers Used in Enclosures—Test Procedures.
2. Institute of Electrical and Electronics Engineers (IEEE):
   a. C37.13, Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures.
   b. C37.16, Standard for Preferred Ratings, Related Requirements, and Application Recommendation for Low-Voltage AC (635V and below) and DC (3200V and below) Power Circuit Breakers.
   c. C37.20.1, Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.
   d. C37.20.3, Standard for Metal Enclosed Interrupter Switchgear.
   e. C37.100, Standard Definitions for Power Switchgear.
3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. Underwriters Laboratories, Inc. (UL):
   a. 489, Standard for Safety for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
   b. 1558, Standard for Safety for Metal-Enclosed, Low-Voltage Power Circuit Breaker Switchgear.

1.02 SUBMITTALS

A. Action Submittals:

1. Descriptive product information.
2. Itemized Bill of Material.
3. Dimensional drawings.
4. Operational description.
5. Anchoring instructions and details.
6. One-line, three-line, and control schematic drawings.
7. Connection and interconnection drawings.
8. Ground Fault Protection: Relay time-current characteristics.

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9. Bus data.
10. Incoming line section equipment data.
11. Transformer section equipment data.
12. Conduit entrance locations.
13. 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. Manufacturer's installation instructions.
3. Factory Test Report.
4. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
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 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 Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

1.04 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage and deliver prior to 90 percent Project completion the following spare parts:

1. Power and Control Fuses: One complete set.
2. Indicating Lights: One complete set.
3. Paint: One pint, to match enclosure exterior finish in color and quality.

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PART 2 PRODUCTS

2.01 MANUFACTURERS

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

1. Caterpillar Switchgear.
2. Cummins.
3. Kohler.

2.02 GENERAL REQUIREMENTS

A. Service: 480 volts, three-phase, three-wire, having an available short circuit current at line terminals 65,000A rms symmetrical.

B. Designed and assembled in accordance with IEEE C37.20.3, IEEE C37.100, ANSI C37.50, and UL 1558.

C. Switchgear and its major components shall be end products of one manufacturer in order to achieve standardization for appearance, operation and maintenance, spare parts replacement, and manufacturer's services.

D. Operating Conditions:

1. Ambient Temperature: Maximum 40 degrees C.
2. Equipment shall be fully rated without derating for operating conditions.

E. Lifting lugs on equipment and devices weighing over 100 pounds.

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

2.03 STATIONARY STRUCTURE

A. Type: ANSI C37.50 switchgear construction, consisting of breaker, transition, and auxiliary sections assembled to form a rigid, self-supporting, metal enclosed structure.

B. Material: 11-gauge minimum cold-rolled steel, formed with reinforced steel members.

C. Grounded metal barriers between each breaker, main bus, branch cabling, and instrumentation/control.

D. Modular-designed steel frame with removable plates and individual, bolted, steel-framed vertical sections.

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E. Individual, hinged doors over each breaker, metering, and auxiliary compartments.

F. Cable Installation and Termination Compartments:

1. Rear hinged doors, capable of being bolted closed.
2. Cable bending space in accordance with NFPA 70.
3. Cable supports in each vertical section.

G. Breaker Compartments:

1. Individual, grounded compartments, with:
   a. Sheet steel, top, bottom, sides, and nonventilated compartment door with padlocking features.
   b. Flame-retardant, arc track-resistant nonmetallic rear barrier.
   c. Drawout rails, stationary breaker contacts, interlocks, and necessary control and indicating devices.
   d. Shutters over stationary contacts when breaker is in TEST or DISCONNECT position.
   e. Padlocking provision on rackout rails for locking breaker in TEST or DISCONNECT position.
2. Drawout Mechanism:
   a. Shall retain removable element in connected position.
   b. Mechanical interlocks to ensure breaker is open before moved from a position, or when between positions.
   c. Four Distinct Breaker Positions: CONNECTED, TEST, DISCONNECTED, and WITHDRAW.
   d. Indicators to display breaker position.
   e. Capable of being operated without opening breaker door.
3. Breaker frame grounded to steel frame throughout travel of drawout mechanism.
4. Each compartment designed for specific breaker frame size.
5. Future breaker compartments fully equipped with electrical connections, bolted metal barrier across compartment face, and compartment door.

H. Slide-Out Instrument Tray:

1. Mount above associated breaker.
2. Accessible from front of switchgear.
3. For control circuitry, breaker close and trip fuses, indicating lights.

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2.04 ENCLOSURE

A. Finish: Baked enamel applied over rust-inhibiting phosphated base coating.

1. Color:
   a. Exterior: Provide gray finish as approved by Engineer.
   b. Interior: White.
   c. Unpainted Parts: Plated for corrosion resistance.

B. Indoor Enclosure:

1. NEMA 250, Type 1, with formed edges on hinged and nonhinged panels.
2. Rear, full-height, bolt-on panels for each enclosure section.
3. Cable Termination Access: Padlock provision.

2.05 BUSWORK

A. Material: Phase silver-plated copper throughout entire length of sufficient cross section to limit temperature rise at rated current to 55 degrees C.

B. Bus Arrangement: A-B-C, left-to-right, top-to-bottom, and front-to-rear, as viewed from front.

C. Brace for short circuit currents 65,000 amperes rms symmetrical.

D. Main Horizontal Bus: Nontapered, continuous current rating 3,200A.

E. Ground Bus:

1. Material: Copper.
2. Rating: 800 amperes.
3. Bolted to each vertical section.
4. Ground lug for 4/0 copper conductor on each end of bus.
5. Bus Connections and Joints: Bolted, with Belleville washers.

F. Extend each bus entire length of switchgear with provision for extension to future units.

2.06 PROTECTIVE DEVICES

A. Power Air Circuit Breakers:

1. Main, Tie, and feeder breakers in accordance with IEEE C37.13 and IEEE C37.16.
2. Arrangement: Fully rated main and branch feeder circuit breakers.

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3. Three-pole electrically and mechanically trip-free with:
    a. Self-aligning primary and secondary contacts.
    b. Integral, solid state, over-current trip programmer.
    c. Arc quenchers.
    d. Closing Mechanism: Electric.
    e. Stored energy mechanism with maximum five-cycle closing.
    f. Solid state trip device.
4. Individually mounted, drawout breaker listed for 100 percent continuous ampere rating.
5. Frame Size: As shown on the Drawings.
6. Interrupting Rating: 65,000 amperes rms symmetrical at 480 volts.

B. Mechanical Operation:

1. Front mounted, spring charging handle.
2. Mechanical closing breaker handle.
3. Mechanical trip, escutcheon mounted, trip pushbutton handle.

C. Electrical Operation:

1. Motor or solenoid automatic charging, plus manual charging.
2. Electrically closing, escutcheon mounted pushbutton with mechanical closing upon loss of control power.
3. Electrical trip, escutcheon mounted, trip pushbutton.
4. Control Power Voltage: 120V ac.

D. Color-Coded Visual Indicators: Contacts OPEN and CLOSED, plus mechanism CHARGED and DISCHARGED.

E. Accessories:

1. Slow breaker closing handle for contact adjustments.
2. Breaker lifting hoist and travel rail on top of switchgear.
3. Auxiliary a/b contacts on main, tie, and feeder breakers.

F. Test Facilities:

1. Breakers with integral external test points for portable test kit.
2. Handheld test kit for functional testing of trip circuitry of each breaker.

G. Solid State Trip Units: Flux-shift trip and current sensors.

1. Protective Programmers:
    a. Self-powered, automatic rms sensing micro-electronic processor.
    b. No external relays or accessories.
    c. Printed circuit cards with gold-plated contacts.

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d. Programmable Controls:
   1) Fixed-point, with repetitive accuracy and precise unit settings.
   2) Trip adjustments made by nonremovable, discrete step switching.
e. Field-Installable Rating Plugs:
   1) Long-time pickup LED indicator and test receptacle.
   2) Matching load and cable requirements.
   3) Interlocked with tripping mechanism.
   4) Breaker to remain trip-free with plug removed.
   5) Keyed rating plugs to prevent incorrect application.
f. Long-time pickup light.
g. Selective coordination time/current curve shaping adjustable functions:
   1) Current setting.
   2) Long-time pickup.
   3) Long-time delay.
   4) Instantaneous pickup with short-time for main, tie, and feeders.
   5) Short-time delay for main, tie, and feeders with I2T function, and IN-OUT switch.
   6) Ground fault pickup.
   7) Ground fault delay with I2T function.
   8) High instantaneous pickup with short-time delay.
   9) Zone selective interlock.
h. Fixed, instantaneous pickup for main, tie, and feeders.
i. Fault Trip Indicators: Mechanical push-to-reset type for overload and short circuit overload trip.
j. Rejection Pins: For each programmer frame size.

2. Phase Current Sensors:
   a. Multi-ratio type.
   b. Fixed, mounted on breaker frame.
   c. Molded epoxy construction.
   d. One toroidal type for each phase.
3. Ground Fault Sensor:
   a. Neutral bar single-ratio CT mounted in cable compartment.
   b. Molded epoxy construction.
   c. Shorting bar.

2.07 CONTROL WIRING

A. NFPA 70, Type SIS, single-conductor, Class B, stranded copper, rated 600 volts for control, instrumentation, and power/current circuits.

B. Shielded cable rated 600 volts for transducer output and analog circuits.

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C. Enclosed in top and vertical steel wiring troughs, and front-to-rear in nonmetallic wiring troughs.

D. Conductor Lugs: Preinsulated, self-locking, spade type, with reinforced sleeves.

E. Identification: Individually, with permanent wire markers at each end.

F. Splices: Not permitted in switchgear wiring.

2.08 TERMINAL BLOCKS

A. Enclosed in steel wiring troughs.

B. Rated 600 volts, 30 amperes minimum, one-piece barrier type with strap screws.

C. Shorting type for current transformer leads.

D. Provide terminal blocks for:

1. Conductors connecting to circuits external to switchgear.
2. Internal circuits crossing shipping splits.
3. Equipment parts requiring replacement and maintenance.

E. Spare Terminals: Not less than 20 percent.

F. Group terminal blocks for external circuit wiring leads.

G. Maintain 6-inch minimum space between columns of terminal blocks.

H. Identification: Permanent, for each terminal and columns of terminals blocks.

I. Manufacturer: General Electric; Type EB-5.

2.09 TEST FACILITIES

A. Breakers with integral external test points for portable test kit.

B. Handheld test kit for functional testing of trip circuitry of each breaker.

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2.10 POWER METERS

A. Bus A and Bus C of the low voltage switchgear shall each be provided with a digital power meter. The power meter provided shall meet the following requirements:

1. Operates on 120V and shall include an Ethernet gateway for future integration into the plant control system. Any switches required to enable the front display of the power meter to be in operation concurrently with the remote interface shall be included with the meter.
2. Digital power meter shall be capable of displaying the following parameters:
    a. Voltage.
    b. Current.
    c. Frequency.
    d. Real Power.
    e. Apparent Power.
    f. Power Factor.
    g. Current and voltage harmonic distortion.
    h. Individual harmonics.
    i. Data logging.
3. Digital power meter shall be model PM8000 as manufactured by Square D, or equal.

2.11 MIMIC BUS

A. One-line displaying bus arrangement, circuit protective devices, and branch circuit extensions.

B. Breaker status indicating lights: Push-to-test type; red for breaker closed and green for breaker open.

C. Strips: Self-sticking plastic tape, applied to face of switchgear.

D. Nameplates to identify incoming lines, protective devices, and feeder circuits.

2.12 EQUIPMENT IDENTIFICATION

A. Master Nameplate:

1. Deep-etched aluminum with manufacturer’s name and model number.
2. Riveted to main vertical section.

B. Section Identification:

1. Stamped metallic, riveted to each vertical section.

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2. Serial number, bus rating, and section reference number.
3. Size: Manufacturer's standard.

C. Nameplate:

1. Engraved, acrylic for each circuit breaker cubicle and door-mounted device.
2. Black with white block type characters.
3. Character Height: 3/16-inch.
4. Size: Manufacturer's standard as required for three lines, with 15 characters per each line.
5. Inscriptions: As shown on one-line diagram.
6. Blank plates for future spaces.
7. Attachment Screws: Stainless steel panhead.

D. Cubicle Labels:

1. Nonmetallic, applied inside each cubicle compartment.
2. Device serial number, rating, and description.
3. Size: As required.

E. Metering Instruments: Meter type identified on meter face below pointer or dial.

F. Control Switches: Deep-etched, aluminum escutcheon plate.

G. Relays and Devices:

1. Stamped metallic, riveted to instrument case.
2. Manufacturer's name, model number, relay type, and rating data.

H. Switchgear Signs:

1. Two signs each on front and back of switchgear.
2. Size: Manufacturer's standard.
3. Engraved, acrylic.
4. Color: Red with white.
5. Inscription: DANGER/HIGH VOLTAGE/KEEP OUT.
6. Characters: Gothic type, 2 inches high.
7. Attachment: Four rivets each sign.

2.13 FACTORY TESTING

A. In accordance with IEEE C37.20.1.

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PART 3 EXECUTION

3.01 INSTALLATION

A. Install equipment in accordance with manufacturer's instructions and recommendations.

B. Secure equipment to mounting pads with anchor bolts.

C. Install equipment plumb and in longitudinal alignment with pad or wall.

D. Coordinate terminal connections with installation of secondary feeders.

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 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.
4. 1 person-day for plant startup.
5. 1 person-day for post-startup training.

B. Furnish startup services and training of Owner's personnel at such times as requested by Owner.

C. Provide Manufacturer's Certificate of Proper Installation in accordance with Section 01 43 33, Manufacturers' Services.

3.03 SUPPLEMENTS

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

1. Supplement 1, Switchgear 20LVSG-1 – Preliminary Layout Drawings.

END OF SECTION

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DIMENSIONS – INCHES
[mm]

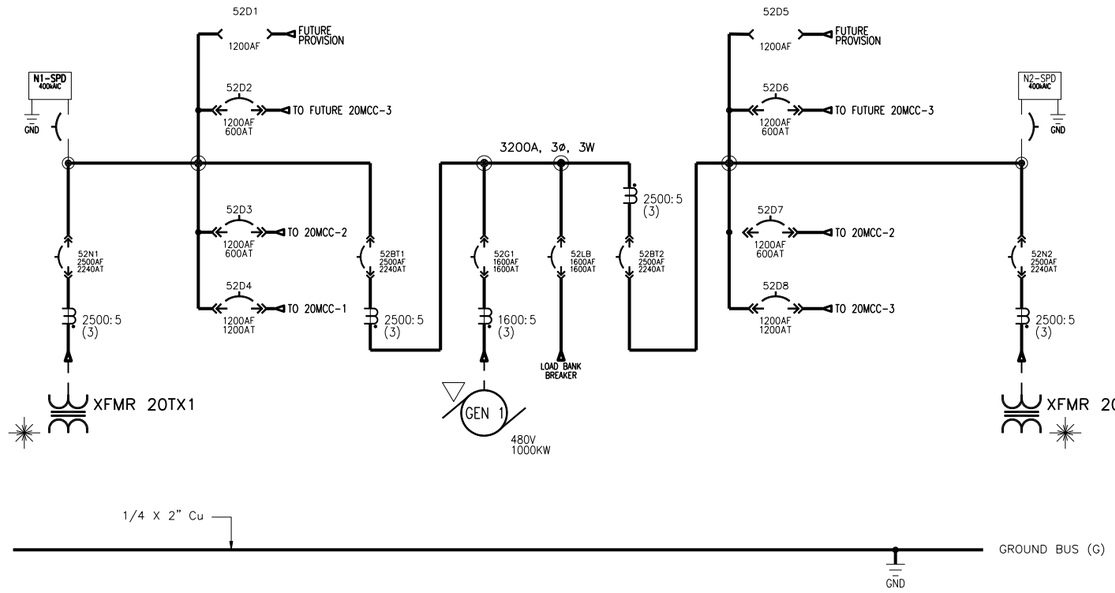
ESTIMATED SHIPPING WEIGHTS:

SECT 1 – 2,345 LBS.
SECT 2 – 3,000 LBS.
SECT 3 – 1,545 LBS.
SECT 4 – 1,545 LBS.
SECT 5 – 1,545 LBS.
SECT 6 – 1,545 LBS.
SECT 7 – 3,000 LBS.
SECT 8 – 2,345 LBS.

ESTIMATED SHIPPING SPLIT WEIGHTS:
SS SECT'S 1–2 – 5,345 LBS.
SS SECT'S 3–4 – 3,090 LBS.
SS SECT'S 5–6 – 3,090 LBS.
SS SECT'S 7–8 – 5,345 LBS.

✳ SUPPLIED BY OTHERS

▽ SUPPLIED BY DEALER



FRONT ELEVATION
20LVSG–1

NOTE: 1) EACH SOURCE BREAKER IS INSTALLED IN A "SERVICE ENTRANCE RATED" STRUCTURE WITH A "REMOVABLE MAIN BONDING JUMPER" INSTALLED. THE INSTALLING ELECTRICAL CONTACTOR IS RESPONSIBLE FOR THE INSTALLATION OR REMOVAL OF THE "MAIN BONDING JUMPER(S)" IN COMPLIANCE WITH NFPA 70 NATIONAL ELECTRICAL CODE ARTICLE 250 OR AS APPROVED BY THE LOCAL AUTHORITY HAVING JURISDICTION (AHJ).

CATERPILLAR SWITCHGEAR AMERICA'S, LLC
PROPOSAL RELEASE
CERTIFIED ENGINEERING DRAWING

CATERPILLAR®

PRODUCTION ENGINEER: TBD
APPLICATIONS ENGINEER: TBD

TITLE:
WILLIAMS WTP
FRONT ELEVATION AND ONE-LINE (SWGR – 20LVSG-1)
480/277V UTILITY / GENERATOR PARALLELING SWITCHGEAR

NO.	REVISION	DATE
A	ISSUED FOR PROPOSAL	MM-DD-YR
B	RE-ISSUED FOR PROPOSAL	MM-DD-YR

REV LEVEL: B
DESIGNER: P.Simoneschi
DATE CREATED: 01/05/2021
MODIFIED BY: R.MIRYALA
MODIFIED DATE: 01/22/2021
SHEET NUMBER: 1 OF 8
SCALE: N.T.S.
APPROVED BY: Engineer
APPROVED DATE: MM-DD-YR
FILE NAME: P01
P01

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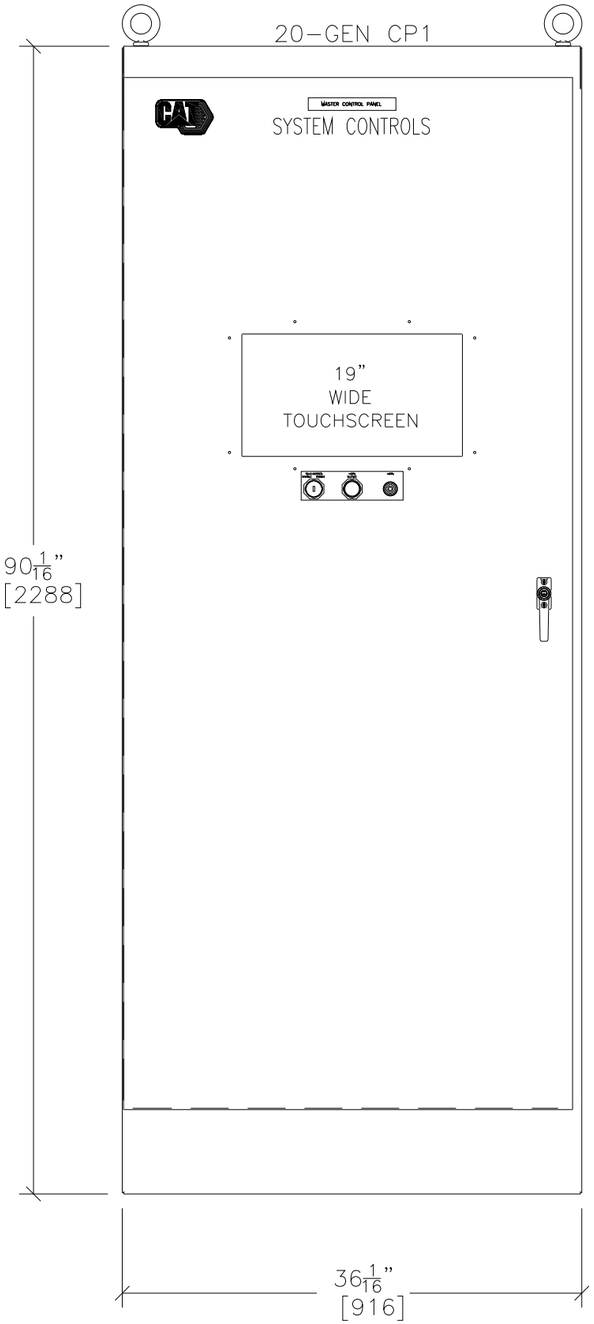
DIMENSIONS – INCHES
[mm]

ESTIMATED SHIPPING WEIGHTS:

SECT CP1 – 850 LBS.



FRONT ELEVATION

CATERPILLAR SWITCHGEAR AMERICAS, LLC
CERTIFIED ENGINEERING OPTIONAL
PROPOSAL RELEASE

CATERPILLAR®

PRODUCTION ENGINEER: TBD
APPLICATIONS ENGINEER: TBD

TITLE:
WILLIAMS WTP
FRONT ELEVATION (CONTROL PANELS)
480/277V UTILITY / GENERATOR PARALLELING SWITCHGEAR

DESIGNER:	MODIFIED BY:
P.Simoneschi	R.MIRYALA
DATE CREATED:	MODIFIED DATE:
01/05/2021	01/05/2021
SHEET NUMBER: 2 OF 8	

SCALE: N.T.S.
REV LEVEL: B
P02

APPROVED BY: Engineer
APPROVED DATE: MM–DD–YR
FILE NAME: P02

NO.	REVISION	DATE
A	ISSUED FOR PROPOSAL	MM–DD–YR
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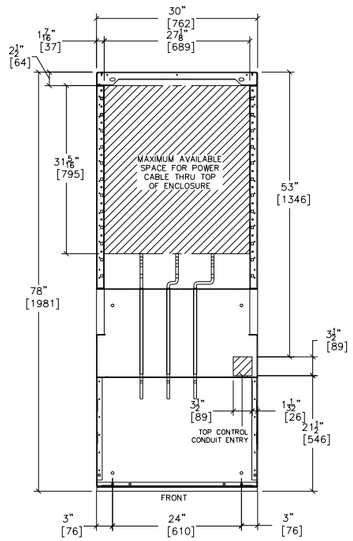
DIMENSIONS – INCHES [mm]

36.00 INCHES (914.4 mm) IS THE RECOMMENDED FRONT CLEARANCE FOR BREAKER REMOVAL WITH TOP-OF-SWITCHGEAR-MOUNTED BREAKER LIFTER. IF A PORTABLE BREAKER LIFTER IS TO BE USED, ALLOW AT LEAST 84.00 INCHES (2133.6 mm) OF AISLE SPACE.

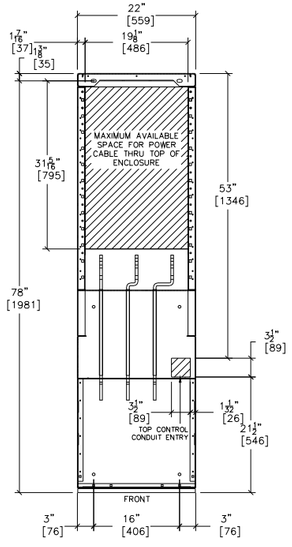
IF USING HINGED REAR DOORS ADD 1.25 INCHES (31.8 mm).

STUB CONDUIT 2.00 INCHES (50.8 mm) MAXIMUM IN POWER CABLE AREA, 1-INCH (25.4 mm) MAXIMUM IN CONTROL CONDUIT AREA.

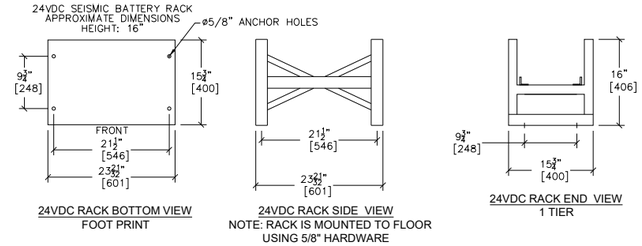
⊗ CENTER OF GRAVITY



SECTs 1,2,6,7
TOP VIEW
TOP CONDUIT ENTRY



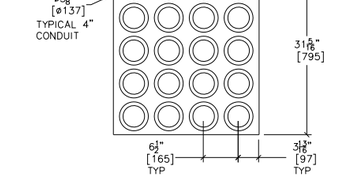
SECTs 3-5
TOP VIEW
TOP CONDUIT ENTRY

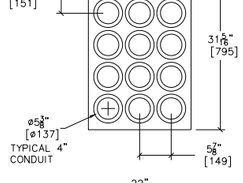


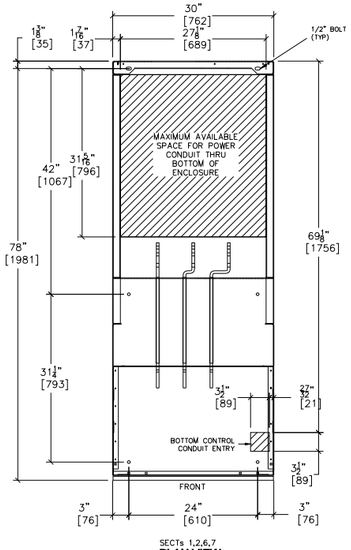
24VDC RACK BOTTOM VIEW
FOOT PRINT

24VDC RACK SIDE VIEW
NOTE: RACK IS MOUNTED TO FLOOR USING 5/8" HARDWARE

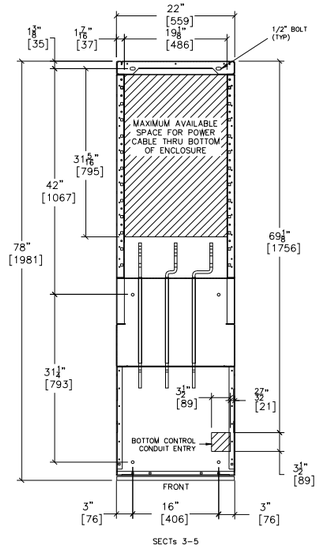
24VDC RACK END VIEW
1 TIER



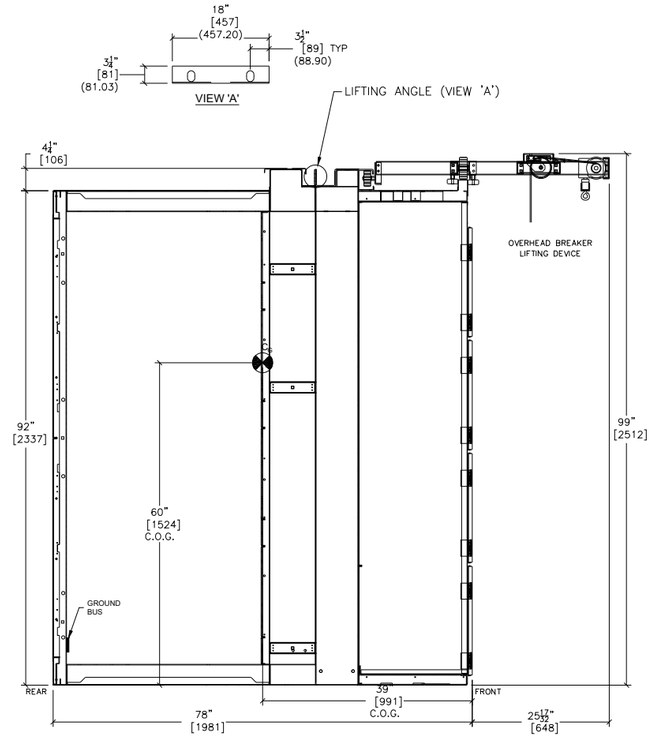




SECTs 1,2,6,7
PLAN VIEW
BOTTOM CONDUIT ENTRY



SECTs 3-5
PLAN VIEW
BOTTOM CONDUIT ENTRY



SIDE VIEW
TYPICAL FOR:
SECTs 1-7

CATERPILLAR SWITCHGEAR AMERICA'S, LLC
CERTIFIED ENGINEERING DRAWING
PROPOSAL RELEASE

CATERPILLAR®

PRODUCTION ENGINEER: TBD
APPLICATIONS ENGINEER: TBD

TITLE:
WILLIAMS WTP
CONDUIT ENTRY, SIDE VIEW, AND BATTERY RACK
480/277V UTILITY / GENERATOR PARALLELING SWITCHGEAR

DESIGNER:	P.Simoneschi
DATE CREATED:	01/05/2021
REV LEVEL:	B
MODIFIED BY:	R.MIRYALA
MODIFIED DATE:	01/05/2021
SCALE:	N.T.S.
SHEET NUMBER:	3 OF 8
APPROVED BY:	Engineer
APPROVED DATE:	MM-DD-YR
FILE NAME:	P03

P03

NO.	REVISION	DATE
A	ISSUED FOR PROPOSAL	MM-DD-YR
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CABINET TO PANEL GROUND DETAIL

CONTROL PANEL GROUNDING NOTES:

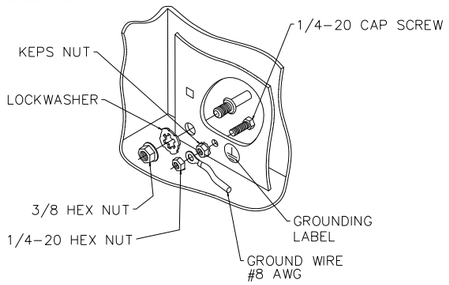
1. INSERT THE ¼–20x7/8 BOLT THROUGH THE HOLE IN THE PANEL AS SHOWN

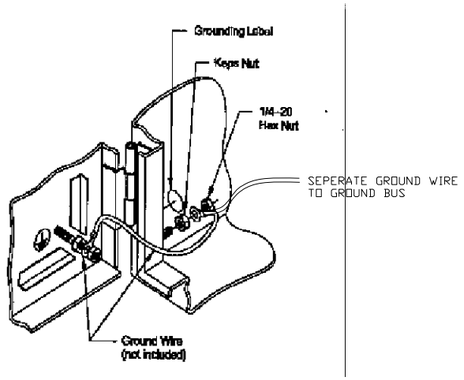
2. SECURE BOLT WITH KEPS NUT. THE KEPS NUTS MUST PENETRATE INTO THE PAINT TO INSURE ELECTRICAL CONTINUITY

3. ATTACH THE GROUND WIRE AND SECURE WITH ¼–20 HEX NUT AS SHOWN

4. INSTALL THE LOCKWASHER UNDER ONE OF THE NUTS SECURING THE PANEL TO INSURE GROUNDING BETWEEN THE PANEL AND THE ENCLOSURE.

5. ATTACH GROUNDING LABEL INCLUDED ADJACENT TO THE BOLT AS SHOWN.

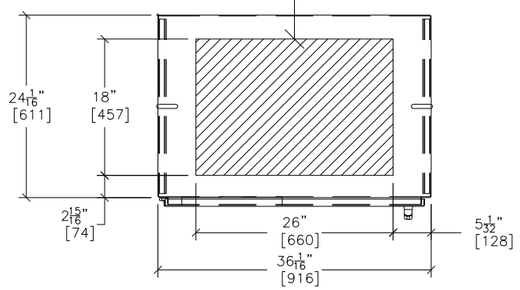




APPROXIMATE CENTER OF GRAVITY

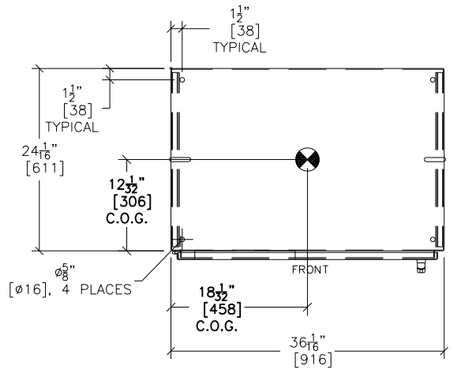
DIMENSIONS – INCHES [mm]

MAXIMUM AVAILABLE SPACE FOR CUSTOMER SECONDARY CONNECTION THRU BOTTOM OR TOP ENTRY (SEE HUB INSTALLATION GUIDE PROVIDED BY HOFFMAN)



TYPICAL FOR:
CP1

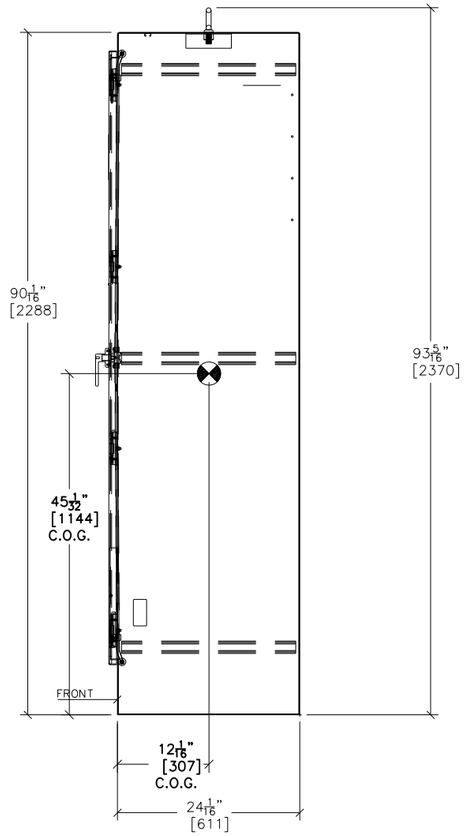
TOP VIEW
BOTTOM OR TOP AVAILABLE CONDUIT ENTRY SPACE



TYPICAL FOR:
CP1

ANCHOR PLAN

NOTE: LIFTING EYES CAN BE REMOVED AND MOUNTING HOLES USED TO ADD BRACE TO TOP OF CABINET AND WALL.



TYPICAL FOR:
CP1

SIDE VIEW

CATERPILLAR SWITCHGEAR AMERICAS, LLC
CERTIFIED ENGINEERING DOCUMENT
PROPOSAL RELEASE

CATERPILLAR®

PRODUCTION ENGINEER: TBD
APPLICATIONS ENGINEER: TBD

TITLE:
WILLIAMS WTP
TOP VIEW AND SIDE VIEW (CONTROL PANELS)
480/277V UTILITY / GENERATOR PARALLELING SWITCHGEAR

DESIGNER: P.Simoneschi	MODIFIED BY: R.MIRYALA
DATE CREATED: 01/05/2021	MODIFIED DATE: 01/05/2021
SHEET NUMBER: 4 OF 8	
SCALE: N.T.S.	REV LEVEL: B
APPROVED BY: Engineer	
APPROVED DATE: MM-DD-YR	
FILE NAME: P04	P04

NO.	REVISION	DATE
A	ISSUED FOR PROPOSAL	MM-DD-YR
B	RE-ISSUED FOR PROPOSAL	MM-DD-YR

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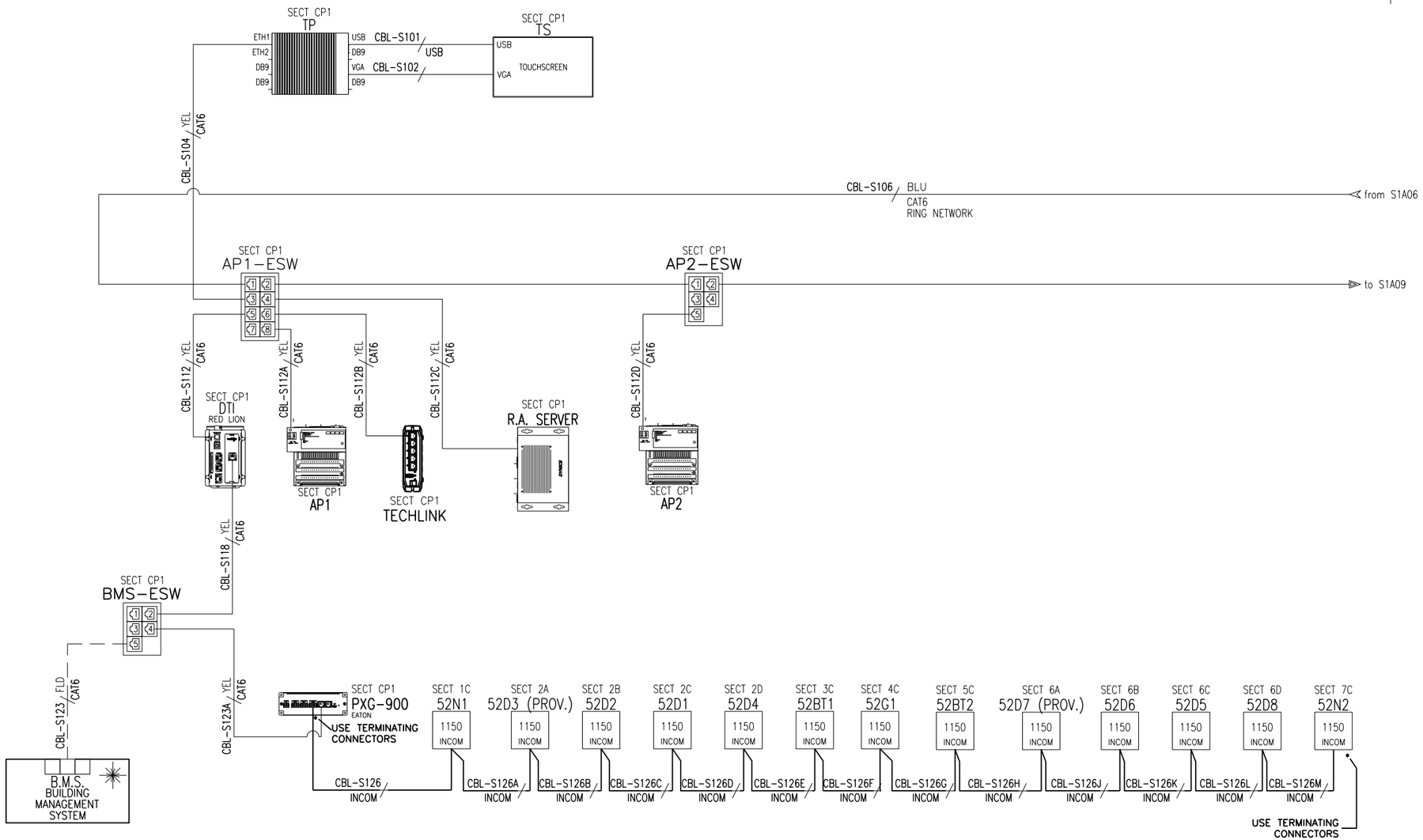
SUPPLIED BY OTHERS



NOTE: DETAILED WIRING, TERMINATION POINTS, AND IP ADDRESSES ARE PROVIDED IN THE WIRING DRAWINGS.

PROPOSAL RELEASE

CATERPILLAR SWITCHGEAR AMERICAS, LLC CERTIFIED ENGINEERING DOCUMENT

CATERPILLAR®

PRODUCTION ENGINEER: TBD
APPLICATIONS ENGINEER: TBD

TITLE:
WILLIAMS WTP
AUTOMATION COMMUNICATIONS PLAN
480/277V UTILITY / GENERATOR PARALLELING SWITCHGEAR

REV LEVEL:	DESIGNER:	MODIFIED BY:
B	P.Simoneschi	R.MIRYALA
SCALE:	DATE CREATED:	MODIFIED DATE:
N.T.S.	01/05/2021	01/05/2021
APPROVED BY:	SHEET NUMBER:	
Engineer	5 OF 8	
APPROVED DATE:		
MM-DD-YR		
FILE NAME:	P05	

P05

NO.	REVISION	DATE
A	ISSUED FOR PROPOSAL	MM-DD-YR
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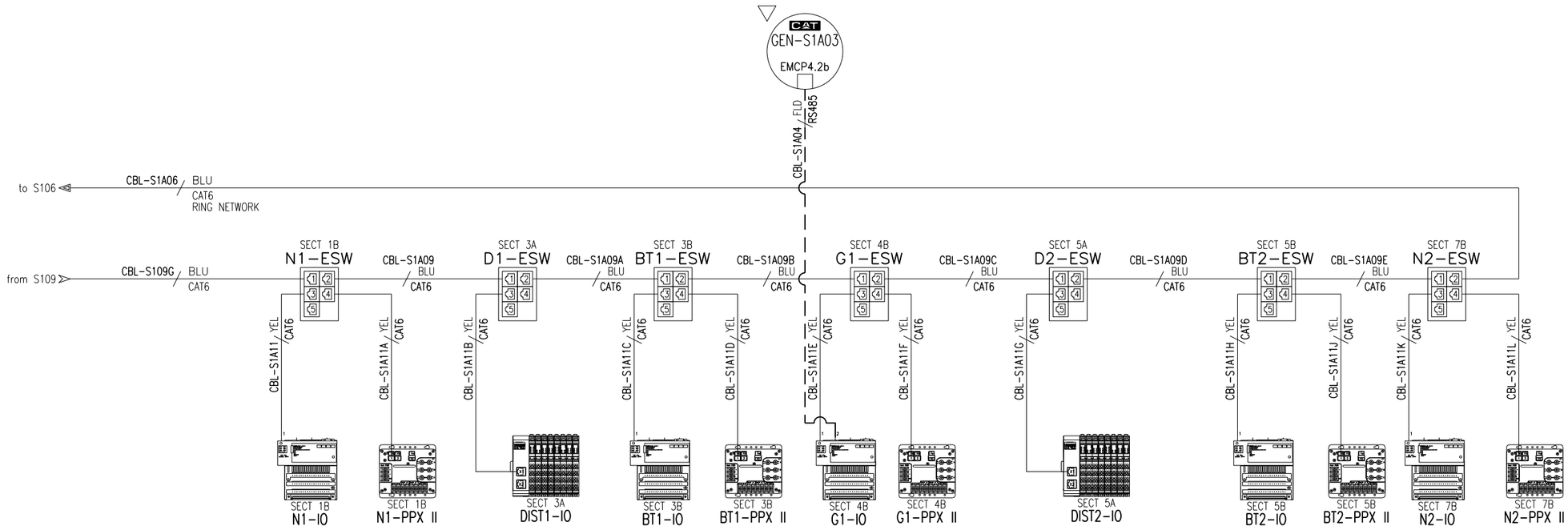
S1A38

SUPPLIED BY DEALER



NOTE: DETAILED WIRING, TERMINATION POINTS, AND IP ADDRESSES ARE PROVIDED IN THE WIRING DRAWINGS.

NO.	REVISION	DATE
A	ISSUED FOR PROPOSAL	MM-DD-YR
B	RE-ISSUED FOR PROPOSAL	MM-DD-YR

PROPOSAL RELEASE
CERTIFIED ENGINEERING DOCUMENT
CATERPILLAR SWITCHGEAR AMERICAS, LLC

CATERPILLAR®

PRODUCTION ENGINEER: TBD
APPLICATIONS ENGINEER: TBD

TITLE:
WILLIAMS WTP
AUTOMATION COMMUNICATIONS PLAN
480/277V UTILITY / GENERATOR PARALLELING SWITCHGEAR

SCALE:	N.T.S.
REV LEVEL:	B
DESIGNER:	P.Simoneschi
MODIFIED BY:	R.MIRYALA
DATE CREATED:	01/05/2021
MODIFIED DATE:	01/05/2021
SHEET NUMBER:	6 OF 8
APPROVED BY:	Engineer
APPROVED DATE:	MM-DD-YR
FILE NAME:	P06

P06

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CONTROL CIRCUIT CONDUIT SCHEDULE (SEE NOTE 1)

CONDUIT			CONDUCTOR		CONDUIT	
NO.	FROM	TO	QTY-SIZE	FUNCTION	SIZE	TABLE
1	GEN 1	SECT 4	1 - 2 COND. #16 SHIELDED TWISTED PAIR, BELDEN 8719 OR EQUIVALENT	GEN 1 EMCP 4.3 (DATA LINK)	NOTE 4 & 5	TYPE D, NOTE 6
			1 - 3 COND. #16 SHIELDED TWISTED TRIPLET, BELDEN 8618 OR EQUIVALENT	GEN 1 ADEM III (SPEED BRICK)		
			1 - 2 COND. #16 SHIELDED TWISTED PAIR, BELDEN 8719 OR EQUIVALENT	GEN 1 CDVR (ANALOG VOLTAGE CONTROL)		
			3 - #14 AWG	GEN 1 CDVR (MANUAL VOLTAGE CONTROL)	NOTE 4 & 5	TYPE A
			4 - #10 AWG	24VDC POWER		
			18 - #14 AWG	GEN 1 DISCRETE		
2	EMERGENCY POWER PANEL	SECT CP1	3 - #10 AWG	120VAC FOR 24V DC BATTERY CHARGER (1Ø, 20A)	NOTE 5	TYPE C
3	24V DC STATION BATTERIES	SECT CP1	4 - #10 AWG	24V DC POWER	NOTE 5	TYPE A
4	BUILDING MANAGEMENT SYSTEM	SECT CP1	1 - CAT 6++ BELDEN 3632/3633	DATA TABLE INTERFACE	NOTE 5	TYPE D
5	20LVSG-1	SECT CP1	4 - #10 AWG	24V DC POWER	NOTE 5	TYPE A
6	20LVSG-1	SECT CP1	1 - CAT 6++ BELDEN 3632/3633	NETWORK COMMUNICATIONS INTERFACE	NOTE 5	TYPE D

NOT FOR CONSTRUCTION

NOTES:

1) ELECTRICAL CONTRACTOR RESPONSIBLE FOR ADHERENCE TO ALL APPLICABLE STANDARDS AND CODES.
2) ELECTRICAL CONTRACTOR MAY MODIFY ROUTING AND COMBINE CONDUITS OF THE SAME TYPE.
3) ELECTRICAL CONTRACTOR TO TERMINATE FIELD WIRING AT BOTH ENDS.
4) CONDUIT TYPES A AND D MAY BE COMBINED.
5) CONDUIT TO BE SIZED BY INSTALLER.
6) SEPARATE METALLIC CONDUIT MUST BE USED FOR EACH WIRE TYPE (A, B, C, & D). WIRE TYPES A & D MAY BE COMBINED IN THE SAME METALLIC CONDUIT.
7) SPARES TO BE LEFT 10' LONG, COILED AND TAPED IN BOTTOM OF ENCLOSURE.
8) ELECTRICAL CONTRACTOR TO PROVIDE 20% SPARES.
9) ALL CONTROL WIRING TO BE STRANDED 90°C COPPER UNLESS SPECIFIED OTHERWISE.
10) ATS CONDUIT AND CONDUCTOR ARE REPRESENTATIVE OF ONE (1) ATS. NUMBER OF CONDUITS DEPENDENT ON NUMBER OF ATS.
11) ALL WIRING TO BE 600V INSULATED.
12) DETAILED FIELD INTERCONNECT POINTS ARE PROVIDED IN THE FIELD INTERCONNECT (F) DRAWINGS.
13) PER NEC THIS MUST BE A DEDICATED CONDUIT AND CANNOT BE COMBINED WITH OTHER WIRING.

CONDUIT TABLE	
A	DC CONTROL <= 30V
B	DC CONTROL > 30V
C	AC CONTROL
D	SIGNAL LEVEL
E	FIBER OPTIC

CATERPILLAR SWITCHGEAR AMERICAS, LLC
PROPOSAL RELEASE
CERTIFIED ENGINEERING DRAWING

CATERPILLAR®

PRODUCTION ENGINEER: TBD
APPLICATIONS ENGINEER: TBD

TITLE:
WILLIAMS WTP
CONTROL CONDUIT SCHEDULE
480/277V UTILITY / GENERATOR PARALLELING SWITCHGEAR

NO.	REVISION	DATE
A	ISSUED FOR PROPOSAL	MM-DD-YR
B	RE-ISSUED FOR PROPOSAL	MM-DD-YR

DESIGNER: P.Simoneschi
DATE CREATED: 01/05/2021
MODIFIED BY: R.MIRYALA
MODIFIED DATE: 01/22/2021
REV LEVEL: B
SCALE: N.T.S.
SHEET NUMBER: 7 OF 8
APPROVED BY: Engineer
APPROVED DATE: MM-DD-YR
FILE NAME: P07
P07

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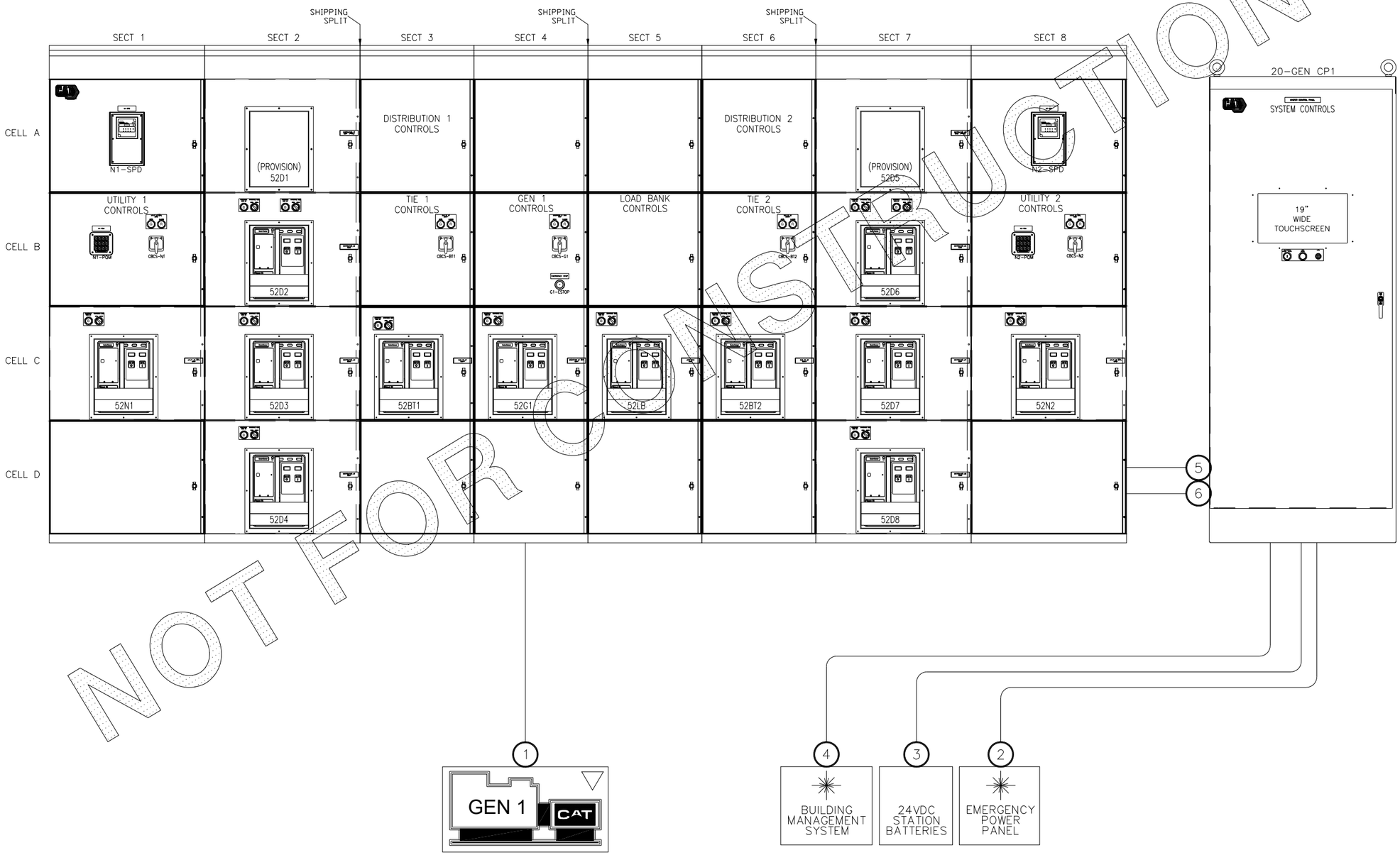
NOTES:
- SEE CONDUIT SCHEDULE (P07) FOR CONDUCTOR REQUIREMENTS.

✳ SUPPLIED BY OTHERS

▽ SUPPLIED BY DEALER



NOT FOR CONSTRUCTION

CATERPILLAR SWITCHGEAR AMERICAS, LLC
CERTIFIED ENGINEERING DOCUMENT
PROPOSAL RELEASE

CATERPILLAR®

PRODUCTION ENGINEER: TBD
APPLICATIONS ENGINEER: TBD

TITLE:
WILLIAMS WTP
CONTROL CONDUIT SCHEDULE - ELEVATION
480/277V UTILITY / GENERATOR PARALLELING SWITCHGEAR

DESIGNER:	P.Simoneschi
DATE CREATED:	01/05/2021
MODIFIED BY:	R.MIRYALA
MODIFIED DATE:	01/22/2021
SHEET NUMBER:	8 OF 8
SCALE:	N.T.S.
REV LEVEL:	B
APPROVED BY:	Engineer
APPROVED DATE:	MM-DD-YR
FILE NAME:	P08
	P08

NO.	REVISION	DATE
A	ISSUED FOR PROPOSAL	MM-DD-YR
B	RE-ISSUED FOR PROPOSAL	MM-DD-YR

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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. Underwriters Laboratories, Inc. (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.
   c. Space for future protective devices.

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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.

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.

1.04 EXTRA MATERIALS

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

Item	Quantity
Touch-up paint for panelboards	One half-pint container

PART 2 PRODUCTS

2.01 MANUFACTURERS

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

1. Square D Co.
2. Eaton/Cutler-Hammer.
3. Siemens.

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 low voltage panelboards for application at 600V or less in accordance with this section, including panelboards installed in other equipment specified in Section 26 32 13.13, Diesel Engine Generator Set and Control Panel. All panelboards located within the generator enclosure shall be provided by the same manufacturer as all other panelboards provided as part of this Project.

B. Provide equipment in accordance with NEMA PB 1, NFPA 70, and UL 67.

C. 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.

D. 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.

E. Short Circuit Current Rating (SCCR): Integrated equipment short circuit rating for each panelboard assembly shall be no less than the following:

1. Minimum SCCR at 208Y/120 or 120/240 volts shall be 22,000 amperes rms symmetrical.
2. Minimum SCCR at 480Y/277 volts shall be 65,000 amperes rms symmetrical.

F. Series-Connected Short Circuit Current Ratings: Panelboards shall be fully rated; application of series-connected device ratings is unacceptable.

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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.

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. 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 all 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.

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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.

E. Specialty Breakers: Where indicated, provide breakers with the following features:

1. 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.

F. 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).

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.

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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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: 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, grounding electrode, etc.
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.
3. Termination Points: Bolted crimp compression lugs for conductors 6 AWG and larger.
4. Oversize Neutral: Provide oversized neutral terminal bus as indicated.

D. Provision for Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances for future protective device ampere ratings indicated.

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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.

H. Provide typewritten circuit directory for each panelboard.

I. In addition to conduit or nipples otherwise required for feeder and branch circuit wiring between multi-section panelboard sections, provide nipples for branch circuits two trade sizes larger than required for installed branch circuit wires or an empty 2-inch nipple, or a 1-1/4-inch trade size conduit if tubs are more than 24 inches apart.

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. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.
9. Anchoring instructions and details.
10. Anchoring instructions and details.
11. Typed Tabulation:
    a. Motor name; tag (equipment) numbers as shown on 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.
16. Interconnection 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.

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1.04 QUALITY ASSURANCE

A. Provide products manufactured within scope of UL that conform to UL Standards and have applied UL Listing Mark.

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.
2. Eaton Electrical/Cutler-Hammer.
3. Siemens.

2.02 GENERAL

A. Like Items of Equipment: End product of one manufacturer and same manufacturer as low voltage 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, sized seismically by a licensed structural engineer registered in the State where equipment is to reside, and as specified in Section 05 50 00, Metal Fabrications.

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H. Seismic Zone and Importance Factor: As specified in Section 01 61 00, Common Product Requirements.

I. Operating Conditions:

1. Ambient Temperature: Maximum 40 degrees C
2. Altitude: 1,000 feet above sea level.
3. Equipment to be fully rated.

J. Enclosures: In accordance with NEMA 250.

K. Equipment Finish:

1. Electrocoating process applied over rust-inhibiting phosphated base coating.
2. Exterior Color: 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: As shown on the Drawings.
3. Short Circuit Rating: 65,000 amperes rms symmetrical at 480 volts for entire motor control center as a complete assembly.
4. Main and branch circuit breakers, controllers, wire connections, and other devices to be front mounted and accessible, unless otherwise noted.
5. NEMA ICS 18, Part 3.
   a. Class: II.
   b. Type: B.

B. Enclosure:

1. Type: NEMA 250 Type 1, indoor.
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. However, the depth of any part of the equipment cannot exceed the dimensions as shown on the Drawings. Additionally, the overall length of each motor control center also cannot exceed the overall length of the equipment as shown on the Drawings.
   c. Do not exceed space shown.

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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.
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.
   c. Provide separate low level signal/network raceway in wireway.
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: Main leads enter from bottom for 20MCC-1, 20MCC-2, and 50MCC-1. Control and feeder circuits enter from top and bottom.

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 300 amperes minimum, but shall be sized based on the specific loads that are connected to the vertical bus.
   b. Tin-plated at joints.
   c. Provide Belleville washers on bus connection bolts.

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3. Neutral Bus: None.
4. Ground Bus:
   a. Copper, tin-plated, rated a minimum of 600 amperes, entire width of control center and in each vertical wireway.
   b. Provide Belleville washers on bus connection bolts.
5. Bus Bracing: 65,000 amperes rms symmetrical.

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 2#14 AWG wires minimum.
3. 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: Circuit breaker.
   e. Combination Full Voltage, Magnetic Starter:
      1) Control: As shown on Drawings.
   f. Combination Reversing, Magnetic Starter:
      1) Control: As shown on Drawings.
      2) Suitable for squirrel cage motors.
   g. Communications: As shown on the Drawings.
   h. Padlockable operating handle when de-energized with up to three-lock capability.
   i. Unit door interlocked to prevent opening when disconnect is in closed position.
   j. Mechanical interlocked to prevent placing disconnect in ON position when unit door is open.
   k. Minimum Dimensions: 12 inches high by full section width, less vertical wireway.
4. Disconnecting Device:
   a. As indicated.
   b. Padlockable in OPEN position for up to three locks.

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5. 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.
    d. Tripping indicated by operating-handle position.
    e. Interrupting capacity required for connection to system with short-circuit capacity indicated.
    f. Shunt trip for ground fault protection.
6. Solid State Motor Overload Protection:
    a. Inverse-time-limit characteristic.
    b. Phase loss, phase unbalance and Class II ground fault protection.
    c. Current operated electronic circuitry with adjustable trip.
    d. Class 10/20/30 relay trip, switch selectable.
    e. One N.O. auxiliary contact for remote monitoring.
    f. Manual reset.
    g. Provide in each ungrounded phase.
    h. Mount within starter unit.
    i. Communications: As shown on the Drawings.
7. Motor Thermal Protector Interface: Manual-reset interposing relay for connection to motor-mounted thermal protector system.
8. 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.

F. Incoming Line Terminal:

1. Construction: As specified in Paragraph, Motor Controller Unit.
2. Incoming Service Feeder: Cable at the bottom of the equipment.
3. Mechanical type CU-/AL lugs for 75 degrees C cable.

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G. Main Protective Device and Feeder Unit:

1. Construction: As specified in Paragraph Motor Controller Unit.
2. Incoming Service Feeder: Cable.
3. Instantaneous Trip Mode Selector Switch: Provide switch on main circuit breaker for bypassing long and short time trip settings, and lowered instantaneous trip settings for incident energy reduction during maintenance. In addition, provide the following:
   a. Mode Status Light.
   b. Output contact, rated 5A at 120V ac, for remote Mode status to Plant Control System.
4. Solid State Trip Circuit Breaker:
   a. In accordance with UL 489.
   b. Main protective device where shown on the Drawings.
   c. Insulated or molded case breakers with ambient insensitive solid-state trips and having current sensors and logic circuits integral in breaker frame.
   d. 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.
   e. Setting adjustments to be covered by a sealable, tamper-proof, transparent cover (insulated case breakers only) or by compartment door for other breakers).
   f. 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.
5. 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.
6. Key Interlocking:
   a. Mechanical lock cylinders within main and tie breaker compartments as shown.
   b. Key and Lock Cylinder Type: Kirk.
   c. Keys to be captive when breakers are closed.
   d. Two main and one tie breaker arrangements as shown on the Drawings.

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H. Key Interlocks:

1. Two Main and One Tie Breaker Arrangement:
   a. Two keys available for each group of three locks.
   b. Two out of three breakers closed at any time.

I. SPD: As specified in Section 26 43 00, Surge Protection Devices.

J. 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.

K. Nameplates:

1. Laminated plastic; white, engraved to black core.
2. Provide for each motor control center and each unit.
3. Engrave with inscription shown on single-line diagram.
4. Provide blank nameplates on spaces for future units.
5. Attach with stainless steel panhead screws on face of control center.

L. Space Heaters: Thermostatically controlled. Locate in bottom of each vertical section for operation from 120-volt power source derived external from the motor control center. The heaters will not be energized when the equipment is installed in the final location as shown on the Drawings. The heaters are only being provided in the event that the equipment will be temporarily be stored by the Contractor before it is installed in the locations shown on the Drawings.

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.

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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.

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 seismic 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.

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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.
   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. Trip Class: Standard, Class 20.

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 Job Site or classroom as designated by Owner, for minimum person-days listed below, travel time excluded:

1. 2 person-days for installation assistance, and inspection of installation.
2. 2 person-days for functional and performance testing.
3. 2 person-days for plant startup.
4. 2 person-days 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. Capable of controlling 100 percent tungsten filament and fluorescent lamp loads.
5. Rating: 20 amps, 120/277 volts.
6. Automatic grounding clip and integral grounding terminal on mounting strap.
7. Special Features: Provide the following features in comparable devices where indicated: Three-way and four-way.
8. Manufacturers and Products, Industrial Grade:
   a. Cooper Arrow Hart; AH1220 Series.
   b. Bryant; 4901 Series.
   c. Hubbell; 1221 Series.
   d. Leviton; 1221 Series.

B. Switch, Motor Rated:

1. Type: Two-pole or three-pole, manual motor starting/disconnect switch without overload protection.
2. UL 508 listed.
3. Totally enclosed snap-action switch. Quick-make, slow-break design with silver alloy contacts.
4. Minimum General Purpose Rating: 30 amperes, 600V ac.
5. Minimum Motor Ratings:
   a. 2 horsepower for 120V ac, single-phase, two-pole.
   b. 3 horsepower for 240V ac, single-phase, two-pole.
   c. 15 horsepower for 480V ac, three-phase, three-pole.
6. Screw-type terminal.
7. Manufacturers and Products:
   a. Cooper Arrow Hart.
   b. Hubbell Bryant: HBL78 Series.
   c. Leviton.

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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.
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: Provide the following features in comparable devices where indicated: 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.

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, Corrosion-Resistant:

1. Meet requirements of general-purpose receptacle.
2. Nickel coated metal parts.
3. Manufacturers and Products:
    a. Hubbell Bryant; HBL53CM62 Series.
    b. Leviton; 53CM-62 Series.
    c. Cooper Arrow Hart; 5362CR Series.

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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. Nylon:

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. Cast Metal:

1. Material: Copper-free aluminum, with gaskets.
2. Screw: Oval-head stainless steel.

E. Sheet Steel:

1. Finish: Zinc electroplate.
2. Screws: Oval-head stainless steel.
3. Manufacturers:
   a. Appleton.
   b. Crouse-Hinds.

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F. 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.
   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. Die cast metal cover.
   c. Locking type.
   d. 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.

G. Raised Sheet Steel: 1/2-inch high zinc- or cadmium-plated steel designed for one-piece drawn type sheet steel box.

2.05 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: Gray.
2. Other Areas: Gray.

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.

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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.

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.

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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.

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 metal box.
   b. Install such that hinge for protective cover is above receptacle opening.
4. Ground Fault Interrupter: Install feed-through model at locations where ground fault protection is specified for “downstream” conventional receptacles.
5. Special-Purpose 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.

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E. Type (Exterior):

1. Switch: Weatherproof.
2. Receptacle in Damp Location: Weatherproof Type 1.
3. Receptacle in Wet Location: Weatherproof Type 2.

F. Type (Interior):

1. Office Areas: Stainless steel.
2. Other Areas: Stainless steel.
3. Flush Mounted Box: Stainless steel.
4. Surface Mounted, Metal Box:
   a. General Purpose Areas (Dry, Non-process): Sheet steel.
   b. Other Areas: Cast metal.
5. Surface Mounted, Aluminum Box:
   a. General Purpose Areas: Stamped.
   b. Other Areas: Cast metal.
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 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.

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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.

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. 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.
4. 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: All AFDs shall include a minimum of a 5 percent input 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 and load conditions specified. Normal source system short-circuit available at drive shall be calculated from data furnished. 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. Layout of controller face showing pushbuttons, switches, instruments, and indicating lights.
10. Complete system operating description.
11. Complete system schematic (elementary) wiring diagrams.
12. Complete system interconnection diagrams between controller, drive motor, and related components or controls external to system, including wire numbers and terminal board point identification.

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13. One-line diagram of system, including component ratings.
14. Description of diagnostic features being provided.
15. Descriptive literature for control devices such as relays and timers.
16. Itemized bill-of-materials listing system components.
17. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Statement of Supplier qualifications.
2. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
3. Special shipping, storage and protection, and handling instructions.
4. Manufacturer's printed installation instructions.
5. Factory functional test reports.
6. Certified copy of test report for identical motor tested in accordance with NEMA MG 1-12.53a and IEEE 112, Test Method B, showing rated load, rated speed efficiency meeting or exceeding specified values; motors not as specified will be rejected.
7. Field test reports.
8. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
9. Suggested spare parts list to maintain equipment in service for period of 1 year and 5 years. Include list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
10. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
11. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
12. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.05 QUALITY ASSURANCE

A. Supplier: Minimum 5 years' experience in furnishing similar size and type adjustable frequency, controlled speed, drive systems.

1.06 EXTRA MATERIALS

A. Furnish for each drive unit:

1. Complete set of components likely to fail in normal service.
2. Plug-in subassemblies.
3. Printed circuit boards.
4. SCRs.
5. Potentiometers.

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6. Integrated circuits.
7. One complete power bridge and one spare printed circuit card for each modular, plug-in type card in controller.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Components and accessories specified in this section shall be products of:

1. Eaton Cutler Hammer.
2. Square D.
3. Danfoss.

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 50 volts dc within 1 minute after de-energizing following NEMA CP 1 and NFPA 79. Design dc link capacitor for a MTBF of 5 years.
6. Operate with open circuited output.
7. Input Voltage: 480V ac plus or minus 10 percent.
8. Output Voltage: 0 to 480 volts, three-phase, 0 to 66-Hz, minimum.

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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 65,000 amps rms symmetrical at 480 volts.
13. Furnish drives with output current-limiting reactors mounted within equipment enclosure.
14. Diagnostics: Comprehensive for drive adjustment and troubleshooting:
    a. Memory battery backup; 100-hour minimum during power loss.
    b. Status messages will not stop drive from running but will prevent it from starting.
    c. Fault Condition Messages and History: First fault protection function to be activated, ability to store six successive fault occurrences in order. Minimum faults numerically:
        1) Overcurrent (time and instantaneous).
        2) Overvoltage.
        3) Undervoltage (dc and ac).
        4) Overtemperature (drive, motor windings, motor bearing, pump bearing).
        5) Serial communication fault.
        6) Short-circuit/ground fault (motor and drive).
        7) Motor stalled.
        8) Semiconductor fault.
        9) Microprocessor fault.
        10) Single-phase voltage condition.
15. Drive Protection:
    a. Fast-acting semiconductor fuses.
    b. Overcurrent, instantaneous overcurrent trip.
    c. Dc undervoltage protection, 70 percent dropout.
    d. Dc overvoltage protection, 130 percent pickup.
    e. Overtemperature, drive, inverter, converter, and dc link components.
    f. Overtemperature, motor, and pump.
    g. Single-phase protection.
    h. Reset overcurrent protection (manual or automatic reset).
    i. Active current limit/torque limit protection.
    j. Semiconductor fault protection.

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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 full wave diode bridge rectifier to provide constant dc voltage to drive's dc bus. All AFDs shall include a minimum of a 5 percent input line reactor to minimize the harmonics that are propagated upstream of the AFD enclosure.

C. Furnish series choke and capacitors on dc bus to reduce ripple in rectifier output and to reduce harmonic distortion reflected into incoming power feeders.

D. Controller: Microprocessor-controller PWM inverter to convert to dc voltage to variable voltage, adjustable frequency, three-phase ac output. Output voltage shall vary proportionally with frequency to maintain constant ratio of volts to hertz up to 60-Hz; above 60-Hz, voltage shall remain constant with drive operating in constant horsepower output mode.

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E. Enclosure:

1. NEMA 250, Type 12, gasketed, freestanding, enclosure for mounting against wall, completely front accessible, and hinged doors. Properly sized to dissipate heat generated by controller within limits of specified operating conditions (including ambient temperature and ambient airflow). Enclosure not to exceed dimensions shown on Drawings.
2. Cable termination compartment door interlocked main circuit breaker, defeatable (lockable in the open position), emergency stop pushbutton, 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 above for incoming power wiring . The motor feeders shall exit the AFD enclosure from the bottom.
4. Size forced-ventilation for periodic operation to cool each unit with maximum room ambient temperature of 95 degrees F. Furnish redundant fans such that if one fan fails remaining fans furnish adequate ventilation for drive when operating at maximum capacity. Furnish filters on ventilation intakes.
5. Wiring:
    a. Bundle stranded copper wiring neatly with nylon tie wraps or with continuous plastic spiral binding.
    b. Label each terminal for permanent identification of leads.
    c. Identify each wire at each end with imprinted mylar adhesive-back wire markers.
    d. Incorporate in as-installed wiring diagrams for wire and terminal numbers shown.
    e. Wiring across door hinge, use 19-strand, NEMA WC 57 Class C stranding looped for proper twist rather than bending at hinge.
    f. Wire connections internal to panels by crimp-on terminal types.
    g. For multiple enclosure systems, complete interconnection wiring with gasketed enclosure openings for wiring.
    h. Multipoint plug receptacles for control wiring crossing equipment shipping splits.
6. Selector switches, indicating lights, potentiometers, instruments, protective devices, and major system components identified by means of mechanically attached, engraved, laminated nameplates.

F. Operator Interface:

1. Controls: Mount drive local control on front door of enclosure and include control switch and membrane type keypad for the following operator functions:
    a. Start (when in local mode).
    b. Stop (when in local mode).

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c. Speed increase (when in local mode).
d. Speed decrease (when in local mode).
e. Parameter mode selection (recall programmed parameters).
f. LOCAL/OFF/REMOTE control selection (in remote, furnish for remote RUN command digital input and speed increase/decrease via remote 4 mA to 20 mA analog signal).
g. Fault reset, manual for faults, except loss of ac voltage which is automatic upon return.
h. RUN/preset speed.
i. Parameter lock, password or key switch lockout of changes to parameters.
j. Start disable, key switch or programmed code.
k. Refer to the Drawings for specific control of the plant drain pump AFDs, digested sludge pump AFDs, and the hydronic pump AFDs.

2. Control circuit disconnect shall de-energize circuits in units that are not de-energized by main power disconnect device as required by California Administrative Code.
3. 120 volts, single-phase, 60-Hz circuits for control power and operator controls from internal control power transformer. Furnish power for motor space heaters rated 120 volts.
4. Arrange component and circuit such that failure of a single component cannot cause cascading failure(s) of other component(s).
5. Alphanumeric Display: During normal operation and routine test, the following parameters shall be available:
   a. Motor current (percent of drive rated current).
   b. Output frequency (Hertz).
   c. Output voltage.
   d. Running time.
   e. Local/remote indicator.
   f. Status of digital inputs and outputs.
   g. Analog input and output values.
   h. Output motor current per leg.
   i. All test points.
6. Adjustable Parameters: Set drive operating parameters and indicate in numeric form. Potentiometers may not be used for parameter adjustment. Minimum setup parameters available:
   a. Frequency range, minimum, maximum.
   b. Adjustable acceleration/deceleration rate.
   c. Volts per Hertz (field weakening point).
   d. Active current limit/torque limit, 0 percent to 140 percent of drive rating.
   e. Adjustable voltage boost (IR compensation).
   f. Preset speed (adjustable, preset operating point).
   g. Provision for adjustment of minimum and maximum pump speed to be furnished as function of 4 mA to 20 mA remote speed signal.

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G. Signal Interface:

1. Digital Input:
   a. Accept a remote RUN command contact closure input.
   b. High temperature contact closure input from field mounted motor temperature monitoring relay.
2. Digital Output: Furnish three discrete output dry contact closures rated 5 amps at 120 volts.
   a. DRIVE RUNNING.
   b. DRIVE FAULT (with common contact closure for all fault conditions).
   c. DRIVE IN REMOTE MODE.
3. Analog Input: When LOCAL/OFF/REMOTE switch is in REMOTE, control drive speed from remote 4 mA to 20 mA dc signal.
   a. Make provisions for adjustment of minimum and maximum motor speed which shall result from this signal.
   b. Factory set this adjustment to comply with operating speed range designated in driven equipment specifications.
   c. Frequency resolution shall be 0.1 percent of base speed.
4. Analog Output: Furnish two 4 mA to 20 mA dc signals for actual frequency, actual load.

H. Accessories:

1. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in readily visible location.
2. Lifting Lugs: Equipment weighing over 100 pounds.
3. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications.

2.04 PROJECT SPECIFIC AFD REQUIREMENTS

A. The following are Project specific requirements that are related to each of the adjustable frequency drives that are to be provided as part of this project which are not located within a vendor control panel. Refer to the applicable equipment specification for any Project specific requirements for any AFDs that are located within a vendor control panel.

B. Digested Sludge Pump AFDs (85-AFD-11-1 and 2):

1. The AFDs shall include a NEMA 12 enclosure and main circuit breaker.
2. The AFDs shall be sized at a minimum of 1.15 times the motor nameplate FLA.

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3. The AFDs shall include a minimum input line reactor of 5% within each drive.
4. The drive shall include a DV/DT output filter to accommodate a motor feeder length of 450 feet.
5. The drive enclosure shall not exceed the dimensions as shown on the Drawings. The drive enclosure shall be floor-mounted as shown on the Drawings.
6. The drive shall have the incoming power enter from the top of the enclosure and the outgoing motor feeder to exit from the bottom of the enclosure.
7. The controls provided for the drive shall be as shown on the associated control diagram. Refer to the Drawings for the associated control diagram.

C. Plant Drain Pump AFDs (20-AFD-70-1 and 2):

1. The AFDs shall include a NEMA 12 enclosure and main circuit breaker.
2. The AFD shall be sized at a minimum of 1.15 times the motor nameplate FLA.
3. The AFDs shall include a minimum input line reactor of 5 percent within each drive.
4. The drive enclosure shall not exceed the dimensions as shown on the Drawings. The enclosure shall be floor-mounted as shown on the Drawings.
5. The drive shall have the incoming power enter from the top of the enclosure and the outgoing motor feeder to exit from the bottom of the enclosure.
6. The controls provided for the drive shall be as shown on the associated control diagram. Refer to the Drawings for the associated control diagram.
7. The AFD shall include a FVNR bypass contactor to enable the pump to automatically operate at constant speed should the associated AFD fail.
8. The AFD shall include a relay from the pump supplier to remotely indicate MOISTURE and/or HIGH TEMPERATURE within the associated pump.

D. Hydronic Pump AFDs (20-AFD-P-01 and 2):

1. The AFDs shall include a NEMA 12 enclosure and main circuit breaker.
2. The AFD shall be sized at a minimum of 1.15 times the motor nameplate FLA.
3. The AFDs shall include a minimum input line reactor of 5% within each drive.
4. The drive enclosure shall not exceed the dimensions as shown on the Drawings. The drive enclosure shall be wall-mounted as shown on the Drawings.
5. The drive shall have the incoming power enter from the top of the enclosure and the outgoing motor feeder to exit from the bottom of the enclosure.
6. The controls provided for the drive shall be as shown on the associated control diagram. Refer to the Drawings for the associated control diagram.

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2.05 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.

2.06 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.

B. Factory Tests and Adjustments: Test all control panels actually furnished.

C. Record test data for report.

D. Functional Test: Perform manufacturer's standard, and the following tests if they are not part of the manufactures standard testing performed:

1. Test diodes, transistors, and GTOs at a thermal level of 125 degrees C.
2. Test TTL and CMOS chips at 70 degrees C.
3. Test printed circuit boards while heat cycled to maximum temperature of 65 degrees C.
4. Test run power sections at maximum 40 degrees C for 12 hours and run with motors for 6 hours.
5. Test assembled drive at maximum 40 degrees C and full load, full speed for 4 hours.
6. Test power capacitors and active components.
7. Operate controller with motor throughout its specified range, and at rated power supply load for 1 hour.
8. Resonance: When harmonic filters are furnished to meet specified harmonic distortion requirements, perform analysis and furnish documentary evidence that filter elements do not resonate with remainder of system parameters at harmonic frequencies present.

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: 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.
6. Record test data for report.

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.

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3.03 MANUFACTURERS' SERVICES

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

1. 1 person-day for installation assistance and inspection.
2. 1 person-day for functional and performance testing and completion of 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 of Owner's personnel. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by 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 32 13.13
DIESEL ENGINE GENERATOR SETS AND CONTROL PANEL

PART 1 GENERAL

1.01 WORK INCLUDED

A. This section covers the Work necessary to furnish, install, connect, and test one (1) completely factory-assembled 480V, 1,000 kW standby rated diesel engine generator set, and freestanding control equipment, to be located at the Williams WWTP. The engine generator set at this location shall be installed in a weatherproof, sound attenuated walk-in style enclosure.

B. This section does not stand alone and must be read in conjunction with Section 26 23 00, Low Voltage Switchgear. The diesel generator set and freestanding control panel specified herein and the low voltage switchgear specified in Section 26 23 00, Low Voltage Switchgear, shall be furnished by a single supplier. The one (1) generator control panel (20-GEN-CP1) and the 480V low voltage switchgear (20LVSG-1) shall be products of a single supplier.

C. Data exchange between the generator PLC specified herein and the plant control system at the Williams WWTP is a major requirement. Work closely with Process Instrumentation and Control System (PICS) Subcontractor to implement this data exchange as specified. Refer to the Supplement 2 – Generator System PLC I/O Communication Requirements for additional details on the specific I/O that will be conveyed between the PLCs associated within the low voltage switchgear and the plant control system.

1.02 SYSTEM RESPONSIBILITY

A. The Contractor shall be responsible for furnishing, installing, and testing the complete standby power system described herein, including satisfactory open transition operation of the generator.

B. The Contractor shall be responsible for furnishing and installing all incidental materials, regardless of whether or not they are specifically shown on Drawings, and testing required for the complete system as specified. Furnish and install low voltage switchgear as specified in Section 26 23 00, Low Voltage Switchgear. Provide a completely integrated generator control system for the one (1) generator to be installed as part of this Contract.

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C. The Contractor will be responsible for providing and installing all diesel fuel required for testing the generation system. Additionally, the Contractor shall also be responsible for completely refilling the main bulk fuel storage tank upon successful completion of any generator testing that is required up to Substantial Completion for the Project. The Owner will only be responsible for any fuel usage after successful completion of all system testing is performed and the Owner has accepted the equipment.

1.03 SYSTEM DESCRIPTION

A. The engine generator system at the Williams WWTP shall be comprised of a completely wired and operating system to automatically or manually start one (1) diesel engine generator unit.

B. The generation system will be used as a standby power source as required during emergency conditions. All protection and control systems required to meet this requirement shall be provided.

C. The new generator set shall be a totally assembled package unit mounted on its own rigid base, supplied with spring type vibration isolators as recommended by engine generator manufacturer. It shall be free of harmful critical speeds and torsional vibrations within the operating range of speed and capacity.

D. The generator set shall consist of diesel engine, generator, battery system, control system, unit instrumentation, sound-attenuated weather-proof enclosure, as well as all related mechanical and electrical accessories as specified herein or as shown on the Contract Drawings.

E. The switchgear requirements are specified in Section 26 23 00, Low Voltage Swichgear.

F. The engine generator shall be designed to start and maintain the priority loads specified in Supplement 1 - Table 1, Load Analysis without exceeding the specified voltage drop limit of 20 percent and the specified frequency drop limit of 10 percent.

G. The fully integrated mechanical and electrical components that constitute this system shall be designed so as to enable either a fully automatic mode of operation or as a fully manual system that can be started, governed, and protected with safety shutdown for low oil pressure, high water or oil temperature, over-speed, and other indicated conditions.

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1.04 SUBMITTALS

A. Submittals shall include the following specific information:

1. Shop Drawings:
   a. Complete performance data (continuous and transient ratings) on the engine generator. Rating shall be at ambient conditions as specified in service conditions. Major engine loads including jacket water circulation pumping, lubrication oil pumping, inlet air losses, and exhaust gas back pressure losses are to be included to allow determination of net output rating. Indicate net engine shaft horsepower, generator output power and voltage, and specific fuel consumption in gallon/hour versus kW output.
   b. Generator descriptive information, output ratings, subtransient reactance, transient response characteristics, winding short circuit ratings, and percent voltage dip versus kVA inrush characteristics plotted on graph paper.
   c. Generator performance parameters at nameplate rating to include, but not limited to, the following items:
      1) Harmonic content.
      2) Waveform deviation factor.
      3) TIF.
      4) Machine constants.
      5) Short circuit capability.
      6) Heat rejection.
   d. Dimensional, outline drawings showing the general arrangement, weight, and construction of the engine generator unit, enclosure, and all accessories.
   e. Enclosure shall be designed to meet the structural design criteria identified on Structural Notes 1 and 2 sheets of the Contract Drawings. Enclosure drawings shall be signed and sealed by a Professional Engineer registered in the State of Alabama attesting to structural design compliance.
   f. Dimensional, general arrangement drawings, control system description, schematics and logic diagrams, detailing the construction and instrumentation arrangement of the engine generator panel. One-line, side section, front elevation, bill-of-materials, and schematic diagrams of the generator control cabinet are to furnished.
   g. Control system description, schematic/wiring diagrams, all external signal interfaces for the engine control panel (ECP), locally mounted on the engine.

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h. Catalog cuts of all major equipment items, all accessories, and instrumentation and control items and a bill-of-materials of miscellaneous equipment.

i. Complete electrical elementary control and connection diagrams covering the electrical devices and functions provided on the engine generator and in the engine generator control panel. All diagrams shall be in accordance with NEMA ICS 1-101.

j. Noise projections and supporting calculations for the engine generator operated at 25, 50, 75 and 100 percent loading with the associated generator enclosures. Projections shall be for a 5-foot contour around engine generator corrected to free field conditions and shall include (referenced to 0.00002 Newton/sq.m):
   1) An "A" weighted projection on the specified contour (dBA).
   2) Spectral noise projections at 63, 125, 250, 500, 1,000, 2,000, 4,000, and 8,000 Hertz on the same contour.
   3) Calculations which show the anticipated noise values at the nearest property line of the facility.

k. A detailed torsional analysis report describing the engine generator mass elastic model. Vibration amplitude projections shall be included for all critical speeds as existing between zero speed and 110 percent normal speed.

l. A fuel air exhaust mass balance and heat balance for the engine at rated operation. Radiant and convective jacket heat losses and lubrication oil cooling loads are to be included. Provide information herein for the mufflers to be supplied under this Contract.

m. Complete list of spare parts which the supplier recommends be kept on hand.

n. Written installation instructions and prestartup servicing instructions.

o. Written engine generator test procedure instructions and protective device calibrations and settings.

p. Information, including costs, for additional 1-year, 2-year, 3-year, 5-year, and 10-year extended warranties and inspection service contracts, as well as 1-year renewable maintenance agreements.

q. Panelboard schedules for the 208/120V panelboard that is located within the generator enclosure.

r. Catalog cut sheets on the 30KVA, 480V-208/120V step-down transformer located within the generator enclosure. Additionally, catalog cutsheets on the primary disconnecting means for the 30KVA transformer.

s. Plan Drawing that details the size and location of all equipment contained within the walk-in type enclosure.

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t. Section Drawings that detail the size and location of all equipment contained within or appurtenant to the walk-in enclosure.
u. Detailed catalog cutsheets on the space heaters and lights that are to be provided within the generator enclosure. The Drawings provided shall detail the equipment located within the corresponding generator enclosure.

2. Operation and Maintenance Manuals:
   a. Shop Drawing information as specified.
   b. Provide complete detailed information on how to operate the equipment during startup, sustained operation, test conditions, shutdown, and emergency and fault conditions.
   c. Provide information and data necessary for lubrication, tolerance adjustment, calibration, and other necessary servicing. Provide definition of all servicing frequencies.
   d. Copies of all tests reports made on engine generator.
   e. Description of parts and service availability.
   f. Certification, copies of analyses, or test reports demonstrating appropriate vibration analysis and design in all modes.
   g. Certified Factory Test Report.
   h. Manufacturer's Certificate of Performance.
   i. Manufacturer's Certificate of Proper Installation.
   j. See additional requirements in as specified in Division 1, General Requirements.

1.05 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 Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.
3. International Building Code (generators, isolators, enclosures).

1.06 WARRANTY/MAINTENANCE AGREEMENT

A. Three year maintenance agreement shall be provided for the one (1) generator and shall include quarterly maintenance checks, yearly preventive maintenance checks, oil change, and a 4-hour load bank test at the end of the agreement.

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B. A complete engine-generator package, including control equipment, shall be covered by the system manufacturer for a period of 3 years after acceptance of the system by the Owner. This warranty shall cover all materials provided, labor, and miscellaneous disposal items.

C. All startup, troubleshooting and warranty repairs will be performed by factory trained service personnel employed by the seller without any exceptions. All costs including travel and mileage to the Site shall be included at no additional costs to the Owner.

D. The system manufacturer shall provide complete contract information to the Owner for purchasing extended warranties of either 1, 5, or 10 years duration in addition to the 3-year warranty that is to be provided with this equipment. Provide manufacturer's extended 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 Section found defective during a period of 3 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.

E. The system manufacturer shall provide complete contract information on extended maintenance agreements renewable on a 1-year basis that would be in addition to the maintenance requirements contained herein.

F. The costs for services described in Paragraphs D and E will be by construction Change Order or by separate Contract at the Owner's discretion.

1.07 EXPERIENCE

A. A complete, engine-generator package shall be the product of one manufacturer, hereinafter referred to as the "Manufacturer," who has been regularly engaged in the production of complete generating systems for at least 25 years. The generator control panel (20-GEN-CP1) and the 480V paralleling switchgear (20LVSG-1) shall be product of single supplier with the same experience requirements as specified for the engine generator. All components shall have been designed to achieve optimum physical and performance compatibility with each other and prototype tested to prove integrated design capability. The complete system shall have been factory fabricated, assembled, and production tested.

B. The engine must be the main component designed and manufactured by the manufacturer. Equipment suppliers that are not producers of the engine will not be considered nor approved.

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C. The seller and servicer shall be the same company and be the generator set manufacturer's authorized representative who is trained and approved for installation, maintenance and warranty repair. A supplier that requires a third party to perform warranty repairs or other services for the engine or other components on the manufactured genset will not be considered nor approved.

D. Seller/servicer shall have a power systems sales and service facility within 60 miles of the project site, and guarantee 8 hours emergency response time for technicians to arrive at project site at all times (365/24/7).

1.08 PARTS AND SERVICE

A. The Manufacturer shall maintain a local factory parts depot from which 80 percent generator set parts may be obtained in necessary quantities at any time during the day or night within 24 hours. A parts and service facility within 60 miles employing factory trained generator set technicians capable of four hour site response and complete servicing including warranty repair and preventative maintenance service contracts shall be maintained by the Manufacturer.

1.09 RELATED WORK SPECIFIED UNDER OTHER SECTIONS

Section	**Item**
26 23 00	Low Voltage Switchgear
26 22 00	Low Voltage Transformers
26 24 16	Panelboards
40 27 02	Process Valves and Operators
43 40 05	Above Grade Double Walled Fuel Storage Tank System

A. The basis of design shown on the Drawings is based on the first named manufacturer. Significant changes to the design shown on the Drawings may be required should the Contractor propose to use a different manufacturer. However, note that any and all modifications required to accommodate any other manufacturer shall be paid for entirely by the Contractor at no additional expense to the Owner. Additionally, if the Contractor proposes to provide any manufacturer other than the first named supplier, then any labor that is incurred by the Engineer to modify the design Drawings required to accommodate the alternate manufacturer shall also be paid for by the Contractor.

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PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The Diesel Engine Generator Sets and Engine Control Panels (ECP) shall be:

1. Caterpillar, (Basis of design).
2. Cummins.
3. Kohler.

B. Engine Generator Enclosures:

1. Chillicothe Metal Co., Chillicothe, IL.
2. Phoenix Products, Jacksonville, FL.
3. Pritchard Brown, Baltimore, MD.

C. Generator/Switchgear Control Panel:

1. Caterpillar Switchgear (Basis of design).
2. Cummins.
3. Kohler.

D. Alternator:

1. Leroy Somer.
2. Marathon.
3. Kato.

2.02 GENERAL

A. Unless otherwise indicated, provide all first-quality, new materials and equipment, free from any defects, in first-class condition, and suitable for the space provided. Provide materials and equipment approved by UL wherever standards have been established by the agency.

B. 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.

C. Unless otherwise indicated, provide materials and equipment which are the standard products of manufacturers regularly engaged in the production of such materials and equipment. Provide the manufacturer's latest standards design that conforms to these Specifications.

D. The proposed engine generator set and the auxiliaries shall fit within the outdoor enclosure outline shown on the Contract Drawings.

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2.03 SERVICE CONDITIONS

A. Service Conditions will be as follows:

1. Altitude: 20 feet above sea level.
2. Atmospheric Pressure: 14.7 psia.
3. Ambient Exterior Temperature, Maximum: 104 degrees F.
4. Ambient Exterior Temperature, Minimum: 3 degree F.
5. Relative Humidity: 40 percent to 100 percent, high humidity.
6. Climate classification for corrosion protection/protective coatings: Humid Sub-tropical per Koppen Climate Classification system.
7. The enclosure shall be designed to allow operation of the engine/generators within the environment specified above.
8. Generator set shall be capable of operating at 100 percent rating with no limitation on run hours or load factor during an emergency without impact on manufacturer's warranty.

2.04 GENERATOR RATINGS

A. Ratings:

1. Operate at 1,800 rpm.
2. Rated at 1,000KW/1250 kVA at 0.8 PF, based on specified service conditions.
3. Voltage: 480 volts, three-phase, three-wire, 60-Hz.
4. Rated based on standby service.

B. Emissions:

1. Engines: Meet emission requirements specified in 40 CFR Chapter I Part 89 for stationary Internal Combustion (IC) engines.

C. Vibration Design:

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

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2.05 ENGINE

A. General:

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

B. Type:

1. Diesel Cycle, four-stroke type with unit mounted radiator and fan cooling.
2. Minimum Displacement: As recommended by generator manufacturer.
3. Minimum Number of Cylinders: As recommended by generator manufacturer.

C. Starting System:

1. Type: Automatic, using 12-volt or 24-volt battery-driven starter acting in response to control panel.
2. Starter: Capable of three complete cranking cycles without overheating.
3. Batteries:
   a. Sized as recommended by engine manufacturer.
   b. Lead-acid type.
   c. Capable of providing 15 seconds minimum of cranking current at 0 degree C and three complete 15-second cranking cycles at 40 degrees C.
   d. Housed in acid-resistant frame isolated from engine generator main frame.
   e. Located such that maintenance and inspection of engine is not hindered.
   f. Complete with battery cables and connectors.
4. Battery Charger:
   a. UL 1236 listed and labeled.
   b. 10-amp automatic float, taper and equalize charge type, with plus or minus 1 percent voltage regulation over a plus or minus 10 percent input voltage variation.
   c. Temperature compensated to operate over an ambient range of minus 30 degrees C to 50 degrees C.
   d. Located by generator manufacturer on generator skid or wall-mounted within generator enclosure.
   e. Include:
      1) Ammeter and voltmeter.
      2) Fused ac input and dc output.
      3) Power ON pilot light.
      4) AC failure relay and light.
      5) Low and high dc voltage alarm relay and light.

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f. Alarm relay dry contacts rated 4 amps at 120V ac.
g. Wire battery charger status and alarm contacts back to generator control panel for remote monitoring.

D. Fuel System:

1. A mechanical positive displacement fuel supply pump driven off the engine shall deliver fuel from the external above ground fuel storage tank to the engine. Pump shall be suitable for operation with No. 2 diesel fuel oil and deliver the 100 percent load fuel capacity with up to a 12-foot maximum suction lift when measured at the fuel pump inlet connection. A premium grade, extremely low head-loss premium fuel oil filter with replaceable elements shall be provided.
2. All fuel filters shall be conveniently located, ahead of injection pumps so the fuel will have been thoroughly filtered before it reaches the pumps. No screens or filters requiring cleaning or replacement shall be used in injection pump or injection valve assemblies. The combination fuel separator/coalescor/filter shall be a manifold unit with shutoff valves and shall be installed on the fuel supply line between the fuel storage tank and the engine driven pump, and shall be as manufactured by Racor model 79/1000FHV (10 micron rated), or equal.
3. Provide fuel oil cooler, suitable for operation of generator set at full rated load in ambient temperature specified if required for operation due to design of engine and installation.
4. Fuel Connections to Engine: Flexible hose, with Type 304 stainless steel woven wire exterior protective covering. Hose material shall be suitable for the application.
5. Manual fire safe shutoff valves shall be ball valve style of three piece design, with stainless steel body and end caps, stainless steel ball and stem, reinforced Teflon seats and seals, and socket welding ends. Valves shall be of fire safe rated utilizing secondary metal seating surfaces to ensure shutoff if the primary seats are destroyed by fire. Fire safe isolation valves shall be Contromatics, Jamesbury, or equal.

E. Governing System:

1. Electro-mechanical or electro-hydraulic type.
2. Regulates speed as required to hold generating frequency within tolerable limits and within 5 percent of nominal design speed.
3. Accessories:
   a. Manual speed control device.
   b. Positive overspeed trip switch.

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F. Jacket Water Cooling System:

1. Radiator:
   a. Consisting of jacket water pump, fan assembly, fan guard, and duct flange outlet.
   b. Cooling System: Rated for full load operation.
   c. Fan: Suitable for use in a system with 0.5 in H_2O restriction.
   d. Sized based on a core temperature that is 20 degrees F higher than rated operation temperature.
2. Engine Thermostat: As recommended by manufacturer to regulate engine water temperature.
3. Jacket Water Heater:
   a. Suitable for operation on 208V to be fed from the 208/120V panelboard located within the generator enclosure.
   b. Maintain engine water temperature at 120 degrees F with a minimum ambient temperature of 3 degrees F.
   c. Thermostatically controlled.
4. Engine Cooling Liquid: Fill cooling system with a 50/50-ethylene glycol/water mixture prior to shipping.

G. Lubrication System:

1. Type: Full-pressure.
2. Accessories:
   a. Pressure switch to initiate shutdown on low oil pressure.
   b. Oil filter with replaceable element.
   c. Bayonet type oil level stick.
   d. Valved oil drain extension.
3. Oil Cooling System: Water-cooled heat exchanger utilizing jacket water.

H. Exhaust System:

1. Muffler: Rated as recommended by generator manufacturer to meet the specified sound limitation requirements identified in paragraph 2.13.H hereinafter when operated as part of an enclosure/exhaust silencer system.
2. Wrap exposed length of exhaust pipe, silencer and flex fitting with thermal insulating wrap.
3. Exhaust Pipe: Standard wall Type 304 stainless steel, with fittings selected to match piping materials.

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4. Pipe Connections: Welded.
5. Engine Connection:
   a. Flanged, flexible, corrugated, Type 321 stainless steel expansion fitting, specifically suited for diesel exhaust service.
   b. Length as required for flexibility and expansion in piping arrangement as indicated on the Contract Drawings.

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

2.06 GENERATOR

A. General:

1. Meet requirements of NEMA MG 1.
2. Synchronous type with 2/3 pitch, revolving field, drip-proof construction, air cooled by a direct drive centrifugal blower fan.
3. Stator Windings:
   a. Skewed for smooth voltage waveform.
   b. Reconnectable, 12 lead.
4. Overspeed Capability: 125 percent.
5. Waveform Deviation from Sine Wave: 5 percent maximum.
6. Telephone Interference Factor: 50 maximum.
7. Total Harmonic Current and Voltage Distortion: 5 percent maximum, measured at generator main circuit breaker.

B. Insulation System:

1. Class H, with a maximum rise of 105 degrees C over 40 degree C ambient in accordance with NEMA MG 1.
2. Vacuum pressure impregnated (VPI).

C. Excitation System:

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

D. Voltage Regulation:

1. Solid state, three-phase sensing type.
2. Adjustable output voltage level to plus or minus 5 percent.
3. Provisions for proper voltage regulation for existing or future adjustable frequency drives as part of generator load.
4. Conformal coating environmental protection.

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E. Voltage and Frequency Regulation Performance:

1. Steady State Voltage Regulation: Less than plus or minus 1 percent from no load to continuous rating point.
2. NEMA MG 1 Defined Transient Voltage Dip: Less than 20 percent voltage drop or 10 percent frequency drop under any of the Load Steps indicated in the supplements at the end of this section.
3. Steady State Frequency Regulation: Plus or minus 1.5-Hz overload range.

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

G. The manufacturer of the alternator proposed shall be clearly outlined in the generator submittal.

2.07 FUNCTIONAL REQUIREMENTS-GENERATOR CONTROL SYSTEM

A. A redundant PLC based system shall be provided for control of the generator system. The PLC hardware and all control/monitoring devices, including a PLC operator interface (OI) panel, shall be furnished in the generator control panel (20-GEN-CP1). The generator control system shall be designed for the following modes of operation.

1. Automatic operation (includes load test).
2. Off.
3. Test, no load.
4. Manual.

B. Supplement 2 - Table 2 Generator System PLC I/O Communication Requirements provides general guidance on hardwired I/O and data exchange requirements. The Contractor shall provide all hardwired I/O and data exchange with the plant control systems at the Williams WWTP for satisfactory operation of the generator and switchgear system.

C. A four-position selector switch (AOTM) shall be provided for selecting any of the operational modes specified above. When the AOTM switch is locked in the off position, the generators cannot be operated. The Auto, Test, and Manual modes of operation are specified as follows.

D. Automatic Operation: When the AOTM switch is in the Auto position, the generator system shall be set for automatic operation. The control switches for main, tie, and generator breakers are disabled and these breakers are operated by the automatic control system. There are three different scenarios within the automatic operation.

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E. Automatic Operation for Load Testing of Generator:

1. This operation shall be an automatic open transition load assumption and return. The load testing of the generator system can be initiated from the PMCS workstations. Operators make certain decisions to initiate generator startup.
2. Note that the PMCS is the existing plant monitoring and control systems at the C. C. Williams WWTP. All PLC hardware, sequencing, and logic is part of the generator supplier's scope of work.
   a. The PMCS operator decides the number of generators to be started. The operator takes into account any generator units “out of service” based on inputs received from the generator PLC.
   b. The PMCS operator shall determine the specific bus (“A” or “C”) that the generators shall transfer load from. The split bus operation is outlined in the paragraph noted above and shall be the same operation for load testing of the generation system.

F. Automatic Operation when One of the Two Utility Sources Fails (as measured at the 480V switchgear 20LVSG-1):

1. When one of the two utility sources fails, and the AOTM switch is in the “automatic” position, open the main breaker of the failed source and lock this breaker in the open position until such time that the PLC calls for closing the breaker. After a preset adjustable time delay, sequentially close the generator bus tie breakers (GBTB1 and GBTB2). Now the entire plant is fed from the single available source. PMCS operators will initiate startup of the plant loads connected to the failed bus. Certain automatic loads will start up automatically, in a sequential manner.
2. When voltage returns to normal at the failed source, implement the following sequence to reconnect the failed source to its bus for restoring normal operation: Open the generator bus tie breakers (GBTB1 and GBTB2). Wait a predetermined, but adjustable, time delay and then close the main breaker of the failed source.
3. The sequence specified above will allow a “open transition” return to normal power.

G. Automatic Operation when Both Sources of Power Fail (as measured at the 480V switchgear 20LVSG-1):

1. When the AOTM switch is in the automatic position and both sources of normal utility power have failed, the system shall implement the following sequences.

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2. The generator PLC shall start all available generators. Transmit number of generators running and related data to PMCS. Should the utility power return while the PLC is going through these steps, then shut down the started generator following a cooling off period, adjustable from 5 to 40 minutes.
3. Based on number of generators running, the PMCS control system will lockout certain nonpriority loads.
4. Open the two utility main breakers (UM1 and UM2) located within the 480V switchgear and keep these breakers locked for the duration of generator operation until such time that the PLC system calls each breaker to close again. Open all the feeder breakers (F1, F2, F3, F4, F5, F6, F7, and F8). Once the above feeder breakers are all verified as opened, then sequentially close the two tiebreakers (GBTB1 and GBTB2). The feeder breakers shall be sequentially closed to energize each of the motor control centers and the associated downstream loads. Sequential closing of the feeder breakers will enable the generation system to recover following the closing of each feeder breaker and energization of the associated loads. Once the feeder breakers are closed, inform PMCS via data link that standby power is available on Buses A, C. PMCS control system will then ENABLE various pumps and major equipment start commands and switch any other loads as required. The plant is now running on standby power. Certain loads in automatic mode will start automatically, as they are ENABLED by the PMCS system in a sequential manner, preventing simultaneous starting of multiple loads.
5. When normal voltage returns to both utility sources, following a preset time delay, implement the “open transition return to utility” sequence for each utility source as described above.

H. Manually Initiated Semi-Automatic “Split-Bus” Operation:

1. This semi-automatic procedure will be used by operators to initiate a split-bus operation of the standby generator system. Operators can run half the plant on utility power (Bus A or C) and the other half (Bus C or A) on standby generator.
2. This mode of operation will be used for periodic testing of the new standby generation system and is applicable only when voltage is available on both utility main breakers (UM1 and UM2) in the 480V switchgear 20LVSG-1. This feature provides additional flexibility and reliability to the system in that if the generator trips during operation only half the plant is affected. The operation shall be initiated either from the plant computer system (PMCS) workstations, using soft switches on graphic displays OR from the generator control panels (20-GEN-CP1). This paragraph outlines functional requirements for the split bus operation.

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3. Soft Switches on Plant Computer System (PMCS) HMI (Under PICS Subcontractor):
   a. The soft switches on the plant control system HMI for the split bus manual operation and associated logic specified for the PMCS shall be implemented by the PICS Subcontractor.
   b. Provide a three position "soft switch" on the HMI to be labeled as "Split Bus Operation Selector." The soft switch shall have three distinct positions as follows:
      1) Position 1: OFF. When the switch is in this position, the manual split bus operation is disabled.
      2) Position 2: Bus "A" to Standby Power. In this position split bus operation is initiated and only Bus "A" is switched to stand-by power. Bus "C" remains on Utility Feeder No. 2.
      3) Position 3: Bus "C" on Standby Power. In this position, split bus operation is initiated and only Bus "C" is switched to stand-by power. Bus "A" remains on the Utility Feeder No. 1.
   c. Provide a soft switch labeled "RETURN Bus A to Utility Source No. 1" [Click to initiate return to Utility].
   d. Provide a soft switch labeled "RETURN Bus C to Utility Source No. 2" [Click to initiate return to utility].
   e. The soft switches specified in subparagraph c and subparagraph d are enabled only when the three position split bus selector is NOT in OFF position and should be RESET/DISABLED when the three position switch is in OFF position.
   f. All switch positions are transmitted to the generator PLC as "bits" to be read by the PLC. The fiber optic Ethernet link is used for this data exchange.
4. Split Bus Operation with Bus "A" on Standby Power (Generator PLC Logic):
   a. This sequence is initiated by the generator PLC when the split-bus selector switch (soft switch on central computer HMI) or the soft switches in the control panels 20-GEN-CP1 are in "Bus 'A' to stand-by power position" as confirmed by the "bit" written into the PLC from the computer system. The automatic sequence is as follows:
      1) Make sure that:
         a) The split bus operation with Bus "A" on stand-by power has been initiated.
         b) Normal utility power is available at both ends of 20LVSG-1.

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2) The PLC initiates start-up and synchronization of all available generators on Bus “B” and transfer of Bus “A” loads to Bus “B” as follows:
   a) Start all available diesel generators. The engine “START” command shall be a contact closure sent to the locally mounted engine control panels (ECPS).
   b) Make sure that the two tiebreakers (GBTB1 and GBTB2) are open. Close the generator output circuit breaker for the first generator to reach operating voltage and frequency.
   c) After all available engine generators are running on generator Bus “B,” the Bus A main circuit breaker (UM1) shall open. Once the Bus A main circuit breaker (UM1) is open, the generator bus tie breaker 1 (GBTB1) shall close allowing the on-site generation system to energize the loads on Bus A.
   d) When it is desired to switch Bus “A” back to utility, the operator clicks on the “Return Bus A to utility” button at PMCS-HMI or on 20-GEN-CP1. When the generator PLC system reads the bit from the PMCS corresponding to the “return Bus A to utility,” the PLC shall initiate a “open transition return to utility” sequence as described in the following steps.
   e) Generator Bus Tie breaker 1 (GBTB1) shall open. The Bus A main circuit breaker (UM1) shall close after a preset, but adjustable time delay.
   f) Note that the tiebreaker between Bus “B” and Bus “C” (GBTB2) is always OPEN during this operation, and Bus “C” is fed from the utility.

5. Split Bus Operation with Bus “C” on Standby Power (Generator PLC Logic):
   a. This sequence is initiated by the generator PLC when the split-bus selector switch (soft switch on central computer HMI) or the soft switches in the control panel 20-GEN-CP1 are in “Bus ‘C’ to stand-by power position” as confirmed by the “bit” written into the PLC from the computer system. The automatic sequence is as follows:
      1) Make sure that:
         a) The split bus operation with Bus “C” on stand-by power has been initiated.
         b) Normal utility power is available at both ends of 20LVSG-1.

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2) The PLC initiates start-up and synchronization of all available generators on Bus "B" and transfer of Bus "C" loads to Bus "B" as follows:
   a) Start all available diesel generators. The engine "START" command shall be a contact closure sent to the locally mounted engine control panels (ECPS).
   b) Make sure that the two tiebreakers (GBTB1 and GBTB2) are open. Close the generator output circuit breaker for the first generator to reach operating voltage and frequency.
   c) After all available engine generators are running on generator Bus "B," the Bus C main circuit breaker (UM2) shall open. Once the Bus C main circuit breaker (UM2) is open, the generator bus tie breaker 2 (GBTB2) shall close allowing the on-site generation system to energize the loads on Bus C.
   d) When it is desired to switch Bus "C" back to utility, the operator clicks on the "Return Bus C to utility" button at PMCS-HMI or on 20-GEN-CP1. When the generator PLC system reads the bit from the PMCS corresponding to the "return Bus C to utility," the PLC shall initiate a "open transition return to utility" sequence as described in the following steps.
   e) Generator Bus Tie breaker 2 (GBTB2) shall open. The Bus C main circuit breaker (UM2) shall close after a preset, but adjustable time delay.
   f) Note that the tiebreaker between Bus "B" and Bus "A" (GBTB1) is always OPEN during this operation, and Bus "A" is fed from the utility.

I. AOTM Switch in "Test" Position (No Load Test):

1. When the AOTM switch is in the "Test" position, the following test operations shall be feasible.
2. When the operator enters a "start" signal and the number of generators to be started at the PLC operator interface panel, implement the following:
   a. Start all available generators.
   b. Make sure that the two tiebreakers (GBTB1 and GBTB2) are open. Close the generator output circuit breaker for the first generator to reach operating voltage and frequency.
3. At this point, the available generator shall be running, at no load, on Bus "B". Both tiebreakers shall be open.
4. When the operator enters a "stop" signal through the PLC operator interface panel, the generator shall be shut down following an adjustable cooling off period.

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J. AOTM Switch in Manual Position: When this switch is in Manual position the entire operation is strictly manual by passing the PLC and utilizing the backup electromechanical system to implement the following functions (MANUALLY):

1. Start each generator system.
2. Close and open appropriate tie and utility main breakers.
3. Close and open appropriate feeder breakers.
4. The entire open transition assumption of load and return to utility shall be manually feasible. Provide all safety interlocks for safe manual operation.
5. In manual mode, individual breaker control switches (CS), engine control switches (ECS), shall be used to perform required functions.

K. During all modes of operation (automatic, manual, test, and split bus operation) hard wired interlocks shall prevent closing of both tiebreakers (GBTB1 and GBTB2) when both utility main breakers (UM1 and UM2) are closed.

L. During factory tests, first show that the entire system works as specified.

M. Bulk Fuel Storage Tank:

1. See Specification Section 43 40 05, Above Grade Double-Walled Fuel Storage Tank System for interface coordination.
2. Instrumentation:
   a. Provide monitoring system for the generator fuel storage tank to measure, display, and transmit the following status signals to the Engine Control Panel (ECP):
      1) Fuel Tank Level (4-20mA).
      2) Fuel Tank High Level Alarm (Discrete).
      3) Fuel Tank Interstitial Leak Detection (Discrete).

2.08 GENERATOR SYSTEM CONTROL PANEL (20-GEN-CP1)

A. General:

1. Furnish complete freestanding control panel assembly for operation and control of the generator system that consists of one generator to be installed. Refer to Section 40 99 00, Package Control Systems, for specific control panel requirements. The control panel sections shall be UL listed.

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2. Furnish one engine control panels (20-GEN-CP1) to allow the plant operators to locally, or remotely, monitor the status of the 480V electrical distribution system, and the generation system. The generator control panel shall be 36-inches wide, 24-inches deep, and 90-inches high. Each control panel shall include a NEMA 1 enclosure and a 19-inch Elo touchscreen.
3. All control and indication devices shall be furnished as shown on Drawings. Control devices and instruments shown on the generator control panel are for general guidelines only. The Supplier shall provide all devices required for satisfactory operation. Devices can be re-arranged to suit manufacturer's standard as long as the functional requirements are satisfied.
4. Each engine generator control panel shall include the following basic components:
    a. ac voltmeter, 0-600V scale.
    b. Voltmeter switch, reading phase to phase.
    c. ac ammeter, scale as required.
    d. Ammeter switch.
    e. ac wattmeter, scale as required.
    f. Circuit breaker control switch. One for each main utility breaker (UM1 and UM2).
    g. Circuit breaker control switch. One for each generator bus tie breaker (GBTB1 and GBTB2).
    h. Circuit breaker control switch. One for each feeder breaker (F1 – thru F8).
    i. Circuit breaker control switch. One for each generator breaker and load bank breaker.
    j. Generator running time meter.
    k. Frequency meter, 55- to 65-Hz scale.
    l. Voltage control potentiometer, furnished by engine generator supplier.
    m. Mounting and connection only of governor controller and speed setting potentiometer, furnished by engine generator supplier.
    n. Mounting and connection only of voltage regulator, furnished by engine generator supplier.
    o. Engine control switch with OFF-AUTO-MAN nameplate.
    p. Reset button.
    q. The touchscreen shall display the following alarms:
        1) Low lube oil pressure, shutdown.
        2) High water temperature, shutdown.
        3) Overcrank, shutdown.
        4) Overspeed, shutdown.
        5) Overcurrent (breaker trip and lockout), shutdown.
        6) High water temperature, alarm.
        7) Low lube oil pressure, alarm.

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8) Battery charger failure, alarm.
9) Engine not in AUTO, flashing status.
10) Engine running, status.
11) Circuit breaker open, status.
12) Circuit breaker closed, status.
13) Overvoltage, shutdown.
14) Undervoltage, alarm.
15) Loss of field.

r. Wire all above points to PLC digital input module and annunciate (hard wired) at the panel annunciator.
s. Light test pushbutton.
t. Set of required dry contacts.
u. Furnish, install, and wire a PLC remote I/O rack in each generator section to pick up Inputs/Outputs and communicate with the CPU located in master section.

5. The generator system control panel shall be provided with a separate subsection for metering and control.
6. The generator system control panels shall be furnished with the following basic components:
   a. Solid state dc powered redundant Programmable Logic Controllers (PLCs). The PLCs shall be programmable in the field and shall provide for control of the engine generator set's starting, loading, running, paralleling with all generators on generator bus, CLOSED transition load assumption, and transfer. PLC logic shall meet all functional requirements specified herein.
   b. The PLC shall continuously monitor the generator tie and main circuit breaker auxiliary switches to determine how many generators are connected to the bus and the engine starting and annunciation controls to determine if an engine or generator fault exists. The Programmable Logic Controllers shall use the above information to implement specified functional requirements. The PLC replacement parts and programmer should be commonly available from local distributors.
   c. The PLCs shall communicate with the PMCS via an ethernet connection. The protocol used to communicate with the plant control system shall be Ethernet/IP TCIP. Provide necessary hardware and software to establish this communication link. Provide read and write bit and word locations within the PLC memory as specified in the PLC I/O communication requirements, part of the Supplement 2 to this section.
   d. The PLCs provided include an Ethernet TCP/IP data link as shown on the supplements in Section 26 23 00, Low Voltage Switchgear.
   e. Master-Auto-Manual-Test switch (AOTM).

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f. Provide one 19-inch operator interface panels mounted on panel front as shown. This panel shall allow accessing/display of various PLC parameters and allow manual data entry and modification of parameters. The operator interface shall be programmed to implement the specified functional requirements including soft switches and graphic displays. The operator interface shall be Elo 19-inch Touchscreen complete with a control net communication module. All SCADA functions accomplished via Touch Screen. Provide password protection.

g. All PLC hardware, ethernet switches, operator interface panels, and fiber optic repeaters shall be powered from the best available 24 volts source. This feature will enable the system to communicate with the plant control system even if no power is available from the local utility or from the onsite generation system.

h. Test switch.

i. Provide control interfaces to lockout relays, CTS, PTS as required.

j. Station alarm horn with silence pushbutton.

k. Lead unit selector switch.

l. Typical for Utility Bus A and Bus C:
   1) ac voltmeter, 0 volt to 600 volts scale.
   2) Voltmeter switch, reading phase-to-phase.
   3) ac ammeter, scale as required.
   4) Ammeter switch.
   5) Watt-hour demand meter with 15-minute demand register, switchboard type.
   6) Lockout relay (86).

m. Annunciator with the Following Alarms (Back Lit, LED Type):
   1) Generator bus under frequency.
   2) Generator bus over frequency.
   3) Generator bus undervoltage.
   4) Generator bus overvoltage.
   5) System not in auto.
   6) Start signal received.
   7) System under test.
   8) PLC malfunction.
   9) Low PC battery voltage.
   10) Tiebreaker lockout (1 per breaker).
   11) Tiebreaker open (1 per breaker).
   12) Tiebreaker closed (1 per breaker).
   13) Normal light available per phase (typical for utility sources No. 1 and No. 2).
   14) Horn silence.

n. Set of required dry contacts.

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7. An automatic dc control sensor system shall be provided in the engine generator control panels to provide dc control voltage. DC control power shall be obtained from any one of the engine starting batteries or the station power supply through a 24V dc converter. The sensor shall automatically select the best control voltage from the available batteries. The dc control voltage sensor shall ensure a stable system control voltage as long as any one of the battery sources are available. Panel control power shall be 24V dc.
8. A dc under- and over-voltage protection circuit shall be provided to protect the system from low or undervoltage.
9. The generator control panel shall provide two (2) hard-wired outputs to the elevator control panel located on the Second Floor of the Dewatering Building. The hard-wired outputs shall be as follows:
   a. NORMAL UTILITY POWER AVAILABLE.
   b. IMPENDING TRANSFER OF GENERATOR BACK TO UTILITY. This signal shall be relayed to the elevator control panel 20 seconds before the plant loads are transferred from the standby generator to the normal utility source.

2.09 LOCAL GENERATOR CONTROL PANEL (WITHIN GENERATOR ENCLOSURE)

A. Control Panel:

1. Rating: NEMA 250, Type 12.
2. Material: Steel.
3. Instrument Identification: Face label or engraved, black, laminated plastic nameplate with white 1/4-inch-high letters, attached with Type 422 stainless steel screws.
4. UL 508 listed.
5. Tested to meet or exceed IEEE 587 requirements for voltage surge resistance.
6. Controls: Solid-state, microprocessor based.
7. Control Panel: Designed and built by generator manufacturer to provide operating, monitoring, and control functions for generator set.

B. Instrumentation:

1. Type: Suitable for engine-mounted vibration environment.
2. Mounting: Nonshock mounted.
3. Alarm and Signal Contacts: Rated 5 amps at 120V ac, dry.
4. Fault Indication Lamps: Push-to-test type.
5. Meters: Digital with analog display, plus or minus 2 percent accuracy.

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C. Operator Controls and Indicators:

1. HANDCRANK/STOP/AUTO/ENGINE TEST selector switch.
2. Generator voltage adjustment.
3. Voltmeter PHASE SELECTOR switch.
4. Ammeter PHASE SELECTOR switch.
5. Voltmeter.
6. Ammeter.
7. Kilo-Watts (kW).
8. Power Factor.
9. FREQUENCY meter.
10. Engine OIL PRESSURE indicator.
11. Engine jacket WATER TEMPERATURE indicator.
12. Engine SPEED indicator (RPM).
13. Engine OIL TEMPERATURE indicator.
14. RUNNING TIME indicator.
15. DC battery voltage.
16. Emergency Stop button.

D. Alarm Indicators with Manual Pushbutton RESET:

1. Low oil pressure.
2. High jacket water temperature.
3. Engine overspeed.
4. Engine overcrank.
5. Low/high dc voltage.

E. External Interfaces:

1. The local generator control panel shall be capable of energizing the solenoid 60FV-10-1 whenever the generator is called to run. The solenoid shall be located near the aboveground fuel storage tank and wired to the local generator control panel.
2. The local generator control panel shall accept I/O from instrumentation that is associated with the external bulk diesel fuel storage tank (60-T-10-1). An I/O module shall be included within the local generator control panel to enable the control panel to interface with the following external I/O:
   a. Fuel Tank Level – Analog Signal.
   b. Fuel Tank HIGH LEVEL – Discrete Signal.
   c. Fuel Tank LEAK – Discrete Signal.

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3. The above I/O shall be relayed to the plant control system via the serial link between the generator control panel and the low voltage switchgear 20LVSG-1.
4. The generator suppliers submittal Drawings shall specifically indicate the specific size, number, and location of the external conduits that will enter the generator enclosure. This constraint is required to ensure that that any opening provided for the external conduits to enter the generator enclosure is properly coordinated between the Contractor and the generator supplier.

2.10 PLC I/O, DATA EXCHANGE, GRAPHIC DISPLAYS

A. The minimum hardwired I/O requirements are summarized in Supplement 2 - Table 2 – Generator System PLC I/O Communication Requirements. Provide all hardwired I/O required to meet the functional requirements. Coordinate all hardwired control signals between the PLC, switchgear breakers/protective relays and engine control panels (ECPs).

B. Data exchange between the generator PLC and the plant control shall be accomplished via a Ethernet link as shown on Drawings. Provide ethernet switches as required to implement the data link. Provide all data needed to implement SCADA functions at the plant control system HMI. Coordinate with PICS Subcontractor to implement the data exchange.

C. Assist PICS Contractor in implementing graphic displays at the plant control system HMI. The graphic displays at the generator OI and the plant HMI should look similar.

D. The protocol used to communicate with the plant control system shall be Ethernet/IP CIP. Provide all equipment required to facilitate this protocol.

2.11 SUBBASE AND VIBRATION ISOLATORS

A. The engine and generator shall be mounted on a common steel frame sufficiently rigid to prevent deflection between vibration isolators. The engine generator shall be mounted on Korfund Series L vibration isolators. Vibration isolators shall be sized by the isolator manufacturer and shall be such to limit the maximum vibration transmissibility to 10 percent.

2.12 TORSIONAL VIBRATION

A. Each complete engine generator set shall be so designed, constructed, and installed as to be free from objectionable vibration in any mode. Freedom from torsional vibration shall be demonstrated by torsion graph records taken during the factory test of this or a similar unit.

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2.13 FACTORY PAINT

A. Each complete engine generator set, including the control cabinet shall be given a factory-applied primer and two finish coats of the manufacturer's premium heat-resistant engine coating system suitable for long term service in a humid sub-tropical corrosive environment. The color shall be as selected by the manufacturer. All areas damaged during shipment shall be touched up after installation.

2.14 SOUND ATTENUATED WEATHERPROOF WALK-IN STYLE ENCLOSURE

A. Provide the Owner with a weatherproof (not “weather protective”) generator set enclosure, for the engine generator, complete in every detail and requiring no additional in-field modifications or assembly except where specifically allowed by these Specifications. The enclosure is to be accurately dimensioned so as to be in compliance with the National Electrical Code (NEC) and the National Fire Protection Association (NFPA) for clearance of all specified items included therein, and all applicable fire codes for a structure and application of this type.

B. Dimensions: Enclosure dimensions shall be such that a minimum of 24 inches on each side of the engine and 36 inches at the generator end of the unit shall be kept as walking clearance for maintenance and operating personnel. The height of the enclosure shall provide a minimum of 7-foot 6-inch clear headroom at the interior.

C. Design: The enclosure shall be of formed steel or aluminum construction. A minimum thickness of 14-gauge shall be used for all component parts. The roof of the enclosure shall be strengthened to support the exhaust silencer (internally mounted within the enclosure) as recommended by the manufacturer for this application. The enclosures structural design elements shall be of robust construction designed to withstand the wind gust value of the International Building Code as specified in the Design Criteria listed on Structural Notes 1 and 2 (Drawings 01-G-006 and 01-G-0007 of the Contract Documents).

D. Doors: Four doors shall be provided with the generator enclosure. All doors on the enclosure shall be located to allow ease of maintenance on the generator set and allow access to instruments, controls, engine gauges, etc. The doors shall be fitted with stainless steel hinges with stainless steel pins. Nylon wear bushings shall also be provided. Personnel door shall be fully gasketed to form a weathertight perimeter seal. A three-point latching assembly with interior latch release and exterior surface mounted stainless steel padlocking handles.

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E. Louvers: All louvers shall have sufficient free area to allow for 120 percent of the total engine/generator cooling air requirements used in this application. Louvers shall be of all aluminum construction and shall spring open when the generator runs, and motorized to close when the generator stops. In the event of a louver motor malfunction or failure, the louvers shall incorporate a fail-safe operation to remain in or revert to the open position.

F. Details: Provide Type 304 stainless steel mounting brackets for the exhaust silencer specified. In addition, a stainless steel vertical tail pipe extension (with reef curb) terminating in a counter-weighted rain cap fitted with a bird screen shall also be supplied. All components of the enclosure shall be assembled utilizing 0.375-inch minimum stainless steel bolts, nuts, and lock washers. In addition, watertight neoprene washers shall be used on all roof bolts. The enclosure roof shall be a welded one piece monolith type deck. Neoprene washers are unacceptable.

G. Finish: The enclosure shall be painted artic white to minimize the heat gain within the sound attenuated generator enclosure.

H. Sound Attenuation: The entire enclosure including the louvered openings shall have sound attenuation material mechanically attached to the interior surfaces of the unit. Sound absorbing material shall be held in place by a perforated galvanized steel metal liner, mill finished, to form a removable section easily inspected by maintenance personnel. The sound attenuation material and fastening system shall apply to the enclosure roof as well as side panels and doors, and shall consist of a minimum of 2-inch thick sound insulation mineral wool covered by 1/2-inch sound insulating foam. Note: Where equipment manufacturer's analysis determines a greater sound insulation material thickness is required to meet the specified sound attenuation for the enclosure and exhaust silencer system the manufacturer shall provide this increased insulation thickness. The louvered openings shall be equipped with sound attenuating tubes, baffles, or hoods as required to meet the specified air flow and decibel ratings noted herein. The sound rating of the unit shall not exceed 65 dbA when measured at 23 feet from any outside face of the enclosure in a free field environment. The Contractor shall also be responsible for performing a field test of the noise emissions from the generator enclosure with the generator in operation at 25, 50, 75, and 100 percent load to verify that the maximum noise emissions do not exceed the maximum allowable noise values from the generator enclosure.

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I. Internal Wiring: All wiring within each generator enclosure shall be in conduits specifically manufactured for electrical use. All connections at the generator set shall be flexible, and all shall be provided and installed prior to shipment to the installation site. The conduits provided shall meet the requirements of Section 26 05 33, Raceways and Boxes while the conductors provided shall meet the requirements of Section 26 05 05, Conductors.

J. Interior Lighting (DC): Three (3) battery-operated lights deriving its power from other than the engine cranking batteries shall be installed in a strategic location within each generator enclosure and shall be controlled by a switch located by one of the entrance doors. One light shall be located on each side of the engine while the third light shall be located near the end of the generator near the main terminal box. The lights shall be large enough to provide illumination in an emergency situation to both the instrument control panel and the engine cranking battery. The switch controlling these lights shall be a wind-up timer type which automatically shuts off after a preset interval not to exceed one hour. A means to automatically charge the emergency light battery shall be included.

K. Interior Lighting (AC): Six (6) 48-inch, LED lights shall be installed within each enclosure and strategically located on either side of the generator set. All lights shall be ceiling mounted and parallel to the length of the generator unless shown otherwise. Their AC power source shall be taken from the 208/120V panelboard supplied with the engine generator. Two 3-way switches shall operate these fixtures. Further, each light switch box shall have its own grounded duplex receptacle mounted therein for use by maintenance personnel.

L. Exterior Lighting: Each enclosure shall be equipped with lights on the exterior of the structure as shown in the Contract Drawings, wired into the 208/120V panelboard and activated automatically by way of photoelectric cells which will switch the lights on during evening hours and off during daylight hours. One light fixture shall be located above each man-door of the generator enclosure. The fixtures for the lights shall be of vandal-proof design, and mounted above each entrance door of the enclosure. Each light shall be equipped with a switch to bypass the photoelectric cell controlling its automatic operation.

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M. Low Voltage Power: Each generator enclosure shall be equipped with one (1) panelboard and one (1) step-down transformer to distribute power to the miscellaneous loads associated with each generator enclosure. A single 45A, 480V circuit breaker is located within 20MCC-2 and shall be used to distribute all 480V power to the generator enclosure. The 45A, 480V power feed shall be a single entry point for commercial power supply to the generator enclosure. A 60A fused disconnect switch with 45A fuses, 30KVA transformer, and 208/120V lighting panel shall be mounted within the generator enclosure and allow for Site condition conduit entry. The placement of the panel and transformer shall be shown on the Submittal Drawings. All internal wiring and conduit runs to the various ancillary equipment supplied with the package shall be prewired at the factory in accordance with all governing codes pursuant to this application. The 208/120V power panel shall be considered as part of the emergency load and shall derive its power source as shown on Drawings. All components of the electrical panelboard shall be located within the generator enclosure such that they meet the working clearances outline in the National Electric Code (NEC). The electrical equipment included within each generator enclosure shall include the following items:

1. One (1) 60A fused disconnect with 45A fuses shall act as the primary disconnecting means for the 30KVA transformer.
2. 30KVA, 480V-208/120V step-down transformer. The transformer shall meet the requirements of Section 26 22 00, Low Voltage Transformers and shall be from the same manufacturer as the other dry-type transformers provided throughout the rest of this Project.
3. 100A, NEMA 12, 208/120V Lighting Panelboard. Lighting panel shall include a 100A main breaker and all necessary distribution breakers to feed the various items provided as part of the generator package. The panelboard shall meet the requirements of Section 26 24 16, Panelboards and shall be from the same manufacturer as the other panelboards provided throughout the rest of this Project.

N. Oil and Water Drains: All necessary fittings, hoses, shutoff valves, shall be provided to facilitate lube oil and water drain at the exterior of the enclosure. In addition, engines equipped with crankcase breather tubes shall have this tube terminate at the exterior of the enclosure directly under the radiator air discharge louver.

O. Enclosure Flooring: The floor of the enclosure shall be designed and constructed in such a manner as to prevent the entrance of rodents. This shall be accomplished with solid metal or "diamond plate" and must be capable of fully supporting any ancillary equipment specified which may be secured to it plus the anticipated weight of maintenance personnel and their tools. Minimum floor thickness shall be 1/4-inch steel.

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P. Skin Cooling: Under no circumstances shall the floor area or any of its parts be considered for cooling air intake or discharge requirements of the generator set or its associated equipment, nor shall its properties as a “heat sink” or heat dissipating medium be utilized in any manner whatsoever in this application.

Q. Ventilation: Provide exhaust fan and intake and exhaust louvers for ventilation when engine/generator is not running. Size to maintain temperature within 10 degrees above the maximum ambient temperature specified in Paragraph Service Conditions. Provide backdraft damper on exhaust louver and motorized damper on intake louver. Control fan and motorized damper with an adjustable thermostat located near a doorway. The exhaust fan shall be powered from the 208/120V panelboard that is located within each generator enclosure.

R. Heaters: Two (2) 5KW space heaters shall also be provided within each generator enclosure to maintain the minimum temperature as specified within the generator enclosure. The space heaters shall operate on 208, three-phase power and shall include an integral disconnecting means and thermostat. The heaters shall be powered from the 208/120V panelboard located within each generator enclosure.

S. Provide enclosure certified to meet IBC International Building Code for the specified wind loading as specified on Structural Notes 1 and 2 (Drawings 01-G-0006 and 01-G-0007).

T. The roof of the generator enclosure shall be positively sloped to prevent any accumulation of water.

2.15 ACCESSORY VALVES

A. Engine generator manufacturer to furnish miscellaneous accessory valves identified on the Contract Drawings for operation of the engine generator and above grade storage tank system. Valves are specified by “V” number designation and include the following styles/types:

1. Type V-420, non-lubricated plug valves (fuel oil service).
2. Type V-954, fusible link shutoff valves (fuel oil service): Tag number: 90FV-10-1.
3. Type V-955, process solenoid valves (fuel oil service).

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PART 3 EXECUTION

3.01 ENGINE GENERATOR INSTALLATION

A. The engine generators shall be installed on the Site by the Contractor.

3.02 ENGINE CONTROL PANEL

A. Factory installed inside the enclosure.

3.03 TESTS

A. Factory Test: Each engine generator set shall be tested at the manufacturer's plant before shipment. The test shall consist of a steady load run of the durations listed below at each applied load rating with a load power factor of 0.8:

1. 25 percent load for 1 hour.
2. 50 percent load for 1 hour.
3. 75 percent load for 1 hour.
4. 100 percent load for 4 hours.

B. Complete test reports shall be made which shall show the generator output voltage, load current, oil pressure, and engine coolant temperature at 15-minute intervals. Test results shall be reviewed and approved by the Contractor, Owner, and Engineer prior to shipment of the equipment to the Site.

C. The Factory Tests on each Generator shall include:

1. Resistance of all windings (cold).
2. Insulation resistance of all windings.
3. High potential on all windings.
4. Open circuit saturation.
5. Voltage balance on windings.
6. Current balance on windings.
7. Voltage transient at rated kVA (voltage regulation, stability, and response).
8. Regulator range test (voltage adjust).
9. Phase sequence.
10. Mechanical balance (vibration).
11. Inherent voltage regulation.
12. Shaft currents with calculated summary of parallel operation.

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D. The factory test on the generator control panels and associated 480V switchgear shall include simulation of entire control system as specified in the functional requirements. Use of a laptop, or similar equipment, to simulate the Ethernet data exchange with the switchgear PLCs is also a requirement that must be verified as part of the factory test. An approved test plan must be in-place before scheduling a factory test. The Engineer and Owner will participate in the witnessed factory test of the switchgear and the associated generator control panels. Provide 4 weeks' notice to the Owner and Engineer before any factory test is conducted to allow witnessing the tests.

E. Field Test:

1. An in-place static alignment check of all rotating components shall be made prior to first startup, after units are secured in-place and all final connections are made.
2. Perform field relay coordination and calibration before conducting any tests.
3. At a time when the engine generator system is complete and the plant can be operated from the standby source, the generating set shall be given load and operational tests. The unit shall be operated at full and partial loads for at least 8 hours, including at least 1 hour at 25, 50, 75 percent rated load and 4 hours at 100 percent rated load. In addition, a 4-hour Performance Acceptance Test (PAT) shall be performed under plant load. During this test, the generator shall be loaded as shown in Table 1 of the Supplements. At least two motor starting tests shall be performed to verify specified performance for the preloads and motor loads. Tests shall utilize a recording oscillograph to print all transient voltage dips throughout the motor starting sequence. Complete transfer/retransfer operational tests shall be performed proving automatic and manual transfer. All specified functional requirements shall be verified by actual tests, including load assumption and transfer back to utility. Control system test must be jointly performed with the PICS Subcontractor. Show that data exchange between the generator PLC and the plant control system is working satisfactorily and the graphics at the plant HMI dynamically and accurately display all data acquired from generator PLC. Complete records shall be kept throughout the tests, including water temperature, oil pressure, ambient air temperature, voltage, current, frequency, kilowatts load, and power factor. Operational tests shall show that the system operates as specified, and shall include verification of preliminary alarm and shutdown functions, and check of other operational options available to the operator.

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4. Demonstrate engine generator safety shutdowns and performance results.
5. A vibration analysis shall be performed on each unit after all other tests have been completed and after a minimum of 24 hours running time has been accumulated on the engine. Required dynamic balancing shall be performed at this time to bring the running unit within the tolerance as specified.
6. Tests shall be conducted by an authorized representative of the manufacturer of the standby power system. Costs of this representative shall be included in the bid for this equipment. At least 5 working days' notice of beginning of test shall be given to the Owner and Engineer to allow witnessing of the test. Required instrumentation not included in the system equipment, and any supplemental load banks required to test the systems under rated load conditions shall be provided by the supplier. Upon completion of the tests, final adjustments and alignment check shall be made to the equipment, fuel, and oil filters shall be replaced, belt drive tensions checked, and the proper operation of all equipment demonstrated to the Contractor and the Owner's representative. The Owner and Engineer shall be instructed in the maintenance and operation of the equipment.

3.04 MANUFACTURERS' SERVICES

A. Manufacturer's Onsite Services shall include:

1. Assistance during product (system, subsystem, or component) installation to include observation, guidance, instruction of Contractor's assembly, erection, installation or application procedures.
2. Inspection, checking, and adjustment as required for product (system, subsystem, or component) to function as warranted by manufacturer and necessary to furnish Manufacturer's Certificate of Proper Installation.
3. Revisiting the site as required to correct problems and until installation and operation are acceptable to Contractor.
4. Resolution of assembly or installation problems attributable to, or associated with, respective manufacturer's products and systems.
5. Assistance during functional and performance testing, and facility startup and evaluation.
6. Training of Owner's personnel in the operation and maintenance of respective product as required.
7. Additional requirements may be specified elsewhere.
8. Assist the PICS Subcontractor and Owner’s consultant in testing control system via plant PLC system.

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B. Manufacturer's Certificate of Proper Installation:

1. A Manufacturer's Certificate of Proper Installation form shall be completed and signed by the equipment manufacturer's representative.
2. Such form shall certify that the signing party is a duly authorized representative of the manufacturer, is empowered by the manufacturer to inspect, approve, and operate their equipment and is authorized to make recommendations required to assure that the equipment is complete and operational.

C. Training:

1. Furnish manufacturers' representatives for detailed classroom and hands-on training to Owner's personnel on operation and maintenance of specified product (system, subsystem, component).
2. Furnish trained, articulate personnel to coordinate and expedite training, to be present during training coordination meetings with Owner, and familiar with operation and maintenance manual information specified in Division 1, General Requirements.
3. Manufacturer's representative shall be familiar with facility operation and maintenance requirements as well as with specified equipment.
4. Furnish complete training materials, to include operation and maintenance data, to be retained by each trainee.

D. Onsite Services:

1. Present at site or classroom designated by Contractor, the minimum person-days listed below, travel time excluded:
   a. 1 person-day for installation assistance and inspection.
   b. 2 person-days for functional and performance testing and completion of Manufacturer’s Certificate of Proper Installation including testing via plant PLC system.
   c. 2 person-days for prestartup classroom onsite training.
   d. 2 person-days for facility startup.

3.05 SUPPLEMENTS

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

1. Supplement 1, Table 1 – Load Analysis.
2. Supplement 2, Table 2 – Generator System PLC I/O Communication Requirements.
3. Supplement 3, Preliminary Generator Enclosure Layout Drawings.

END OF SECTION

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Williams WWTP Final Design

Save Save As Cancel **Sizing Id:** 10656575 | **Created By:** Greg Yarberry | **Created Date:** 01/04/2021 | **Modified Date:** 01/24/2021 5:34:51 PM

Define Site Conditions | Add Loads | Select Generator Set | Data & Reports

Download PDF Reports | Download Drawings & Spec Sheets | Create Guide Spec

Project Sizing Report

Sizing Id	10656575
Project Name	Williams WWTP Final Design
Customer Name	MAWSS
Region	U.S.
Prepared By	Greg Yarberry
Modified Date	24-Jan-2021

Electricity Supply	60 Hz 480/277 V
Connection	STAR
Max. Ambient Temperature	104.0 F
Altitude	1,000.0 Ft. A.S.L
Humidity	95%

Load Analysis Summary

Max Transient Load Step	396.6 SkVA / 295.1 SkW
Peak Transient Load Step	1,032.3 SkVA / 881.3 SkW
Final Running Load	875.9 kVA / 789.6 kW / 0.90 PF
Max Running Non Linear Load	710.1 RkVA
Maximum Running Load	875.9 kVA / 789.6 kW
Selection Criteria	Step 5 Peak SkW requirements

Generator Set

Generator Set Model	(1) of C32
Model Type	-
Voltage Regulator and Slope	CDVR 2:1 slope;
Feature Code	C32DR70
Fuel	Diesel
Sizing Methodology	Conventional
Capacity Used	82.9%

Nameplate Rating	1,000.0 ekW / 1,250.0 kVA / 0.8 PF
Site Output Rating	952.1 ekW / 1,190.1 kVA
Rating Type	Standby
Open / Enclosure	Open
UL Listed	Yes

Engine

Make/Model	C32
Aspiration	TA
Cylinder Configuration	VEE - 12
Speed	1800 RPM
Engine Performance Number	DM9933
Fuel Consumption at 100% Load	71.5 gph

Emissions / Certifications	EPA ESE
Governor	ADEM4
Aftercooler Type	ATAAC
Displacement	1,959 Cubic Inch / 32 Liter
Bore	145
Stroke	162

Alternator

Alternator Type / Frame Size	SR5 / 1402
Alternator Winding Pitch	0.6667
Excitation / Winding Type	IE / RANDOM
Alternator Arrangement Number	4326118
Subtransient Reactance X''d	0.1573

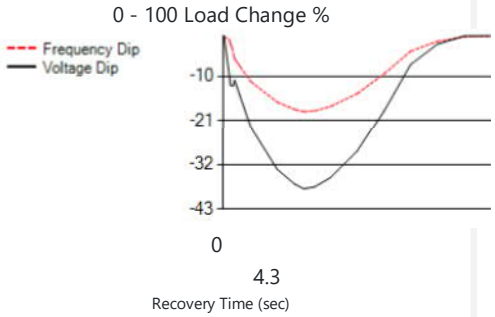
Insulation Class	H
Temperature Rise	125 C
Number Of Poles	4
Number of Leads	6
Rated Amps	1,503.5

**** See your Caterpillar dealer and/or Spec Sheet for technical information.

***** Package Power Tolerance: +/- 5%

Block Load(Only) Transient Response *

0 - 25	<5%	5.9	< 3
0 - 50	6.5	12.7	< 3
0 - 75	12.4	25.0	3.2
0 - 100	18.7	38.0	4.3



Transient Performance

Block Load (only) Transient Response values are at factory conditions with a resistive load. This information is representative of a typical Cat generator set, but is not guaranteed. Generator set block load capabilities at site conditions may vary from factory transient response test results due to site altitude, site ambient, and engine to engine variation.

Load Report

Project Name	Williams WWTP Final Design
Customer Name	MAWSS
Region	U.S.
Prepared By	Greg Yarberry
Modified Date	24-Jan-2021
Generator Set Model	(1) of C32

Electricity Supply	60 Hz 480/277 V
Rating Type	Standby
Max. Ambient Temperature	104.0 F
Altitude	1,000.0 Ft. A.S.L
Humidity	95%
Nameplate Rating	1,000.0 ekW / 1,250.0 kVA / 0.8 PF

Step 1													
1.1	1x30.00 kVA - Lighting Panel 20LP1: Fluorescent Lighting, Distr. 3-Phase	10%	20%			38.0	28.5	30.0	28.5				
1.2	1x30.00 kVA - Lighting Panel 20LP2: Fluorescent Lighting, Distr. 3-Phase	10%	20%			38.0	28.5	30.0	28.5				
1.3	1x30.00 kVA - Lighting Panel 20LP3: Fluorescent Lighting, Distr. 3-Phase	10%	20%			38.0	28.5	30.0	28.5				
1.4	1x30.00 kVA - Lighting Panel 20LP4: Fluorescent Lighting, Distr. 3-Phase	10%	20%			38.0	28.5	30.0	28.5				
1.5	1x30.00 kVA - Lighting Panel 20LP5: Fluorescent Lighting, Distr. 3-Phase	10%	20%			38.0	28.5	30.0	28.5				
1.6	1x30.00 kW - Power Panel 20PP1: Fluorescent Lighting, Distr. 3-Phase	10%	20%			40.0	30.0	31.6	30.0				
1.7	1x20.00 kW - Power Panel 20PP2: Fluorescent Lighting, Distr. 3-Phase	10%	20%			26.7	20.0	21.1	20.0				
1.8	1x25.00 kW - Power Panel 20PP4 : Fluorescent Lighting, Distr. 3-Phase	10%	20%			33.3	25.0	26.3	25.0				
1.9	2x60.00 HP - Plant Drain Pumps 1 and 2: NEMA, 3-Phase Motor, VFD, 110% Current Limit, Single Operating Point, 6 Pulse	10%	20%			11.4	10.3	114.3	102.9				
1.10	2x5.00 HP - Polymer Water Booster Pump 1 and 2: NEMA, 3-Phase Motor, VFD, 110% Current Limit, Single Operating Point, 6 Pulse	10%	20%			1.1	1.0	10.9	9.8				
1.11	4x1.00 HP - Exhaust Fans: NEMA, 3-Phase Motor, Across the line, Loaded, Single Operating Point, NEMA L	10%	20%			38.0	26.6	5.4	4.0				
1.12	1x3.00 HP - Exhaust Fans: NEMA, 3-Phase Motor, Across the line, Loaded, Single Operating Point, NEMA J	10%	20%			22.6	13.8	3.5	2.7				
1.13	1x25.00 kW - Power Panel 20PP3: Fluorescent Lighting, Distr. 3-Phase	10%	20%			33.3	25.0	26.3	25.0				
1.14	2x5.00 HP - Hydronic Pump 1 and 2: NEMA, 3-Phase Motor, VFD, 110% Current Limit, Single Operating Point, 6 Pulse	10%	20%			1.1	1.0	10.9	9.8				
	Step 1 Total	**10%**	**20%**	**<5%**	**7.1%**	**396.6**	**295.1**	**399.0**	**371.7**				
	Total Through Step 1									**528.7**	**417.6**	**399.0**	**371.7**

Step 2													
2.1	2x30.00 HP - Digested Sludge Pumps 1 and 2: NEMA, 3-Phase Motor, VFD, 110% Current Limit, Single Operating Point, 6 Pulse	10%	20%			5.9	5.3	59.2	53.3				
2.2	1x3.00 HP - Mechanical Grinder: NEMA, 3-Phase Motor, Across the line, Loaded, Single Operating Point, NEMA J	10%	20%			22.6	13.8	3.5	2.7				
2.3	1x5.00 HP - Mechanical Grinder: NEMA, 3-Phase Motor, Across the line, Loaded, Single Operating Point, NEMA H	10%	20%			33.5	19.1	5.6	4.4				
2.4	1x20.00 HP - Smith Sludge Pump 1: NEMA, 3-Phase Motor, Across the line, Loaded, Single Operating Point	10%	20%			106.0	47.7	19.7	16.6				
2.5	2x7.50 HP - Biosolids Holding Tank Mixers: NEMA, 3-Phase Motor, Across the line, Loaded, Single Operating Point, NEMA G	10%	20%			89.1	47.2	16.1	13.0				
2.6	1x5.00 HP - Polymer Mixing Pump : NEMA, 3-Phase Motor, Across the line, Loaded, Single Operating Point, NEMA H	10%	20%			33.5	19.1	5.6	4.4				
	Step 2 Total	**10%**	**20%**	**<5%**	**<5%**	**289.1**	**152.2**	**109.3**	**94.4**				
	Total Through Step 2									**711.8**	**577.2**	**507.3**	**466.1**
Step 3													
3.1	2x10.00 HP - Conveyors 7 and 8: NEMA, 3-Phase Motor, Across the line, Loaded, Single Operating Point, NEMA G	10%	20%			118.8	60.6	20.9	17.1				
3.2	2x5.00 HP - Conveyors 1 and 2: NEMA, 3-Phase Motor, Across the line, Loaded, Single Operating Point, NEMA H	10%	20%			67.0	38.2	11.2	8.9				
3.3	2x7.50 HP - Conveyors 3 and 4: NEMA, 3-Phase Motor, Across the line, Loaded, Single Operating Point, NEMA G	10%	20%			89.1	47.2	16.1	13.0				
3.4	2x7.50 HP - Conveyors 5 and 6: NEMA, 3-Phase Motor, Across the line, Loaded, Single Operating Point, NEMA G	10%	20%			89.1	47.2	16.1	13.0				
	Step 3 Total	**10%**	**20%**	**<5%**	**5.4%**	**363.9**	**193.2**	**64.2**	**52.0**				
	Total Through Step 3									**832.6**	**659.3**	**570.1**	**518.2**

Step 4													
4.1	4x20.00 HP - BFP Sludge Feed Pump: NEMA, 3-Phase Motor, VFD, 110% Current Limit, Single Operating Point, 6 Pulse	10%	20%			8.0	7.2	79.9	71.9				
4.2	4x15.00 HP - BFP Washwater Pumps: NEMA, 3-Phase Motor, VFD, 110% Current Limit, Single Operating Point, 6 Pulse	10%	20%			6.1	5.5	60.6	54.6				
4.3	4x0.50 HP - BFP Sludge Distributor: NEMA, 3-Phase Motor, VFD, 110% Current Limit, Single Operating Point, 6 Pulse	10%	20%			0.3	0.2	2.7	2.4				
4.4	4x3.00 HP - BFP Gravity Belt: NEMA, 3-Phase Motor, VFD, 110% Current Limit, Single Operating Point, 6 Pulse	10%	20%			1.3	1.2	13.4	12.1				
4.5	4x7.50 HP - BFP Belt Drive: NEMA, 3-Phase Motor, VFD, 110% Current Limit, Single Operating Point, 6 Pulse	10%	20%			3.1	2.8	31.5	28.3				
4.6	4x2.00 HP - BFP Hydraulic Tensioning System: NEMA, 3-Phase Motor, Across the line, Loaded, Single Operating Point, NEMA K	10%	20%			68.0	43.5	9.9	7.6				
	Step 4 Total	**10%**	**20%**	**<5%**	**<5%**	**85.5**	**60.4**	**197.7**	**176.8**				
	Total Through Step 4									**839.0**	**747.8**	**767.7**	**695.0**

Step 5													
5.1	1x75.00 HP - Future Reactor Feed Pump: NEMA, 3-Phase Motor, VFD, 110% Current Limit, Single Operating Point, 6 Pulse	10%	20%			7.1	6.4	70.6	63.6				
5.2	1x1.00 HP - Future Ammonia Scrubber: NEMA, 3-Phase Motor, Across the line, Loaded, Single Operating Point, NEMA L	10%	20%			9.5	6.7	1.4	1.0				
5.3	3x10.00 HP - Future Transfer Cake Conveyor: NEMA, 3-Phase Motor, Across the line, Loaded, Single Operating Point, NEMA G	10%	20%			178.2	90.9	31.4	25.7				
5.4	1x0.50 HP - Future Sulfamic Acid Feeder: NEMA, 3-Phase Motor, Across the line, Loaded, Single Operating Point, NEMA M	10%	20%			5.3	4.0	0.7	0.5				
5.5	1x1.50 HP - Future Silo Bin Activator: NEMA, 3-Phase Motor, Across the line, Loaded, Single Operating Point, NEMA K	10%	20%			12.8	8.5	1.9	1.4				
5.6	1x0.33 HP - Future Silo Bin Dust Activator: NEMA, 3-Phase Motor, Across the line, Loaded, Single Operating Point, NEMA M	10%	20%			5.3	4.0	0.5	0.3				
5.7	1x2.00 HP - Future Lime Silo Feeder: NEMA, 3-Phase Motor, VFD, 110% Current Limit, Single Operating Point, 6 Pulse	10%	20%			0.2	0.2	2.3	2.1				
	Step 5 Total	**10%**	**20%**	**<5%**	**<5%**	**216.4**	**120.7**	**108.4**	**94.7**				
	Total Through Step 5									**1,032.3**	**881.3**	**875.9**	**789.6**

Load Analysis Summary : Generator set meets site requirements

						Maximum Step				Maximum Peak		Final Running	
						SkVA	SkW			SkVA	SkW	kVA	kW
						396.6	295.1			1,032.3	881.3	875.9	789.6

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TABLE 2
GENERATOR SYSTEM
PLC I/O COMMUNICATION REQUIREMENTS

Signal Description	PLC Hard Wired I/O				PLC Data Link				Remarks
					Bits		Words		
	DI	DO	AI	AO	Read	Write	Read	Write	
Generator 1 Out-Of-Service	1				1				General: Control switch not in AUTO
START Generator 1		1							
Generator 1 Running	1				1				
STOP Generators 1		1							
Generators 1 OFF	1				1				
20LVSG-1 Main Bkr Bus A Open/Closed Status	2				2				
20LVSG-1 Main Bkr Bus A Open/Close Commands		2				2			
20LVSG-1 Main Bkr Bus C Open/Closed Status	2				2				
20LVSG-1 Main Bkr Bus C Open/Close Commands		2				2			
20LVSG-1 GBTB1/GBTB2 Open/Close Status	4				4				
20LVSG-1 GBTB1/GBTB2 Open/Close Commands		4				4			
20LVSG-1 Bus A Feeder F1/F3/F5/F7 Open/Closed Status	8				8				

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TABLE 2
GENERATOR SYSTEM
PLC I/O COMMUNICATION REQUIREMENTS

Signal Description	PLC Hard Wired I/O				PLC Data Link				Remarks
					Bits		Words		
	DI	DO	AI	AO	Read	Write	Read	Write	
20LVSG-1 Bus A Feeder F1/F3/F5/F7 Open/Close Commands		8				8			
20LVSG-1 Bus C Feeder F2/F4/F6/F8 Open/Close Status	8				8				
20LVSG-1 Bus C Feeder F2/F4/F6/F8 Open/Close Commands		8				8			
20LVSG-1 Bus B Generator Breaker Open/Closed Status	2				2				
20LVSG-1 Bus B Generator Breaker Open/Close Commands		2				2			
20LVSG-1 Bus B Load Bank Breaker Open/Close Status	2				2				
20LVSG-1 Bus B Load Bank Breaker Open/Close Commands		2				2			
20LVSG-1 Bus A V, Hz, KW, KWh			4				4		
20LVSG-1 Bus B V, Hz, KW, KWh			4				4		
20LVSG-1 Bus C V, Hz, KW, KWh			4				4		
Generator 1 Governor Control			4	4					
AOTM Switch in AUTO, TEST, MANUAL, or OFF positions	4				4				

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TABLE 2
GENERATOR SYSTEM
PLC I/O COMMUNICATION REQUIREMENTS

Signal Description	PLC Hard Wired I/O				PLC Data Link				Remarks
					Bits		Words		
	DI	DO	AI	AO	Read	Write	Read	Write	
Number of Generators to be Started								1	Value sent to PLC
Start Generator System for Load Test						1			
Generator System Ready for Load Transfer	1				1				
Generator 1 Alarms	17				17				There are 17 points per generator[1]; see Specifications
Generator 1 RUN TIME							4		
Miscellaneous status	20				20				
Split Bus Operation on Bus “A”								1	
Split Bus Operation on Bus “C”								1	
480V Switchgear Battery Charger Failure	1				1				
Generator 1 Battery Charger Failure	1				1				
Fuel Tank Level			1						
Fuel Tank LOW LEVEL	1								
Fuel Tank LEAK	1								
Engine Generator IN AUTO	1								

Note: Read implies CS reading from PLC write implies CS writing to PLC.

[1] Signal list in this table is not all inclusive, and is for guidance only. The Electrical Subcontractor shall provide all I/O required for satisfactory operation of the generator system.

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YANCEY ENGINEERED SOLUTIONS

GRIFFIN, GA

DRAWINGS PREPARED FOR:

YPS -EPG DEPARTMENT

PROJECT NAME: WILLAIMS WWTP

C32 1,000KW W/ ALUMINUM UL2200 SOUND ATTENUATED ENCLOSURE

YES JOB # XX-XXXX DATE: 3/30/2020

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APP'D
ALL	A	ORIGINAL SUBMITTAL	3/6/2020	BAK
ALL	B	CUSTOMER COMMENTS	3/30/2020	DMG

DRAWING SET OUTLINE	
SHEET 1	COVER SHEET
SHEET 2	BILL OF MATERIALS
SHEET 3	ELEVATION VIEWS
SHEET 4	ELEVATION VIEWS
SHEET 5	ELECTRICAL DETAILS
SHEET 6	PLAN VIEWS

PROJECT NOTES:

1) GENSET: CATERPILLAR C32, 1,000KW
   WEIGHT: 20,000 LBS.
   DIMENSIONS: 164.00"L X 66.30"W X 85.10"H
   ENGINE DWG # 552-7044
2) ENCLOSURE WALLS: 0.08 ALUMINUM PANELS
3) ENCLOSURE FRAME: 2"x4"x0.125" AL TUBING. (B)
4) ENCLOSURE COLOR: TBD.
5) TOTAL PACKAGE WEIGHT: 44,000 LBS
6) INTERIOR LINING: PERFORATED GALVANIZED STEEL
7) SOUND ATTENUATION LEVEL: 65dBA@23FT (AVG FREE FIELD)
8) SOUND ATTENUATION MATERIAL: 4" HEAVY MINERAL WOOL. (B)
9) TANK SHALL BE PROVIDED W/8-POINT LIFTING EYES.
10) ENCLOSURE UL 2200 LISTED, 160MPH WIND LOAD. (B)
11) DESIGN AIR FLOW:
    INTO ENCLOSURE: 40,733 CFM, 0.0710 LBS./FT3
    OUT OF ENCLOSURE: 44,559 CFM, 0.06F1 LBS./FT3
    MAX AMBIENT SPEC: 123°F@2460FT ASL.
12) SUBBASE INFORMATION:
    SUBBASE WEIGHT (DRY): 10,700 LBS

GENERAL NOTES:

1) DIMENSIONS AND WEIGHTS PROVIDED IN THESE DOCUMENTS ARE ESTIMATES BASED ON CALCULATION. FINAL ACTUAL WEIGHTS AND DIMENSIONS WILL BE VERIFIED BY YANCEY ENGINEERED SOLUTIONS (YES) AT TIME OF SHIPMENT. CAT DEALER TO PROVIDE PROPER NOTICE FOR PICKUP TO ALLOW COORDINATION AND COMMUNICATION OF KEY INFORMATION FOR PERMITS, LIFTING, AND SITE CRANE SIZING (BY OTHERS).

2) SIGNED DRAWINGS ARE REQUIRED BY DEALER PRIOR TO PRODUCTION RELEASE. SIGNED PRODUCTION DRAWINGS CONTAINING ALL INFORMATION HEREIN WILL SUPERCEDE ANY VERBAL OR WRITTEN SPECIFICATIONS.

3) ALL WARRANTY WORK PERFORMED BY PURCHASING DEALER MUST BE PRE-APPROVED BY YES.

4) REFER TO YES STANDARD TERMS AND CONDITIONS.

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APPROVED AS NOTED ☐
REVISE AS NOTED, RESUBMIT ☐

SIGNATURE _____ DATE _____

NAME (PLEASE PRINT) _____ TITLE _____

CUSTOMER: YPS-EPG DEPARTMENT

THIRD-ANGLE PROJECTION

REFERENCE: ALUMINUM 0.080" SKIN ON ALUMINUM 2x4x.125 TUBING

UNITS REQ'D: 2

DO NOT SCALE

REVISION B

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YANCEY ENGINEERED SOLUTIONS
96 ETHRIDGE MILL IND PARK
GRIFFIN, GA30224

DATE 3/30/2020

WILLIAMS WWTP
GENERAL ARRANGEMENT SUBMITTAL
COVER SHEET

DRW.	BAK	JOB SERIAL NO.	XX-XXXX
CHK.	KYB		
APP.	X		
APP.	X	SCALE: NTS	SHEET 1 OF 6

created using AutoCAD

ITEM	QTY.	ITEM DESCRIPTION	SHT #	SUPPLIER	MFG. DWG. #
1	1	CUSTOMER PROVIDED CATERPILLAR C32 (1,000kW) GENSET.	3,4,6	YPS	552-7044
2	1	ENCLOSURE: 2"x4"x0.125" ALUM. TUBING COVERED IN 0.08 ALUMINUM PANELS. SLOPED ROOF. B	3,4	YES	
		UL2200 LEVEL 2 SOUND ATTENUATED ENCLOSURE. 65dBA@25FT (AVG FREE FIELD). WALK-IN DESIGN.			
3	4	MAINTENANCE ACCESS DOORS FITTED WITH WATERTIGHT RUBBER SEALS, DRIP LEDGES AND ALL FITTED WITH		YES	
		HEAVY DUTY REFRIGERATOR STYLE CHROME PLATED HANDLES, KEYED-ALIKE & PAD LOCKABLE, STEEL PIANO			
		HINGE. FITTED WITH PANIC RELEASE & A DOOR-HOLD-BACK LATCH.			
4	1	REAR MOUNTED PLENUM W/ BIRDSCREENING FOR VERTICAL AIR INTAKE, FITTED W/ MOTORIZED LOUVERS.	3	YES	CD-100
5	1	FRONT PLENUM FITTED WITH GRAVITY FED DISCHARGE LOUVERS FOR VERTICAL RADIATOR AIR DISCHARGE.	3	YES	CB-600
6	1	EXHAUST SILENCER: ø54x16, CRITICAL GRADE, INTERNALLY INSULATED, DISC-TYPE.	3,4	YES	
		PROVIDE EXHAUST DRAIN WITH PETCOCK TO EXTERIOR.			
7	1	EXHAUST ELBOW WITH WELDED RAINGUARD. (SHIP LOOSE).	3,4	YES	
8	1	FLEXIBLE CONNECTOR TO ENGINE.	3,4	YES	
9	1	RAINCAP (SHIP LOOSE).	3	YES	
10	1	OIL & WATER DRAIN BULKHEAD FITTINGS.	3	YES	
11	1	HEAVY DUTY STEEL SUBBASE FRAME WITH WELDED 2" RAINGUARD, ELECTRICAL STUB-UP AREA INCLUDED.	3,4,6	YES	
		FOUR POINT LIFT. LIFTING LUGS ARE WELDED TO SUBBASE AND RATED TO LIFT COMPLETE PACKAGE.			
		PAINTED WITH TWO COATS OF BLACK FINISH.			
12	4	24VDC INTERIOR, LED, VAPOR PROOF LIGHT FIXTURES. B	3,5	YES	
13	1	60 MINUTE TIMER FOR ITEM# 12. B	3,5	YES	
14	1	EXHAUST FAN WITH WEATHER HOOD INSTALLED IN DISCHARGE WALL. B	3,5	YES	
15	2	4.5kW SPACE HEATER, THERMOSTATICALLY CONTROLLED. B	3,5	YES	
16	1	EXHAUST FAN THERMOSTAT. B	3,5	YES	
17	1	CAT BATTERY SET (2) AND RACK.	3	YPS	
18	1	10A BATTERY CHARGER.	3,6	YPS	
19	4	100W EXTERIOR LED WALL PACK LIGHTS (SHIP LOOSE). B	3,5	YES	
20	1	PHOTOCELL FOR WALL PACK LIGHTS (SHIP LOOSE). B	5	YES	
21	1	100A, 120/208V, 3Ø, BASIC CIRCUIT BREAKER TYPE LOAD CENTER.	3,6	YES	
22	4	120VAC INTERIOR, 48" LED LIGHTS WITH PROTECTIVE GUARD.	3,6	YES	
23	2	3-WAY SWITCH, WALL MOUNTED.	3,6	YES	
24	2	GFCI DUPLEX RECEPTACLES.	3,6	YES	
25	1	30kVA DRY TRANSFORMER, 480V PRIMARY, 120/208V SECONDARY, 3Ø. MOUNTED ON WALL.	3,5	YES	
26	1	60AT/60AF FUSED DISCONNECT SWITCH, NEMA-1, 480V, 3Ø.	3,4	YES	
27	1	SMALL DOCUMENT HOLDER.	3,4,7	YPS	
28	2	ALUMINUM PERSONAL TRAVEL RESTRAINT SYSTEM TIE-OFF.			
29	6	VIBRATION ISOLATORS.			

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APP'D
ALL	A	ORIGINAL SUBMITTAL	3/6/2020	BAK
ALL	B	CUSTOMER COMMENTS	3/30/2020	DMG

YANCEY ENGINEERED SOLUTIONS

SHIP LOOSE ITEMS TO BE INSTALLED AT SITE BY OTHERS

ITEM	QTY.	ITEM DESCRIPTION
7	1	EXHAUST ELBOW.
9	1	RAINCAP.
19	4	LED WALLPACK LIGHTS B
20	1	PHOTOCELL B
	1	CAT BOX.

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APPROVED AS NOTED ☐
REVISE AS NOTED, RESUBMIT ☐

SIGNATURE _____ DATE _____

NAME (PLEASE PRINT) _____ TITLE _____

CUSTOMER: YPS-EPG DEPARTMENT B

REFERENCE: ALUMINUM 0.080" SKIN ON ALUMINUM 2x4x.125 TUBING

UNITS REQ'D: 2

THIRD-ANGLE PROJECTION

DO NOT SCALE

REVISION: B

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YANCEY ENGINEERED SOLUTIONS
96 ETHRIDGE MILL IND PARK
GRIFFIN, GA30224

DATE: 3/30/2020

WILLIAMS WWTP
GENERAL ARRANGEMENT SUBMITTAL
B.O.M.

DRW.	BAK
CHK.	KYB
APP.	X
APP.	X

JOB SERIAL NO. XX-XXXX

SCALE: NTS

SHEET 2 OF 6

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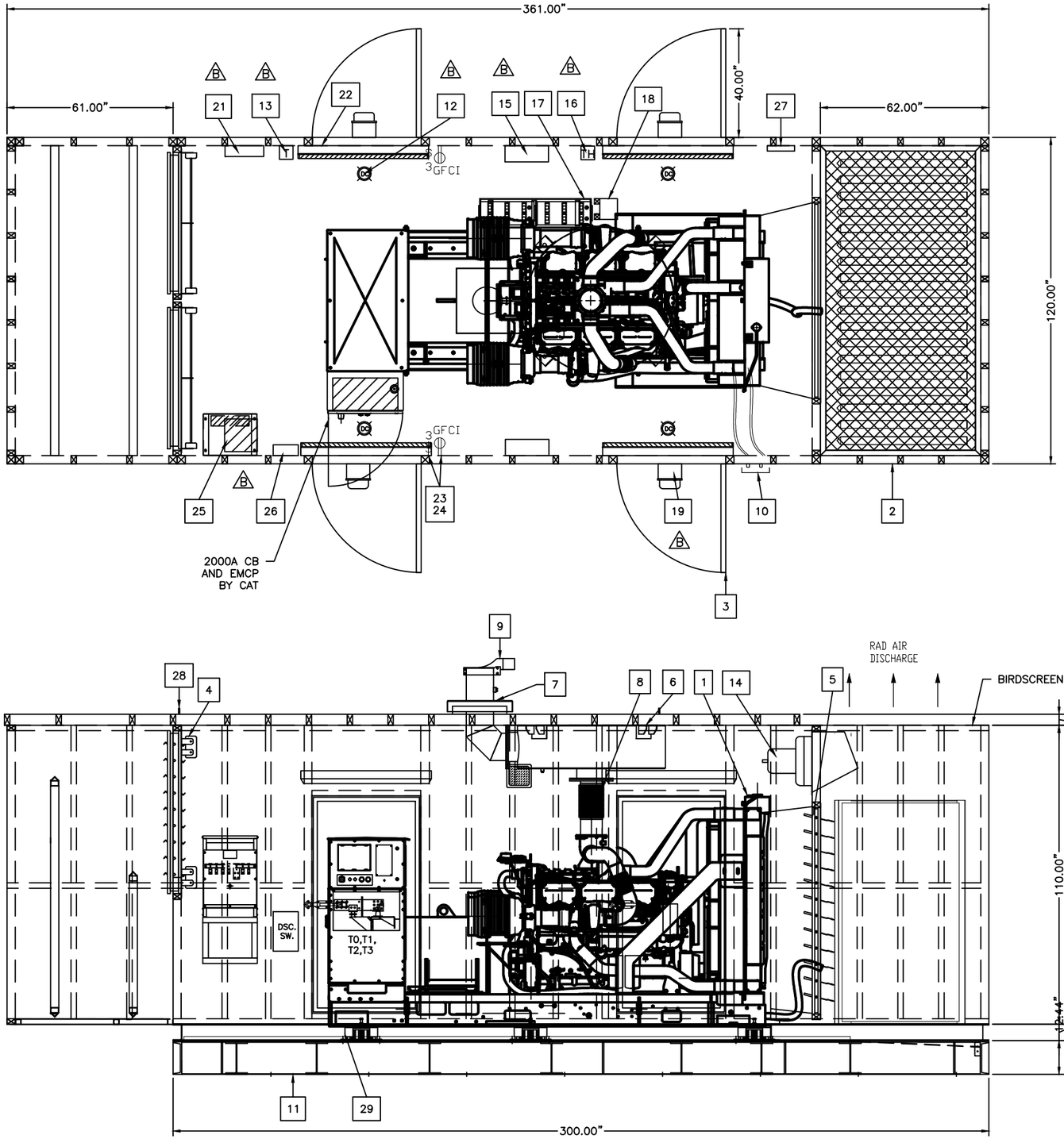
REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APP'D
ALL	A	ORIGINAL SUBMITTAL	3/6/2020	BAK
ALL	B	CUSTOMER COMMENTS	3/30/2020	DMG



TOP VIEW

RIGHT SIDE VIEW

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CUSTOMER: YPS–EPG DEPARTMENT	THIRD–ANGLE PROJECTION
REFERENCE: ALUMINUM 0.080" SKIN ON ALUMINUM 2x4x.125 TUBING	DO NOT SCALE
UNITS REQ'D: 2	REVISION B
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YANCEY ENGINEERED SOLUTIONS — 96 ETHRIDGE MILL IND PARK, GRIFFIN, GA30224	DATE 3/30/2020

WILLIAMS WWTP
GENERAL ARRANGEMENT SUBMITTAL
ELEVATION VIEWS

DRW.	BAK	JOB SERIAL NO.	
CHK.	KYB	XX–XXXX	
APP.	X		
APP.	X	SCALE: NTS	SHEET 3 OF 6

created using AutoCAD

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APP'D
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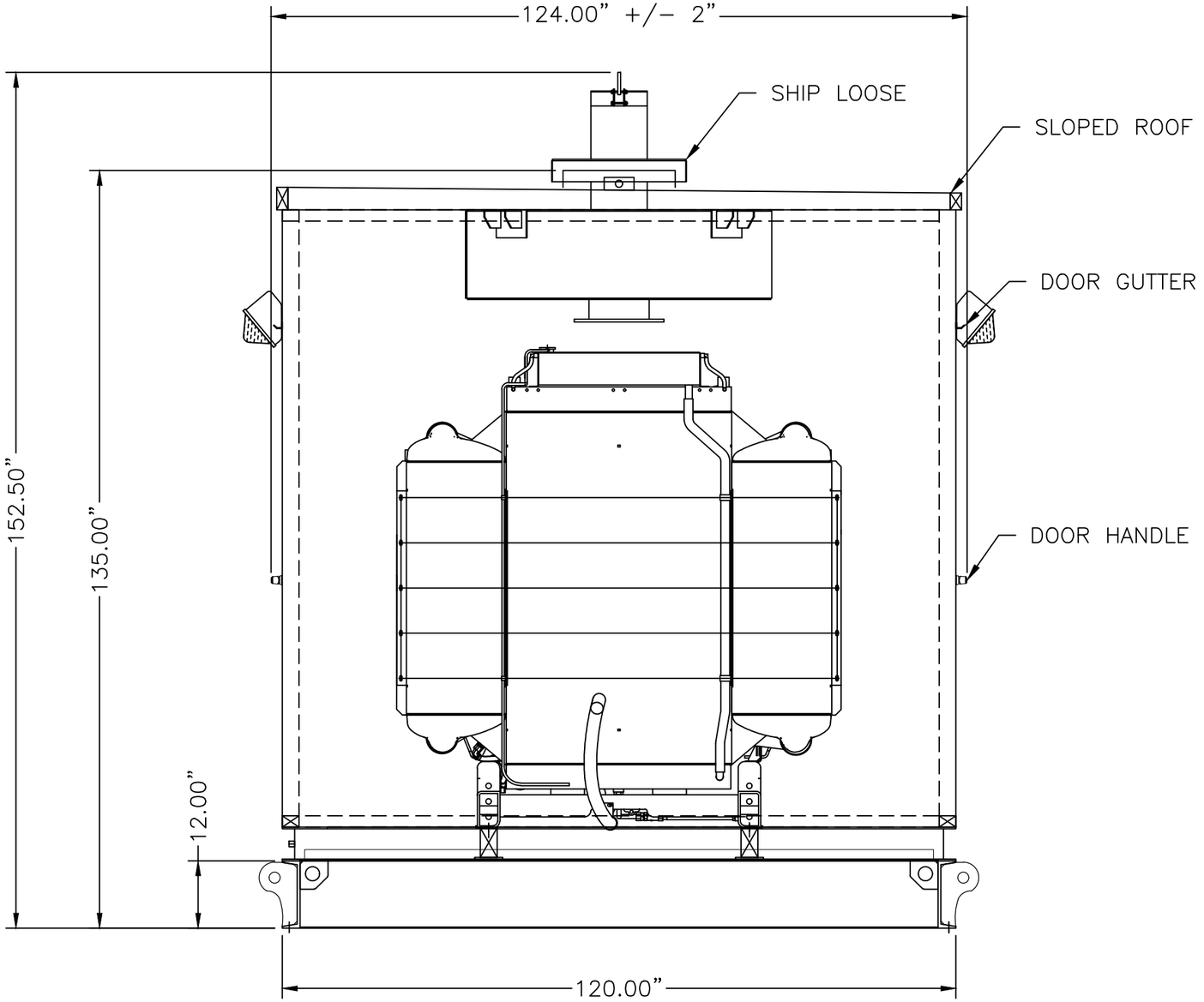
ALL	B	CUSTOMER COMMENTS	3/30/2020	DMG



FRONT VIEW

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SIGNATURE | DATE

NAME (PLEASE PRINT) | TITLE

CUSTOMER:
YPS–EPG DEPARTMENT

THIRD–ANGLE PROJECTION

REFERENCE: ALUMINUM 0.080" SKIN ON ALUMINUM 2x4x.125 TUBING

UNITS REQ'D: 2

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96 ETHRIDGE MILL IND PARK
GRIFFIN, GA30224

DATE
3/30/2020

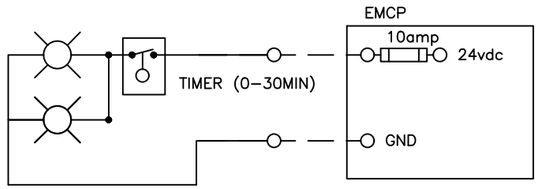
WILLIAMS WWTP
GENERAL ARRANGEMENT SUBMITTAL
ELEVATION VIEWS

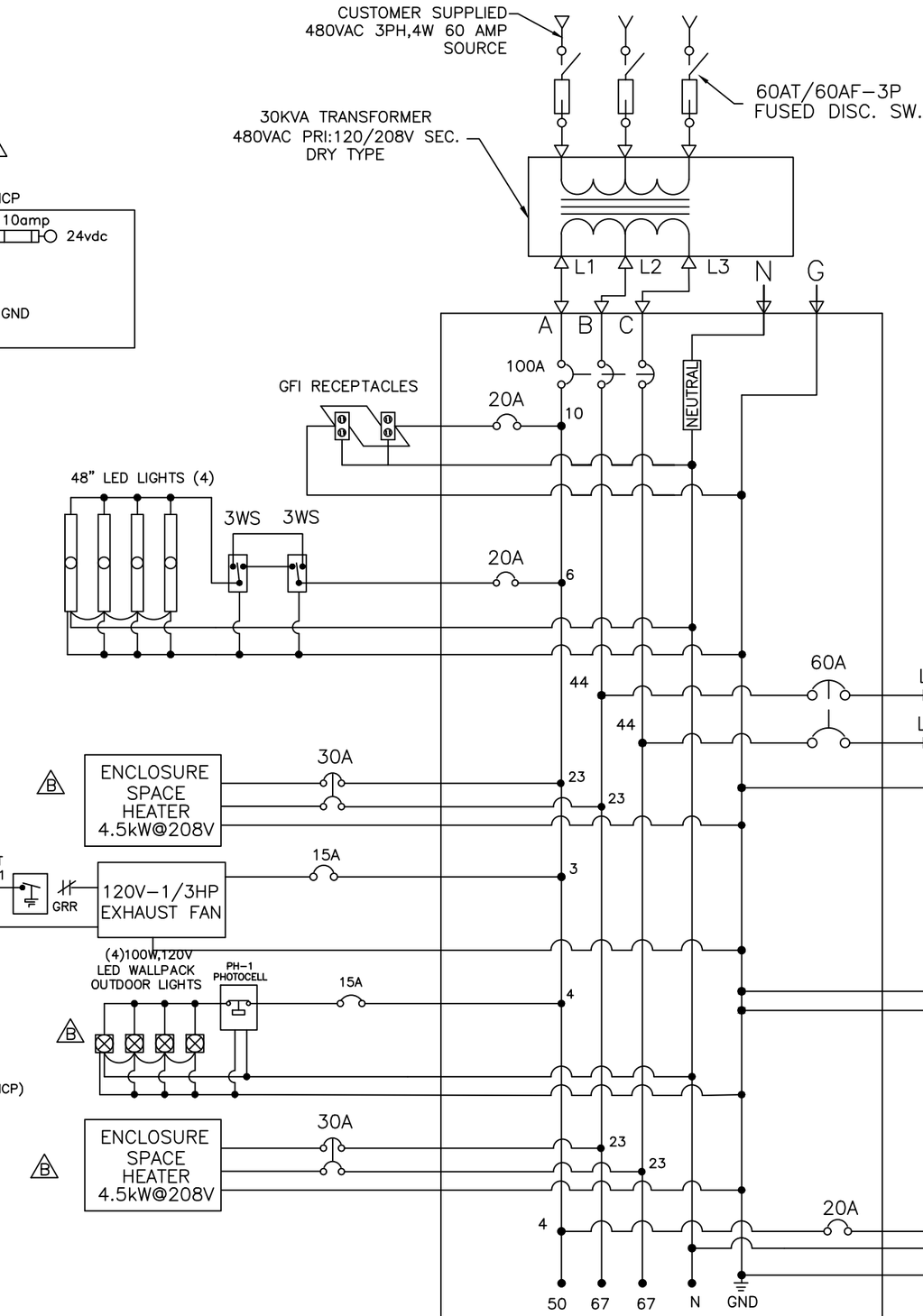
DRW.	BAK	JOB SERIAL NO.	
CHK.	KYB	XX–XXXX	
APP.	X		
APP.	X	SCALE: NTS	SHEET 4 OF 6

created using AutoCAD

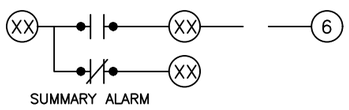
REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APP'D
ALL	A	ORIGINAL SUBMITTAL	3/6/2020	BAK
ALL	B	CUSTOMER COMMENTS	3/30/2020	DMG

DC LED LIGHTING: B





BATTERY CHARGER ALARMS (BY DEALER)



B

LIGHTING & POWER PANEL LOAD SCHEDULE

DESCRIPTION	TRIP	POLE	AMP LOAD PHASE L1	AMP LOAD PHASE L2	AMP LOAD PHASE L3	POLE	TRIP	
RECEPTACLES (GFCI)	20	1	10	44		2	60	GENSET JACKET WATER HEATER
INTERIOR LED LIGHTS	20	1	6		44	–	–	GENSET JACKET WATER HEATER
	–	–	4			1	20	BATTERY CHARGER
SPACE HEATER#1	30	1	23			–	–	
SPACE HEATER#1	–	–		23		–	–	
EXHAUST FAN	15	1	3			–	–	
LED WALLPACK LIGHTS	15	1	4			–	–	
SPACE HEATER#2	30	2		23		–	–	
SPACE HEATER#2	–	–			23	–	–	
TOTAL LOAD PER PHASE	–	–	50	67	67			
MAIN CIRCUIT BREAKER SIZE	100A							

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REVISE AS NOTED, RESUBMIT ☐

SIGNATURE DATE

NAME (PLEASE PRINT) TITLE

CUSTOMER:
YPS–EPG DEPARTMENT

THIRD–ANGLE PROJECTION

REFERENCE: ALUMINUM 0.080" SKIN ON ALUMINUM 2x4x.125 TUBING

UNITS REQ'D: 2

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YANCEY ENGINEERED SOLUTIONS | 96 ETHRIDGE MILL IND PARK GRIFFIN, GA30224 | DATE 3/30/2020

WILLIAMS WWTP
GENERAL ARRANGEMENT SUBMITTAL
ELECTRICAL DETAILS

DRW.	BAK	JOB SERIAL NO.	
CHK.	KYB	XX–XXXX	
APP.	X		
APP.	X	SCALE: NTS	SHEET 5 OF 6

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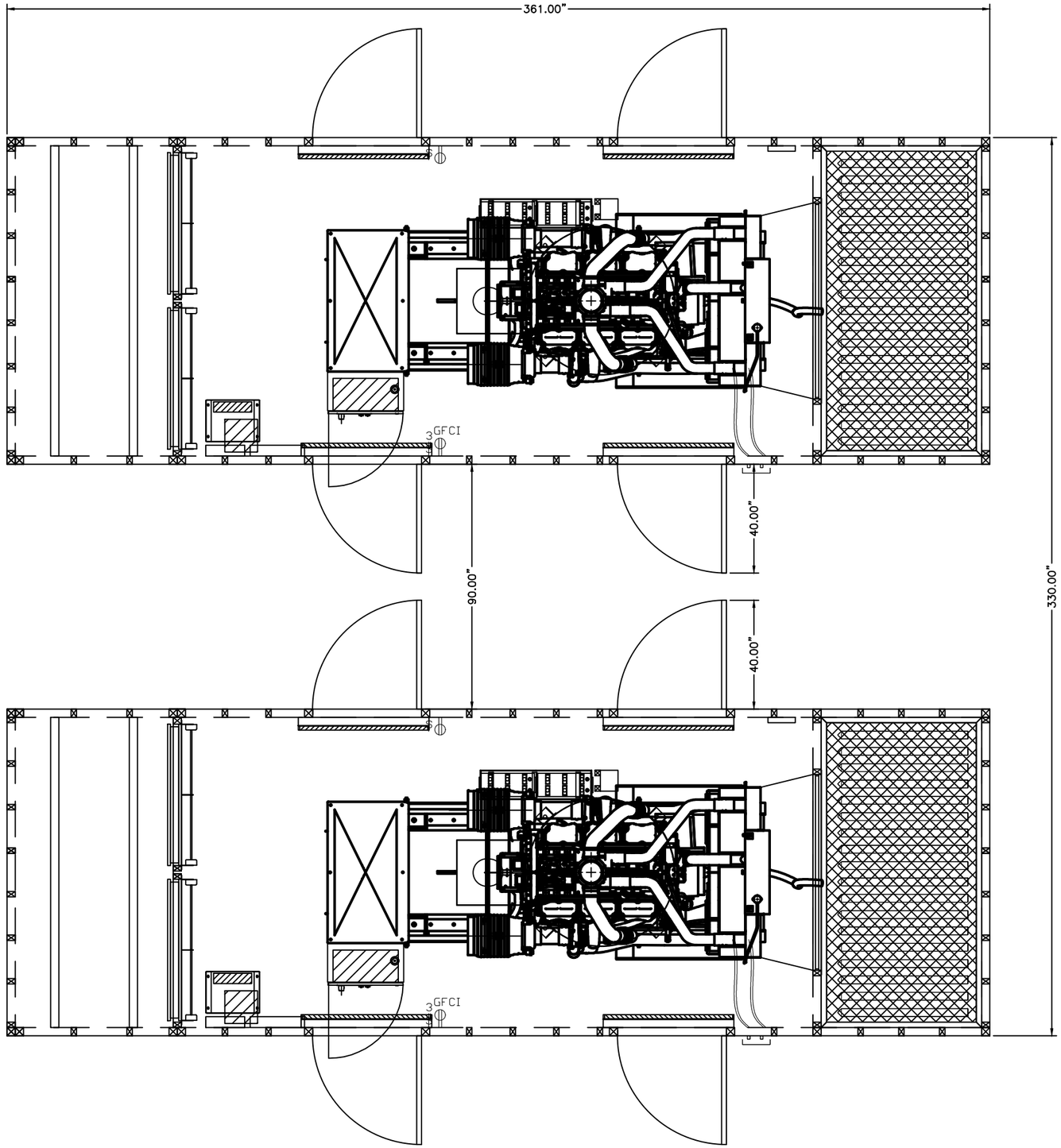
REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APP'D
ALL	A	ORIGINAL SUBMITTAL	3/6/2020	BAK
ALL	B	CUSTOMER COMMENTS	3/30/2020	DMG



TOP VIEW

TOP VIEW

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SIGNATURE | DATE

NAME (PLEASE PRINT) | TITLE

CUSTOMER:
YPS–EPG DEPARTMENT

THIRD–ANGLE PROJECTION

REFERENCE: ALUMINUM 0.080" SKIN ON ALUMINUM 2x4x.125 TUBING

UNITS REQ'D: 2

DO NOT SCALE

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B

YANCEY ENGINEERED SOLUTIONS
96 ETHRIDGE MILL IND PARK
GRIFFIN, GA30224

DATE
3/30/2020

WILLIAMS WWTP
GENERAL ARRANGEMENT SUBMITTAL
PLAN VIEWS

DRW.	BAK
CHK.	KYB
APP.	X
APP.	X

JOB SERIAL NO.
XX–XXXX

SCALE: NTS

SHEET 6 OF 6

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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 structures:

1. New Dewatering and Controls Building.
2. New Chlorine and SO2 Building.

B. 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. Electronic CAD Drawings:
   a. Lightning protection system layout.
   b. Component locations.
   c. Detailed plans.
2. Down conductor.
3. Connecting conductor.
4. Bond strap.
5. Air terminals.
6. Fittings.
7. Connectors.
8. Ground rods.

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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 the designer.

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.

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.

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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. However, the specific material to be used shall be coordinated with the roof material of the associated structure that is to be protected.

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, or Solid aluminum if required by the specific roof material used, with tapered or blunt points as required for application.
2. Diameter: 1/2 inch minimum.
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 Conductor: Smooth twist stranding as determined by the system designer
3. Connecting Conductor: Concentric stranding as determined by the system designer.
4. Bonding Conductor: Flexible strap, minimum 3/4-inch wide by 1/8-inch thick as determined by the system designer.
5. Main down and connecting conductors shall bear the UL 96 Label A, applied every 10 feet.
6. Grounding Conductors: Stranded bare copper.

C. Cable Fastener and Accessories: Capable of withstanding minimum pull of 100 pounds.

D. Fittings:

1. Heavy-duty.
2. Bolts, Screws, and Related Hardware: Stainless steel.

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E. Ground Rods:

1. Material: Copper-clad.
2. Diameter: 3/4 inch.
3. Length: 10-foot segmented ground rods with provisions to add additional 10-foot segments if required.

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 pitchpockets 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 foot.
   b. Horizontal: 4 foot.
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, sewer, and other system 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. Critec TDX200M Modular Series.

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: -50dB 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
240 Δ	--	--	1200	1200
480 Δ	--	--	2000	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): 20kA.

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2.04 PANELBOARD SPD

A. Provide SPD meeting IEEE C62.41.1 and IEEE C62.41.2 Location in accordance with Category B.

B. Surge Current Capacity:

1. Distribution: 120 kA per phase; 60 kA per mode.
2. Branch: 80 kA per phase; 40 kA per mode

C. Maximum Continuous Operating Voltage (MCOV): Not less than 125% of the nominal system voltage.

D. Nominal Discharge Current (I_N): 10kA.

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 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 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.

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PART 3 EXECUTION

3.01 APPLICATION REQUIREMENTS

A. Provide SPDs when indicated on Drawings or in the equipment specifications.

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 30-60-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 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.

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10. National Electrical Manufacturers Association (NEMA).
11. National Fire Protection Association (NFPA): 255, Standard Method of Test of Surface Burning Characteristics of Building Materials
12. Underwriters Laboratories Inc. (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. 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.
   b. Manufacturer’s standard finish color selection for enclosure finishes.
   c. 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 cooling performance data at design operating conditions.
   d. Air Pressurization Unit: Documentation that media filter modules are UL rated Class 1.

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B. Informational Submittals:

1. Manufacturer's documentation that media filter modules rated UL Class 1.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services, air-conditioning units, and motors.
3. Detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement or details shown to equipment furnished.
4. Sample copy of guarantee.
5. Test reports.
6. 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. Cooling Equipment: Minimum operating efficiencies, defined as EER, as specified in ASHRAE 90.1.

B. Units shall be certified by UL and CSA, and shall be UL or ETL listed and labeled.

C. Cooling performance rated in accordance with AHRI testing procedures.

D. 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 EXTRA MATERIALS

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

Item	Quantity
Fan Belts	One complete set for each belt-driven fan.
Filters	One complete set per unit.
Filter (Filter Housing 20-FH-01)	Two complete sets per unit. One set installed into service and the second set turned over to the owner.

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

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.

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2.02 EQUIPMENT SCHEDULES

A. Refer to Drawings.

2.03 PACKAGED INDOOR WATER-SOURCE HEAT PUMP UNITS-ABOVE CEILING (20-WSHP-04 THRU 20-WSHP-11)

A. General:

1. Factory assembled, packaged indoor water-source heat pump unit.
2. Contained within unit enclosure shall be factory wiring, piping, controls, compressor, and holding charge of R-410A refrigerant.
3. Factory run-tested in both heating and cooling modes with full water flow.
4. Unit capable of starting with 40 degrees F entering air temperature and 40 degrees F entering water temperature in heating mode with AHRI water and airflow rates.
5. Unit Configuration: Packaged, above ceiling, horizontal.

B. Unit Cabinet:

1. Fabricated from G-90 galvanized steel, phosphatized, and coated with baked enamel finish.
2. Insulated sheet metal panel separating fan compartment from compressor compartment.
3. Removable access panels providing full access to compressor, and control and fan sections.
4. Separate openings and knockouts for entrance of line voltage, condensate piping, and low voltage control wiring.
5. Water connections and electrical knockouts located so as to not interfere with serviceability of unit.
6. Interior insulated with 1-inch thick, 1.5-pound per cubic foot density, coated glass fiber insulation, attached with adhesive material.
7. Fiberglass insulation exposed edges tucked under flanges to prevent introduction of glass fibers into airstream.
8. Ducted Units: Provide duct flanges for connection of supply and return ductwork, and filter racks.

C. Evaporator Fan:

1. Double-inlet, double-width, forward-curved fan.
2. Direct-drive or belt-drive as standard with unit.
3. Motor: Totally enclosed and permanently lubricated, with integral overload protection.

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D. Compressor:

1. Fully hermetic reciprocating or scroll type.
2. Equipped with oil system, operating oil charge, and motor.
3. Internal overload and over-temperature protection.
4. Motor shall be NEMA rated, Class F, suitable for operation in a refrigerant atmosphere.
5. Reciprocating compressors shall be equipped with crankcase heaters.
6. Scroll compressors shall have high discharge gas temperature protection.
7. Compressor assembly shall be installed on rubber vibration isolators.

E. Refrigerant to Air Coil:

1. Constructed of aluminum, fins mechanically bonded to internally enhanced seamless copper tubes, with galvanized steel tube sheets.
2. Condensate Drain Pan: Plastic, extending full length of air coil, insulated, with primary and secondary drain fittings, minimum 3/4-inch copper drain tube, extending outside unit casing.
3. Coat entire coil with anticorrosion protective coating, as scheduled in Equipment Schedule and in accordance with Article Factory Dip-Applied Protective Coating.

F. Water to Refrigerant Coil:

1. Co-axial tube-within-a-tube or shell-and-tube water-cooled type.
2. Supply and return water connections with female NPT copper fittings located outside cabinet for connection to flexible hoses.
3. Suitable for Propylene glycol 30%.

G. Refrigeration Components:

1. Brass liquid line and suction line service valves with service gauge port connections.
2. Accumulator.

H. Controls:

1. Factory selected, assembled, and tested.
2. Refer to Drawings for required capacity and voltage requirements. As a clarification there will be no neutral leg available for.
3. Unit shall be furnished with a BACnet communication card to interface with the building automation system. Furnish a wall mounted premium quality thermostat that is compatible with the unit control systems.

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4. Refrigerant Metering:
    a. Reverse flow bypass metering device with internal check valves.
    b. Heating mode metering device.
5. Control box within unit cabinet containing 24-volt transformer, 24-volt activated two-pole or three-pole compressor contactor, low voltage terminal junction block.
6. Time delay restart to prevent compressor reverse rotation on single-phase scroll compressors.
7. Automatic restart on power failure.
8. Safety lockout if any outdoor unit safety is open.
9. Start capacitor and relay (single-phase units without scroll compressors).
10. Safeties:
    a. Reversing valve shall be energized in cooling mode, with "fail-safe" to heating mode.
    b. Circuit-breaker protected control circuit.
    c. High condensing temperature protection.
    d. Compressor motor current and temperature overload protection.
    e. High refrigerant pressure relief.
    f. Low voltage protection.
    g. High voltage protection.
    h. Unit shutdown on high or low refrigerant pressures. Low-pressure switch shall not be monitored for first 90 seconds after compressor start command to prevent nuisance safety trips.
    i. Unit shutdown on low water temperature.
    j. Water coil freeze protection (selectable for water or antifreeze).
    k. Air coil freeze protection (check filter switch).
    l. Condensate overflow shutdown.
    m. Automatic intelligent reset. Unit shall automatically reset 5 minutes after trip if fault has cleared. Should fault reoccur three times sequentially then permanent lockout will occur.
    n. Ability to defeat time delays for servicing.
    o. Selectable 24-volt or pilot duty dry contact alarm output.
    p. 24-volt output to cycle a motorized water valve with compressor contactor.

I. Filters:

1. Rack mounted.
2. One-inch thick strainer type with pleated nonwoven fabric media.
3. Rated at 30 percent efficiency and 90 percent average arrestance in accordance with ASHRAE 52.2.
4. Manufacturer and Product: Farr; 30/30.

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J. Accessories: Provide as scheduled in Equipment Schedule.

K. Manufacturers and Products:

1. Carrier; 50 RVC/RHC.
2. Climatemaster; TR Series.
3. Florida Heat Pump; EC and LV Series.
4. Water Furnace; Versatec and Envision.

2.04 WATER SOURCE HEAT PUMP-FLOOR MOUNT (20-WSHP-01,02,03)

A. General Description:

1. Self-contained unit shall include compressors, evaporator coils, filters, supply fans, reheat coil, and unit controls.
2. Unit shall be factory assembled and tested including and run testing of the supply fans and factory wired electrical system. Run test report shall be supplied with the unit.
3. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
4. Unit components shall be labeled, including pipe stub-outs, refrigeration system components and electrical and controls components.
5. Installation, Operation and Maintenance manual shall be supplied within the unit.
6. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's access door.
7. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's access door.
8. R-410A refrigerant.
9. ECM driven direct drive backward curved plenum supply fans.
10. Double sloped stainless-steel drain pans.
11. Hinged access doors with lockable handles.
12. Variable capacity compressor with 10-100% capacity.
13. Factory installed acoustic insulation in the compressorized section.

B. Construction:

1. Unit shall be provided with a horizontal intake, have a draw-through supply fan configuration and discharge air vertically.
2. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.

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3. Unit insulation shall have a minimum thermal resistance R-value of 6.25. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D1929-11 for a minimum flash ignition temperature of 610°F.
4. Unit construction shall 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.
5. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Sealing shall be included between panels and between access doors and openings to reduce air leakage. Refrigerant piping and electrical wiring through cabinet panels shall include sealing to reduce air leakage.
6. Access to filters, compressors, cooling coil, reheat coil, condensers, supply fans and electrical, and controls components shall be through hinged access doors.
7. Access doors shall be flush mounted to cabinetry, with stainless steel removable pin hinges and zinc cast lockable handles. Units shall include a 304 stainless steel sloped drain pan. Drain pan connection shall be available on the right (left) side of the air handling section of the unit.
8. Cooling coils shall be mechanically supported above the drain pan by multiple supports that allow drain pan cleaning and coil removal.
9. Interior ceiling, floor, service doors, fan inlet cone, damper rack, and filter rack in the air stream are spray coated with a two-part polyurethane, heat baked coating. The coils, coil casings, condensate drain pans, damper blades and gears, fan wheel, fan motor, and compressor cabinet are not coated. Option is intended for use in coastal saltwater conditions under the stress of heat, salt, sand and wind and is applicable to all corrosive environments where a polyurethane coating is acceptable. Coating withstands at least 2,500 hours when tested under ASTM B 117-95 requirements.
10. Unit shall include an exterior corrosion protection which shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects when tested in a salt spray and fog atmosphere in accordance with ASTM B117-95 test procedure.
11. Unit shall include a 5-inch forklift base.

C. Electrical:

1. Unit shall be provided with an integrated control panel.
2. Unit shall be provided with standard power block for connecting power to the unit.

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3. Control circuit transformer and wiring shall provide 24V ac control voltage from the line voltage to the unit.
4. Unit shall have a 5kAIC SCCR.

D. Supply Fans:

1. Unit shall include direct drive, unhoused, backward curved, plenum supply fans.
2. Fan and motor assembly shall be dynamically balanced.
3. Motors shall be a high efficiency electronically commutated motor (ECM).
4. Supply air shall discharge vertically-up from the unit.
5. Blower and motor assembly shall be mounted on rubber isolators.

E. Cooling Coil:

1. Evaporator Coil:
   a. Coil shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.
   b. Coil shall be hydrogen or helium leak tested.
   c. Coil shall be furnished with factory installed thermostatic expansion valves. The sensing bulbs shall be field installed on the suction line immediately outside the cabinet.
   d. Coils shall have a flexible, epoxy polymer e-coat uniformly applied to all coil surface areas without material bridging between fins. Humidity and water immersion resistance shall be up to a minimum 1,000 hours each (ASTM D2247-92 and ASTM D870-92). Corrosion durability shall be confirmed through testing, with coating capable of withstanding at least 10,000 hours of salt spray per ASTM B117-90. Coated coils shall receive a spray-applied, UV-resistant polyurethane topcoat to prevent UV degradation of the e-coat. Coating shall carry a 5 year warranty, from the date of original equipment shipment from the factory. Instructions coil cleaning, maintenance, and recording keeping must be followed. Refer to the unit Installation, Operation and Maintenance Manual.

F. Refrigeration System:

1. Unit shall be factory charged with R-410A refrigerant.
2. Compressors shall be R-410A scroll type with thermal overload protection and independently circuited.
3. Unit shall include a variable capacity scroll compressor which shall be capable of modulation from 10-100 percent of its rated capacity.

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4. Compressor shall carry a 5 year non-prorated warranty, from the date of original equipment shipment from the factory.
5. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged compressor access doors shall be fabricated of double wall, rigid polyurethane foam insulated panels to prevent the transmission of noise outside the cabinet.
6. Compressors shall be isolated from unit with the compressor manufacturer's recommended rubber vibration isolators, to reduce any transmission of noise from the compressor into the building area.
7. Unit shall be equipped with thermostatic expansion valve type refrigerant flow control.
8. Unit shall be configured as a water-source condensing unit.
9. Unit shall be configured as a water-source heat pump. Unit shall be equipped with an automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low pressure sides, factory installed liquid line heat pump filter drier, reversing valve and thermostatic expansion valves on the indoor coil. Reversing valve shall energize during the cooling mode of operation.
10. Modulating hot gas reheat shall be provided on the lead refrigeration circuit. Refrigeration circuit shall be provided with hot gas reheat coil, modulating valves, receiver tank, electronic controller, supply air temperature sensor and a dehumidification control signal terminal which allow the unit to have a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space.
11. Each refrigeration circuit shall be equipped with suction and discharge compressor isolation valves.

G. Condensers

1. Water-cooled condensing section shall contain coaxial tube-in-tube heat exchangers. Heat exchanger shall be circuited in a counter flow arrangement to the refrigerant system. Tubes shall be cupronickel. Field piping connections shall be external to the self-contained unit. Connections shall be labeled, extend beyond the unit casing and be factory sealed to prevent condensation in the panel assembly. Maximum operating pressure on the water side of the condenser shall be 300 psi.
2. Unit shall include factory installed head pressure control module and each heat exchanger shall include factory installed head pressure control valve which modulates the condenser water flow based on head pressure and allows cooling operation below 65°F condenser water temperature.

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3. Coils shall have a flexible, epoxy polymer e-coat uniformly applied to all coil surface areas without material bridging between fins. Humidity and water immersion resistance shall be up to a minimum 1,000 hours each (ASTM D2247-92 and ASTM D870-92). Corrosion durability shall be confirmed through testing, with coating capable of withstanding at least 10,000 hours of salt spray per ASTM B117-90. Coated coils shall receive a spray-applied, UV-resistant polyurethane topcoat to prevent UV degradation of the e-coat. Coating shall carry a 5 year warranty, from the date of original equipment shipment from the factory. Instructions coil cleaning, maintenance, and recording keeping must be followed. Refer to the unit Installation, Operation and Maintenance Manual.

H. Filters

1. Unit shall include 2 inch thick, pleated panel filters with an ASHRAE MERV rating of 8, in a prefilter box upstream of the cooling coil.
2. For 20-WSHP-01 the unit shall not have filters in the unit. All filters will be external to the unit.
3. Unit shall include a clogged filter switch.
4. Unit shall include factory installed Magnehelic gauge measuring the pressure drop across the filter rack.

I. Controls:

1. Furnish a factory mounted controller that is BACnet communication port compatible with MS/TP with an LCD/LED display that can be used for unit set up and monitoring.
2. Provide a wired thermostat shipped loose that allows for display of room temperature and humidity as well as certain status and setpoints.
3. Factory Installed and Factory Provided Controller:
    a. Unit controller shall be capable of controlling all features and options of the unit. Controller shall be factory installed in the unit controls compartment and factory tested.
    b. Controller shall be capable of standalone operation with unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling available without dependence on a building management system.
    c. Controller shall have an onboard clock and calendar functions that allow for occupancy scheduling.
    d. Controller shall include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.
    e. Constant Volume Controller.

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4. Unit shall modulate cooling with constant airflow to meet space temperature cooling loads.
5. With modulating hot gas reheat, unit shall modulate cooling and hot gas reheat as efficiently as possible, to meet space humidity loads and prevent supply air temperature swings and overcooling of the space.
6. Unit shall modulate heating with constant airflow to meet space temperature heating loads. Staged heating capacity shall modulate based on space temperature.
7. Unit shall modulate heating with constant airflow to meet space temperature heating loads. Modulating heating capacity shall modulate based on supply air temperature.
8. Supply air temperature sensor and space temperature sensor with temperature setpoint reset and unoccupied override shall be furnished with the unit for field installation.

J. Accessories: Unit shall be provided with a low voltage safety shutdown terminal block for field installation of a smoke detector which shuts off the unit's control circuit.

K. Manufacturers and Products:

1. Aaon; SB.
2. Or Equal.

2.05 FILTER HOUSING (20-FH-01)

A. Side access filter housings are designed to accommodate ASHRAE rated filters as indicated in equipment schedules. Factory assembled flanged units suitable for installation in a duct. Housings accommodate filters of different types and efficiencies. Filters are easily serviced through quick-opening hinged access doors. Factory-gasketed filters, channels, and doors ensure positive sealing. Housings shall be rated for minus 6.0-inch w.g. to plus 6.0-inch w.g. The leakage rate is less than 0.5 percent of airflow at 6.0-inch w.g. internal static pressure. Refer to Extra Materials section on number of filters to provide.

B. Housings shall include filter tracks for filters as identified in the filter schedule. Housings shall be constructed of 16-gauge stainless steel type 304 with upstream and downstream outwardly turned flanges. Filter tracks are extruded aluminum. All filter tracks shall be gasketed with replaceable polypropylene pile air seals. Access doors shall be sealed with neoprene gasketing on the perimeter. Gasketing also seals the filter edge to the door.

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C. Filters shall be as follows:

1. Pre-filter: 24-inch by 24-inch by 24-inch thick filter that is 100 percent synthetic non-woven, media rated at 500 FPM that achieves a MERV 8 rating (AAF PREpleat or equal).
2. Carbon Filter: 24-inch by 24-inch by 11.5-inch thick with gaskets. Filter shall be constructed of a pleated media with highly activity carbon particles bonded into a matrix of carbon granulate embedded between two non-woven synthetic layers (AAF VariSorb XL or equal).
3. Final filter bag style: 24-inch by 24-inch by 22-inch media that is rated for 500 FPM that achieves a MERV 13 rating. Media shall be injection molded into a support frame that creates and air tight seal. Pocket shall be tapered for better holding capacity (AAF DriPAK NX or equal).

D. Manufacturers and Products:

1. AAF/Flanders; SureSeal.
2. Camfil-Farr.

2.06 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: Use one of the following materials:

1. Epoxy Modified Phenolic. Straight phenolic materials are not acceptable.
2. Epoxy or epoxy urethane.
3. Polyelastomer: Complex chain linked polyelastomer material.

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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.
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: Coil finish shall meet or exceed the following criteria:

1. Salt Spray Test: In accordance with ASTM B117, minimum 3,000-hour duration, with no fin corrosion or degradation.
2. Thermal Efficiency: Loss no greater than 1 percent after coating application.
3. 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. Bronzglow; Husky.
2. Aero-Marine Engineering Inc.; Technicoat 10-1.
3. AST ElectroFin Inc; ElectroFin.

2.07 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.

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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.

2.08 ACCESSORIES

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

B. Equipment Identification Plates: Furnish 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 tag indicated in this Specification and as shown on Drawings.

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.

2.09 SOURCE QUALITY CONTROL

A. Factory Tests:

1. Direct expansion coils leak tested underwater with 200-psig air. Pressure tested to 450 psig.

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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. Isolate sheet metal duct connections from portions of unit not internally spring-isolated from fans, or other vibrating or rotating equipment.

C. Inspect internal casing insulation, seal exposed edges, and butt joints with mastic to ensure insulation will not be loosened during operation.

D. 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.

E. 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. 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).

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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.
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.

C. Coils shall be cleaned with environmentally friendly coil cleaners. The use of chemicals that can impact or contaminate the environment shall not be permitted.

END OF SECTION

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ITEM	ITEM TYPE	EQUIP. NO.	DWG REF	FACILITY	SOURCE LOCATION	AREA SERVED	QTY	MANUF.	MODEL	DESCRIPTION	COMMENTS
1	SEC SERVER SWITCH	20-SC-SW-00	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	SERVER RM	1	FORTINET	FORTISWITCH 124E-FPOE	MANAGED CENTRAL SWITCH, 24 PORT POE+ (370W), 4 SFP.	RACK-MOUNTED PROVIDE SFP MODULES, MULTIMODE (LC)
2	ACCESS CONTROL SVR	20-SC-SVR-01	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	SERVER RM	1	3xLOGIX	S-SVR50-8	INFINIAS SERVER 50, 1U, SUPPORT 50 DOORS, BUILT-IN POE FOR FIRST 8 DOORS.	RACK-MOUNTED
3	NETWORK VIDEO RECORDER	20-SC-NVR-01	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	SERVER RM	1	AVIGILON	HD-NVR4-STD-48TB	48 TB HD NVR VALUE WITH MICROSOFT WINDOWS 10 ENTERPRISE EMBEDDED AND AVIGILON CONTROL CENTER	RACK-MOUNTED
4	INTERCOM MASTER	20-SC-INTMS-01	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	CONTROL RM	1	AIPHONE	IX-MV	MASTER VIDEO INTERCOM	DESK UNIT
5	SEC WORKSTATION	20-SC-WS-01	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	CONTROL RM	1	DELL	PRECISION 7920	SECURITY WORKSTATION	INCLUDE MOUSE AND KEYBOARD. COMPONENT SPECS SHALL MATCH COMPONENT CODE Y119 AS DEFINED IN 40 94 13, SUP. 2
6	CAMERA	CAM-01	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	NORTH WEST VIEW	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
7	CAMERA	CAM-02	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	SOUTH WEST VIEW	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
8	CAMERA	CAM-03	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	SOUTH EAST VIEW	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
9	CAMERA	CAM-04	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	NORTH EAST VIEW	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
10	CAMERA	CAM-40	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	TRUCK DRIVE-THRU (PROCESS AREA)	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
11	CAMERA	CAM-41	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	TRUCK DRIVE-THRU (PROCESS AREA)	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
12	CAMERA	CAM-42	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	TRUCK DRIVE-THRU (PROCESS AREA)	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
13	CAMERA	CAM-43	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	TRUCK DRIVE-THRU (PROCESS AREA)	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
14	CAMERA	CAM-44	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	BFP RM (PROCESS AREA)	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
15	CAMERA	CAM-45	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	BFP RM (PROCESS AREA)	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
16	CAMERA	CAM-46	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	BFP RM (PROCESS AREA)	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
17	CAMERA	CAM-47	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	BFP RM (PROCESS AREA)	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
18	CAMERA	CAM-48	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	BFP RM (PROCESS AREA)	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
19	CAMERA	CAM-49	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	BFP RM (PROCESS AREA)	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
20	CAMERA	CAM-50	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	STAIRS 1	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
21	CAMERA	CAM-51	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	LOBBY RM	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
22	CAMERA	CAM-52	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	ELECTRICAL WEST RM	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
23	CAMERA	CAM-53	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	ELECTRICAL EAST RM	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
24	CAMERA	CAM-54	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	STAIRS 2	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
25	CAMERA	CAM-55	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	TRAINING RM	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
26	CAMERA	CAM-56	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	STAIRS 1	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
27	CAMERA	CAM-57	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	LOBBY RM	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
28	CAMERA	CAM-58	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	SERVER RM	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
29	CAMERA	CAM-59	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	CONTROL RM	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
30	CAMERA	CAM-60	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	HALLWAY VIEW WEST	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
31	CAMERA	CAM-61	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	HALLWAY VIEW EAST	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE

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ITEM	ITEM TYPE	EQUIP. NO.	DWG REF	FACILITY	SOURCE LOCATION	AREA SERVED	QTY	MANUF.	MODEL	DESCRIPTION	COMMENTS
32	CAMERA	CAM-62	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	STAIR 2	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
33	CAMERA	CAM-69	06-TY-5001 50-TY-2001	C.C. WILLIAMS	CHLORINE/SO2 BUILDING	CHLORINE STORAGE RM	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
34	CAMERA	CAM-70	06-TY-5001 50-TY-2001	C.C. WILLIAMS	CHLORINE/SO2 BUILDING	SO2 STORAGE RM	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
35	CAMERA	CAM-71	06-TY-5001 50-TY-2001	C.C. WILLIAMS	CHLORINE/SO2 BUILDING	CHLORINE FEED RM	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
36	CAMERA	CAM-72	06-TY-5001 50-TY-2001	C.C. WILLIAMS	CHLORINE/SO2 BUILDING	SO2 FEED RM	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
37	CAMERA	CAM-73	06-TY-5001 50-TY-2001	C.C. WILLIAMS	CHLORINE/SO2 BUILDING	ELECTRICAL RM	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
38	CAMERA	CAM-05	06-TY-5001 80-TY-2001	C.C. WILLIAMS	ADMIN BUILDING	ADMIN BUILDING	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
39	CAMERA	CAM-06	06-TY-5001 80-TY-2001	C.C. WILLIAMS	ADMIN BUILDING	ADMIN BUILDING	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
40	CAMERA	CAM-33	06-TY-5001 80-TY-2001	C.C. WILLIAMS	ADMIN BUILDING	ADMIN BUILDING HALLWAY	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
41	CAMERA	CAM-34	06-TY-5001 80-TY-2001	C.C. WILLIAMS	ADMIN BUILDING	ADMIN BUILDING HALLWAY	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
42	CAMERA	CAM-09	06-TY-5001 94-TY-2002	C.C. WILLIAMS	MAINTENANCE BUILDING	MAINTENANCE BUILDING	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
43	CAMERA	CAM-10	06-TY-5001 94-TY-2002	C.C. WILLIAMS	MAINTENANCE BUILDING	MAINTENANCE BUILDING	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
44	CAMERA	CAM-63	06-TY-5001 94-TY-2002	C.C. WILLIAMS	MAINTENANCE BUILDING	MAINTENANCE BUILDING	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
45	CAMERA	CAM-64	06-TY-5001 94-TY-2002	C.C. WILLIAMS	MAINTENANCE BUILDING	MAINTENANCE BUILDING	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
46	CAMERA	CAM-65	06-TY-5001 94-TY-2002	C.C. WILLIAMS	MAINTENANCE BUILDING	MAINTENANCE BUILDING	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
47	CAMERA	CAM-66	06-TY-5001 94-TY-2002	C.C. WILLIAMS	MAINTENANCE BUILDING	MAINTENANCE BUILDING	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
48	CAMERA	CAM-67	06-TY-5001 94-TY-2002	C.C. WILLIAMS	MAINTENANCE BUILDING	MAINTENANCE BUILDING	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
49	CAMERA	CAM-68	06-TY-5001 94-TY-2002	C.C. WILLIAMS	MAINTENANCE BUILDING	MAINTENANCE BUILDING	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
50	CAMERA	CAM-31	06-TY-5001 82-TY-2001	C.C. WILLIAMS	BLOWER BUILDING	BLOWER BUILDING	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
51	CAMERA	CAM-35	06-TY-5001 82-TY-2001	C.C. WILLIAMS	BLOWER BUILDING	NORTH-EAST WALL	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
52	CAMERA	CAM-74	06-TY-5001 82-TY-2001	C.C. WILLIAMS	BLOWER BUILDING	NORTH-WEST WALL	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
53	CAMERA	CAM-75	06-TY-5001 83-TY-2001	C.C. WILLIAMS	ELEC/GEN BUILDING	ELEC/GEN BUILDING	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
54	CAMERA	CAM-76	06-TY-5001 83-TY-2001	C.C. WILLIAMS	ELEC/GEN BUILDING	ELEC/GEN BUILDING	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
55	CAMERA	CAM-77	06-TY-5001 91-TY-2001	C.C. WILLIAMS	HEADWORK BUILDING	HEADWORK BUILDING	1	AVIGILON	4.0C-H5A-D1-IR	TYPE 2- INDOOR, FIXED CAMERA. H5A DOME CAMERA (SURFACE MOUNT) WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
56	VIDEO INTERCOM	CAMI-01	99-TY-5003	C.C. WILLIAMS	POLE 01	NORTH ENTRY GATE	1	AIPHONE	IX-DF	VIDEO INTERCOM DOOR STATION	
57	VIDEO INTERCOM	CAMI-02	99-TY-5003	C.C. WILLIAMS	POLE 01	NORTH ENTRY GATE	1	AIPHONE	IX-DF	VIDEO INTERCOM DOOR STATION	
58	ACCESS CONTROL KIT	CR-103A	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	BFP RM (PROCESS AREA)	1	3xLOGIX	S-DOOR-KIT-WH	INFINIAS SINGLE DOOR KIT COMES WITH HID PROX READER AND DOOR CONTACT SENSOR	INTERFACE WITH ELECTRO-STRIKE LOCK. PROVIDE INFINIAS PVC ACCESS CONTROL PROX. CARD
59	ACCESS CONTROL KIT	CR-103B	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	BFP RM (PROCESS AREA)	1	3xLOGIX	S-DOOR-KIT-WH	INFINIAS SINGLE DOOR KIT COMES WITH HID PROX READER AND DOOR CONTACT SENSOR	INTERFACE WITH ELECTRO-STRIKE LOCK. PROVIDE INFINIAS PVC ACCESS CONTROL PROX. CARD
60	ACCESS CONTROL KIT	CR-106B	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	ELEC RM	1	3xLOGIX	S-DOOR-KIT-WH	INFINIAS SINGLE DOOR KIT COMES WITH HID PROX READER AND DOOR CONTACT SENSOR	INTERFACE WITH ELECTRO-STRIKE LOCK. PROVIDE INFINIAS PVC ACCESS CONTROL PROX. CARD
61	ACCESS CONTROL KIT	CR-112A	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	TRAINING RM	1	3xLOGIX	S-DOOR-KIT-WH	INFINIAS SINGLE DOOR KIT COMES WITH HID PROX READER AND DOOR CONTACT SENSOR	INTERFACE WITH ELECTRO-STRIKE LOCK. PROVIDE INFINIAS PVC ACCESS CONTROL PROX. CARD
62	ACCESS CONTROL KIT	CR-S01A	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	STAIR 1	1	3xLOGIX	S-DOOR-KIT-WH	INFINIAS SINGLE DOOR KIT COMES WITH HID PROX READER AND DOOR CONTACT SENSOR	INTERFACE WITH ELECTRO-STRIKE LOCK. PROVIDE INFINIAS PVC ACCESS CONTROL PROX. CARD
63	ACCESS CONTROL KIT	CR-S02A	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	STAIR 2	1	3xLOGIX	S-DOOR-KIT-WH	INFINIAS SINGLE DOOR KIT COMES WITH HID PROX READER AND DOOR CONTACT SENSOR	INTERFACE WITH ELECTRO-STRIKE LOCK. PROVIDE INFINIAS PVC ACCESS CONTROL PROX. CARD

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ITEM	ITEM TYPE	EQUIP. NO.	DWG REF	FACILITY	SOURCE LOCATION	AREA SERVED	QTY	MANUF.	MODEL	DESCRIPTION	COMMENTS
64	ACCESS CONTROL KIT	CR-205A	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	SERVER RM	1	3xLOGIX	S-DOOR-KIT-WH	INFINIAS SINGLE DOOR KIT COMES WITH HID PROX READER AND DOOR CONTACT SENSOR	INTERFACE WITH ELECTRO-STRIKE LOCK. PROVIDE INFINIAS PVC ACCESS CONTROL PROX. CARD
65	ACCESS CONTROL KIT	CR-207A	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	CONTROL RM	1	3xLOGIX	S-DOOR-KIT-WH	INFINIAS SINGLE DOOR KIT COMES WITH HID PROX READER AND DOOR CONTACT SENSOR	INTERFACE WITH ELECTRO-STRIKE LOCK. PROVIDE INFINIAS PVC ACCESS CONTROL PROX. CARD
66	ACCESS CONTROL KIT	CR-93B	06-TY-5001 93-TY-2001	C.C. WILLIAMS	ADMIN BUILDING	BACK ENTRY	1	3xLOGIX	S-DOOR-KIT-WH	INFINIAS SINGLE DOOR KIT COMES WITH HID PROX READER AND DOOR CONTACT SENSOR	PROVIDE ELECTRO-MAGNETIC LOCK AND INFINIAS PVC ACCESS CONTROL PROX. CARD. PROVIDE EXTERNAL 24 VDC POWER SUPPLY FOR MAG-LOCKS IF REQUIRED.
67	ACCESS CONTROL KIT	CR-93C	06-TY-5001 93-TY-2001	C.C. WILLIAMS	ADMIN BUILDING	EAST ENTRY	1	3xLOGIX	S-DOOR-KIT-WH	INFINIAS SINGLE DOOR KIT COMES WITH HID PROX READER AND DOOR CONTACT SENSOR	PROVIDE ELECTRO-MAGNETIC LOCK AND INFINIAS PVC ACCESS CONTROL PROX. CARD. PROVIDE EXTERNAL 24 VDC POWER SUPPLY FOR MAG-LOCKS IF REQUIRED.
68	ACCESS CONTROL KIT	CR-93A	06-TY-5001 93-TY-2001	C.C. WILLIAMS	ADMIN BUILDING	FRONT ENTRY	1	3xLOGIX	S-DOOR-KIT-WH	INFINIAS SINGLE DOOR KIT COMES WITH HID PROX READER AND DOOR CONTACT SENSOR	PROVIDE ELECTRO-MAGNETIC LOCK AND INFINIAS PVC ACCESS CONTROL PROX. CARD. PROVIDE EXTERNAL 24 VDC POWER SUPPLY FOR MAG-LOCKS IF REQUIRED.
69	ACCESS CONTROL KIT	CR-94A	06-TY-5001 94-TY-2002	C.C. WILLIAMS	MAINTENANCE BUILDING	MAIN ENTRY	1	3xLOGIX	S-DOOR-KIT-WH	INFINIAS SINGLE DOOR KIT COMES WITH HID PROX READER AND DOOR CONTACT SENSOR	PROVIDE ELECTRO-MAGNETIC LOCK AND INFINIAS PVC ACCESS CONTROL PROX. CARD. PROVIDE EXTERNAL 24 VDC POWER SUPPLY FOR MAG-LOCKS IF REQUIRED.
70	ACCESS CONTROL KIT	CR-94B	06-TY-5001 94-TY-2002	C.C. WILLIAMS	MAINTENANCE BUILDING	ENTRY 2	1	3xLOGIX	S-DOOR-KIT-WH	INFINIAS SINGLE DOOR KIT COMES WITH HID PROX READER AND DOOR CONTACT SENSOR	PROVIDE ELECTRO-MAGNETIC LOCK AND INFINIAS PVC ACCESS CONTROL PROX. CARD. PROVIDE EXTERNAL 24 VDC POWER SUPPLY FOR MAG-LOCKS IF REQUIRED.
71	ACCESS CONTROL KIT	CR-82A	06-TY-5001 82-TY-2001	C.C. WILLIAMS	BLOWER BUILDING	ENTRY	1	3xLOGIX	S-DOOR-KIT-WH	INFINIAS SINGLE DOOR KIT COMES WITH HID PROX READER AND DOOR CONTACT SENSOR	PROVIDE ELECTRO-MAGNETIC LOCK AND INFINIAS PVC ACCESS CONTROL PROX. CARD. PROVIDE EXTERNAL 24 VDC POWER SUPPLY FOR MAG-LOCKS IF REQUIRED.
72	ACCESS CONTROL KIT	CR-83A	06-TY-5001 83-TY-2001	C.C. WILLIAMS	ELEC/GEN BUILDING	WEST ENTRY	1	3xLOGIX	S-DOOR-KIT-WH	INFINIAS SINGLE DOOR KIT COMES WITH HID PROX READER AND DOOR CONTACT SENSOR	PROVIDE ELECTRO-MAGNETIC LOCK AND INFINIAS PVC ACCESS CONTROL PROX. CARD. PROVIDE EXTERNAL 24 VDC POWER SUPPLY FOR MAG-LOCKS IF REQUIRED.
73	ACCESS CONTROL KIT	CR-83B	06-TY-5001 83-TY-2001	C.C. WILLIAMS	ELEC/GEN BUILDING	EAST ENTRY	1	3xLOGIX	S-DOOR-KIT-WH	INFINIAS SINGLE DOOR KIT COMES WITH HID PROX READER AND DOOR CONTACT SENSOR	PROVIDE ELECTRO-MAGNETIC LOCK AND INFINIAS PVC ACCESS CONTROL PROX. CARD. PROVIDE EXTERNAL 24 VDC POWER SUPPLY FOR MAG-LOCKS IF REQUIRED.
74	ACCESS CONTROL KIT	CR-91A	06-TY-5001 91-TY-2001	C.C. WILLIAMS	HEADWORK BUILDING	WEST ENTRY	1	3xLOGIX	S-DOOR-KIT-WH	INFINIAS SINGLE DOOR KIT COMES WITH HID PROX READER AND DOOR CONTACT SENSOR	PROVIDE ELECTRO-MAGNETIC LOCK AND INFINIAS PVC ACCESS CONTROL PROX. CARD. PROVIDE EXTERNAL 24 VDC POWER SUPPLY FOR MAG-LOCKS IF REQUIRED.
75	ACCESS CONTROL KIT	CR-91B	06-TY-5001 91-TY-2001	C.C. WILLIAMS	HEADWORK BUILDING	EAST ENTRY	1	3xLOGIX	S-DOOR-KIT-WH	INFINIAS SINGLE DOOR KIT COMES WITH HID PROX READER AND DOOR CONTACT SENSOR	PROVIDE ELECTRO-MAGNETIC LOCK AND INFINIAS PVC ACCESS CONTROL PROX. CARD. PROVIDE EXTERNAL 24 VDC POWER SUPPLY FOR MAG-LOCKS IF REQUIRED.
76	SEC SWITCH PANEL	20-SC-SWP-00A	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	ELECTRICAL RM	1	HOFFMAN	A302416LP & A30P24	ENCLOSURE, TYPE 12 30"H X 24"W X 16"D & SUBPANEL	PAINTED GRAY STEEL; SINGLE DOOR; FRONT ACCESS. (INDOOR APPLICATION)
77	SEC SWITCH PANEL	20-SC-SWP-00B	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	ELECTRICAL RM	1	HOFFMAN	A302416LP & A30P24	ENCLOSURE, TYPE 12 30"H X 24"W X 16"D & SUBPANEL	PAINTED GRAY STEEL; SINGLE DOOR; FRONT ACCESS. (INDOOR APPLICATION)
78	SEC SWITCH PANEL	20-SC-SWP-00C	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	ELECTRICAL RM	1	HOFFMAN	A302416LP & A30P24	ENCLOSURE, TYPE 12 30"H X 24"W X 16"D & SUBPANEL	PAINTED GRAY STEEL; SINGLE DOOR; FRONT ACCESS. (INDOOR APPLICATION)
79	SEC SWITCH	20-SC-SW-00A1	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	ELECTRICAL RM	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
80	SEC SWITCH	20-SC-SW-00A2	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	ELECTRICAL RM	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
81	SEC SWITCH	20-SC-SW-00B1	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	ELECTRICAL RM	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
82	SEC SWITCH	20-SC-SW-00B2	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	ELECTRICAL RM	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
83	SEC SWITCH	20-SC-SW-00C1	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	STORAGE RM	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
84	SEC SWITCH	20-SC-SW-00C2	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	STORAGE RM	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
85	PWR SUPPLY	20-SC-PS-00A1	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	ELECTRICAL RM	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
86	PWR SUPPLY	20-SC-PS-00A2	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	ELECTRICAL RM	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
87	PWR SUPPLY	20-SC-PS-00B1	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	ELECTRICAL RM	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
88	PWR SUPPLY	20-SC-PS-00B2	06-TY-5001 20-TY-2001 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 1ST FLOOR	ELECTRICAL RM	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
89	PWR SUPPLY	20-SC-PS-00C1	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	STORAGE RM	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
90	PWR SUPPLY	20-SC-PS-00C2	06-TY-5001 20-TY-2002 20-TY-6001	C.C. WILLIAMS	DEWATERING BUILDING- 2ND FLOOR	STORAGE RM	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
91	SEC SWITCH PANEL	50-SC-SWP-14	06-TY-5001 50-TY-2001	C.C. WILLIAMS	CHLORINE/SO2 BUILDING	CHLORINE/SO2 BUILDING	1	HOFFMAN	A242412LP & A24P24	ENCLOSURE, TYPE 12 24"H X 24"W X 12"D & SUBPANEL	PAINTED GRAY STEEL; SINGLE DOOR; FRONT ACCESS. (INDOOR APPLICATION)
92	SEC SWITCH	50-SC-SW-14	06-TY-5001 50-TY-2001	C.C. WILLIAMS	CHLORINE/SO2 BUILDING	CHLORINE/SO2 BUILDING	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
93	PWR SUPPLY	50-SC-PS-14	06-TY-5001 50-TY-2001	C.C. WILLIAMS	CHLORINE/SO2 BUILDING	CHLORINE/SO2 BUILDING	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
94	INTERCOM MASTER	93-SC-INTMS-02	80-TY-2001	C.C. WILLIAMS	ADMIN BUILDING	SECERTARY RM	1	AIPHONE	IX-MV	MASTER VIDEO INTERCOM	DESK UNIT
95	SEC SWITCH PANEL	93-SC-SWP-01	06-TY-5001 80-TY-2001	C.C. WILLIAMS	ADMIN BUILDING	MECHANICAL RM	1	HOFFMAN	A242412LP & A24P24	ENCLOSURE, TYPE 12 24"H X 24"W X 12"D & SUBPANEL	PAINTED GRAY STEEL; SINGLE DOOR; FRONT ACCESS. (INDOOR APPLICATION)
96	SEC SWITCH	93-SC-SW-01A	06-TY-5001 80-TY-2001	C.C. WILLIAMS	ADMIN BUILDING	MECHANICAL RM	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)

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ITEM	ITEM TYPE	EQUIP. NO.	DWG REF	FACILITY	SOURCE LOCATION	AREA SERVED	QTY	MANUF.	MODEL	DESCRIPTION	COMMENTS
97	PWR SUPPLY	93-SC-PS-01A	06-TY-5001 80-TY-2001	C.C. WILLIAMS	ADMIN BUILDING	ADMIN BUILDING	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
98	SEC SWITCH	93-SC-SW-01B	06-TY-5001 80-TY-2001	C.C. WILLIAMS	ADMIN BUILDING	MECHANICAL RM	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
99	PWR SUPPLY	93-SC-PS-01B	06-TY-5001 80-TY-2001	C.C. WILLIAMS	ADMIN BUILDING	ADMIN BUILDING	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
100	SEC SWITCH PANEL	94-SC-SWP-03	06-TY-5001 94-TY-2002	C.C. WILLIAMS	MAINTENANCE BUILDING	MAINTENANCE BUILDING	1	HOFFMAN	A242412LP & A24P24	ENCLOSURE, TYPE 12 24"H X 24"W X 12"D & SUBPANEL	PAINTED GRAY STEEL; SINGLE DOOR; FRONT ACCESS. (INDOOR APPLICATION)
101	SEC SWITCH	94-SC-SW-03A	06-TY-5001 94-TY-2002	C.C. WILLIAMS	MAINTENANCE BUILDING	MAINTENANCE BUILDING	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
102	PWR SUPPLY	94-SC-PS-03A	06-TY-5001 94-TY-2002	C.C. WILLIAMS	MAINTENANCE BUILDING	MAINTENANCE BUILDING	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
103	SEC SWITCH	94-SC-SW-03B	06-TY-5001 94-TY-2002	C.C. WILLIAMS	MAINTENANCE BUILDING	MAINTENANCE BUILDING	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
104	PWR SUPPLY	94-SC-PS-03B	06-TY-5001 94-TY-2002	C.C. WILLIAMS	MAINTENANCE BUILDING	MAINTENANCE BUILDING	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
105	SEC SWITCH PANEL	82-SC-SWP-18	06-TY-5001 82-TY-2001	C.C. WILLIAMS	BLOWER BUILDING	BLOWER BUILDING	1	HOFFMAN	A242412LP & A24P24	ENCLOSURE, TYPE 12 24"H X 24"W X 12"D & SUBPANEL	PAINTED GRAY STEEL; SINGLE DOOR; FRONT ACCESS. (INDOOR APPLICATION)
106	SEC SWITCH	82-SC-SW-18	06-TY-5001 82-TY-2001	C.C. WILLIAMS	BLOWER BUILDING	BLOWER BUILDING	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
107	PWR SUPPLY	82-SC-PS-18	06-TY-5001 82-TY-2001	C.C. WILLIAMS	BLOWER BUILDING	BLOWER BUILDING	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
108	SEC SWITCH PANEL	83-SC-SWP-12	06-TY-5001 83-TY-2001	C.C. WILLIAMS	ELEC/GEN BUILDING	ELEC/GEN BUILDING	1	HOFFMAN	A242410LP & A24P24	ENCLOSURE, TYPE 12 24"H X 24"W X 10"D & SUBPANEL	PAINTED GRAY STEEL; SINGLE DOOR; FRONT ACCESS. (INDOOR APPLICATION)
109	SEC SWITCH	83-SC-SW-12	06-TY-5001 83-TY-2001	C.C. WILLIAMS	ELEC/GEN BUILDING	ELEC/GEN BUILDING	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
110	PWR SUPPLY	83-SC-PS-12	06-TY-5001 83-TY-2001	C.C. WILLIAMS	ELEC/GEN BUILDING	ELEC/GEN BUILDING	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
111	SEC SWITCH PANEL	91-SC-SWP-04	06-TY-5001 91-TY-2001	C.C. WILLIAMS	HEADWORK BUILDING	HEADWORK BUILDING	1	HOFFMAN	A242412LP & A24P24	ENCLOSURE, TYPE 12 24"H X 24"W X 12"D & SUBPANEL	PAINTED GRAY STEEL; SINGLE DOOR; FRONT ACCESS. (INDOOR APPLICATION)
112	SEC SWITCH	91-SC-SW-04	06-TY-5001 91-TY-2001	C.C. WILLIAMS	HEADWORK BUILDING	HEADWORK BUILDING	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
113	PWR SUPPLY	91-SC-PS-04	06-TY-5001 91-TY-2001	C.C. WILLIAMS	HEADWORK BUILDING	HEADWORK BUILDING	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
114	CAMERA	CAM-07	06-TY-2002	C.C. WILLIAMS	POLE 01	NORTH EAST PERIMETER	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
115	CAMERA	CAM-08	06-TY-2002	C.C. WILLIAMS	POLE 01	NORTH ENTRY GATE	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
116	SEC SWITCH PANEL	CP-SC-SWP-02	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 01	POLE 01	1	HOFFMAN	A24H2412SS6LP & A24P24	ENCLOSURE, TYPE 4X 24"H X 24"W X 12"D & SUBPANEL	316SST, POWER-COATED WHITE WITH SUN SHIELDS, SINGLE DOOR; FRONT ACCESS. (OUTDOOR APPLICATION)
117	SEC SWITCH	CP-SC-SW-02	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 01	POLE 01	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
118	PWR SUPPLY	CP-SC-PS-02	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 01	POLE 01	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
119	CAMERA	CAM-11	06-TY-2002	C.C. WILLIAMS	POLE 02	WEST PERIMETER	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
120	CAMERA	CAM-12	06-TY-2002	C.C. WILLIAMS	POLE 02	WEST PERIMETER	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
121	CAMERA	CAM-13	06-TY-2002	C.C. WILLIAMS	POLE 02	WEST PERIMETER	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
122	SEC SWITCH PANEL	CP-SC-SWP-05	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 02	POLE 02	1	HOFFMAN	A24H2412SS6LP & A24P24	ENCLOSURE, TYPE 4X 24"H X 24"W X 12"D & SUBPANEL	316SST, POWER-COATED WHITE WITH SUN SHIELDS, SINGLE DOOR; FRONT ACCESS. (OUTDOOR APPLICATION)
123	SEC SWITCH	CP-SC-SW-05	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 02	POLE 02	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
124	PWR SUPPLY	CP-SC-PS-05	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 02	POLE 02	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
125	CAMERA	CAM-14	06-TY-2002	C.C. WILLIAMS	POLE 03	SOUTH-WEST PERIMETER	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
126	CAMERA	CAM-15	06-TY-2002	C.C. WILLIAMS	POLE 03	SOUTH-WEST PERIMETER	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
127	SEC SWITCH PANEL	CP-SC-SWP-06	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 03	POLE 03	1	HOFFMAN	A24H2412SS6LP & A24P24	ENCLOSURE, TYPE 4X 24"H X 24"W X 12"D & SUBPANEL	316SST, POWER-COATED WHITE WITH SUN SHIELDS, SINGLE DOOR; FRONT ACCESS. (OUTDOOR APPLICATION)
128	SEC SWITCH	CP-SC-SW-06	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 03	POLE 03	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
129	PWR SUPPLY	CP-SC-PS-06	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 03	POLE 03	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
130	CAMERA	CAM-16	06-TY-2002	C.C. WILLIAMS	POLE 04	SOUTH PERIMETER	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
131	CAMERA	CAM-17	06-TY-2002		POLE 04	SOUTH PERIMETER	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE

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ITEM	ITEM TYPE	EQUIP. NO.	DWG REF	FACILITY	SOURCE LOCATION	AREA SERVED	QTY	MANUF.	MODEL	DESCRIPTION	COMMENTS
132	SEC SWITCH PANEL	CP-SC-SWP-07	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 04	POLE 04	1	HOFFMAN	A24H2412SS6LP & A24P24	ENCLOSURE, TYPE 4X 24"H X 24"W X 12"D & SUBPANEL	316SST, POWER-COATED WHITE WITH SUN SHIELDS, SINGLE DOOR; FRONT ACCESS. (OUTDOOR APPLICATION)
133	SEC SWITCH	CP-SC-SW-07	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 04	POLE 04	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
134	PWR SUPPLY	CP-SC-PS-07	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 04	POLE 04	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
135	CAMERA	CAM-18	06-TY-2002	C.C. WILLIAMS	POLE 05	SOUTH-EAST PERIMETER	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
136	CAMERA	CAM-19	06-TY-2002	C.C. WILLIAMS	POLE 05	SOUTH-EAST PERIMETER	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
137	SEC SWITCH PANEL	CP-SC-SWP-08	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 05	POLE 05	1	HOFFMAN	A24H2412SS6LP & A24P24	ENCLOSURE, TYPE 4X 24"H X 24"W X 12"D & SUBPANEL	316SST, POWER-COATED WHITE WITH SUN SHIELDS, SINGLE DOOR; FRONT ACCESS. (OUTDOOR APPLICATION)
138	SEC SWITCH	CP-SC-SW-08	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 05	POLE 05	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
139	PWR SUPPLY	CP-SC-PS-08	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 05	POLE 05	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
140	CAMERA	CAM-20	06-TY-2002	C.C. WILLIAMS	POLE 07	EAST PERIMETER	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
141	CAMERA	CAM-21	06-TY-2002	C.C. WILLIAMS	POLE 07	EAST PERIMETER	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
142	CAMERA	CAM-22	06-TY-2002	C.C. WILLIAMS	POLE 07	EAST GATE	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
143	SEC SWITCH PANEL	CP-SC-SWP-10	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 07	POLE 07	1	HOFFMAN	A24H2412SS6LP & A24P24	ENCLOSURE, TYPE 4X 24"H X 24"W X 12"D & SUBPANEL	316SST, POWER-COATED WHITE WITH SUN SHIELDS, SINGLE DOOR; FRONT ACCESS. (OUTDOOR APPLICATION)
144	SEC SWITCH	CP-SC-SW-10	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 07	POLE 07	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
145	PWR SUPPLY	CP-SC-PS-10	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 07	POLE 07	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
146	CAMERA	CAM-23	06-TY-2002	C.C. WILLIAMS	POLE 15	POWER POLE NO. 15	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
147	SEC SWITCH PANEL	CP-SC-SWP-11	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 15	POWER POLE NO. 15	1	HOFFMAN	A24H2412SS6LP & A24P24	ENCLOSURE, TYPE 4X 24"H X 24"W X 12"D & SUBPANEL	316SST, POWER-COATED WHITE WITH SUN SHIELDS, SINGLE DOOR; FRONT ACCESS. (OUTDOOR APPLICATION)
148	SEC SWITCH	CP-SC-SW-11	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 15	POWER POLE NO. 15	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
149	PWR SUPPLY	CP-SC-PS-11	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 15	POWER POLE NO. 15	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
150	CAMERA	CAM-24	06-TY-2002	C.C. WILLIAMS	POLE 09	CHLORINE/SO2 BUILDING	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
151	SEC SWITCH PANEL	CP-SC-SWP-13	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 09	POLE 09	1	HOFFMAN	A24H2412SS6LP & A24P24	ENCLOSURE, TYPE 4X 24"H X 24"W X 12"D & SUBPANEL	316SST, POWER-COATED WHITE WITH SUN SHIELDS, SINGLE DOOR; FRONT ACCESS. (OUTDOOR APPLICATION)
152	SEC SWITCH	CP-SC-SW-13	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 09	POLE 09	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
153	PWR SUPPLY	CP-SC-PS-13	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 09	POLE 09	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
154	CAMERA	CAM-25	06-TY-2002	C.C. WILLIAMS	POLE 10	CHLORINE/SO2 BUILDING	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
155	SEC SWITCH PANEL	CP-SC-SWP-15	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 10	POLE 10	1	HOFFMAN	A24H2412SS6LP & A24P24	ENCLOSURE, TYPE 4X 24"H X 24"W X 12"D & SUBPANEL	316SST, POWER-COATED WHITE WITH SUN SHIELDS, SINGLE DOOR; FRONT ACCESS. (OUTDOOR APPLICATION)
156	SEC SWITCH	CP-SC-SW-15	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 10	POLE 10	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
157	PWR SUPPLY	CP-SC-PS-15	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 10	POLE 10	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
158	CAMERA	CAM-26	06-TY-2002	C.C. WILLIAMS	POLE 11	EAST PERIMETER	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
159	CAMERA	CAM-27	06-TY-2002	C.C. WILLIAMS	POLE 11	NORTH-EAST PERIMETER	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
160	SEC SWITCH PANEL	CP-SC-SWP-16	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 11	POLE 11	1	HOFFMAN	A24H2412SS6LP & A24P24	ENCLOSURE, TYPE 4X 24"H X 24"W X 12"D & SUBPANEL	316SST, POWER-COATED WHITE WITH SUN SHIELDS, SINGLE DOOR; FRONT ACCESS. (OUTDOOR APPLICATION)
161	SEC SWITCH	CP-SC-SW-16	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 11	POLE 11	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
162	PWR SUPPLY	CP-SC-PS-16	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 11	POLE 11	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES

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ITEM	ITEM TYPE	EQUIP. NO.	DWG REF	FACILITY	SOURCE LOCATION	AREA SERVED	QTY	MANUF.	MODEL	DESCRIPTION	COMMENTS
163	CAMERA	CAM-28	06-TY-2002	C.C. WILLIAMS	POLE 12	NORTH PERIMETER	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
164	CAMERA	CAM-29	06-TY-2002	C.C. WILLIAMS	POLE 12	NORTH PERIMETER	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
165	CAMERA	CAM-30	06-TY-2002	C.C. WILLIAMS	POLE 12	EXIT GATE	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE
166	SEC SWITCH PANEL	CP-SC-SWP-17	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 12	POLE 12	1	HOFFMAN	A24H2412SS6LP & A24P24	ENCLOSURE, TYPE 4X 24"H X 24"W X 12"D & SUBPANEL	316SST, POWER-COATED WHITE WITH SUN SHIELDS, SINGLE DOOR; FRONT ACCESS. (OUTDOOR APPLICATION)
167	SEC SWITCH	CP-SC-SW-17	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 12	POLE 12	1	TRANSITION NETWORKS	SISPM1040-384-LRT-C	TYPE 1- ETHERNET SWITCH, 8 POE PORTS (30W/EACH), TOTAL POE BUDGET 240W, AND 4 SFP SLOTS.	PROVIDE SFP MODULES, MULTIMODE (LC)
168	PWR SUPPLY	CP-SC-PS-17	06-TY-5001 06-TY-2002 99-E-5003	C.C. WILLIAMS	POLE 12	POLE 12	1	TRANSITION NETWORKS	25104	48V DC POWER SUPPLY, 240W	POWER FOR SECUIRITY DIN RAIL INDUSTRIAL SWITHCES
169	CAMERA	CAM-32	06-TY-2002	C.C. WILLIAMS	POLE 04	NORTH-EAST PERIMETER	1	AVIGILON	4.0C-H5A-BO-IR	TYPE 1- OUTDOOR, FIXED CAMERA. H5A BULLET CAMERA WITH SELF-LEARNING VIDEO ANALYTICS AND IR ILLUMINATOR.	PROVIDE SURGE SUPP. PROVIDE ALL ASSOCIATED HARDWARE

BILL OF MATERIALS

Notes:
1. Pole no. 6 to be removed. The new cameras to be installed on Pole no. 7. The following Tags are not used:
CP-SC-SWP-09
CP-SC-SW-09
CP-SC-PS-09

2. The following camera tags are not used:
CAM-36 to CAM-39

3. Camera on Camera Pole no. 8 to be removed. Camera Pole no. 8 will not be used. The new cameras to be installed on Power Pole no. 15.

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SECTION 28 05 13
CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This section provides Specifications for low-voltage wire and cable used to support the security system.

B. The Work includes all labor, materials, appliances, tools, equipment, facilities, transportation, and services necessary for, or incidental to, performing all operations of the Work of this section, complete, as shown on the Drawings or specified herein. Work includes, but is not limited to, the following:

1. Furnish and install all data/power cabling as required on the Drawings.
2. Perform end-to-end tests of cable pairs, and verify assignments and terminations.
3. The entire system shall be supported by engineering documentation in accordance with the provisions of these Specifications, specifically including:
    a. Wiring diagrams showing all devices, terminations, and interconnections.
    b. Connection diagrams showing interfaces between the devices, panels, and system head-ends.
    c. Cable assignments and terminations, showing all pair assignments and termination locations.

C. All required signal and power cables not shown on Drawings, but required as per equipment manufacturers' and/or system Drawings

1.02 RELATED SECTIONS

A. Section 26 05 05, Conductors.

B. Section 28 00 00, Electronic Safety and Security.

C. Section 28 10 00, Access Control and Intrusion Detection.

D. Section 28 23 00, Video Surveillance.

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1.03 REFERENCES

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

1. IEEE C2 - National Electrical Safety Code.
2. American National Standards Institute (ANSI).
3. BICSI – Business Industry Consulting Services International – Telecommunications Distribution Methods Manual (TDMM) 12th Edition.
4. American Society for Testing and Materials (ASTM):
   a. B3, Soft or Annealed Copper Wire.
   b. B8, Soft or Annealed Copper Wire Concentric Lay Stranded Copper Conductors, Hard, Medium Hard, or Soft.
5. Insulated Cable Engineers Association, Inc. (ICEA) and National Electrical Manufacturers Association (NEMA):
   a. ICEA S-95-658/NEMA WC70.
6. National Fire Protection Association (NFPA) 70: National Electrical Code (NEC).
7. NETA ATS - National Electrical Testing Association Acceptance Testing Specifications.

1.04 SUBMITTALS

A. Provide submittals in accordance with Section 28 00 00, Electronic Safety and Security.

B. Refer to the requirements of Sections 28 10 00, Electronic Access Control and Intrusion Detection and 28 23 00, Video Surveillance.

1.05 DELIVERY, STORAGE AND HANDLING

A. Provide markings on wire and cable in accordance with applicable NEMA and NEC requirements.

B. Ship each material securely wrapped, packaged, and labeled for safe handling during shipment and storage.

C. Store wire and cable in secure and dry storage facility.

1.06 WARRANTY

A. Contractor shall warranty the low-voltage wiring installation for 1 year from the effective date of beneficial use.

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PART 2 PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Unless otherwise noted, all materials and equipment shall be new, of the type, capacity, and quality specified and free from defects. Material shall bear the label of, and be listed by, the Underwriters' Laboratories (UL) unless of a type for which label or listing service is not provided.

B. Materials shall be of same brand or manufacturer throughout for each class of material or equipment, wherever possible.

2.02 WIRE AND CABLE

A. Data/Signal Composite Cabling – Type A: Smartwire Model 4461140 (latest version), one 18 AWG, four conductor non-shielded, one 22 AWG, six conductor shielded, one 22 AWG, four conductor non-shielded, and one 22 AWG, two conductor non-shielded, or approved equal.

B. Data/Signal Cabling – Type B: West Penn Model AQC3186 (latest version), 18 AWG, six conductor twisted, shielded, waterblocked construction or approved equal.

C. Data/Signal Cabling – Type D: West Penn Model 4246 (Black jacket) (latest version), 23 AWG, four pair (CAT6), or approved equal.

D. Data/Signal Cabling – Type E: West Penn Model M57622 (Black jacket) (latest version), 24 AWG, four pair (CAT6), waterblocked construction, or approved equal.

E. Power/Signal Cabling – Type K: West Penn Model AQC439 (latest version), 22 AWG, four pair, shielded, waterblocked construction or approved equal.

2.03 CABLE LABELING

A. All cable labels, faceplates, patch panels and pathways shall be labeled in accordance with EIA/TIA 606A standards.

B. Labels shall be a self-laminating vinyl.

C. Labels shall be a minimum of 1-inch wide and 1-1/4-inch long, the printed area shall be no less than 1/2-inch high.

D. Generate labels using a handheld labeler Model ID ProPlus, or equal.

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2.04 ACCESSORIES

A. Control Conductors: Termination on saddle-type terminals shall be wired directly with a maximum of two conductors. Termination on screw type terminals shall be made with a maximum of two spade connectors. Splices are not allowed.

B. Cable Supports and Fasteners: Design for use with channel inserts. Conform to NFPA 70.

C. Conductor Bundling Straps: Provide conductor bundling straps formed from self-extinguishing nylon having a temperature range of minus 65 degrees F to plus 250 degrees F.

D. Lubricant shield for electrical connections shall be Kopr-Kote.

PART 3 EXECUTION

3.01 CONDUCTOR INSTALLATION

A. Low-Voltage Signal and Power Cables:

1. Refer to the requirements of Section 26 05 05, Conductors.
2. Provide wiring systems complete as indicated. Provide ample slack wire for motor loops, service connections, and extensions.
3. Do not bend cables during installation, either permanently or temporary, to radii less than twelve times the outer diameters, except where conditions make the specified radius impracticable and shorter radii are permitted by NFPA70 and NEMA WC 7, Appendix N.
4. Bundle cable and conductors neatly and securely with nylon straps located in cabinets and control boards. Use nylon bundling straps. Bundle power cables separate from control cables.
5. Wire Pulling: Comply with the requirements of Section 26 05 04, Basic Electrical Materials and Methods and the following:
   a. Install wire and cable in conduit as indicated. Do not pull wiring into conduit until conduits and outlets have been thoroughly cleaned and swabbed. Do not use block and tackle or other mechanical means for pulling conductors smaller than No. 2 AWG in raceways.
   b. Provide suitable installation equipment, including cable guides, to prevent cutting and abrasion of conduits and wire during the pulling of feeders. Use water-soluble lubricant and installation procedure as recommended by the cable manufacturer.
   c. Pull cables installed in a single conduit together.

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6. Raceway installation shall be completed before any cable installation.
7. Seal cable and wiring entering building/structure from underground.
8. Install conductors and cables in underground handholes and manholes such that the conductors and cables loop once (minimum) around the perimeter. Do not pull tightly around but allow for additional slack, minimum 18 inches.

B. Splices:

1. No splices will be accepted without Owner Representative written approval. If conductors are damaged during installation, the Contractor shall remove the damaged conductor set and furnish/install a new set of conductors with no splices.
2. All splices, connections, and end of line resistors shall be soldered connections.
3. Splices in underground or wet locations shall be Scotchcast or otherwise sealed in approved waterproof epoxy casing.
4. In general, no splices will be allowed in manholes, handholes or other below-grade located boxes. In special circumstances where splices are required, the Owner Representative may allow their use; however, the Contractor shall not proceed until written approval has been received from the Owner Representative.
5. Splices shall not be made in push button control stations, control devices (i.e., pressure switches, flow switches, etc.), conduit bodies, switchgear, etc.

C. Signal Cable Connections:

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
2. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
3. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
4. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack. Outlets to be "pigtail" spliced, not "feed-through."
5. In wet, damp, corrosive, or outdoor areas all copper connections shall be coated with KOPR-KOTE (do not use on stainless steel grounding).

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D. Fiber Cable Terminations:

1. Terminate cables in accordance with TIA/EIA 568.
2. Slack: Provide minimum 6 feet slack fiber at each end, coiled neatly in cable management equipment, for patch panels, fiber centers, hubs and switches.
3. Connectors: Terminate at least two spare fibers in each cable to specified connectors. The design intent is that ST connectors be used on the field side, and LC connectors be used on the rack side.
4. Connect into fiber management system.

3.02 SIGNAL CABLING

A. All signal transmission circuits shall be run as twisted pairs or triads. In no case shall a circuit be made up using conductors from different pairs or triads. Triads shall be used wherever three wire circuits are required. Triads shall not be formed by using two pairs.

B. Terminal blocks shall be provided at all instrument cable junctions, and all circuits shall be identified at such junctions.

C. Signal circuits shall be run without splices between instruments, terminal boxes, or panels.

D. Shields shall be grounded at the control modules or instrument power source and isolated at all other locations. Terminal blocks shall be provided for interconnecting shield drain wires at all junction boxes where required. Where individual circuit shielding is required, each shield circuit shall be provided with its own block.

E. Single pair cables shall be utilized exclusively unless the conduit schedule specifically requires the use of a multiple pair instrumentation cable, or as approved by the Owner Representative.

F. End of line resistors shall be installed at all field device locations, as required.

3.03 IDENTIFICATION

A. Cable Tagging:

1. Cable tagging shall conform to EIA/TIA 606A standards.
2. Cable labeling shall be approved by the Owner, such that at each cable end, origination and destination can be quickly and clearly ascertained. Spare cables shall be so identified.
3. Label text shall be printed utilizing the “Small” text size setting.
4. Label text shall be printed on three lines utilizing the “WIRE” setting.

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5. Label shall be affixed to cable jacket no more than 1 inch from where jacket is stripped back to allow ease of cable identification.
6. Label shall be affixed to cable jacket by adhering the white printed portion of the label directly to the jacketing and then wrapping the clear portion of the label around and over the white printed portion to protect the printed text of the label.
7. Label shall be positioned so that it can be easily read without needing to adjust or reposition label or surrounding cabling.
8. Contractor shall provide a written schedule for all cables that are installed under all related sections for all Work.

3.04 QUALITY CONTROL

A. All wires and cables shall be factory-tested to ensure that they have been manufactured in accordance with the applicable standards.

B. Test components of installation in accordance with standards and Specifications.

C. Provide equipment, instrumentation, supplies and skilled staff necessary to perform testing.

D. All wires and cables shall be field-tested after installation as follows:

1. Insulation resistance and continuity tests shall be made by the Contractor in the presence of the Owner Representative after cable has been pulled in ducts and conduits, prior to connecting the new cables to existing cables or to equipment for all power cables #8 and larger.
2. Provide testing of category 6 cables by using EIA/TIA TSB-67 testing guidelines at level II accuracy and fiber by using EIA/TIA -455-191 testing guidelines to insure a complete and operable end-to-end data connection.
3. Provide and deliver test results upon Work completion.
4. Defects in the cable installation revealed by the tests specified shall be corrected by replacement or repairs satisfactory to the Owner, after which the Contractor shall repeat the tests until he obtains test results satisfactory to the Owner.

END OF SECTION

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SECTION 28 10 00
ELECTRONIC ACCESS CONTROL AND INTRUSION DETECTION

PART 1 GENERAL

1.01 WORK INCLUDED

A. Furnish and install a card access system as shown on the Drawings and specified herein.

B. Configure all access control devices to integrate with the Access Control and Intrusion Detection and Video Surveillance Systems.

C. Provide network equipment and infrastructure upgrades as necessary to expand and isolate the security network to support the work required.

D. Install Category 6 cable to each access controller from the designated network switch.

E. Provide power circuits to support new equipment and access control panels as shown on the Drawings.

F. Program the access control server to include the following:

1. All hardware devices installed as a part of this Work.
2. All access and user defined authorization levels, as required by plant operations coordinated through the Owner Representative.
3. All input of alarm condition messages.
4. Import of mapping displays and program all associated map icons.

G. Program and install the access control system to allow system administrators to carry out the following tasks from a single workstation:

1. View system status, intrusion, access control and video alarms.
2. Administer the entire system.
3. Filter and request reports.
4. Display alarms or device status as a continually updated list or as a graphical map with icons updating in real time.
5. Arm or disarm intrusion detection devices.
6. Program automatic lock and unlock schedules for access controlled doors.
7. Manually lock and unlock access controlled doors and gates.

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8. Put the facility into lockdown mode, automatically locking down all doors with one set of commands.
9. Add or delete users.
10. Issuance or revocation of credentials.

H. Ensure new access cards, card format and access control system work with Owner's existing card access system, such that existing cards will continue to work with new system, in addition to new cards added. Coordinate with Owner Representative.

I. Ensure throughout the construction process that all doors are restored to an operable, locking condition by close of business each day. It is not acceptable that doors which should be locked be left in a non-lockable condition at end of day.

1.02 RELATED SECTIONS

A. Section 08 11 00, Metal Doors and Frames.

B. Section 08 71 00, Door Hardware.

C. Section 26 05 33, Raceways and Boxes.

D. Section 28 00 00, Electronic Safety and Security.

E. Section 28 05 13, Conductors and Cables for Electronic Security.

F. Section 28 23 00, Video Surveillance.

G. Section 40 90 00, Instrumentation and Control for Process Systems.

1.03 SYSTEM DESCRIPTION

A. The access control and intrusion detection system shall include network switches, intelligent field panels, reader interface modules, input/output modules, card readers, door contacts, electronic locking hardware, sensors, power supplies, batteries other auxiliary equipment, and a complete raceway and wiring system from the field devices to accommodate the connection of the field devices.

B. The access control and intrusion detection system shall be able to perform the following functions as a minimum:

1. Generating and reporting an event every time a card reader is used to gain access.
2. Capability to trigger alarms and actions of intruder.

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3. Ability to email specific personnel when certain event occurs.
4. Ability to integrate with video surveillance system.

C. Designated doors shall require access control card readers for entry.

D. Designated doors shall be monitored for alarm conditions, such as door held open and door forced conditions.

E. Facility doors are to fail secure (locked) upon expiration of battery power.

1.04 QUALITY ASSURANCE

A. Reference the quality assurance requirements indicated within Division 1, General Requirements and Section 28 00 00, Electronic Safety and Security.

B. Contractor who will be performing the work shall maintain current licenses and manufacturer certifications required to provide the specific type of work specified in this Contract.

C. System components shall be installed by a Contractor of established reputation and experience who has completed similar installations, utilizing similar systems and devices specified for this Project, for a period of at least 5 years and who shall be able to refer to similar installations rendering satisfactory services.

1.05 SUBMITTALS

A. Provide submittals as indicated within Division 1, General Requirements, and Section 28 00 00, Electronic Safety and Security.

1.06 OPERATION AND MAINTENANCE DATA

A. Provide Operation and Maintenance data as indicated within Division 1, General Requirements and Section 28 00 00, Electronic Safety and Security.

B. Provide six bound sets of manuals and one searchable PDF file in a CD-ROM or DVD-ROM that includes operating instructions; maintenance recommendations, parts list, wiring and connection diagrams modified to reflect as-built conditions.

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C. Manuals: Final copies of the manuals as specified bound in hardback, loose-leaf binders and one searchable PDF file in a CD-ROM or DVD-ROM shall be delivered within 30 days after completing the installation test. Each manual's contents shall be identified on the cover. The manual shall include name, address, and telephone number of the installing contractor and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and tab sheets. Tab sheets shall be placed at the beginning of each chapter or section and at the beginning of each appendix. The final copies delivered after completion of the installation test shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:

1. Hardware Manual: The manual shall describe all equipment furnished including:
   a. General description and Specifications.
   b. Installation and checkout procedures.
2. Operator's Manual: The operator's manual shall fully explain all procedures and instructions for the operation of each system device.
3. Maintenance Manual: The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.
4. As-Built Drawings: The Contractor shall maintain a separate set of Drawings, elementary diagrams, and wiring diagrams of the ACAMS to be used for record drawings. The Contractor with all changes and additions shall accurately keep this set up to date to the ACAMS. In addition to being complete and accurate, this set of Drawings shall be kept neat and shall not be used for installation purposes. Provide final As-Built drawings, two half-sized (11 by 17) print and two AutoCAD drawing files (Version 2015) in a CD-ROM or DVD-ROM.

PART 2 PRODUCTS

2.01 ACCESS CONTROL SOFTWARE

A. The level access control software shall be infinias ESSENTIALS, manufactured by 3xLOGIC infinias.

2.02 ACCESS CONTROL SERVER (20-SC-SVR-01)

A. Servers shall meet manufacturer's minimum hardware requirements and Owner's standard build requirements. Minimum requirements:

1. Processor: Intel Celeron @2.0 GHz or higher.
2. System memory: 4 GB.
3. Disk space: 240 GB or higher storage.

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4. Display: Support for HDMI (1920 by 1080) or VGA (1920 by 1080).
5. NIC: 100M /1000 Mbps Ethernet.
6. OS: Windows 7 Embedded (or higher) with pre-loaded infinias ESSENTIALS software.
7. Accepted Manufacture: 3XLOGIC (recommended infinias Server 50 or higher).

2.03 SECURITY WORKSTATION:

A. ACS and CCTV Server (20-SC-WS-01):

1. There shall be one combined unit serving both ACS and CCTV.
2. Server requirements shall include, but not be limited to the following:
   a. Operating system compatible with the ACS software being provided.
   b. Processor: Intel Xeon E3-1270v6 3.8 Ghz.
   c. Ethernet: 1 Gb network adapter.
   d. Available Drive Size: 2TB, 4TB, 6TB, 8TB, 10TB, 14TB.
   e. Max data storage: 252 TB (raw); 224 TB (usable).
   f. Power: 350W.
   g. Bays: 4.
   h. Input Power 100V to 240V.
   i. Manufacturer and Product: Dell; R330.
3. Discrete, dry relay contact rated for 120-volt, to provide general alarm to SCADA system.

B. Desktop Video Display Monitor (20-SC-MON-01):

1. The desktop video display monitors are to comply with the following minimum requirements:
   a. Display Type: 24-inch high definition (HD), black, 16:9 aspect ratio.
   b. Brightness (typical): 300 cd/m2.
   c. Resolution: 1920 by 1080.
   d. Response: 1ms response time.
   e. Connectivity: VGA, HDMi, BNC, S-Video, Audio.
2. Manufacturer and Product: Tatung, TME24A.

2.04 ACCESS CONTROLLER (AC)

A. Distributed architecture shall allow access controller to operate independently of the host server.

B. The architecture shall place key access decisions, event/action processing and alarm monitoring functions within the controllers, eliminating degraded mode operation.

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C. Flash memory management shall support firmware updates and revisions to be downloaded to the system. Upgrades to the hardware and software shall occur seamlessly without the loss of database, configurations, or historical report data.

D. ACP Communication Schemes:

1. Network Communications:
   a. The first field panel in a chain of panels shall have the ability to communicate with its monitoring client PC over the local or wide area network.
   b. The network interface shall support both "10 base T" and "100 base TX" (10/100) communications speeds.
   c. The network interface shall support encryption utilizing AES algorithm.

E. AC – One Reader Configuration: ACs serving a single card reader in a hardwired fashion shall be configured as follows:

1. (Quantity 1) infinias Ethernet-Enabled Integrated Single Door Controller (eIDC), supporting the following:
   a. IP network port.
   b. Two card readers inputs: Card Reader IN and Card Reader OUT.
   c. One form-C relay output.
   d. Two Open collector outputs.
   e. Four configurable inputs.
   f. Tamper: Integrated infrared tamper.
   g. Communication: Ethernet, 10Base-T.
   h. Power: Direct from POE switch or external power supply (24 VDC, 1A).
   i. Accepted manufacture: 3xLOGIC infinias.
   j. Recommended part number: Single Door Kit (S-DOOR-KIT-WH-ST). The kit includes the following:
      1) Intelli-M Ethernet-Enabled Integrated Door Controller (S-EIDC32).
      2) Surface Mount Box (S-SMB-5075).
      3) HID ProxPoint Plus Reader (A-CRS-6005-GRY).
      4) ROFU Electric Door Strike (S-STRK-2400-05).
      5) GRI Flush-Mount / Metal-Mount Door Sensors.

2.05 ELECTRIFIED DOOR HARDWARE

A. Coordinate access controlled door hardware with existing conditions and the requirements of Section 08 71 00, Door Hardware.

B. Locks shall match existing non electrified hardware type whenever possible.

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2.06 MOTION/REQUEST-TO-EXIT (REX) SENSOR

A. Furnish and install Request-To-Exit PIR with wrap around coverage as shown on the contract plan and specified herein.

1. Current Draw: 0.026A at 12V dc.
2. Relay Latch Time: Adjustable to 60 seconds.
3. Alarm output: Two form C relays Contacts.
4. Coverage Area: 8 feet by 10 feet.
5. Product: Bosch DS 150i or approved equal.

2.07 ELECTROMAGNETIC LOCKS

A. Furnish and install magnalocks for the existing door and gates as shown on the contract plan and specified herein.

1. Holding Force: 1,200 pounds [544 kg].
2. Current Draw and Voltage: 250mA at 12V dc; 150mA at 24V dc.
3. Operating Temperature: Minus 40 to plus 140 degrees F [-40 to +60C].
4. Product: Securitron M62 Magnalock or approved equal.

2.08 INTERCOM

A. Provide new video master station:

1. 3.5-inch LCD display.
2. IP enabled.
3. Acceptable Manufacturer: Aiphone model number IX-MV.

B. Provide outdoor intercom station with integrated camera.

1. Vandal-resistant, stainless-steel faceplate.
2. Operating Temperature: 14 degrees F to 140 degrees F.
3. Acceptable Manufacturer: Aiphone model number IX-DF with SXB-ISDVF backbox for surface mounting.

2.09 CONTROL ENCLOSURES

A. Reference Section 40 90 00, Instrumentation and Control for Process Systems, for general control panel requirements.

2.10 SPARE PARTS

A. Provide the following spare parts:

1. Two intelligent 2 door controller module.
2. Two 2 reader interface module.

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3. Two door status contacts.
4. Two card readers.
5. One request to exit motion sensor.
6. 200 Access cards
7. One spare 48V dc power supply shall be provided.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation shall be accomplished in professional manner by qualified personnel regularly engaged in and experienced in this type of work.

B. Install all devices in accordance with manufacturer's instructions.

C. All wiring shall be installed in accordance with NFPA 70, the National Electrical Code.

D. Install controllers and devices in accordance with manufacturer's instruction at locations indicated on the contract plan and assure real-time communication between access controller and access control management server.

E. System Integrator shall provide complete wiring diagrams as part of the submittal. All the wiring shall be installed by system integrator in order to insure a complete operating and trouble-free system.

3.02 FIELD QUALITY CONTROL

A. Perform full acceptance testing and commissioning in accordance with the requirements of Division 1, General Requirements and Section 28 00 00, Electronic Safety and Security.

B. Test proper operation of controllers and readers in all modes and conditions. Present card to the readers to validate if reader functions correctly.

C. System integrator shall submit written test report that the system has been 100 percent tested and approved.

1. Final test shall be witnessed by Owner Representative.
2. Final test report shall be submitted prior to substantial completion.

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D. Door Testing:

1. Provide the following additional ACS tests indicated below:
   a. Access Granted – No Entry:
      1) Present a valid card at the reader – do not open door.
      2) Validate card reader LED turns green and door unlocks.
      3) Validate card reader LED turns red and door relocks.
      4) Mark result on testing sheet.
   b. Strike Time: Document actual time between door unlock and lock (typically less than 5 seconds).
   c. Access Granted – Valid Entry:
      1) Present a valid card at the reader.
      2) Validate card reader LED turns green and door unlocks.
      3) Turn handle, open door.
      4) Validate card reader LED turns red and door relocks.
      5) Mark result on testing sheet.
   d. Relock On:
      1) OPEN: As soon as the door opens it relocks.
      2) CLOSED: The door remains unlocked until the door closes.
   e. Valid Request to Exit ("REX") / Exit:
      1) Verify no alarm for door forced.
      2) If motion REX, repeat from multiple angles.
      3) Check to see if door unlocks on REX.
      4) Mark results on testing sheet.
   f. Confirming Door Set for Unlock on REX:
      1) Walk up to door.
      2) Activate REX device (motion or handle turn).
      3) Try to open door.
      4) Mark results on testing sheet.

3.03 PERSONNEL TRAINING AND DOCUMENTATION

A. Refer to the requirements of Division 1, General Requirements and Section 28 00 00, Electronic Safety and Security.

B. The Contractor shall provide personnel training to operating staff and documentation including full operational instructions and maintenance material for the card access system that shall describe in sufficient detail how it works and how to operate it without needing an Owner Representative to help interpret the diagrams.

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3.04 ADJUSTING

A. Make proper adjustment to controller, extensions and readers for correct operation in accordance with manufacturer's instructions.

3.05 WARRANTY

A. The Contractor shall provide a written warranty covering the performance, workmanship, and installation of new equipment furnished under this section.

B. Refer to the requirements of Division 1, General Requirements, and Section 28 00 00, Electronic Safety and Security.

END OF SECTION

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SECTION 28 23 00
VIDEO SURVEILLANCE

PART 1 GENERAL

1.01 WORK INCLUDED

A. Furnish and install a digital video surveillance system as shown on the Drawings and specified herein.

B. Configure all cameras to integrate with the Video Surveillance System and the Access Control and Intrusion Detection System.

C. Provide network equipment and infrastructure upgrades as necessary to expand and isolate the security network to support the work required.

D. Furnish and install recording servers to store the video recording system.

E. Provide and install network switches to support new equipment.

F. Supply and install new patch cords for all connections. Configure switching equipment for both basic and advanced features as described in this Specification.

G. Provide power circuits to support new equipment and video cabinets as shown on the Drawings.

H. Utilize mid-span PoE injectors to provide sufficient power to accommodate camera needs, where those camera power needs exceed inherent PoE network switch capabilities.

I. Provide testing of Category 6 cables to insure a complete and operable end-to-end data connection. Provide and deliver test results upon Work completion.

1.02 SYSTEM DESCRIPTION

A. The system shall include internet protocol (IP) color cameras, environmental enclosures, mounting brackets, Network Video Recorder (NVR) with adequate storage for 10 days video image recording and archive, cables and devices for remote camera setup and control, including signal transmission, processing, and conversion as required to provide a fully functional, tested and operational system.

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B. The video surveillance system shall be used for surveillance of indoor and outdoor areas against intrusion and for effective visual monitoring and verification of validity of alarms and other alert conditions.

C. Remote activation and control of any set of cameras from its central monitoring computer in control room shall be as indicated on the Drawings.

D. The video surveillance shall consist of the following major components as below:

1. Video Recording Server.
2. Video Management Software and software camera licensing.
3. Network switches.
4. Cameras.

E. The video surveillance shall provide the following functionalities:

1. The ability to record and recall emergencies and incidents.
2. The ability to track persons of interest and recall.
3. The ability to monitor and track facility activities.
4. The ability to utilize video as evidence during an investigation.
5. The ability to integrate with access control management system.

F. A Detection, Classification, Recognition, Identification (DCRI) criteria shall be used to define the purpose and image quality for each video surveillance camera.

1. Detection-level Imaging: Sufficient detail and clarity shall be available to determine the presence of a human-sized target in the field of view. The object shall be discernible from its surroundings and can be distinguished from the background when in motion. Detection-level video shall have at minimum 20 to 30 pixels on target.
2. Classification-level Imaging: Sufficient detail and clarity shall be available to determine if a human-sized target can be distinguished between human and animal, or between animal and small vehicle, for example. All properties of detection-level imaging shall apply. Classification-level video shall provide object information, such as approximate orientation in space, physical stance (e.g., standing, crawling) and direction of motion. Classification-level video shall have at minimum 30 to 40 pixels on target.

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3. Recognition-level Imaging: Sufficient detail and clarity shall be available to determine if a human-sized target is a threat or non-threat based on equipment carried and/or other contextual cues. All properties of Detection- and Classification-level imaging shall apply. Additionally, body movements, different uniform types, and the presence of headgear, backpacks, or other objects shall be determined. Recognition-level video shall have at minimum 40 to 50 pixels on target.
4. Identification-level Imaging: Sufficient detail and clarity is available to allow for an already familiar human-sized target to be determined as a specific individual. All properties of Detection-, Classification-, and Recognition-level images shall apply. Additionally, the target's type of headgear shall be distinguished (e.g., bicycle helmet or soldier's helmet) and specific objects on the body can be determined (e.g., weapons, phones). Identification-level video shall have at minimum 60 to 90 pixels on target.

G. Screen Layout: There are two display monitors (wall-mount) at the C. C. Williams Control Room reserved for video surveillance and security. For the monitor, assume a grid of a 6 by 6 matrix for a total of a maximum of thirty six potential simultaneous views. For identification purposes, assume column designations of A through F, and row designations of 1-6, such that the upper left cell is A1 and the lower right cell is F6. The overall screen display for video shall be laid out and submitted for the Owner approval prior to finalizing the programming.

H. Small Desktop Monitor: Designated for alarm monitoring and video playback views across all sites:

I. Control Narrative:

1. Security Access Control to Video Interface: Upon an alarm condition such as a door forced or door held open condition detected from the security access control system, the appropriate video camera will be called up and displayed automatically on the appropriate video monitor.
2. Provide a submittal of all control functions that will be programmed for approval by Owner prior to the start of configuration.

J. Video storage duration design basis is 10-days storage. Size storage units to provide a minimum of 10-days storage. Owner will be performing a weekly replication for the saved video storage data and back it up in the servers, located at the main office.

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1.03 RELATED SECTIONS

A. Section 26 05 33, Raceways and Boxes for Electrical Systems.

B. Section 28 05 13, Conductors and Cables for Electronic Security.

C. Section 28 10 00, Electronic Access Control and Intrusion Detection.

D. Section 40 90 00, Instrumentation and Control for Process Systems.

1.04 QUALITY ASSURANCE

A. Reference the quality assurance requirements indicated within Division 1, General Requirements and Section 28 00 00, Electronic Safety and Security.

B. System components shall be installed by a Contractor of established reputation and experience who has completed similar installations, utilizing similar systems and devices specified for this Work, for a period of at least 5 years and who shall be able to refer to similar installations rendering satisfactory services.

C. Contractor who will be performing the work shall maintain current licenses and manufacturer certifications required to provide the specific type of work specified in this Contract. This shall include Three customer references demonstrating projects of similar complexity and scope.

D. The System Integrator shall utilize installation and service technicians who are factory-trained and certified. Security standard as following shall be met when the system integrator perform system configuration for network switch, ISP interface and firewall.

E. Network Switching Standards:

1. Basic Switching Configuration: IP addressing, Port VLAN configuration, SNPMv3 management and trap support, Multiple Security Accounts for Read Only, Read Write and Administrative functions, SSH, 802.1Q VLAN trunk and 802.1 ad Link aggregation of multiple data links between switches.

1.05 SYSTEM INTEGRATOR QUALIFICATIONS

A. It is the intent of these Specifications that Division 28, Electronic Safety and Security Sections related to Digital Video Management System and Access Control Management System, be supplied and installed by one Contractor.

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B. The Contractor shall have full service for UL listing and shall have a Florida Contractor License for the last 5 years. This requirement is to allow the Contractor to supervise the installation necessary for the video surveillance System and meet all applicable Florida Electrical Code provisions and standards required for the installation of the Facilities Systems.

C. The Contractor shall demonstrate that there are no litigations pending against their license.

D. Site representative: Minimum 3 years of experience installing and configuring systems equal in complexity to the Video Surveillance System as required.

E. The Contractor shall submit the equipment submittal document as required in other sections with his/her qualification and a detailed written plan indicating work to be performed to meet the objective of this Contract prior to construction. The list of qualification shall include name and certification of each individual who will perform configuration and installation for this Contract. A copy of certification shall be provided for verification.

1.06 SUBMITTALS

A. Provide submittals as indicated within Division 1, General Requirements and Section 28 00 00, Electronic Safety and Security.

B. Product Data: Provide complete product data, electrical characteristic and connection requirements, which includes the following: Manufacturer’s data for material and equipment including security camera, servers, network switches, enclosures, and any other communication equipment provided as part of video surveillance system.

1.07 OPERATION AND MAINTENANCE DATA

A. Provide Operation and Maintenance data as indicated within Division 1, General Requirements and Section 28 00 00, Access Control and Intrusion Detection.

B. Provide six bound sets of manuals including operating instructions; maintenance recommendations and parts list including wiring and connection diagrams modified to reflect as-built conditions.

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C. Manuals: Final copies of the manuals as specified bound in hardback, loose-leaf binders shall be delivered within 30 days after completing the installation test. Each manual's contents shall be identified on the cover. The manual shall include name, address, and telephone number of the installing contractor and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and tab sheets. Tab sheets shall be placed at the beginning of each chapter or section and at the beginning of each appendix. The final copies delivered after completion of the installation test shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:

1. Hardware Manual: The manual shall describe all equipment furnished including: General description and Specifications.
2. Operator's Manual: The operator's manual shall fully explain all procedures and instructions for the operation of each system device.
3. Maintenance Manual: The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.
4. As-Built Drawings: The Contractor shall maintain a separate set of drawings, elementary diagrams, and wiring diagrams of the ACS to be used for record drawings. The Contractor with all changes and additions shall accurately keep this set up to date to the ACS. In addition to being complete and accurate, this set of drawings shall be kept neat and shall not be used for installation purposes.

D. Provide one electronic copy of all O&M manuals in 'pdf' format.

PART 2 PRODUCTS

2.01 VIDEO MANAGEMENT SYSTEM

A. The networked Video Management System (VMS) shall consist of the following components:

1. Scalable video management software hosted on commercial grade servers with Microsoft Windows operating system.
2. Industry standard server and storage platforms.
3. The VMS shall be a true hybrid system capable of integrating existing or new analog and/or IP cameras into the IP infrastructure.
4. The VMS shall support virtually all leading IP and analog camera and encoder manufacturers for user choice and design flexibility.

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5. The VMS shall be full featured with client software applications intended for:
    a. Live video monitoring.
    b. Real-time alarm monitoring and display.
    c. Alarm display prioritization.
    d. System management
    e. Instantaneous retrieval of archived video.
    f. Evidence production on AVI files that can be viewed on any PC.
    g. Export of tamper evident video on recordable CD's or DVD's.

B. Video Management System Concept of Operation

1. The VMS and its manufacturer shall provide the following key functions and capabilities:
2. The system shall operate in a Microsoft Windows environment. It shall be an IT server based solution purpose-built for the capture, processing, storage and retrieval of unlimited amounts of digital video and supporting audio, alarm, associated systems (access control, etc.), and other surveillance data.
3. The VMS shall support a wide range of deployments including new, all-IP camera environments as well as incorporating existing analog cameras, cabling and other security and IT infrastructure where appropriate to maximize existing investments.
4. The VMS software shall operate consistently on stand-alone or integrated host and storage platforms from recognized IT industry suppliers. This hardware independence shall allow the host and storage platforms to be sourced from the VMS manufacturer, an integrator certified by the VMS manufacturer or supplied by the customer for optional loading and certification by the VMS manufacturer at the manufacturer's facility.
5. The VMS shall capture video, audio, alarm, associated systems and other data from a single or multiple servers.
6. Each server shall be capable of sixty four direct connect analog cameras and an unlimited number of IP camera sources depending on selected model.
7. The VMS shall have the ability to write to DAS, NAS iSCSI and Fiber SAN in addition to local storage. The VMS storage volume can be configured in RAID levels 0, 1, 5, 6, 10, 50 and JBOD.
8. The VMS shall support all leading industry-standard compression formats including Motion JPEG, MPEG-4 and H.264.
9. The VMS shall simultaneously handle recording, archiving, retrieving, playback and live distribution of video and audio. The software shall operate in a continuous recording mode or according to a programmed time/date schedule. Recording functions may also be triggered by events and motion detection.

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10. Live and archived video/audio data shall be available to authorized users at any time over local or wide area network connections.
11. The VMS shall incorporate a Web Client so live and recorded video may be viewed via the Internet by authorized users.
12. The VMS shall be capable of exporting video clips or images to CD/DVD's without third party software. All images or clips shall include an executable player that verifies no tampering has occurred and can be played on standard PC's.
13. The VMS Server software shall utilize a high performance, multi-threaded, application engine. This allows multiple tasks to be executed at the same time and is required to take full advantage of multiple core or multi-processor technology.
14. The VMS software must minimize user actions required ("mouse clicks") wherever possible. The ten most common operator tasks shall average not more than 2.8 clicks to complete.
15. The VMS software shall utilize a camera abstraction layer. Video shall be captured in such a way as to provide seamless support of multiple, disparate video source technologies transparent to the user and allowing for the integration of new capture technologies as they become available.
16. The VMS shall provide direct support of IP-based video sources in such a way that the use of camera manufacturer supplied COM application software interfaces such as ActiveX controls are not required.
17. The VMS shall provide a Video Proxy capability allowing for a designated server to be a single point of client connection requests for video recording to any of multiple recording servers.
18. The VMS shall support QuickTrack recording allowing a user to custom record a series of cameras being focused on. This provides the ability to record the cameras of interest when tracking a suspect across multiple cameras.
19. The VMS shall be capable of integrated operation with other security related systems such as Access Control Systems (ACS), Central Station Monitoring Systems (CSMS) and Video Analytics Systems (VAS) or applications.

C. Software Licensing:

1. The VMS manufacturer shall license the software on a per video channel basis only, in such a way that there are no license fees associated with client applications, site installation, user accounts, add-on features or other license fees. The licensing program characteristics are:
2. IP camera license shall not be tied to a hardware address (MAC Address).
3. The VMS Server software shall not be tied to the server hardware.

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4. Camera licenses may be moved between servers.
5. All server and camera licenses are moveable without requiring manufacturer action of any type.
6. All VMS Client software modules shall be included in the base VMS software cost. Modules include Administration Console, Alarm Client, Video Client, Mapping Client, Web Client and SpotLight.
7. Client applications can be installed an unlimited number of times and may be running simultaneously without additional licensing cost.
8. Licensing for directly connected analog cameras shall include for no additional cost, PCI or PCIe, connected encoding hardware. The VMS manufacturer shall allow for trade in or conversion of the encoding hardware for the equivalent number of IP camera licenses in the future allowing the user to switch from analog cameras to IP cameras without incurring additional licensing cost.

2.02 VIDEO MANAGEMENT SOFTWARE

A. Avigilon Control Center (ACC) Enterprise System. Acceptable Manufacturers: Avigilon Systems.

2.03 VIDEO SURVEILLANCE NETWORK VIDEO RECORDER (20-SC-NVR-01)

A. Servers shall meet manufacturer's minimum hardware requirements and Owner's standard build requirements.

B. Avigilon HD Network Video Recorders (NVRs) Server series:

1. 48TB Storage or higher.
2. Raid 5.
3. Up to 2U form factor rack mounting.
4. Memory: 16GB or higher.
5. Acceptable Manufacturers: Avigilon, model HD-NVR4-STD-48TB.

2.04 SECURITY WORKSTATION

A. ACS and CCTV Server (20-SC-WS-01):

1. There shall be one combined unit serving both ACS and CCTV.
2. Server requirements shall include, but not be limited to the following:
   a. Operating system compatible with the ACS software being provided.
   b. Processor: Intel Xeon E3-1270v6 3.8 Ghz.
   c. Ethernet: 1 Gb network adapter.
   d. Available Drive Size: 2TB, 4TB, 6TB, 8TB, 10TB, 14TB.
   e. Max data storage: 252 TB (raw); 224 TB (usable).

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f. Power: 350W.
g. Bays: 4.
h. Input Power 100V to 240V.
i. Manufacturer and Product: Dell; R330.

3. Discrete, dry relay contact rated for 120-volt, to provide general alarm to SCADA system.

2.05 SERVER MAIN ETHERNET SWITCH (20-SC-SW-00)

A. Furnish, install and configure combination PoE network switch; all components systems shall be the latest version or technology available in the market when the video surveillance system is being installed.

B. Main Server Switch:

1. Managed PoE layer 2 switch.
2. Temperature Rating: Minus 40 degrees F to plus 140 degrees F, 10 percent to 90 percent Non-condensing humidity
3. Input Power; 90 to 265V ac.
4. Capacity:
   a. 24 PoE ports.
   b. PoE output; up to 370W.
   c. 2U form factor rack mounting.
5. Storage: 32TB.
6. Acceptable Manufacturers: FortiSwitch Secure Access Family, model FS-124E-FPOE.

2.06 INDUSTRIAL ETHERNET SWITCH – TYPE 1

A. General: Furnish and install industrial Ethernet switch as specified in the following:

1. Managed hardened PoE+ Ethernet network switch
2. Features: Store-and-forward architecture with 24 Gbps switching, loop protection and supports LLDP protocol.
3. Operating Temperature: Minus 40 degrees C to plus 75 degrees C.
4. Class I, Div. 2 Certification.
5. Input Power: 48 - 57V dc, redundant power inputs with reverse polarity protection and overload current protection.
6. Data Transfer Rate (copper): 10/100/1000 Mbps, 14,880/148,800 pps.
7. Ports:
   a. Eight 10/100/1000 Base-T PoE+ ports (30 watts per port, all four ports simultaneously).
   b. Four 100/1000Base-X SF ports.

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8. Acceptable Manufacturer: Transition Networks, Model SISPM1040-384-LRT-C, Managed Industrial Switch.
9. Power Supply: Transition Networks, Model 25105, 240W industrial DIN rail mounted 48V dc power supply.

2.07 ETHERNET SURGE PROTECTION UNIT – SINGLE PORT

A. General:

1. Furnish and install Ethernet surge protection for all Ethernet connections to devices mounted outdoors. Protected devices shall include, but not be limited to IP video cameras, radar, intercom, etc.
2. Point of use surge protector to be installed at the network switch end and equipment end of devices, in accordance with manufacturer's instructions.
3. Characteristics:
   a. Port: Single port.
   b. Service Voltage: 48V.
   c. Clamping Voltage: 72V.
   d. Protection Modes: Line-ground, line-line.
   e. Surge Current Rating: 20,000A per pair.
   f. Power Handling: 144 Watts.
   g. Data Rate: 1000 Mbps.
   h. Connection Method: Shielded RJ45 in/out; compatible with CAT6 cabling.
   i. PoE+ compatible.
   j. Operating Temperature: Minus 40 degrees C to plus 70 degrees C.
   k. Acceptable Manufacturer: DITEK, model DTK-MRJPOES

2.08 ETHERNET SURGE PROTECTION UNIT – EIGHT- PORT

A. General:

1. Furnish and install Ethernet surge protection for all Ethernet connections to devices mounted outdoors. Protected devices shall include, but not be limited to IP video cameras, radar, intercom, etc.
2. Point of use surge protector to be installed at the network switch end and equipment end of devices, in accordance with manufacturer's instructions.
3. Characteristics:
   a. Port: Eight ports.
   b. Service Voltage: 48V.
   c. Clamping Voltage: 72V.
   d. Protection Modes: Line-ground, line-line.
   e. Surge Current Rating: 20,000A per pair.
   f. Power Handling: 144 Watts.

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g. Data Rate: 1,000 Mbps.
h. Connection Method: Shielded RJ45 in/out, 8 Channels; compatible with CAT6 cabling.
i. PoE+ compatible.
j. Operating Temperature: Minus 40 degrees C to plus 70 degrees C.
k. Acceptable Manufacturer: DITEK, model DTK-WM8NETS.

2.09 ETHERNET SURGE PROTECTION UNIT – MULTI-PORT

A. General:

1. Furnish and install Ethernet surge protection for all Ethernet connections to devices mounted outdoors. Protected devices shall include, but not be limited to IP video cameras, radar, intercom, etc.
2. Multiport surge protector to be installed at the primary network switch within the Control Room, in accordance with manufacturer's instructions.
3. Characteristics:
   a. Ports: 12-port.
   b. Mounting: 1U rack mount.
   c. Service Voltage: 48V.
   d. Clamping Voltage: 72V.
   e. Protection Modes: Line-ground, line-line.
   f. Surge Current Rating: 30,000A per pair.
   g. Power Handling: 144 Watts.
   h. Data Rate: Gigabit Ethernet.
   i. Connection Method: Shielded RJ45 in/out (12 ports); compatible with CAT6 cabling.
   j. PoE+ compatible.
   k. Operating Temperature: Minus 40 degrees C to plus 70 degrees C.
   l. Acceptable Manufacturer: DITEK, model DTK-RM12POE

2.10 FIBER CHANNEL SFP MODULES

A. General:

1. Furnish and install fiber SFP modules to convert Ethernet signal transmitted over copper conductors to Ethernet signal transmitted over fiber.
2. Environmental: Minus 10 to plus 85 degrees C.
3. Input Power: 3.3V.
4. Output Signal: 1000Base-SX 850nm multimode (LC connectors).
5. Acceptable Manufacturer: Transition Networks, Model Transition TN-SFP-SX.

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2.11 TYPE 1 - OUTDOOR FIXED IP CAMERA SYSTEM COMPONENTS

A. General:

1. Furnish and install indoor/outdoor fixed IP security camera as specified in the following.
2. Hardware and System Specifications:
   a. Form Factor: Bullet Camera
   b. Image sensor: 1/2.8-inch Progressive scan CMOS.
   c. Lens: 3.3-9 mm (with integrated IR Illuminators).
   d. IR Illuination Max Distance: 50 m – full tele or 30 m – full wide.
   e. Horizontal angle of view based on aspect ratio (16:9): 34 degree – 92 degree.
   f. Vertical Angle of view based on aspect ratio (16:9): 18 degree – 50 degree.
   g. Day and night: Automatically removable infrared-cut filter.
   h. Minimum illumination: Color: 0.03 lux, B/W: 0.015 lux, F1.8, P-Iris.
   i. Video compression: H.264, Motion JPEG.
   j. Resolutions: 4 MP, (16:9): 2560 by 1440, (4:3): 2304 by 1728.
   k. Model: AVIGILON H5A CAMERAS, 4.0C-H5A-BO1-IR.

2.12 TYPE 2 – SURFACE-MOUNT INDOOR FIXED IP CAMERA SYSTEM COMPONENTS (SURFACE MOUNT)

A. General:

1. Furnish and install indoor/outdoor fixed IP security camera as specified in the following.
2. Hardware and System Specifications:
   a. Form Factor: Dome Camera
   b. Image sensor: 1/2.8-inch Progressive scan CMOS.
   c. Lens: 3.3-9 mm (with integrated IR Illuminators).
   d. IR Illuination Max Distance: 35 m – full tele or 15 m – full wide.
   e. Horizontal angle of view based on aspect ratio (16:9): 34 degree – 92 degree.
   f. Vertical Angle of view based on aspect ratio (16:9): 18 degree – 50 degree.
   g. Day and night: Automatically removable infrared-cut filter.
   h. Minimum illumination: Color: 0.03 lux, B/W: 0.015 lux, F1.8, P-Iris.
   i. Video compression: H.264, Motion JPEG.
   j. Resolutions: 4 MP, (16:9): 2560 by 1440, (4:3): 2304 by 1728.
   k. Model: AVIGILON H5A CAMERAS, 4.0C-H5A-DO1-IR.

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2.13 TYPE 3 - OUTDOOR FIXED IP CAMERA SYSTEM COMPONENTS

A. General:

1. Furnish and install indoor/outdoor fixed IP security camera as specified in the following.
2. Hardware and System Specifications:
   a. Form Factor: Bullet Camera
   b. Image sensor: 1/2.8-inch Progressive scan CMOS.
   c. Lens: 9-22 mm (with integrated IR Illuminators).
   d. IR Illuination Max Distance: 90 m – full tele or 60 m – full wide.
   e. Horizontal angle of view based on aspect ratio (16:9): 14 degree – 31 degree.
   f. Vertical Angle of view based on aspect ratio (16:9): 8.2 degree – 17.4 degree.
   g. Day and night: Automatically removable infrared-cut filter.
   h. Minimum illumination: Color: 0.058 lux, B/W: 0.029 lux, F1.8, P-Iris.
   i. Video compression: H.264, Motion JPEG.
   j. Resolutions: 4 MP, (16:9): 2560 by 1440, (4:3): 2304 by 1728.
   k. Model: AVIGILON H5A CAMERAS, 4.0C-H5A-BO2-IR.

2.14 CONTROL PANELS AND ENCLOSURES

A. Reference Section 40 90 00, Instrumentation and Control for Process Systems, for general control panel requirements.

2.15 SPARE PARTS

A. Provide the following spare parts:

1. One camera of each type.
2. One local site – Site storage unit shall be provided.

PART 3 EXECUTION

3.01 INSTALLATION

A. Installation shall be accomplished in professional manner by qualified personnel regularly engaged in and experienced in this type of work.

B. Install all devices in accordance with manufacturer’s instructions.

C. All wiring shall be installed in accordance with NFPA 70, the National Electrical Code.

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D. Install all the accessories, mounting hardware, power cables and data cables as required to complete a fully functional video surveillance system.

E. Ensure all exterior-mounted Ethernet network components, including cameras, radar and exterior network switches, are protected with Ethernet surge protection, as specified previously within this section.

F. Utilize PoE midspan power injectors (supplied with cameras) for all cameras exceeding built-in network switch PoE power capacity.

G. Installation Details:

1. Location of computer and associated hardware interface devices shall be coordinated with the Owner Representative, to accommodate existing conditions and arrangements.
2. Wall-mounted devices shall be fastened on rigid areas with Type 316L stainless steel brackets and fasteners suitable to wall material.
3. No devices should be mounted on glass wall.
4. Wall penetrations shall not be made in glass.

3.02 FIELD QUALITY CONTROL

A. Perform full acceptance testing and commissioning in accordance with the requirements of Division 1, General Requirements and Section 28 00 00, Electronic Safety and Security.

B. Test proper operation of the video system and cameras in all modes and conditions.

C. Testing Procedures:

1. Testing procedure shall be established to ensure that all electrical wiring and connections are adequate and firm.
2. All grounding is in place.
3. All devices are mechanically fastened properly and firmly on their mounting supports.
4. All software and hardware shall be tested to ensure that DVMS cameras and communication systems perform properly, reliably and consistently.
5. Test proper operation of the video system and cameras in each mode and every condition.
    a. Testing procedure shall be established to ensure that electrical wiring and connections are adequate and firm.
    b. Check to ensure device grounding is in place.

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c. Devices are mechanically fastened properly and firmly on their mounting supports.
d. Software and hardware shall be tested to ensure that VMS, cameras and communication systems perform properly, reliably and consistently.

6. Normal Camera Operation:
   a. Observe camera image during daytime (normal lighting conditions).
   b. Observe camera image during evening (night-time or lighting of conditions).
   c. Confirm camera resolution, field of view, glare-and-low light capabilities are acceptable.
   d. Mark result on testing sheet.
7. Power Loss Mode:
   a. During normal operation, remove power from video system switch(es) or power source(s).
   b. Observe that power transfer to a continuous alternate power source, such as UPS system, is seamless and that normal operation continues.
8. Network Drop Condition:
   a. During normal camera operation, remove network connection from camera.
   b. Observe that alert condition is received on the VMS, indicating network drop.
   c. Mark result on testing sheet.
9. Network Restoration Condition:
   a. Following a network drop condition, restore network connection to camera.
   b. Observe that restoration condition is received on the VMS, indicating network connection restored.
   c. Mark result on testing sheet.
10. Test results shall be recorded and documented evidence submitted to the Owner Representative upon certified completion for final acceptance.

D. System integrator shall submit written test report that the system has been 100 percent tested and approved.

1. Final test shall be witnessed by the Owner Representative.
2. Final test report shall be submitted prior to substantial completion.

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3.03 PERSONNEL TRAINING AND DOCUMENTATION

A. Refer to the requirements of Division 1, General Requirements and Section 28 00 00, Electronic Safety and Security.

B. The Contractor shall provide personnel training to WWE operating staff and documentation including full operational instructions and maintenance material for DVMS system that shall describe in sufficient detail how it works and how to operate it without needing Owner Representative to help interpret the diagrams.

3.04 ADJUSTING

A. Make proper adjustment to cameras and recorders for correct views and operation in accordance with manufacturer's instructions.

3.05 WARRANTY

A. The Contractor shall provide a written warranty covering the performance, workmanship, and installation of new equipment furnished under this section.

B. Refer to the requirements of Division 1, General Requirements, and Section 28 00 00, Electronic Safety and Security.

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. 101, Code for Safety to Life from Fire in Buildings and Structures.
   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 (1,000 Volts Maximum).
6. National Institute for Certification in Engineering Technologies (NICET).
7. Telecommunications Industry Association (TIA):
   a. 232, Interface Between Data Terminal Equipment and Data Circuit Terminating Equipment Employing Serial Binary Data Interchange.
   b. 485, Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems.
8. 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.

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i. 1604, Electrical Equipment for Use in Class I and Class II, Division 2, and Class III Hazardous (Classified) Locations.
j. 1638, Visual Signaling Appliances – Private Mode Emergency and General Utility Signaling.
k. 1971, Signaling Devices for the Hearing Impaired.

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 are, 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. FACP: Fire Alarm Control Panel.

I. HVAC: Heating, Ventilating, and Air Conditioning.

J. I/O: Input/Output.

K. IDC: Initiating Device Circuit.

L. LCD: Liquid Crystal Display.

M. LED: Light-Emitting Diode.

N. MOV: Metal Oxide Varistor.

O. NAC: Notification Appliance Circuit.

P. RAM: Random Access Memory.

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Q. SLC: Signaling Line Circuit.

R. SOM: Sequence of Operations Matrix.

S. 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 be sent. The term zone is typically used when describing conventional, nonaddressable systems.

1.03 SYSTEM DESCRIPTION

A. Design Requirements:

1. Contract Drawings show location of fire alarm panel(s) duct detectors, and fire suppression system switches.
   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. Contract 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, and for interconnection of flow and supervisory switches and alarm bells specified in Section 21 13 00, Fire-Suppression Sprinkler Systems.
5. Coordinate, and include in design, requirements for interfacing with HVAC system.
6. Coordinate design and installation with elevator installation.
7. Equipment suitable for addressable fire alarm system.

B. Performance Requirements:

1. 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:
   a. Audible and visual indications of alarmed devices on fire alarm control panel display, and on remote annunciator.
   b. Closure of doors held open by electromagnetic devices.
   c. For remote buildings with subpanels, transmit common alarm or trouble signal to light appropriate zone lamp at master fire alarm control panel.
   d. Master fire alarm control panel shall transmit common alarm or trouble signal to plant control panel.

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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. Contact output to ECP shall be rated for no less than 5A, 250V ac.
3. Actuation of sprinkler flow switch shall alarm at panel.
4. Discharge of sprinklers in elevator shaft or machine room shall send supervised trip signal to elevator controller/circuit breaker to trip on actuation of temperature detector installed adjacent to sprinkler head and with lower setting.

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. Annunciator configuration and module data.
9. 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.
10. Sequence of Operation Matrix.
11. Battery sizing calculations.
12. Supervisory power requirements for equipment.
13. Alarm power requirements for equipment.
14. Power supply rating justification showing power requirements for system power supplies.
15. Voltage drop calculations for wiring runs, demonstrating worst case condition.
16. Conduit fill calculations.
17. Sample warranty.
18. Recommended types and quantities for spare parts.
19. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

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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.
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.

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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 5 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 Alabama.
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.
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. Municipal/county Departments.
2. Fire Departments.

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.

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1.08 EXTRA MATERIALS

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

Item	Quantity
Special tools required to maintain or dismantle	One complete set

PART 2 PRODUCTS

2.01 MANUFACTURERS

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

1. Siemens Building Technologies.
2. Johnson Controls.
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. Johnson Controls.
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.

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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.

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 120 degrees F.
2. Minimum 32 degrees F.

C. Provide equipment fully rated without derating for these conditions.

2.05 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 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, and device address list.

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2.06 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 12.
   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 5 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. Form CDigital alarm communicator output circuitry for remote alarm control panel.
9. MOV/gas discharge transient protection for power supply module .
10. For addressable systems provide additional 20 percent capacity for future indicating and initiating devices.
11. 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) Door holder bypass.
        2) Elevator bypass.
        3) Manual evacuation.
        4) HVAC shutdown disable.
        5) FM-200 system activation.
        6) Displayable when door is open.
    f. Four function keys for control of variable functions related to primary operations keypad, displayable when door is open.

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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.
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: Single-pole, double-throw, rated 2 amperes at 24V dc and 0.5 ampere at 120V ac.
9. Auxiliary Control Circuit Contacts: Single-pole, double-throw rated, 2 amperes at 24V dc and 0.5 ampere at 120V ac.
10. Two isolated TIA 232 communication port modules.

2.07 INITIATING DEVICE

A. Pull Station, Fire:

1. Double-action station for general alarm.
2. Constructed of red molded polycarbonate material weatherproof housing for Chemical areas, 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. push plate and pull handle for double action operating station without 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, Double -pole contacts rated 3 amperes, 30V dc for resistive loads.
10. Manual Pull Station: Dip switch selectable address, and compatible with fire alarm control panel.

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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, single-pole contacts, rated 3 amperes, 30V dc for resistive loads.
7. Auxiliary relay for fan shutdown door closure Elevator Trip.
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. Intelligent Fire Detectors:

1. Photoelectric and thermal detector software programmable from fire alarm control panel to match specific hazards and reduce nuisance tripping.
2. Addressable base to be field mounted on octagon box.
3. Software programmable to provide pre-alarm notification.
4. Capable of producing alarm from photoelectric detector, thermal detector, or microprocessor logic.
5. Field cleanable chamber with replaceable chamber components.
6. LED in base to provide status; Pulsed green for normal status, flashing amber for fault or fail condition, and flashing red for alarm.
7. Detector suitable for use in a corrosive environment.

D. 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 base for photoelectric detector in accordance with UL 286A, NFPA 72, NFPA 90A, and NFPA 101.

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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 degrees 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, single-pole, double-throw auxiliary relay with 2 amperes, 28V dc rated contacts for resistive loads.

E. 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.

2.08 NOTIFICATION APPLIANCES

A. 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.

2.09 PRINTER

A. System shall have strip printer capable of being mounted directly in main FACP enclosure. Print alarms in easy-to-read red, print other messages, such as trouble notification, in black. This printer shall receive power from system power supply and shall operate via battery back-up if AC mains are lost. Strip printer shall be UL 864 listed.

2.10 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.

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2.11 RACEWAYS

A. Conduit used for installation of Fire Alarm system shall follow requirements as identified in Section 26 05 33, Raceway and Boxes.

2.12 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.

2.13 SURGE SUPPRESSORS

A. Transient Voltage Surge Suppressors (TVSS): In accordance with Section 26 43 00, Transient Voltage Suppression.

2.14 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 and for interconnection of flow and supervisory switches and alarm bells specified in Section 21 13 00, Fire-Suppression Sprinkler Systems and shunt tripping of elevator power for complete and operable system.

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.

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C. Provide outlet and junction boxes that are compatible with raceway system.

D. Mount detector LEDs so they are readily visible from floor.

E. Arrange sampling tubes and duct detectors to monitor duct area and point of duct penetration sealed and reinsulated.

F. Program or configure panels and devices, as required to operate as defined by Sequence of Operations Matrix.

G. Install conductors in accordance with Section 26 05 05, Conductors, and NFPA 70, Article 760.

H. Install initiating alarm, signal, and communication conductors in separate and independent raceway system.

I. Circuit wiring color-code, as established by installer, to be maintained throughout installation.

J. 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.

K. 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.

L. 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.

M. 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.

N. Suppression Sprinkler System: Wire and connect to fire alarm system to suppression sprinkler system. Coordinate work with Section 21 13 00, Fire-Suppression Sprinkler Systems.

O. Wire and connect fire alarm system to elevator communications circuit and alarm. Coordinate Work with Section 14 21 23.16, Machine Room Less Electric Traction Passenger Elevators.

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3.03 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.
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.

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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 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.

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.

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3.04 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.

3.05 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. Smaller conductors are allowable where shown on approved Shop Drawings as part of a manufacturer’s specific communications cable (such as, addressable system.
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.

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.

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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.

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.

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M. T-tapping of circuits is prohibited.

N. Circuits shall be megger tested to voltage rating of their insulation before final terminations are made.

3.06 OVERVOLTAGE AND SURGE PROTECTION

A. Install TVSS for fire alarm control panel in accordance with manufacturer's requirements.

3.07 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.

3.08 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.

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.

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2. Notify Fire Marshal and Owner before start of any required tests. Correct items found at variance with Drawings or 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.
   h. Loss of data communications between system control panels.
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.
   b. Correct annunciator light for each alarm input, at each annunciator and color graphic terminal.
   c. Correct printer logging for system activity.
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.

3.09 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. Interfering or Objectionable Material: Trash, rubbish, and junk; vegetation and other organic matter, whether alive, dead, or decaying; topsoil.

B. Clearing: Removal of interfering or objectionable material lying on or protruding above ground surface.

C. Grubbing: Removal of vegetation and other organic matter including stumps, buried logs, and roots greater than 2-inch caliper to a depth of 12 inches below subgrade.

D. Stripping: Removal of topsoil remaining after applicable clearing and grubbing is completed.

E. Project Limits: Areas, as shown or specified, within which Work is to be performed.

1.02 QUALITY ASSURANCE

A. Obtain Engineer's approval of staked clearing, grubbing, and stripping limits, prior to commencing clearing, grubbing, and stripping.

1.03 SCHEDULING AND SEQUENCING

A. Prepare Site only after adequate erosion and sediment controls are in place.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Clear, grub, and strip areas actually needed for Site improvements within limits shown or specified.

B. Do not injure or deface vegetation that is not designated for removal.

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3.02 LIMITS

A. As follows, but not to extend beyond Project limits.

1. Excavation, Including Trench Excavation: 5 feet beyond top of cut slopes.
2. Fill:
   a. Clearing and Grubbing: 5 feet beyond toe of permanent fill.
   b. Stripping: 2 feet beyond toe of permanent fill.
3. Structures: 5 feet outside of new structures.
4. Roadways: Clearing, grubbing, and stripping 5 feet from edge.
5. Overhead Utilities:
   a. Clearing and Grubbing: Entire width of easements and rights-of-way.
   b. Clearing and Grubbing and Stripping: Wherever grading is required.

B. Remove rubbish, trash, and junk from entire area within Project limits.

3.03 CLEARING

A. Clear areas within limits shown or specified.

B. Fell trees so that they fall away from facilities not designated for removal.

C. Cut stumps not designated for grubbing flush with ground surface.

D. Cut off shrubs, brush, weeds, and grasses to within 2 inches of ground surface.

3.04 GRUBBING

A. Grub areas within limits shown or specified.

3.05 STRIPPING

A. Do not remove topsoil until after clearing and grubbing are completed.

B. Strip areas within limits to minimum depths of 4 inches. Do not remove subsoil with topsoil.

3.06 DISPOSAL

A. Clearing and Grubbing Debris:

1. Dispose of debris offsite.
2. Burning of debris onsite will not be allowed.
3. Limit offsite disposal of clearing and grubbing debris to locations that are approved by federal, state, and local authorities.

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B. 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 15 00
SITE PRE-LOADING

PART 1 GENERAL

1.01 WORK INCLUDED

A. This section covers the work necessary to preload the subsurface soils underneath the following structures: Dewatering and Control building, Bio-Solids Receiving Station, Bio-Solids Holding Tank, and other miscellaneous proposed structures except the Chlorine and SO2 Building, and monitor the performance of the pre-load.

1.02 SUBMITTAL

A. Informational Submittals:

1. Settlement Platform Elevations Readings.
   a. Submit daily during the placement of preload material.
   b. Submit twice a week for the first 2 weeks after the placement of the preload construction of Pre-Load.
   c. Submit weekly for the remaining duration of the pre-loading program.

PART 2 PRODUCTS

2.01 GENERAL

A. The Contractor shall provide all materials necessary to accomplish the work as shown or specified herein. At the completion of the pre-load, the Contractor shall remove the materials from the Site at no additional cost to the Owner.

2.02 PRELOAD MATERIAL

A. The pre-load material shall be structural fill material, as specified in Section 31 23 23, Fill and Backfill, excavated from required excavations and designated borrow sites, free from rocks larger than 3 inches, from roots or organic matter, ashes, cinders, trash, debris, and other deleterious materials.

2.03 SETTLEMENT PLATFORMS

A. Settlement platforms shall be fabricated. Steel pipe and pipe fittings for the standpipe shall be standard weight steel, conforming to ASTM A120, with screwed fittings.

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B. Meet the requirements of Alabama Department of Transportation Special Drawing UBC-210-SP, Option 2.

C. All pipe requiring threading shall be provided with standard taper iron-pipe-size threads. Sufficient threads shall be provided on each length of pipe to permit lengths of pipe to butt within 1/8 inch when connected with a standard pipe coupling.

D. Steel plate for settlement platforms shall conform to ASTM A36. The settlement platform standpipe housing shall be Schedule 40, Type II polyvinyl chloride (PVC) pipe conforming to ASTM D1785.

PART 3 EXECUTION

3.01 CONSTRUCTION SEQUENCE

A. The placement of preload material shall be conducted in the following sequence:

1. Excavate area of pre-load to limits and elevations as specified in Section 31 23 16, Excavation.
2. Install settlement platforms on the excavated grade and install benchmarks at locations at least 200 feet from the center of the preloaded area.
3. Backfill overexcavation with Structural Fill material to limits and elevations as specified in Section 31 23 23, Fill and Backfill.
4. Place preload material to the elevations specified in the Drawings and as specified in Section 31 23 23, Fill and Backfill, and in accordance with the procedures specified hereinafter.

3.02 MONITORING CRITERIA

A. Monitor settlement plates daily during the construction of the pre-load and twice a week for 2 weeks after final pre-load grades have been completed. Monitor the settlement plates weekly, thereafter, or as indicated by the Engineer.

B. After the preload has been in-place for at least 1 month, and recorded settlements are less than 0.01 foot per week and approved by the Engineer, remove preload material and dispose material as needed to fill the Site or as determined by the Owner.

3.03 INSTALLATION OF BENCHMARKS

A. Furnish and install two benchmark posts. Benchmarks shall be installed in areas which are at least 200 feet from the center of the preloaded area. The Contractor shall be responsible for the protection of the benchmarks.

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3.04 INSTALLATION OF SETTLEMENT PLATFORMS

A. Install the settlement platforms. Determine plate elevations prior to placing structural fill material.

B. Install the pipe in sections as the fill progresses so that a minimum 12 inches of the settlement platform standpipe housing is exposed. Prior to the addition of any standpipe sections, transfer the proper elevations between old and new sections.

C. No heavy construction equipment shall be operated within 5 feet of settlement platforms. Construct and compact preload material adjacent to settlement platforms by hand methods.

D. All equipment operators shall take care to avoid disturbance of the settlement platforms during the embankment operation. In the event a settlement platform is damaged by construction equipment, the Engineer shall be notified immediately, and the Contractor shall repair or reconstruct the damaged settlement platform before additional embankment is placed.

E. The Contractor shall measure the elevations of the platforms during the preload period as specified hereinbefore. Copies of settlement measurements shall be submitted to the Engineer for review on a weekly basis.

3.05 PLACEMENT OF PRELOAD MATERIAL

A. Place preload material conforming as specified in Section 31 23 23, Fill and Backfill.

3.06 ACCESS TO PRELOAD AREA

A. The Contractor shall be responsible for constructing or improving the existing subgrade for access to the preload area. The Contractor shall also be responsible for providing any ramps or fill to get trucks to the top of the preload.

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 ft-lb/ft^3 (600 kN-m/m^3)).

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, scalping of sod, stripping of topsoil, excavation to grade, and scarification and compaction of subgrade.

C. Relative Compaction: As defined in Section 31 23 23, Fill and Backfill.

D. Relative Density: As defined in Section 31 23 23, Fill and Backfill.

E. Subgrade: Layer of existing soil after completion of clearing and grubbing and required excavation where new roadway structure, structural foundation, trench bedding, floor slab or placement of fill will be built on.

F. Proof-Rolling: Testing of subgrade by compactive effort to identify areas that will not support the future loading without excessive settlement.

1.03 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in Sections 02 41 00, Demolition; 31 10 00, Site Clearing; and 31 23 16, Excavation, prior to subgrade preparation.

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.

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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. Prior to compaction, processing and moisture condition may be required for the exposed subgrade.

B. Under Earthfill: Minimum two passes with three-wheeled power roller weighing approximately 10 tons. Confirm successful compaction level by testing the upper 6 inches of subgrade and ensure it has achieved minimum of 95 percent relative compaction as determined in accordance with ASTM D698.

C. Under Pavement Structure, Floor Slabs On Grade, or Granular Fill Under Structures: Compact subgrade using a vibratory roller having minimum dynamic force equivalent to 10 ton. Confirm successful compaction level by testing the upper 6 inches of subgrade and ensuring it has achieved minimum of 100 percent relative compaction as determined in accordance with ASTM D698.

D. Subgrade in trenches shall be compacted using rammer type compaction equipment and/or small remote controlled pad-foot vibratory rollers capable of producing a minimum dynamic force equivalent to 3 tons. The compacted subgrade at bottom of trenches shall be compacted to minimum 98 percent relative compaction as determined in accordance with ASTM D698.

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3.03 MOISTURE CONDITIONING

A. Dry Subgrade: Add water, then mix to make moisture content uniform throughout.

B. Wet Subgrade: Aerate material by blading, discing, harrowing, or other methods, to hasten drying process.

3.04 TESTING

A. Measure the in-place density of the prepared subgrade using ASTM D6938.

1. Testing frequency: One test per 2,000 square feet of prepared subgrade, with a minimum of 1 test per proposed structure, slab-on-grade, mat foundations, or spread footings.
2. Acceptance Criteria: Subgrade shall be compacted as specified in section 3.02B and within 2 percent of the optimum moisture content as determined by ASTM D698.

3.05 SUBGRADE PROTECTION UNDER STRUCTURES

A. Protect prepared or compacted subgrade from weather and traffic by installing a 6-inch layer of aggregate base course, meeting the requirements of Section 32 11 23, Aggregate Base Courses.

B. Protective layer under foundations and pavements, shall be compacted to minimum 98 percent of the soil's maximum dry density as determined by ASTM D698.

3.06 CORRECTION

A. Soft or Loose Subgrade:

1. Adjust moisture content and recompact, or
2. Over excavate as specified in Section 31 23 16, Excavation, and replace with suitable material from the excavation, as specified in Section 31 23 23, Fill and Backfill.

B. Unsuitable Material: Over excavate as specified in Section 31 23 16, Excavation, and replace with 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 onsite and offsite spoil disposal sites.

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.

B. Clearing, Grubbing, and Stripping: Complete applicable Work specified in Section 31 10 00, Site Clearing, prior to excavating.

C. Dewatering: Conform to applicable requirements of Section 31 23 19.01, Dewatering, prior to initiating excavation.

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D. Excavation Support: Install and maintain shoring, bracing, and sloping as necessary, as necessary to support sides of excavations and prevent detrimental settlement and lateral movement, which may damage existing facilities, adjacent pavements, utilities, adjacent property, damage or delay the work, or endanger life and health, and completed Work. Install and maintain as required by OSHA or other applicable local, state and federal governmental regulations.

E. Excavation Safety: The Contractor shall be solely responsible for making all excavations in a safe manner. Provide appropriate measures to retain excavation side slopes to ensure that persons working in or near the excavation are protected.

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 STRUCTURAL OVER-EXCAVATION

A. Over-excavate:

1. Beneath the proposed Dewatering and Control building to a depth of 3 feet below existing ground surface shown in Drawings to remove unsuitable layer of soil. The over-excavation area shall be 5 feet beyond the perimeter of the structure’s footprint.

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2. Beneath the existing decommissioned Primary Clarifiers and Control Room to a depth of approximately 15 feet below ground surface to attain the bottom of the tank.
3. Beneath the proposed Chlorine and SO2 Building, and Electrical Generators and other miscellaneous proposed structures that extend beyond the existing Primary Sedimentation Tank footprint to a depth of 5 feet below existing ground surface. The bottoms of the over-excavation area shall be 5 feet beyond the perimeter of the structure's footprint for the Chlorine and SO2 Building, and 3 feet beyond the structure's footprint for the Electrical Generators and other miscellaneous proposed structures.

B. Stockpile the over-excavated material for classification and reuse. Unsuitable material shall be disposed off-site.

C. Compact the bottom of the excavation as specified in Section 31 23 13, Subgrade Preparation.

D. Bottom of over-excavation shall be inspected by a geotechnical engineer.

E. Backfill over-excavation as specified in Section 31 23 23, Fill and Backfill.

3.04 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.

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. Pipe of greater strength or superior pipe bedding, when approved in writing by Engineer, may be used in lieu of maintaining the pipe widths shown or specified.

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3.05 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 stones and rock that exceed 3-inch diameter and that are loose and may roll down slope. 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.

3.06 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 induce excessive settlement.

3.07 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.

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 19.01
DEWATERING

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Water control plan.
2. Well permits.
3. Discharge permits, if required by agency having jurisdiction over the Project.

1.02 WATER CONTROL PLAN

A. As a minimum, include:

1. Descriptions of proposed groundwater and surface water control facilities including, but not limited to, equipment; methods; standby equipment and power supply, pollution control facilities, discharge locations to be utilized, and provisions for immediate temporary water supply as required by this section.
2. Drawings showing locations, dimensions, and relationships of elements of each system.
3. Design calculations demonstrating adequacy of proposed dewatering systems and components.

B. If system is modified during installation or operation revise or amend and resubmit Water Control Plan.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Continuously control water during course of construction, including weekends and holidays and during periods of work stoppages, and provide adequate backup systems to maintain control of water.

B. Remove and control water during periods when necessary to properly accomplish Work.

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3.02 SURFACE WATER CONTROL

A. See Section 01 50 00, Temporary Facilities and Controls, Article Temporary Controls.

B. Remove surface runoff controls when no longer needed.

3.03 DEWATERING SYSTEMS

A. Provide, operate, and maintain dewatering systems of sufficient size and capacity to permit excavation and subsequent construction in dry and to lower and maintain groundwater level a minimum of 2 feet below the lowest point of excavation. Continuously maintain excavations free of water, regardless of source, and until backfilled to final grade.

B. Dewatering systems shall include wells or well points, and other equipment and appurtenances installed outside limits of excavations and sufficiently below lowest point of excavation, or to maintain specified groundwater elevation.

C. Design and Operate Dewatering Systems:

1. To prevent loss of ground as water is removed.
2. To avoid inducing settlement or damage to existing facilities, completed Work, or adjacent property.
3. To relieve artesian pressures and resultant uplift of excavation bottom.

D. Provide sufficient redundancy in each system to keep excavation free of water in event of component failure.

E. Provide 100 percent emergency power backup with automatic startup and switchover in event of electrical power failure.

F. Provide supplemental ditches and sumps only as necessary to collect water from local seeps. Do not use ditches and sumps as primary means of dewatering.

3.04 DISPOSAL OF WATER

A. Obtain discharge permit for water disposal from authorities having jurisdiction.

B. Treat water collected by dewatering operations, as required by regulatory agencies, prior to discharge.

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C. Discharge water as required by discharge permit and in manner that will not cause erosion or flooding, or otherwise damage existing facilities, completed Work, or adjacent property.

D. Remove solids from treatment facilities and perform other maintenance of treatment facilities as necessary to maintain their efficiency.

3.05 PROTECTION OF PROPERTY

A. Make assessment of potential for dewatering induced settlement. Provide and operate devices or systems, including but not limited to reinjection wells, infiltration trenches and cutoff walls, necessary to prevent damage to existing facilities, completed Work, and adjacent property.

B. Securely support existing facilities, completed Work, and adjacent property vulnerable to settlement due to dewatering operations. Support shall include, but not be limited to, bracing, underpinning, or compaction grouting.

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 (600 kN-m/m^3)).
   e. D1556, Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
   f. D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
   g. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   h. D4254, Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
   i. 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. 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.

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B. 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.

C. Relative Density: Calculated in accordance with ASTM D4254 based on maximum index density determined in accordance with ASTM D4253 and minimum index density determined in accordance with ASTM D4254.

D. Prepared Ground Surface: Ground surface after completion of required demolition, clearing and grubbing, stripping of topsoil, excavation to grade, and subgrade preparation.

E. Completed Course: A course or layer that is ready for next layer or next phase of Work.

F. Lift: Loose (uncompacted) layer of material.

G. Geosynthetics: Geotextiles, geogrids, or geomembranes.

H. 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.

I. Influence Area: Area within planes sloped downward and outward at 60-degree angle from horizontal measured from:

1. 1 foot outside outermost edge at base of foundations or slabs.
2. 1 foot outside outermost edge at surface of roadways or shoulder.
3. 0.5 foot outside exterior at spring line of pipes or culverts.

J. Borrow Material: Material from required excavations or from designated borrow areas on or near Site.

K. Selected Backfill Material: Materials available onsite that Engineer determines to be suitable for specific use.

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L. Imported Material: Materials obtained from sources offsite, suitable for specified use.

M. Structural Fill: Fill materials as required under structures, pavements, and other facilities.

N. Embankment Material: Fill materials required to raise existing grade in areas other than under structures.

O. Standard Specifications: When referenced in this section, shall mean the Alabama Department of Transportation, Standard Specifications for Highway Construction, latest Edition.

1.03 SUBMITTALS

A. Informational Submittals:

1. Manufacturer's data sheets for compaction equipment.
2. Certified test results from independent testing agency including, but not limited to, the following information:
   a. Test locations, including elevation or depth and horizontal location shown on a Site Plan.
   b. Description of material tested. Identify the material using the Unified Soil Classification System, ASTM D2487.
   c. Type of compaction equipment and method used.
   d. Test results certified by a Professional Engineer or Geologist licensed in the state of Alabama.

1.04 QUALITY ASSURANCE

A. Notify Engineer when:

1. Overexcavation area is ready for backfilling.
2. Whenever backfilling operations are resumed after a period of inactivity.
3. Soft or loose subgrade materials are encountered.
4. Fill material appears to be deviating from 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.

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A. 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.

B. 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. Earthfill: 2 tests per source.
   b. Granular Fill: 2 tests per source.
   c. Structural Fill: 2 tests per source.
   d. Granular Drain Material: 2 tests per source.
   e. Soil Cover Over Geotextiles: 2 tests per source.
   f. Soil Cover Over Geogrids: 2 tests per source.

2.02 EARTHFILL

A. Excavated material from required excavations free from rocks or concrete debris larger than 3 inches, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials.

B. Material containing more than 10 percent gravel, stones, or shale particles is unacceptable.

C. Provide imported material of equivalent quality, if required to accomplish Work.

2.03 STRUCTURAL FILL MATERIAL

A. Onsite excavated material or imported material meeting the following requirements:

1. USCS Classification: SP, SP-SM in accordance with ASTM D2487.
2. Free from rocks larger than 3 inches, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials.
3. Maximum Gravel Content: 10 percent.
4. Maximum fine Content (Percent Passing No. 200 sieve): 20.
5. Non-Plastic.

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B. Material containing more than 10 percent gravel, stones, or shale particles is unacceptable.

C. Provide imported material of equivalent quality, if required to accomplish Work.

2.04 GRANULAR FILL

A. Free from rocks larger than 1-1/2 inches, from dirt, clay balls, and organic material and other deleterious materials.

B. Well-graded sand from coarse to fine and containing sufficient fines to bind material when compacted, but with maximum 8 percent by weight passing No. 200 sieve.

2.05 GRANULAR DRAIN MATERIAL

A. Clean or gravelly sand with less than 5 percent passing No. 200 sieve, as determined in accordance with ASTM D1140.

2.06 WATER FOR MOISTURE CONDITIONING

A. Free of hazardous or toxic contaminates, or contaminants deleterious to proper compaction.

2.07 ROADWAY BASE COURSE ROCK

A. As specified in Section 32 11 23, Aggregate Base Courses.

2.08 FOUNDATION STABILIZATION ROCK

A. Crushed rock or pit run rock.

B. Uniformly graded from coarse to fine.

C. Free from excessive dirt and other organic material.

D. Maximum 2-1/2-inch particle size.

2.09 SOIL COVER OVER GEOTEXTILES

A. Structural fill or earthfill material.

B. Particle Size: Maximum 1 inch.

C. Free of sharp angular pieces that may damage geotextile or geogrid.

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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 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.

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3.02 BACKFILL UNDER AND AROUND STRUCTURES

A. Under Facilities:

1. Within influence area beneath structures, slabs, pavements, curbs, piping, conduits, duct banks, and other facilities, backfill with structural fill material or granular fill material, unless otherwise shown. Place material in lifts of 8-inch maximum thickness and compact each lift to minimum of 100 percent relative compaction as determined in accordance with ASTM D698.
2. Immediately beneath slabs, pavement, sidewalks and foundations place 8 inches (unless otherwise specified) of Base Course, as specified in Section 32 11 23, Aggregate Base Courses, compacted to a minimum of 100 percent relative compaction as determined in accordance with ASTM D698. In tight areas where compaction equipment is not useable, place 6 inches of granular fill and tamp using hand equipment.

B. Preloading area:

1. Backfill the over-excavation specified in Section 31 23 16, Excavation with structural fill material. Place material in 8-inch maximum thickness and compact each lift to minimum of 100 percent relative compaction as determined in accordance with ASTM D698.
2. Fill the preloading area with structural fill material, where shown or specified. Place material in 12-inch maximum thickness and compact each lift using a bulldozer until firm.

C. Other Areas: Backfill with earthfill to lines and grades shown, with proper allowance for topsoil 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, Pavements, Curbs, Slabs, Piping, and Other Facilities: Unless otherwise shown, place earthfill as follows:

1. Allow for 6-inch thickness of topsoil where required.
2. Maximum 8-inch thick lifts.
3. Place and compact fill across full width of embankment.
4. Compact to minimum 95 percent relative compaction as determined in accordance with ASTM D698.
5. Dress completed embankment with allowance for topsoil, crest surfacing, and slope protection, where applicable.

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3.04 SITE TESTING

A. Gradation:

1. One sample from each 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 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.

B. In-Place Density Tests: In accordance with ASTM D1556 or D6938. At least one sand cone test (ASTM D1556) shall be conducted for each five nuclear density test (ASTM D6938). The sand cone test shall be taken at the general location and elevation as one of the five nuclear density tests to verify accuracy of the nuclear test results.

1. During placement of materials, test as follows:
   a. Fill and Backfill Under Structures: One test every 12 vertical inches of lift per 2,500 square feet, with minimum of 1 test per structure.
   b. Graded Aggregate Base Material: As specified in Section 32 11 23, Aggregate Base Courses.
   c. Fill and Backfill demolition excavations: One test every two lifts (16 inches), per excavated area or every 2,000 square feet of backfill area, whichever produces more tests.
2. Test results showing less than the specified relative compaction are not acceptable. Removal and re-compaction of the unacceptable fill shall be done. Retesting is required.

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: Structural or granular Fill material.
2. Beneath Fill or Backfill: Same material as specified for overlying fill or backfill.

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3. Beneath Slabs-On-Grade: Granular Fill material.
4. Trenches:
    a. Unauthorized Overexcavation: Either trench stabilization material or 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.

3.07 PLACING FILL OVER GEOSYNTHETICS

A. General:

1. Place fill over geosynthetics with sufficient care so as not to damage them.
2. Place fill only by back dumping and spreading only.
3. Dump fill only on previously placed fill.
4. While operating equipment, avoid sharp turns, sudden starts or stops that could damage geosynthetics.

B. Hauling: Operate hauling equipment on minimum of 3 feet of covering.

C. Spreading:

1. Spreading equipment shall be track mounted low ground pressure, D-6 or lighter.
2. Operate spreading equipment on minimum of 12 inches of fill over geosynthetics.
3. Spread fill in same direction as unseamed overlaps to avoid separation of seams and joints.
4. Never push fill downslope. Spread fill over sideslopes by pushing up from slope bottom. If access to bottom of slope is unavailable, progressively place fill, beginning at toe of slope and working upslope, with backhoe or dragline operated from top of slope.

D. Compaction: Compact fill only after uniformly spread to full thickness shown.

E. Geosynthetic Damage:

1. Mark punctures, tears, or other damage to geosynthetics, so repairs may be made.
2. Clear overlying fill as necessary to repair damage.
3. Repairs to geosynthetics shall be made by respective installers as specified in respective specification section for each geosynthetic.

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3.08 ACCESS ROAD SURFACING AND OTHER GRAVELED AREAS

A. Place and compact as specified in Section 32 11 23, Aggregate Base Courses.

3.09 DEMOLITION EXCAVATION BACKFILL

A. Backfill excavations resulting from demolition of existing buried or below ground surface structures with Structural Fill Material as defined above. Backfilling excavation with demolition debris is not authorized.

B. Place and compact backfill material per paragraph 3.02. Backfill Under and Around Structures.

END OF SECTION

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SECTION 31 23 23.15
TRENCH BACKFILL

PART 1 GENERAL

1.01 DEFINITIONS

A. Bedding Material: Granular material upon which pipes, conduits, cables, or duct banks are placed.

B. Imported Material: Material obtained by Contractor from source(s) offsite.

C. Lift: Loose (uncompacted) layer of material.

D. 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.

E. Prepared Trench Bottom: Graded trench bottom after excavation and installation of stabilization material, if required, but before installation of bedding material.

F. 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.

G. Relative Density: As defined by ASTM D4253 and ASTM D4254.

H. Selected Backfill Material: Material available onsite that Engineer determines to be suitable for a specific use.

I. Well-Graded: A mixture of particle sizes that has no specific concentration or lack thereof of one or more sizes producing a material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids. Satisfying both of the following requirements, as defined in ASTM D2487:

1. Coefficient of Curvature: Greater than or equal to 1 and less than or equal to 3.
2. Coefficient of Uniformity: Greater than or equal to 4 for materials classified as gravel, and greater than or equal to 6 for materials classified as sand.

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1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Manufacturer's descriptive literature for marking tapes.

B. Informational Submittals:

1. 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.
2. 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.

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 5 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.

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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.	

2.03 TRENCH STABILIZATION MATERIAL

A. 1-1/2 inch minus crushed gravel or crushed rock, with gradation similar to ALDOT No. 57 or No. 89 stone.

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, or gravel or crushed rock within maximum particle size and other requirements as follows unless otherwise specified.

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.

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5. 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. As specified in Section 31 23 23, Fill and Backfill, for Earthfill.

2.06 CONTROLLED LOW STRENGTH MATERIAL (CLSM)

A. Select and proportion ingredients to obtain compressive strength between 50 psi and 150 psi at 28 days in accordance with ASTM D4832.

B. Materials:

1. Cement: ASTM C150/C150M, Type I or Type II.
2. Aggregate: ASTM C33/C33M, Size 7.
3. Fly Ash (Pozzolan): Class F or Class C fly ash in accordance with ASTM C618, except as modified herein:
    a. ASTM C618, Table 1, Loss on Ignition: Unless permitted otherwise, maximum 3 percent.
4. Water: Clean, potable, containing less than 500 ppm of chlorides.

2.07 CONCRETE BACKFILL

A. Provide as specified in Section 03 30 00, Cast-in-Place Concrete.

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 for:

1. Earth backfill, including specified class.
2. Trench stabilization material.
3. Bedding and pipe zone material.

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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, conduit, direct-buried cable, or duct bank. Do not place concrete, lay pipe, conduit, direct-buried cable, or duct bank in water. Dewatering shall be performed as specified in Section 31 23 19.01, Dewatering.
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.

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 or bedding material.
3. Provide 24-inch minimum overlap at joints.

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3.04 TRENCH STABILIZATION MATERIAL INSTALLATION

A. Rebuild trench bottom with trench stabilization material.

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.

B. Place over full width of prepared trench bottom in two equal lifts when required depth exceeds 8 inches.

C. Hand grade and compact each lift to provide a firm, unyielding surface.

D. Minimum Thickness**:** As follows:

1. Pipe 15 Inches and Smaller: 4 inches.
2. Pipe 18 Inches to 36 Inches: 6 inches.
3. Pipe 42 Inches and Larger: 8 inches.
4. Conduits, Direct-Buried Cables and Duct Banks: 3 inches.

E. 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.

F. Install to form continuous and uniform support except at bell holes, if applicable, or minor disturbances resulting from removal of lifting tackle.

G. 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. Conduits: 3 inches, unless shown otherwise.

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3. Direct-Buried Cable: 3 inches, unless shown otherwise.
4. Duct Bank: 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.
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.

F. 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. Each lift shall be compacted with a minimum of two passes by either a vibratory plate compactor or a power-driven impact compactor. Take care to avoid damaging pipe and pipe coating.

3.07 MARKING TAPE INSTALLATION

A. Continuously install marking tape along centerline of buried piping, at top of pipe zone. 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.

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4. Do not use power driven impact type compactors directly on top of the pipe 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.
7. Place in lifts not exceeding thickness of 8 inches.
8. Mechanically compact each lift prior to placing succeeding lifts to a minimum of 95 percent relative compaction as determined by ASTM D698 prior to placing succeeding lifts.

B. Concrete Backfill:

1. Place above bedding.
2. Minimum Concrete Thickness: 6 inches on top and sides of pipe.
3. Do not allow dirt or foreign material to become mixed with concrete during placement.
4. Allow sufficient time for concrete to reach initial set before additional backfill material is placed in trench.
5. Prevent flotation of pipe.
6. Begin and end concrete backfill within 4 inches of a pipe joint on each end.
7. Do not encase pipe joints except within the limits of the concrete backfill.

C. 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. In traveled areas fill entire trench section to pavement finish grade for a temporary driving surface, and screed off excess and finish with a float.

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.

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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. 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 00
SOIL STABILIZATION

PART 1 GENERAL

1.01 SCOPE

A. Work in the section covers soil stabilization during and after land disturbance and construction activities to control erosion and sediment deposition. This includes, but not limited to, mulching, seeding, and matting and blankets.

B. Chemical stabilization, such as polyacryliamides and tackifiers, are prohibited.

1.02 SUBMITTALS

A. Informational Submittals:

1. Seed certifications.
2. Copies of delivery invoices or other proof of quantities of mulch, lime, and fertilizer.
3. Manufacturer's Installation Instructions: Commercial products.

1.03 DELIVERY, STORAGE, AND PROTECTION

A. As specified in Section 32 92 00, Turf and Grasses.

1.04 SEQUENCING AND SCHEDULING

A. As specified in Section 32 92 00, Turf and Grasses.

B. Prepare topsoil as specified in Section 32 91 13, Soil Preparation, before starting Work of this section.

C. Complete soil preparation, seeding, liming, fertilizing, mulching and matting within 10 days after final grades have been reached.

D. Notify Engineer at least 3 days in advance of:

1. Materials delivery.
2. Start of planting/seeding activity.

E. Seeding: Perform under favorable weather conditions during seasons that are normal for such Work as determined by accepted local practice.

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1.05 MAINTENANCE

A. Operations:

1. Perform during maintenance period to include:
   a. Watering: Keep seeded surface moist.
   b. Washouts: Repair by filling with topsoil, fertilizing, seeding, and mulching.
   c. Mulch: Replace wherever and whenever washed or blown away.
   d. Reseed unsatisfactory areas or portions thereof immediately at end of maintenance period if a satisfactory stand has not been produced.
   e. Reseed during next planting season if scheduled end of maintenance period falls after September 15.
   f. Reseed entire area if satisfactory stand does not develop by July 1 of the following year.

PART 2 PRODUCTS

2.01 FERTILIZER

A. As specified in Section 32 92 00, Turf and Grasses.

2.02 SEED

A. As specified in Section 32 92 00, Turf and Grasses.

2.03 MULCH

A. Wood Cellulose Fiber Mulch:

1. Specially processed wood fiber containing no growth or germination inhibiting factors.
2. Dyed suitable color to facilitate inspection of material placement.
3. Manufactured such that after addition and agitation in slurry tanks with water, material fibers become uniformly suspended to form homogenous slurry.
4. When hydraulically sprayed on ground, material will allow absorption and percolation of moisture.

B. Straw:

1. Threshed straw of oats, wheat, barley, or rye, free from seed of noxious weeds.
2. Suitable for spreading with mulch blower equipment.
3. Average Stalk Length: 6 inches.
4. Seasoned before baling or loading.

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2.04 EROSION CONTROL MATTING

A. Meeting the minimum requirements stated in the Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas (latest edition) for:

1. Class 2.D (Temporary application).
2. Class 5.A (Permanent application).

2.05 REINFORCED PLASTIC COVERING

A. Co-extruded, copolymer laminate reinforced with nonwoven grid of high strength nylon cord submersed in a permanently flexible adhesive media allowing for equal tear resistance in all directions.

B. Black in color and ultraviolet stabilized.

C. Physical Requirement (Minimum Average Roll Values):

1. Tear Strength: 130 pounds.
2. Elongation: 620 percent.
3. Minimum Thickness: 6 mil.

D. Manufacturers:

1. Reef Industries, Inc., Houston, TX.
2. Griffolyn Co., Houston, TX.

PART 3 EXECUTION

3.01 SOIL PREPARATION

A. As specified in Section 32 91 13, Soil Preparation.

3.02 FERTILIZER

A. Apply as specified in Section 32 92 00, Turf and Grasses.

3.03 SEEDING

A. As specified in Section 32 92 00, Turf and Grasses.

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3.04 MULCHING

A. Apply uniformly on seeded areas. Do not apply mulch on seeded areas that will be immediately covered with erosion control matting.

B. Application: Sufficiently loose to permit penetration of sunlight and air circulation, and sufficiently dense to shade ground, reduce evaporation rate, and prevent or materially reduce erosion of underlying soil.

1. Straw: Apply by hand or mechanical means to minimum depth of 2 inches.
2. Wood Cellulose Fiber: 1,000 to 1,500 pounds per acre.

3.05 EROSION CONTROL MATTING

A. Place where shown on Drawings, or as indicated by Engineer, staple/stake in place and with the appropriate overlap in accordance with manufacturer's instruction.

3.06 REINFORCED PLASTIC COVERING

A. Place on areas where hydroseeding and erosion control matting have not controlled erosion and over all temporary stockpiles.

B. Install in single thickness, strips parallel to direction of drainage.

C. Maintain tightly in place by using sandbags on ropes with a maximum 10-foot grid spacing in all directions.

D. Tape or weight down full length, overlap seams at least 12 inches.

E. Remove at final acceptance, unless notified otherwise by Engineer.

3.07 SILT FENCE

A. Install prior to starting earth disturbing activities upslope of fence.

B. One-piece filter fabric or continuously sewn to make one-piece filter fabric for full height of the fence, including portion buried in the toe trench.

C. When joints are necessary, splice filter fabric together only at a support post, with a minimum 6-inch overlap, and securely fasten both ends to support post.

D. Filter fabric shall not extend more than 30 inches above the ground surface. Securely fasten to upslope side of each support post using ties. Filter fabric shall not be stapled to existing trees.

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E. Take precaution not to puncture filter fabric during installation. Repair or replace damaged area.

F. Remove silt fence after upslope area has been permanently stabilized. Immediately dress sediment deposits remaining after the sediment fence has been removed to conform to existing grade. Prepare and seed graded area.

3.08 SOIL STOCKPILE

A. Protect from erosion with silt fence around stockpile area.

B. Stockpiles not used for a period longer than 14 days shall be seeded and mulched.

3.09 FIELD QUALITY CONTROL

A. Upon completion of maintenance period and on written notice from Contractor, Engineer or Owner will within 15 days of receipt, determine if a satisfactory stand has been established.

B. If a satisfactory stand has not been established, Engineer of the Owner will make another determination upon written notice from Contractor following the next growing season.

3.10 MAINTENANCE

A. Soil stabilization measures shall be maintained at all times until permanent stabilization of the Site is achieved.

B. Contractor shall install and add soil stabilization measures as determined by the Engineer or the Owner.

END OF SECTION

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SECTION 31 32 19.16
GEOTEXTILE

PART 1 GENERAL

1.01 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.

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.

F. Seam Efficiency: Ratio of tensile strength across seam to strength of intact geotextile, when tested according to ASTM D4884.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Manufacturer material specifications and product literature.

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.

1.03 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.

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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.

1.04 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.

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. Physical Properties: Conform to requirements in Table No. 2.

Table No. 2
Physical Property Requirements for Nonwoven Geotextile

Property	Requirement	Test Method
Water Permittivity	0.5 $sec.^{-1}$, MinARV	ASTM D4491 (Falling Head)
Apparent Opening Size (AOS)	No. 100 U.S. Standard Sieve Size	ASTM D4751
Grab Tensile Strength, Machine Direction	375 lb/in, MinARV	ASTM D4632
Grab Elongation, Machine Direction	50 percent, MaxARV	ASTM D4632
Puncture Strength	225 lb, MinARV	ASTM D4833

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Table No. 2 Physical Property Requirements for Nonwoven Geotextile		
Property	**Requirement**	**Test Method**
Trapezoid Tear Strength	125 lb, MinARV	ASTM D4533
Ultraviolet Radiation Resistance	70 percent strength retention, MinARV after 500 hours	ASTM D4355

2.02 WOVEN GEOTEXTILE (SILT FENCE APPLICATION)

A. As specified in Section 01 57 13, Temporary Erosion and Sediment Control.

2.03 SEWING THREAD

A. Polypropylene, polyester, or Kevlar thread.

B. Durability: Equal to or greater than durability of geotextile sewn.

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.

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.

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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.

B. Geotextile may be oriented with long dimension of sheet transverse to direction of slope only if sheet width, without unsewn seams, is sufficient to cover entire slope and anchor trench and to extend at least 18 inches beyond toe of slope.

3.03 JOINTS

A. Unseamed Joints:

1. Overlapped.
2. Overlap, unless otherwise shown:
    a. Foundation/Subgrade Stabilization: Minimum 18 inches.
    b. Riprap: Minimum 18 inches.
    c. Drain Trenches: Minimum 18 inches, except overlap shall equal trench width if trench width is less than 18 inches.
    d. Other Applications: Minimum 12 inches.

B. Sewn Seams: Made wherever stress transfer from one geotextile sheet to another is necessary. Sewn seams, as approved by Engineer, also may be used instead of overlap at joints for applications that do not require stress transfer.

1. Seam Efficiency:
    a. Minimum 70 percent.
    b. Verified by preparing and testing minimum of one set of nondestructive Samples per acre of each type and weight of geotextile installed.
    c. Tested according to ASTM D4884.
2. Types:
    a. Preferred: “J” type seams.
    b. Acceptable: Flat or butterfly seams.
3. Stitch Count: Minimum three to maximum seven stitches per inch.

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4. Stitch Type: Double-thread chainstitch according to ASTM D6193.
5. Sewing Machines: Capable of penetrating four layers of geotextile.
6. Stitch Location: 2 inches from geotextile sheet edges, or more, if necessary to develop required seam strength.

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.
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. 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.

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3.06 INSTALLING GEOTEXTILE IN TRENCHES

A. Place geotextile in a way to completely envelope granular drain 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 material is placed to required grade, fold geotextile over top of granular drain material, unless otherwise shown. Maintain overlap until overlying fill or backfill is placed.

3.07 SILT FENCE APPLICATIONS

A. Install geotextile as specified in Section 01 57 13, Temporary Erosion and Sediment Control.

B. Install bottom edge of sheet in toe trench and backfill in a way that securely anchors geotextile in trench.

C. Securely fasten geotextile to wire mesh backing and each support post in a way that will not result in tearing of geotextile when fence is subjected to service loads.

D. Promptly repair or replace silt fence that becomes damaged.

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 DEFINITIONS

A. Completed Course: Compacted, unyielding, free from irregularities, with smooth, tight, even surface, true to grade, line, and cross-section.

B. Completed Lift: Compacted with uniform cross-section thickness.

A. Standard Specifications: When referenced in this section, shall mean the Alabama Department of Transportation Standard Specifications for Highway Construction, Latest Edition.

1.02 SUBMITTALS

A. Informational Submittals:

1. Certified Test Results on Source Materials: Submit copies from commercial testing laboratory 15 days prior to delivery of materials to Project showing materials meeting the physical qualities specified.
2. Certified results of in-place density tests from independent testing agency.

PART 2 PRODUCTS

2.01 AGGREGATE BASE COURSE

A. Meeting the requirements of Type B Crushed Aggregate Base Material in Section 825 of the ALDOT Standard Specifications.

B. For gravel surface applications, Type A crushed aggregate base material in accordance with Section 825 shall be used.

2.02 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.

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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 surface course.

C. Do not place surface course or surfacing materials on soft or muddy 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. Hauling Materials:

1. Do not haul over surfacing in process of construction.
2. Loads: Of uniform capacity.
3. Maintain consistent gradation of material delivered; loads of widely varying gradations will be cause for rejection.

B. 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.
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. Aggregate Base Course:

1. Maximum Completed Lift Thickness: 8 inches.
2. Completed Course Total Thickness: As shown.
3. Spread lift on preceding course to required cross-section.
4. Lightly blade and roll surface until thoroughly compacted.

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5. Add keystone to achieve compaction and as required when aggregate does not compact readily due to lack of fines or natural cementing properties, as follows:
   a. Use leveling course or surfacing material as keystone.
   b. Spread evenly on top of surface course, using spreader boxes or chip spreaders.
   c. Roll surface until keystone is worked into interstices of surface course without excessive displacement.
   d. Continue operation until course has become thoroughly keyed, compacted, and will not creep or move under roller.
6. Blade or broom surface to maintain true line, grade, and cross-section.

3.05 ROLLING AND COMPACTION

A. Commence compaction of each layer of surface after spreading operations and continue until density of 95 percent of maximum density has been achieved as determined by AASHTO T99.

B. Roll each layer of material until material does not creep under roller before succeeding 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 required density before succeeding lift is placed.

F. Surface Defects: Remedy by loosening and rerolling. Reroll entire area, including surrounding surface, until thoroughly compacted.

G. Finished surface shall be true to grade and crown before proceeding with surfacing.

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 Untreated Aggregate Surface Course: Within plus or minus 0.04 foot of grade shown at any individual point.

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3.07 FIELD QUALITY CONTROL

A. In-Place Density Tests:

1. Provide testing laboratory at least 2 hours advance notification prior to testing.
2. Refer to Table 1 for minimum sampling and testing requirements for aggregate surface course.

Table 1
Minimum Sampling and Testing Requirements

Property	Test Method	Frequency	Sampling Point
Gradation	AASHTO T11 and AASHTO T27	One sample every 10 tons but at least every 4 hours of production	Roadbed after processing
Moisture Density (Maximum Density)	AASHTO T99, Method D	One test for every aggregate grading produced	Production output or stockpile
In-Place Density and Moisture Content	ALDOT-222	One for each 10 ton but at least every 2,000 sq ft of area	In-place completed, compacted area

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. M156, Standard Specification for Requirements for Mixing Plants for Hot-mixed, Hot-laid Bituminous Paving Mixes.
   f. M208, Standard Specification for Cationic Emulsified Asphalt.
   g. R35, Standard Practice for Superpave Volumetric Design for Hot Mix Asphalt.
   h. T166, Standard Method of Test for Bulk Specific Gravity (Gmb) of Compacted Hot Mix Asphalt (HMA) Mixtures Using Saturated Surface-Dry Specimens.
   i. T176 Standard Method of Test for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test.
   j. T209, Standard Method of Test for Theoretical Maximum Specific Gravity (Gmm) and Density of Hot Mix Asphalt (HMA).
   k. T245, Standard Method of Test for Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus.
   l. T246, Standard Method of Test for Resistance to Deformation and Cohesion of Hot Mix Asphalt (HMA) by Means of Hveem Apparatus.
   m. T247, Standard Method of Test for Preparation of Test Specimens of Hot Mix Asphalt (HMA) by Means of California Kneading Compactor.
   n. T283, Standard Method of Test for Resistance of Compacted Hot Mix Asphalt (HMA) to Moisture-Induced Damage.

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o. T304, Standard Method of Test for Uncompacted Void Content of Fine Aggregate.
p. T312, Standard Method of Test for Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of a Superpave Gyratory Compactor.

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.
3. ASTM International (ASTM):
   a. D75, Standard Method of Test for Sampling of Aggregates.
   b. D140, Standard Method of Test for Sampling Bituminous Materials.
   c. D979, Standard Method of Test for Sampling Bituminous Paving Mixtures.
   d. D2041, Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures.
   e. D2489, Standard Method of Test for Determining Degree of Particle Coating of Asphalt Mixtures.
   f. D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
   g. D4791, Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.
   h. D5821, Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate.
   i. D6938, Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
   j. E329 REV A, Standard Specification for Agencies Engaged in Construction Inspection Testing, or Special Inspection.

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.

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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.

G. Standard Specifications: Alabama Department of Transportation (ALDOT), Standard Specifications for Highway Construction, latest edition. Tack Coat: Thin layer of emulsified asphalt applied to hard surfaces, including new pavement lifts, to promote adhesion and bonding.

H. Warm Mix Asphalt (WMA): Generic term used to describe reduction in production, paving and compaction temperatures achieved through application of one or combination of several WMA technologies. Technologies involve HMA plant foaming processes and equipment, mineral additives, or chemicals that allow reduction of mix production to temperatures between 185 degrees F to 275 degrees F (85 degrees C to 135 degrees C).

1.03 SUBMITTALS

A. Informational Submittals:

1. Asphalt Concrete Mix Formula:
   a. 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) Percent of asphalt lost due to absorption by aggregate.
      5) Index of Retained Strength (TSR) at optimum asphalt content as determined by AASHTO T283.
      6) Percentage of asphalt cement, to nearest 0.1 percent, to be added to mixture.
      7) Optimum mixing temperature.
      8) Optimum compaction temperature.
      9) Temperature-viscosity curve of asphalt cement to be used.
      10) Brand name of any additive to be used and percentage added to mixture.
2. Test Report for Asphalt Cement: Show appropriate test method(s) for each material and the test results.

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1.04 QUALITY ASSURANCE

A. Qualifications:

1. Independent Testing Laboratory: In accordance with ASTM E329 REV A.
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 (10 degrees C) or air temperature is lower than 40 degrees F (4 degrees C). 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, conform to Section of the Standard Specifications.

B. Tack Coat:

1. Emulsified Asphalt for Tack Coat or Seal Coat: conform to Section 405 of the Standard Specifications.

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. Make adjustments in gradation or asphalt content as necessary to meet design criteria.

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B. Asphalt Concrete: Section 416-A Improved Bituminous Concrete from 1992 edition of ALDOT Standard Specifications and Standard Drawing 1 from the City of Mobile Right-of-Way Standard Drawings.

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.

PART 3 EXECUTION

3.01 GENERAL

A. Traffic Control:

1. In accordance with Section 01 50 00, Temporary Facilities and Controls.
2. Minimize inconvenience to traffic, but keep vehicles off freshly treated or paved surfaces to avoid pickup and tracking of asphalt.

B. Driveways: Repave driveways from which pavement was removed. Leave driveways in as good or better condition than before start of construction.

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.

3.03 APPLICATION EQUIPMENT

A. In accordance with Section 410 of the ALDOT 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.

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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 Section 410 of the ALDOT Standard Specifications.

3.06 PAVEMENT OVERLAY

A. Preparation:

1. Remove fatty asphalt, grease drippings, dust, and other deleterious matter.
2. Surface Depressions: Fill with asphalt concrete mix, and thoroughly compact.
3. Damaged Areas: Remove broken or deteriorated asphalt concrete and patch as specified in Article Patching.
4. Portland Cement Concrete Joints: Remove joint filler to minimum 1/2 inch (12 millimeters) below surface.

B. Application:

1. Tack Coat: As specified in Section 410 of the ALDOT Standard Specifications.
2. Place and compact asphalt concrete as specified in Article Pavement Application.
3. Place first layer to include widening of pavement and leveling of irregularities in surface of existing pavement.
4. When leveling irregular surfaces and raising low areas, the actual compacted thickness of any one lift shall not exceed 2 inches (50 millimeters).
5. Actual compacted thickness of intermittent areas of 120 square yards (100 square meters) or less may exceed 2 inches (50 millimeters), but not 4 inches (100 millimeters).
6. Final wearing layer shall be of uniform thickness, and meet grade and cross-section as shown.

3.07 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.

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B. Application:

1. Patch Thickness: 3 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 to 300 pounds per linear inch (350 Newtons per linear centimeter to 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.

3.08 FIELD QUALITY CONTROL

A. General: Provide services of approved certified independent testing laboratory to conduct tests.

B. Field Density Tests:

1. Perform tests from cores or sawed samples in accordance with AASHTO T166.
2. Measure with properly operating and calibrated nuclear density gauge in accordance with ASTM D6938.
3. Maximum Density: In accordance with ASTM D2041, using sample of mix taken prior to compaction from same location as density test sample.

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C. Testing Frequency:

1. Quality Control Tests:
   a. Asphalt Content, Aggregate Gradation: Once per every 500 tons (400 mg) 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 mg) or once every 8 hours, whichever is greater.
2. Density Tests: Once every 500 tons (450 mg) 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 DEFINITIONS

A. Standard Specification: When referenced in this section, shall mean the 2018 edition of the Alabama Department of Transportation Standard Specifications for Highway Construction.

1.02 SUBMITTALS

A. If Contractor proposes to use a current mix design that meets these Specifications, has been used on previous projects, and less than 1 year has elapsed since it was last used; Contractor shall submit documentation of production of concrete produced from that mix design to Engineer for review. If review verifies concrete produced meets these Specifications and strength requirements, and establishes a correlation between compressive strength and flexural strength, no trial batches for proposed mix design will be required.

B. Provide as required in Section 03 30 00, Cast-In-Place Concrete.

C. Action Submittals: Provide as required in Section 03 30 00, Cast-In-Place Concrete.

D. Informational Submittals: Provide as required in Section 03 30 00, Cast-In-Place Concrete.

1.03 QUALITY ASSURANCE

A. Provide as required in Section 03 30 00, Cast-In-Place Concrete.

B. 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.

C. Hot Weather Concreting: Conform to ACI 305R.

D. Cold Weather Concreting: Conform to ACI 306R.

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1.04 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 required in Section 03 30 00, Cast-In-Place Concrete.

B. Aggregates:

1. General:
   a. As specified in Section 03 30 00, Cast-In-Place Concrete.
   b. Aggregates not in compliance with soundness and durability requirements of ASTM C33 may be used with prior approval of Engineer; provided it can be shown by special testing or record of past performance that these aggregates produce concrete of adequate strength and durability. Aggregate soundness testing for fine and coarse aggregates shall be in accordance with ASTM C33 and ASTM C88.

C. Water: ASTM C94/C94M.

D. Admixtures: As specified in Section 03 30 00, Cast-In-Place Concrete.

2.02 ANCILLARY MATERIALS

A. Tie Bars: Grade 40 deformed steel bars conforming to Section 03 30 00, Cast-In-Place Concrete.

B. Dowels: Conform to requirements of AASHTO M227/M227M, Grade 70.

C. Joint Filler:

1. Preformed expansion joint filler conforming to AASHTO M153 or AASHTO M213.
2. Fillers furnished under AASHTO M213 shall be tested in accordance with ASTM D1751.

D. Joint Sealant: In accordance with the Standard Specifications.

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E. Curing Compound: In accordance with the Standard Specifications.

F. Curing Membranes:

1. White polyethylene sheeting.
2. Waterproof paper.
3. Cotton or jute mats.

G. Evaporation Retardant: Confilm as manufactured by Master Builders Company.

2.03 EQUIPMENT

A. Ready-Mix Concrete Batch Plants: Certified by NRMCA.

B. Ready-Mix Concrete Trucks:

1. Agitator mixer type.
2. Equipped with operable electrically actuated drum revolution counters.
3. Use of nonagitator equipment will not be permitted.
4. Each mixer shall carry a clearly visible manufacturer's plate showing capacity of mixer and other pertinent operating rates and limits.
5. Provision shall be made at mixer for controlled addition of air-entraining admixtures or other special components of mix.
6. Mixing Speed: 70 to 100 revolutions at a mixing speed recommended by truck mixer manufacturer.

C. Hauling Equipment:

1. Hauling equipment shall conform to AASHTO M157, Paragraph 11.6 and Paragraph 12.
2. Upon delivery of each batch of concrete to Site, a trip ticket shall be submitted to Engineer.

D. 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.

E. Smoothness Testing Equipment: Supply two 12-foot straightedges for determining smoothness.

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2.04 CONCRETE MIX DESIGN

A. As specified in Section 03 30 00, Cast-In-Place Concrete, with a minimum flexural strength of 650 psi.

1. If the 650 psi flexural strength specification requires a compressive strength in excess of 4,000 psi, the higher compressive value shall be used as a standard minimum for compressive strength cylinder tests taken during construction.
2. The relationship between compressive strength f_c and modulus of rupture f_r shall be:

$$f_r = k\sqrt{f_c}$$

with k derived from the tests results.

B. Concrete target strengths shall be in accordance with ACI 318/318R.

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. During periods of rain.

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.

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D. Construction Joints: Inspect prior to placement of concrete.

E. 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.

F. Furnish operable vibrator on Site prior to concrete placement.

3.03 PAVING

A. Deliver from hauling vehicles.

B. Contractor's equipment hauling concrete or reinforcement will not be permitted on prepared 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. Concrete shall be vibrated, consolidated, and finished to proper grade and cross section.

D. While placing portland cement concrete, provision shall be made for constructing joints, placing dowels, tie bars, and other devices as called for by Drawings and as provided in Article, Joints.

E. Portland cement concrete shall be rejected if it:

1. Is not in place within 1 hour after being mixed.
2. Has begun to take an initial set prior to placement.
3. Has been retempered with water.

F. Portland cement concrete shall not be fouled with foreign matter.

G. Use vibrators to consolidate portland cement concrete pavement at least 6 feet each side of construction joints and expansion joints.

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H. Defects:

1. Fill areas of minor honeycomb or other minor defect in composition of portland cement concrete along exposed edges of portland cement concrete with a stiff mortar of cement and fine aggregate. Apply to moistened portland cement concrete to satisfaction of Engineer.
2. Area showing serious defects in composition of concrete shall be removed and replaced with pavement of specified quality for full width of strip between longitudinal joints or edges and for a length not less than between the nearest transverse 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 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 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.

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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.

2. Space longitudinal joints as shown on Drawings or as approved by Engineer, at the interface between lanes, normally at intervals between 12 feet to 16 feet.
3. Transverse joints shall be as shown on 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 No. 8 by 36-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 36-inch deformed tie bars at 12-inch centers.
   b. Tie Bars:
      1) Not required at construction joint between portland cement concrete pavement and gutter, except where shown on Drawings and mentioned above.

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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.
      (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 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.

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F. Pavement shall be screeded, floated, and given heavy nylon bristle-broomed skid-resistant surface.

1. Broomed surface with hand broom or mechanical broom device to produce 1/16-inch to 1/8-inch deep striations oriented perpendicular to the direction of travel.

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 moisture-proof 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.

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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 2,500 square feet or fraction thereof of concrete placed each day.

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.

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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.

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 AND SIDEWALKS

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 inches) 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: Alabama Department of Transportation (ALDOT) Standard Specifications for Highway Construction, latest edition.

1.02 SUBMITTALS

A. Informational Submittals: Ready-mix delivery ticket for each truck in accordance with ASTM C94.

1.03 QUALITY ASSURANCE

A. Regulatory Requirements: Conform to the state of Alabama Standard Specifications for Highway Construction.

PART 2 PRODUCTS

2.01 MATERIALS

A. Curb and Gutter: Conform to the requirements of Section 623, Curb, Gutter and Combination Curb and Gutter, Standard Specification.

B. Sidewalks: Conform to Section 618, Concrete Sidewalks and Driveways, of the ALDOT Standard Specifications.

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2.02 EXPANSION JOINT FILLER

A. Preformed asphalt-impregnated, expansion joint material meeting ASTM D994, 1/2-inch thick.

2.03 CONCRETE

A. Curb and Gutter: Conform to the requirements of Section 623, Curb, Gutter and Combination Curb and Gutter, Standard Specification.

B. Sidewalks: Conform to Class A concrete from Section 501, Structural Portland Cement Concrete, of the ALDOT Standard Specifications.

2.04 CURING COMPOUND

A. Liquid membrane forming, clear or translucent, suitable for spray application and meeting ASTM C309, Type 1.

PART 3 EXECUTION

3.01 INSTALLATION

A. Perform Work in accordance with the referenced ALDOT Standard Specifications Sections 618 and 623.

3.02 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.

3.03 CURB CONSTRUCTION

A. Perform Work in accordance with the referenced ALDOT Standard Specifications Sections 623.

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3.04 SIDEWALK CONSTRUCTION

A. Perform Work in accordance with the referenced ALDOT Standard Specifications Sections 618.

B. Thickness: As specified on plans.

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. M248, Standard Specification for Ready-Mixed White and Yellow Traffic Paints.
2. Federal Specifications (FS): A-A-2886A, Paint, Traffic, Solvent Based.

1.02 DEFINITIONS

A. Specification: When referenced in this section, shall mean the 2018 edition of the Alabama Department of Transportation Standard Specifications for Highway Construction.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product Data:
      1) Paint.
      2) Epoxies, resins, and primers to be used.

PART 2 PRODUCTS

2.01 GENERAL

A. All products shall be in accordance with Section 701 of the Standard Specifications.

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2.02 PAINT

A. Class 1 Pavement Paint Material as specified in Section 701 of the Standard Specifications.

B. Color: Blue, white, or yellow.

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 701 of the Standard Specifications.

END OF SECTION

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SECTION 32 31 13
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. A497/A497M, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
   d. A615/A615M, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   e. A780, Standard Specification for Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings.
   f. A824, Standard Specification for Metallic-Coated Steel Marcelled Tension Wire for Use with Chain Link Fence.
   g. 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.
   h. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   i. C150, Standard Specification for Portland Cement.
   j. C387, Standard Specifications for Packaged, Dry, Combined Materials for Mortar and Concrete.
   k. F626, Standard Specification for Fence Fittings.
   l. F900, Standard Specification for Industrial and Commercial Swing Gates.
   m. F934, Standard Specification for Standard Colors for Polymer-Coated Chain Link Fence Materials.
   n. F1043, Standard Specification for Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework.
   o. F1083, Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures.
   p. F1184, Standard Specifications for Industrial and Commercial Horizontal Slide Gates.
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.).

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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) Gates and hardware.
   b. Layout and details of corner, end post, gate, gate post, and baffle construction including types, sizes of members, fabric, fastenings and fittings.
   c. Show gate leaf sizes and bracing, gate swings, which items of hardware are welded to gate leafs in shop, and the location of keepers and stops at the end of the swing
   d. Show closer spacing of posts where narrower bays are needed to keep sloping bottom rails close to sloping grades.
2. Samples: Minimum 6 inches square sample of illustrating design, fabrication of workmanship, and selected color.
3. Test Reports: Field test result for compliance of installation of fence panels, posts, and gates.

B. Informational Submittals:

1. Manufacturer’s data sheets on products used, with the following information:
   a. Preparation instructions and recommendations.
   b. Storage and handling requirements and recommendations.
   c. Recommended installation instructions.
2. Evidence of Supplier and installer qualifications.
3. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

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1.04 QUALITY ASSURANCE

A. Qualifications:

1. Supplier: 5 years' experience.
2. Installer: Experienced installer who has completed decorative fences and gates similar in material, design, and extent to those indicated for Project and whose work has resulted with a record of successful in-service performance with a minimum 3 years' experience.

B. Design, supply of equipment and components, installation, and on-call service shall be product of individual company with record of installations meeting requirements specified.

C. Preinstallation Conference: Conduct conference at Project Site with gate installer to verify layout and operations of automatic gate operating system.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Site in undamaged condition.

B. Store materials and/or products in manufacturer's unopened packaging to protect finished surfaces until ready for installation.

C. Store components off the ground in a dry covered areas, protected from adverse weather conditions, and in a location to prevent damage from construction activities.

1.06 SCHEDULING AND SEQUENCING

A. Complete necessary Site preparation and grading before installing decorative 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.

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1.07 SPECIAL GUARANTEE

A. Decorative Fence: 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 coatings, finishes, and other materials beyond normal weathering.
2. Manufacturer shall provide material replacing rusted components without paying for delivery, tax, or the labor of removing/replacing.
3. Damage from improper design or use, accidents, acts of God, and abuse are not covered under warranty.

PART 2 PRODUCTS

2.01 MATERIALS

A. Components:

1. Posts: Aluminum extrusions of 6005-T-5 alloy in accordance with ASTM B221.
2. Pickets: Aluminum extrusions of 6063-T-52 alloy in accordance with ASTM B221.
3. Channel: Aluminum extrusions of 6005-T-5 alloy in accordance with ASTM B221.

B. Fasteners:

1. Screws of 410 and 18-8 stainless steel conforming to ASTM A276, with self-drilling head.
2. Screws painted to match the finish of fence.

C. Accessories: Post caps, wall brackets, scrolls, finials, flanges and other miscellaneous hardware fabricated of aluminum or other non-ferrous metal castings.

D. Concrete: As specified in Section 03 30 00, Cast-in-Place Concrete.

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2.02 DECORATIVE FENCING

A. General:

1. Municipal Grade:
   a. Aluminum Channel Sections: 1-1/2-inch deep and 1-inch wide with top 0.055 inch and sidewalls 0.082-inch wall thickness, with decorative top corner.
   b. Pickets 3/4 inch by 3/4 inch with a 0.005-inch wall thickness
2. Post Length: As required to allow setting of post into the ground with approximately 1-3/4 inches (305 mm) between bottom of panel and ground.
3. Shall be supplied by the following manufacturer:
   a. Alumi-Guard, Inc.
      2401 Corporate Blvd.
      Brooksville, Florida 34604
      Toll free (877) 258-6448
      Phone (352) 754-8555
4. Substitutions are not permitted.

B. Decorative Fencing:

1. Style: Belmont.
   a. Grade: Municipal.
   b. Channel: Four Channel.
   c. Municipal Picket Spacing: Standard 3.875 inches.
   d. Panel Height: 96 inches.
   e. Posts: 3 inches by 3 inches.
      1) 0.125-inch wall thickness.
   f. Panel Length: Inside posts.
      1) Municipal Nominal 66.62 inches.
      2) Municipal Nominal 91.75 inches.

C. Decorative Gates: Provide to match decorative fencing style specified.

1. Height: 96 inches.
2. Opening Width: Inside posts.
   a. Sliding: 22 feet.
3. Hardware: As specified by manufacturer.
4. Track system: Bottom track.

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D. Fence and Accessory Finish:

1. SuperDurable Polyester Powder Coating: High performance polyester, medium gloss, applied to over 2 mils thickness and complying with AAMA 2604.
2. Fluoropolymers: Superior performance polyester powder coating, medium gloss, applied to 304 mils thickness and complying with AAMA 2604.

E. Color: Black.

F. Performance:

1. Meet or exceed a 4,000-hour salt spray test.
2. SuperDurable Polyester Powder coating meets or exceeds a H-2H pencil hardness in accordance with ASTM D3363.
3. Fluoropolymers meets or exceeds a 4H pencil harness in accordance with ASTM D3363.
4. Meets or exceeds ASTM D3359 adhesion test.

2.03 CONCRETE

A. Provide as specified in Section 03 30 00, Cast-in-Place Concrete.

PART 3 EXECUTION

3.01 GENERAL

A. Install decorative fence as shown on Drawings. Decorative fence shall be in accordance with manufacturer's recommendations and as approved by Engineer.

B. Protect existing chain link fence where not shown to be removed.

C. Provide necessary hardware for a complete fence and gate installation.

D. Any damage to galvanized surfaces, including welding, shall be repaired with paint containing zinc dust in accordance with ASTM A780.

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 fence and finish grade.

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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, 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. 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.

D. Before concrete sets, crown and finish top of concrete to readily shed water.

3.04 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.

3.05 GATE OPERATOR SYSTEMS

A. As specified in Section 32 31 15, Gate Operator Systems.

B. Furnish with equipment and accessories necessary for complete installation.

3.06 CLEANUP

A. Remove excess fencing materials and other debris from Site.

B. Touch-up paint scratched surfaces using paint pens supplied by manufacturer that match fence color. Spray-paint touch and/or overspray is not covered under warranty.

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: Include construction details, material descriptions, dimensions of individual components, and finishes, identifying any deviation from the specified requirements:
      1) Gate operators, motors, and mounting arrangements, switches, and controls; include operating instructions.
      2) Gate access system, including access control features, 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.

B. Informational Submittals:

1. Manufacturer’s recommended installation instructions.
2. Factory test reports, certified.
3. Evidence of Supplier and installer qualifications.

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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 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 1, 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 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. Motor hp not to exceed 2hp. The gate and controller shall operate on a single 30A, 120V power feed.
    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: 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.

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e. Motor Control Enclosure: In accordance with Section 26 05 04, Basic Electrical Materials and Methods. The motor starter required for the gate shall be included within the vendor control panel.
f. Disconnecting Means: Provide with external, NEMA 4X rated, disconnect switch capable of being padlocked in the OFF position.
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: 30 cycles per hour.
    5) Operating Type: Suitable for swing and 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. LiftMaster.
    b. Hy-Security Gate Operator.
    c. Automated Equipment Co.

D. Access System for NW Entry Gate:

1. Coordinate access system devices with a Card reader and video intercom system.
2. 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: Capable of monitoring and auditing gate activity.

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3. For safety, provide photo eyes minimum of 4 feet away from each side of gate.
4. Gate Operation:
   a. Entry: Gate opens when activated by valid card in reader or remotely by video intercom system with button press. 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.
   c. Override or 7-day timer to allow gate to remain open for up to 12 hours with equipment at rest.
5. 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.
6. Manufacturers: LiftMaster.

E. Access System for NE Exit Gate:

1. Coordinate access system devices with a Push-To-Exit pushbutton.
2. Push-To-Exit pushbutton in weatherproof enclosure mounted on steel tube post anchored to concrete foundation outside gate. Face lighted unit fully visible at night.
3. For safety, provide photo eyes minimum of 4 feet away from each side of gate.
4. Gate Operation:
   a. Exit Only: Gate opens when activated by Push-To-Exit pushbutton in pavement or pushbutton inside gate. Gate closes after adjustable time period up to 90 seconds.
   b. Override or 7-day timer to allow gate to remain open for up to 12 hours with equipment at rest.
5. 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.
6. Manufacturers: LiftMaster.

2.03 CONCRETE

A. Reinforcing Steel: ASTM A615/A615M, Grade 60 deformed bars.

B. Welded Wire Fabric: ASTM A1064/A1064M.

C. Formwork: Plywood.

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D. Mix: ASTM C94/C94M, Option A.

1. Cement: ASTM C150/C150M, Type I.
2. Coarse Aggregate Size: 1-1/2 inches.
3. Design for Minimum Compressive Strength at 28 Days: 3,000 psi.

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.

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 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.

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3.04 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.

3.05 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.

C. Minimum time requirements are as follows, travel time excluded:

1. 2 person-days for installation assistance, field testing, and certification of the installation.
2. 1 person-day for startup.
3. 1 person-day for training.

3.06 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 SCOPE

A. Work in this section covers soil preparation for seeding, sodding, and planting activities.

1.02 SUBMITTALS

A. Informational Submittals:

1. Certified Topsoil Analysis Reports:
   a. Indicate quantities of materials necessary to bring onsite 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 QUALITY ASSURANCE

A. Topsoil Analysis/Testing: Perform by state soil testing service or approved certified independent testing laboratory.

1.04 SEQUENCING AND SCHEDULING

A. Rough grade areas to be planted or seeded. Perform Work specified in Section 31 10 00, Site Clearing, 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.

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B. Composition: In general accordance with ASTM D5268:

1. Gravel-Sized Fraction: Maximum 5 percent by weight retained on a No. 10 sieve.
2. Sand-Sized Fraction: Minimum 20 percent to 60 percent passing No. 10 sieve.
3. Silt and Clay-Sized Fraction: Minimum 35 percent to 70 percent.

C. Organic Matter: Minimum 1.5 percent by dry weight as determined in accordance with ASTM D2974.

D. pH: Range 6.0 to 7.0.

E. Textural Amendments: Amend as necessary to conform to required composition by incorporating sand, peat, manure, or sawdust.

F. Source: Stockpile material onsite, in accordance with Section 31 10 00, Site Clearing. 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. Sawdust or Ground Bark:

1. Nontoxic, of uniform texture, and subject to slow decomposition when mixed with soil.
2. Nitrogen-treated, or if untreated mix with minimum 0.15 pound of ammonium nitrate or 0.25 pound of ammonium sulfate per cubic foot of loose material.

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B. Peat:

1. Composition: Natural residue formed by decomposition of reeds, sedges, or mosses in a freshwater environment, free from lumps, roots, and stones.
   a. Organic Matter: Not less than 90 percent on a dry weight basis as determined by ASTM D2974.
   b. Moisture Content: Maximum 65 percent by weight at time of delivery.

C. Fertilizer: As specified in Section 32 92 00, Turf and Grasses.

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. Apply lime at the rate of 50 pounds per 1,000 square feet to subgrade before tilling.

B. Scarify subgrade to minimum depth of 6 inches where topsoil is to be placed.

C. Remove stones over 2-1/2 inches in any dimension, sticks, roots, rubbish, and other extraneous material.

D. Limit preparation to areas which will receive topsoil within 2 days after preparation.

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 6 inches where seeding and planting are scheduled.

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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 one year after all planting under this section is completed.

B. Satisfactory Stand: Seeded area of 3,000 square feet or larger that has:

1. No bare spots larger than 3 square feet.
2. Not more than 10 percent of total area with bare spots larger than 1 square foot.
3. 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: Certification of seed analysis, germination rate, and inoculation:
   a. 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:
      1) Name and address of laboratory.
      2) Date of test.
      3) Lot number for each seed specified.
      4) Test Results: (i) name, (ii) percentages of purity and of germination, and (iii) weed content for each kind of seed furnished.
   b. Mixtures: Proportions of each kind of seed.
2. Seed Inoculant Certification: Bacteria prepared specifically for legume species to be inoculated.
3. Certification of sod; include source and harvest date of sod, and sod seed mix.
4. 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. Sod:

1. Do not harvest if sod is excessively dry or wet to the extent survival may be adversely affected.
2. Harvest and deliver sod only after laying bed is prepared for sodding.
3. Roll or stack to prevent yellowing.
4. Deliver and lay within 24 hours of harvesting.
5. Keep moist and covered to protect from drying from time of harvesting until laid.

C. 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. Complete Work 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, and after trees, shrubs, and herbaceous perennials have been installed.

C. Notify Engineer at least 3 days in advance of:

1. Each material delivery.
2. Start of planting activity.

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1.06 MAINTENANCE SERVICE

A. Contractor: Perform maintenance operations of all area disturbed during construction during maintenance period to include:

1. Watering: Keep surface moist, but not saturated.
2. Washouts: Repair by filling with topsoil, amending as necessary, fertilizing, seeding, and mulching.
3. Mulch: Replace wherever and whenever washed or blown away.
4. Mowing: Monthly from April through October. Up to three additional mowings at Owner request from November through March.
5. Reseed unsatisfactory areas or portions thereof immediately at the end of the maintenance period if a satisfactory stand has not been produced.
6. Reseed/re-sod entire area if satisfactory stand does not develop after 90 days following installation.

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 for Temporary Seed:

1. Nitrogen: 8.
2. Phosphoric Acid: 24.
3. Potash: 24.

D. Mix for Permanent Seed/Sod:

1. Nitrogen: 10.
2. Phosphoric Acid: 10.
3. Potash: 10.

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.

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C. Temporary Seeding Species:

1. Common Bermuda grass (Mar 1 – July 15).
2. Ryegrass (Sep 15 – Nov 15).

D. Permanent Seeding Species: See Drawings for seed mix species, percentage by weight, and application rate.

2.03 SEEDING

A. Start within 2 days of preparation completion.

B. Mechanical: Broadcast seed in two different directions, compact seeded area with cultipacter or roller.

1. Sow seed at uniform rate of:
   a. Common Bermuda: 10 pounds per acre.
   b. Ryegrass: 30 pounds per acre.
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 by 20 percent.
4. Roll with ring roller to cover seed, and water with fine spray.

C. Hydroseeding:

1. Apply on moist soil, only after free surface water has drained away.
2. Prevent drift and displacement of mixture into other areas.
3. Upon application, allow absorption and percolation of moisture into ground.
4. Mixtures: Seed and fertilizer may be mixed together, apply within 30 minutes of mixing to prevent fertilizer from burning.

2.04 SOD

A. Certified, turf species: Zoysia or Tiffway 419 Bermuda.

B. Strongly rooted pads, capable of supporting own weight and retaining size and shape when suspended vertically from a firm grasp on upper 10 percent of pad.

1. Grass Height: 1-1/2 to 2-1/2 inches.
2. Strip Size: Supplier’s standard.
3. Soil Thickness: Uniform; 1 inch plus or minus 1/4 inch at time of cutting.
4. Age: Not less than 10 months or more than 30 months.
5. Condition: Healthy, green, moist; free of diseases, nematodes and insects, and of undesirable grassy and broadleaf weeds. Yellow sod, or broken pads, or torn or uneven ends will not be accepted.

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2.05 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.

2.06 NETTING

A. As specified in Section 31 32 00, Soil Stabilization.

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:

1. Temporary Seeding: 400 pounds per acre.
2. Permanent Seeding/Sodding: 500 pounds per acre.

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3.03 SEEDING

A. Start within 2 days of preparation completion.

B. Mechanical: Broadcast seed in two different directions, compact seeded area with cultipacter or roller.

1. Sow seed at uniform rate of:
   a. Common Bermuda: 10 pounds per acre.
   b. Ryegrass: 30 pounds per acre.
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.

C. Hydroseeding:

1. Apply on moist soil, only after free surface water has drained away.
2. Prevent drift and displacement of mixture into other areas.
3. Upon application, allow absorption and percolation of moisture into ground.
4. Mixtures: Seed and fertilizer may be mixed together, apply within 30 minutes of mixing to prevent fertilizer from burning seed.

A. Mulching: Apply uniform cover of straw mulch at a rate of 2 tons per acre or wood fiber mulch at rate of 1,500 pounds per acre.

B. 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.

C. Water: Apply with fine spray after mulching to saturate top 4 inches of soil.

3.04 SODDING

A. Do not plant when ground is saturated.

B. Lay sod to form solid mass with tightly fitted joints; butt ends and sides, do not overlap.

1. Stagger strips to offset joints in adjacent courses.
2. Work from boards to avoid damage to subgrade or sod.
3. Tamp or roll lightly to ensure contact with subgrade; work sifted soil into minor cracks between pieces of sod, remove excess to avoid smothering adjacent grass.
4. Complete sod surface true to finished grade, even, and firm.

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C. Fasten sod on slopes to prevent slippage with wooden pins 6 inches long driven through sod into subgrade, until flush with top of sod. Install at sufficiently close intervals to securely hold sod.

D. Water sod with fine spray immediately after planting. During first week, water daily or more frequently to maintain moist soil to depth of 4 inches.

3.05 FIELD QUALITY CONTROL

A. Eight weeks after seeding and sodding are 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 4 months before the end of the one-year maintenance period.

3.06 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
CONVEYANCE PIPING—GENERAL

PART 1 GENERAL

1.01 REFERENCES

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

1. American Concrete Institute (ACI): 301, Specifications for Structural Concrete.
2. American Water Works Association (AWWA):
   a. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
   b. C115/A21.15, Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
   c. C207, Steel Pipe Flanges for Waterworks Service - Sizes 4 in. Through 144 in. (100 mm Through 3,600 mm).
   d. C210 Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
   e. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
   f. C217, Petrolatum and Petroleum Wax Tape Coatings for the Exterior of Connections and Fittings for Steel Water Pipelines.
   g. C219, Bolted, Sleeve-Type Couplings for Plain-End Pipe.
   h. C221, Fabricated Steel Mechanical Slip-Type Expansion Joints.
   i. C606, Grooved and Shouldered Joints.
3. 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. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   d. C150/C150M, Standard Specification for Portland Cement.
   e. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
4. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

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1.02 SUBMITTALS

A. Action Submittals:

1. Pipe pressure class.
2. Product Data: Manufacturer's data for couplings, saddles, gaskets, and other pipe accessories. Indicate maximum rated working pressure and test pressure for each item.

B. Informational Submittals: Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.

1.03 DELIVERY, STORAGE, AND HANDLING

A. In accordance with manufacturer's recommendations and as specified in individual Specification(s) following this section.

B. Marking at Plant: Mark each pipe and fitting at plant. Include date of manufacture, manufacturer's identification, specification standard, diameter of pipe dimension ratio and other information required for type of pipe.

C. Pipe, specials, and fittings received at Project Site in damaged condition will not be accepted.

D. Gasket Storage: Store rubber gaskets in cool, well ventilated place, and do not expose to direct rays of sun. Do not allow contact with oils, fuels, petroleum, or solvents.

E. Store and support pipe securely to prevent accidental rolling and to avoid contact with mud, water, or other deleterious materials.

F. Handling:

1. Pipe shall be handled with proper equipment in a manner to prevent distortion or damage. Use of hooks, chains, wire ropes, or clamps that could damage pipe, damage coating or lining, or kink and bend pipe ends is not permitted.
2. Use heavy canvas, or nylon slings of suitable strength for lifting and supporting materials.
3. Lifting pipe during unloading or lifting into trench shall be done using two slings placed at quarter point of pipe section. Pipe may be lifted using one sling near center of pipe, provided pipe is guided to prevent uncontrolled swinging and no damage will result to pipe or harm to workers. Slings shall bear uniformly against pipe.
4. Pipe and fittings shall not be stored on rocks or gravel, or other hard material that might damage pipe. This includes storage area and along pipe trench.

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PART 2 PRODUCTS

2.01 PIPE

A. As specified in the individual specification(s) following this section.

2.02 JOINTS

A. As specified in the individual specification(s) following this section.

2.03 COUPLINGS

A. General: Couplings shall be rated for appropriate operating pressure and hydrostatic test pressure.

2.04 PIPE LOCATING TAPE

A. As specified in Section 31 23 23.15, Trench Backfill.

2.05 PIPE BEDDING AND PIPE ZONE MATERIAL

A. Granular material as specified in Section 31 23 23.15, Trench Backfill.

2.06 TRENCH STABILIZATION MATERIAL

A. As specified in Section 31 23 23.15, Trench Backfill.

PART 3 EXECUTION

3.01 GENERAL

A. Notify Engineer at least 2 weeks prior to field fabrication of pipe or fittings.

B. Furnish feeler gauges of proper size, type, and shape for use during installation for each type of pipe furnished.

C. Distributing Materials: Place materials along trench only as will be used each day, unless otherwise approved by Engineer. Placement of materials shall not be hazardous to traffic or to general public, obstruct access to adjacent property, or obstruct others working in area.

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3.02 EXAMINATION

A. Verify size, material, joint types, elevation, and horizontal location of existing pipeline to be connected to new pipeline or new equipment.

B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

3.03 PREPARATION OF TRENCH

A. Prepare trench as specified in Section 31 23 16, Excavation.

B. Unless otherwise permitted by Engineer, maximum length of open trench shall not exceed 50 feet.

3.04 INSTALLATION

A. General:

1. Join pipe and fittings in accordance with manufacturer's instructions, unless otherwise shown or specified.
2. Inspect pipe and fittings before installation, clean ends thoroughly, remove foreign matter and dirt from inside.

3.05 PLACEMENT OF PIPE LOCATING TAPE

A. Place pipe locating tape in accordance with Section 31 23 23.15, Trench Backfill.

3.06 PIPE BEDDING AND ZONE MATERIAL

A. Place pipe bedding and pipe zone material in accordance with Section 31 23 23.15, Trench Backfill.

3.07 FIELD QUALITY CONTROL

A. Pressure Leakage Testing: As specified in the individual specification(s) following this section.

3.08 CLEANING

A. Following assembly and testing, and prior to final acceptance, flush pipelines with water at 2.5 fps minimum flushing velocity until foreign matter is removed. Dispose of water and flushed foreign matter.

END OF SECTION

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SECTION 33 05 01.12.03 POLYVINYL CHLORIDE (PVC)—GRAVITY SANITARY SEWER	
Item	**Description**
Pipe: 15-inch Diameter and Under	ASTM D3034: SDR 26, except that cell classification shall be 12454-B or 12454-C as defined in ASTM D1784.
Pipe: 18-inch through 24-inch Diameter	ASTM F679: PS 115 psi, except that cell classification shall be 12454-C as defined in ASTM D1784.
Joints	Integral bell and spigot, in accordance with ASTM D3212.
Gaskets	ASTM F477 factory fabricated rubber compression type with solid cross section. Lubricant for joining pipe as approved by pipe manufacturer.
Tee and Wye Fittings	Shall conform to the requirements of ASTM D3034 and ASTM F679. SDR 26.
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 05 13
MANHOLES

PART 1 GENERAL

1.01 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.
   f. Corrosion Resistance/Lining System.

B. Informational Submittals:

1. Experience Record:
   a. Precast concrete production capabilities.
   b. Evidence of current PCI plant certification.
2. Certificate of Compliance: Certify admixtures and concrete do not contain calcium chloride.
3. Test Reports: Precast manufacturer's concrete test cylinders.
4. Certified load test data for precast manhole steps.
5. Manufacturer's recommended installation instructions.
6. Field quality control report.

1.02 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.

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PART 2 PRODUCTS

2.01 GENERAL

A. Mobile Area Water and Sewer System (MAWSS) Standards:

1. Precast manholes (except as modified in the plans) shall be in accordance with Section 12 of the MAWSS Sanitary Sewer Standard Specifications.
2. Precast manholes shall conform to the requirements of ASTM C478, latest edition.

2.02 PRECAST MANHOLES

A. Riser Sections:

1. Fabricate in accordance with ASTM C478.
2. Diameter: Minimum 48 inches or as shown on plans.
3. Wall Thickness: Minimum 5 inches or as specified on the plans.
4. Top and bottom surfaces shall be parallel.
5. Joints: Tongue-and-groove and 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.

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. As specified by Section 12 of the MAWSS Sanitary Sewer Standard Specifications.
2. Confined Plastic or Rubber O-Ring: As recommended by precasting manufacturer.
3. External Wrap: As specified by Section 12 of the MAWSS Sanitary Sewer Standard Specifications.

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F. Polypropylene Steps: As specified by Section 12 of the MAWSS Sanitary Sewer Standard Specifications.

G. Corrosion Resistance/Lining: As specified by Section 12 of the MAWSS Sanitary Sewer Standard Specifications.

2.03 MANHOLE FRAMES AND COVER

A. Castings: As specified by Section 12 of the MAWSS Sanitary Sewer Standard Specifications.

B. Cover: Owner's Standard. True and seat within ring at all points. With the words SEWER or DRAIN in 2-inch raised letters. As specified by Section 12 of the MAWSS Sanitary Sewer Standard Specifications.

2.04 MANHOLE FRAME CONNECTION TO STRUCTURE

A. As specified by Section 12 of the MAWSS Sanitary Sewer Standard Specifications.

2.05 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.

B. Admixtures: May be included; do not exceed the following percentages of weight of cement:

1. Hydrated Lime: 10 percent.
2. 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.

2.06 BACKFILL AROUND AND UNDER MANHOLE

A. Structural fill as specified in Section 31 23 23, Fill and Backfill.

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2.07 FLEXIBLE JOINTS FOR SEALING PIPES IN MANHOLE

A. As specified by Section 12 of the MAWSS Sanitary Sewer Standard Specifications.

2.08 SOURCE QUALITY CONTROL

A. Prior to delivery of precast manhole sections to Site, yard permeability tests may be required at point of manufacture. 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.

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.

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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.

3.03 INSTALLATION OF PRECAST MANHOLES

A. Concrete Base:

1. As specified by Section 12 of the MAWSS Sanitary Sewer Standard Specifications.
2. Precast:
   a. Place on compacted structural fill.
   b. Properly locate, ensure firm bearing throughout, and plumb first section.

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.

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D. Mortar Joints:

1. Thoroughly wet joint with water prior to placing mortar.
2. Place mortar on groove of lower section prior to section installation.
3. Fill joint completely with mortar of proper consistency.
4. Trowel interior and exterior surfaces smooth on standard tongue-and-groove joint.
5. Prevent mortar from drying out and cure by applying approved curing compound or comparable approved method.
6. Do not use mortar mixed for longer than 30 minutes.
7. Chip out and replace cracked or defective mortar.
8. Completed Manhole: Rigid and watertight.

E. External Joint Wraps: Install in accordance with manufacturer's instructions.

F. 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.

3.05 MANHOLE FRAMES AND COVERS

A. As specified by Section 12 of the MAWSS Sanitary Sewer Standard Specifications.

B. Install concrete grade rings as required to set covers flush with surface of adjoining pavement or ground surface, unless otherwise shown or directed.

C. Anchor frame to manhole with specified bolts.

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3.06 MANHOLE PIPING

A. 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.

3.07 FIELD QUALITY CONTROL

A. Hydrostatic Testing and Vacuum Testing:

1. As specified by Section 12 of the MAWSS Sanitary Sewer Standard Specifications.
2. Testing of manhole shall be in accordance with ASTM C-478, latest edition.
3. Provide testing documentation as specified Section 12 of the MAWSS Sanitary Sewer Standard Specifications.
4. 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 DESIGN REQUIREMENTS

A. Design, test, fabricate and install precast concrete utility structure in accordance with the design requirements provided in Section 01 61 00, Common Product Requirements and herein. Precast concrete utility structure shall be designed by a qualified professional engineer registered in the state where Project will be constructed.

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1.03 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.
      6) Location and details of anchorage devices.
      7) Access door details.
   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 calculations.
4. Manufacturer's laboratory test reports including precast manufacturer's concrete test cylinders and inspection of assemblies, joints and seals**.**

1.04 QUALITY ASSURANCE

A. Calculations required for Contractor design and shop drawings shall be sealed, signed and dated by a registered engineer licensed in state where Project will be constructed.

1.05 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.

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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.
4. Nominal Dimensions: As shown on Drawings.
5. Construction: Rigid type and behave monolithically. Do not use panel-type vaults.
6. Design Loads: As determined by ASTM C857, and by using Site-specific values below.
   a. Unit Weight of Soil: As shown on Drawings.
   b. At-Rest Earth Pressure Coefficient: As shown on Drawings.
   c. Groundwater Level: As shown on Drawings.
   d. Live Loads: As shown on Drawings, including HS-20 loading where applicable.
   e. Designed to avoid flotation with a factor of safety as shown on Drawings.
7. Design shall accommodate additional stresses or loads that may be imposed during factory precasting, transporting, erection, and placement.
8. Blockouts for penetrations shall be as shown on Drawings.
9. Sealant:
   a. Nonswelling preformed joint sealants to provide a lasting, watertight bond.
   b. Manufacturer and Product: Henry Company; RAM-NEK.
10. Mortar: Comply with ASTM C387/C387M, Type S or use nonshrink grout as specified in Section 03 30 00, Cast-in-Place Concrete.

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B. Mark each member or element to indicate location in the structure, top surface, and date of fabrication.

C. Vault Floor: Slope of vault floor shall be as shown on Drawings.

2.03 ACCESSORIES

A. Sidewalk Doors: Conform to requirements of Section 05 50 00, Metal Fabrications.

B. Pipe Connections to Vault: Flexible joint conforming to requirements of Section 33 05 13, Manholes.

PART 3 EXECUTION

3.01 GENERAL

A. Subgrade Preparation: Prepare subgrade in accordance with Section 31 23 13, Subgrade Preparation, prior to placing bedding material and structure.

B. 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.

C. Place 6-inch minimum thickness of structural fill or granular fill on prepared 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 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.

3.04 PIPE CONNECTION TO VAULT

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

END OF SECTION

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SECTION 33 13 00
DISINFECTION OF WATER UTILITY DISTRIBUTION FACILITIES

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. B300, Hypochlorites.
   b. B301, Liquid Chlorine.
   c. B302, Ammonium Sulfate.
   d. B303, Sodium Chlorite.
   e. C651, Disinfecting Water Mains.
   f. C652, Disinfection of Water Storage Facilities.
   g. C653, Disinfection of Water Treatment Plants.
2. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
3. Standard Methods for the Examination of Water and Wastewater, as published by American Public Health Association, American Water Works Association, and the Water Environment Federation.
4. MAWAA Section 11; Potable Water Utilities Standard Specifications.

1.02 SUBMITTALS

A. Informational Submittals:

1. Plan describing and illustrating conformance to appropriate AWWA standards, MAWSS Potable Water Utilities Standard Specifications, and this Specification.
2. Procedure and plan for cleaning system.
3. Procedures and plans for disinfection and testing.
4. Proposed locations within system where Samples will be taken.
5. Type of disinfecting solution and method of preparation.
6. Method of disposal for highly chlorinated disinfecting water.
7. Independent Testing Agency: Certification that testing agency is qualified to perform chlorine concentration testing and bacteriological testing in accordance with AWWA standards, MAWSS standards, and this Specification.

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1.03 QUALITY ASSURANCE

A. Independent Testing Agency: Certified in the State of Alabama, with 10 years' experience in field of water sampling and testing. Agency shall use calibrated testing instruments and equipment, and documented standard procedures for performing specified testing.

1.04 SEQUENCING

A. Commence disinfection after completion of following:

1. Completion and acceptance of internal painting of system(s).
2. Hydrostatic and pneumatic testing, pressure testing, functional and performance testing and acceptance of pipelines, pumping systems, structures, and equipment.
3. Disinfection of:
    a. Pumps and associated system piping.
    b. Treatment plant basins and processes used to supply water to system.

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.

2.02 WATER FOR DISINFECTION AND TESTING

A. Clean, uncontaminated, and potable.

B. Owner will supply potable quality water. Contractor shall convey in disinfected pipelines or containers. Make arrangements for water supply and convey water in disinfected pipelines or containers.

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2.03 DISINFECTANT

A. Meeting the requirements of AWWA C651, and as specified in Section 11 of the MAWSS Potable Water Utilities Standard Specifications.

PART 3 EXECUTION

3.01 GENERAL

A. Perform disinfection as specified by Section 11 of the MAWSS Potable Water Utilities Standard Specifications.

B. Conform to AWWA C651 for pipes and pipelines, except as modified in these Specifications.

C. Contractor's Equipment:

1. Furnish chemicals and equipment, such as pumps and hoses, to accomplish disinfection.
2. Water used to fill pipeline may be supplied using a temporary connection to existing distribution system. Provide protection against cross-connections as required by AWWA C651.
3. Pipelines: Disinfect new pipelines that connect to existing pipelines up to point of connection.
4. Disinfect surfaces of materials that will contact finished water, both during and following construction, using one of the methods described in AWWA C652 and AWWA C653. Disinfect prior to contact with finished water. Take care to avoid recontamination following disinfection.

D. Allow freshwater and disinfectant solution to flow into pipe or vessel at a measured rate so chlorine-water solution is at specified strength. Do not place concentrated liquid commercial disinfectant in pipeline or other facilities to be disinfected before it is filled with water.

3.02 TURBIDITY

A. Cleaning of equipment and facilities shall include removal of materials that result in a turbidity exceeding limits stated in Article Testing.

3.03 PIPING AND PIPELINES

A. Cleaning:

1. Before disinfecting, clean foreign matter from pipe in accordance with AWWA C651.

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2. Flush service connections and hydrants. Flush distribution lines prior to flushing hydrants and service connections. Operate valves during flushing process at least twice during each flush.
3. Flush pipe through flushing branches and remove branches after flushing is completed.

B. Disinfecting Procedure: In accordance with AWWA C651, and as specified by Section 11 of the MAWSS Potable Water Utilities Standard Specifications, unless herein modified.

3.04 DISPOSAL OF CHLORINATED WATER

A. Do not allow flow into a waterway without neutralizing disinfectant residual.

B. See appendix of AWWA C651 for acceptable neutralization methods.

3.05 TESTING

A. Collection of Samples:

1. Coordinate activities to allow Samples to be taken in accordance with this Specification.
2. Provide valves at sampling points.
3. Provide access to sampling points.

B. Test Equipment:

1. Clean containers and equipment used in sampling and make sure they are free of contamination.
2. Obtain sampling bottles with instructions for handling from an independent testing laboratory.

C. Chlorine Concentration Sampling and Analysis:

1. Collect and analyze Samples in accordance with AWWA C651.
2. Collect Samples in accordance with applicable AWWA Standard.
3. Analyze Samples for coliform concentrations in accordance with latest edition of Standard Methods for the Examination of Water and Wastewater.

D. If minimum Samples required above are bacterially positive, disinfecting procedures and bacteriological testing shall be repeated until bacterial limits are met.

END OF SECTION

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SECTION 33 71 00
OVERHEAD ELECTRICAL DISTRIBUTION

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): O5.1, Wood Poles.
2. American Society of Mechanical Engineers (ASME): B16.11, Forged Fittings, Socket-Welding and Threaded.
3. American Wood-Preservers' Association (AWPA):
   a. C1, All Timber Products - Preservative Treatment by Pressure Processes.
   b. C4, Poles - Preservative Treatment by Pressure Processes.
   c. C25, Crossarms, Pressure Treatment.
4. ASTM International (ASTM):
   a. A53, Pipe, Steel, Black and Hot-Dipped Zinc-Coated, Welded and Seamless.
   b. A153/A153M, Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   c. A167, Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   d. A475, Zinc-Coated Steel Wire Strand.
   e. B1, Hard-Drawn Copper Wire.
   f. B2, Medium-Hard-Drawn Copper Wire.
   g. B3, Soft or Annealed Copper Wire.
   h. B232/B232M, Concentric-Lay-Stranded Aluminum Conductors, Coated Steel-Reinforced (ACSR).
5. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV through 765kV.
   b. C2, National Electrical Safety Code.
   c. C37.42, American National Standard for Switchgear – Distribution Cutouts and Fuse Links – Specifications.
   d. C62.11, Metal-Oxide Surge Arrestors for Alternating Current Power Circuits.
6. National Electrical Manufacturers Association (NEMA):
   a. C29.2, American National Standard Requirements for Insulators – Wet-Process Porcelain and Toughened Glass - Suspension Type.
   b. C29.3, American National Standard Requirements for Wet-Process Porcelain Insulators - Spool Type.
   c. C29.4, American National Standard Requirements for Wet-Process Porcelain Insulators - Strain Type.

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d. C29.5, American National Standard Requirements for Wet-Process Porcelain Insulators – Low- and Medium-Voltage Types.
e. C29.6, American National Standard Requirements for Wet-Process Porcelain Insulators - High-Voltage Pin Type.
f. C29.7, American National Standard for Wet-Process Porcelain Insulators – High-Voltage Line-Post Type.

7. International Electrical Testing Association (NETA): ATS, Electrical Power Distribution Equipment and Systems.
8. National Fire Protection Association (NFPA): 70, National Electrical Code.
9. Rural Utilities Service (RUS):
   a. 202-1, List of Materials Acceptable for Use on Systems of RUS Electrification Borrowers.
   b. 1728F-700, Wood Poles, Stubs, and Anchor Logs.
   c. 1728H-701, Wood Crossarms (Solid and Laminated Transmission Timbers and Pole Keys).
10. Underwriters Laboratories Inc. (UL):
    a. 6, Rigid Metal Conduit.
    b. 510, Polyvinyl Chloride Polyethylene And Rubber Insulating Tape.

1.02 SUBMITTALS

A. Action Submittals:

1. Product data for the following:
   a. Conductors.
   b. Insulators.
   c. Wood poles and crossarms.
   d. Cutouts.
   e. Surge arrestors.
   f. Guy strand and guards.
   g. Anchors and anchor rods.
   h. Ground rods.
   i. Conduit.
   j. Tape.
   k. Caulk.
   l. Medium Voltage insulated cable terminations.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Poles:

1. Store and handle poles held in storage more than 2 weeks in accordance with ANSI O5.1.
2. Do not use pointed tools capable of producing indentations of more than one inch in depth. Nails and holes are not permitted in top of poles.

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PART 2 PRODUCTS

2.01 MATERIAL AND EQUIPMENT

A. Consider materials specified herein or shown on Drawings which are identical to materials listed in RUS 202-1 as conforming to requirements.

2.02 WOOD POLE

A. Machine trimmed by turning, Southern Yellow Pine conforming to ANSI O5.1 and RUS 1728F-700.

B. Gain, bore, and roof poles before treatment.

C. Pressure treat poles with chromated copper arsenate (CCA), in accordance with AWPA C1 and AWPA C4 as referenced in RUS 1728F-700.

D. Quality of each pole shall be ensured with “WQC” (wood quality control) brand on each piece, or by an approved inspection agency report.

2.03 WOOD CROSSARM

A. Conform to RUS 1728H-701.

B. Pressure treat crossarms with pentachlorophenol, chromated copper arsenate (CCA), or ammoniacal copper arsenite (ACA).

C. Treatment shall conform to AWPA C25.

D. Crossarm Braces: Provide flat steel or steel angle as indicated. Provide braces with 38-inch span for 8-foot crossarms and 60-inch span for 10-foot crossarms.

2.04 HARDWARE

A. Hot-dip galvanized, conforming to ASTM A153/A153M.

2.05 INSULATOR

A. Provide insulators, which are radio interference free.

1. Pin Type Insulators: Porcelain, NEMA C29.6, Class 56-1.
2. Suspension insulators – Polymer, DS-25 class.
3. Guy Strain Insulators: NEMA C29.4, fiberglass type. Fiberglass type shall be minimum 34 inches long and with an ultimate breaking strength of 15.000 pounds.

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2.06 OVERHEAD CONDUCTOR

A. Conductor of bare aluminum conductor steel reinforced (ACSR), ASTM B232/B232M, of size and type indicated.

2.07 GUYS

A. Guy Strands: ASTM A475, high-strength, Class A or B, galvanized strand steel cable. Guy strand shall be as shown in the drawings, but at least 3/8 inch in diameter with ultimate breaking strength of at least 8800 pounds. Provide guy terminations designed for use with the particular strand and developing at least the ultimate breaking strength of the strand.

B. Round Guy Guard: Vinyl or PVC material, yellow colored, 8 feet long, and shatter resistant at sub-zero temperatures.

C. Guy Attachment: Thimble eye.

2.08 ANCHOR AND ANCHOR ROD

A. Anchor shall be a screw anchor as shown in the drawings, of at least 10 inch diameter presenting holding area indicated on Drawings as a minimum. Anchor rod shall be thimble-eye, ¾ inch diameter by 8 feet long. Anchor and anchor rod shall be hot-dip galvanized.

1. Screw Anchor: Screw type anchor having a manufacturer's rating of not less than 8800 pounds in loose to medium sand/clay soil, Class 6 and extra heavy pipe rod conforming to ASTM A53, Schedule 80, and coupling conforming to ASME B16.11.

2.09 GROUNDING

A. Rod:

1. Copper clad steel at least ¾ inch in diameter and 10 feet long.
2. Hard, clean, smooth, continuous, surface throughout length of rod.
3. Die-stamp each near top with name or trademark of manufacturer and length of rod in feet.

B. Wire:

1. Soft drawn copper wire ground conductor, minimum 4 AWG.
2. Ground wire protector may be either PVC or half round wood molding. Wood molding shall be fir, pressure treated in accordance with AWPA C25, or shall be cypress or cedar.

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2.10 SURGE ARRESTOR

A. IEEE C62.11, metal oxide, porcelain housed, surge arrestor arranged for crossarm mounting. RMS voltage rating shall be as shown in the drawings. Arrestor shall be Distribution class.

2.11 FUSED CUTOUT

A. Open type fused cutouts shall be rated 100 amperes where holding 80E fuses and 200 amperes where holding 150 amperes or 200 amperes fuses. All fused cutouts shall be rated at 15/27 kV, conforming to IEEE C37.42. Fuses conforming to IEEE C37.42 with ampere ratings as indicated.

2.12 CONDUIT RISER AND CONDUCTOR

A. Rigid aluminum conduit conforming to UL 6A. Provide conductors as specified in Section 26 05 05, Conductors.

1. Porcelain Insulator Type Terminator:
   a. Comply with requirements of IEEE 48, Class 1, except that requirements of design tightness test need not be met.
   b. Shall not exude any insulating filler compound under either test or service.
   c. Consist of porcelain insulator, copper cable connector-hoodnut assembly and copper aerial lug as required, metal body and supporting bracket, sealed cable entrance, internal stress relief device for shielded cable, and insulating filler compound or material.

2.13 ELECTRICAL TAPES

A. Tapes shall be UL listed for electrical insulation and other purposes in wire and cable splices. Termination, repair, and miscellaneous purpose electrical tapes shall comply with UL 510.

2.14 CAULKING COMPOUND

A. Compound for Sealing Conduit Risers:

1. Puttylike consistency, workable with hands at temperatures as low as 35 degrees F.
2. Shall not slump at 300 degrees F and shall not harden materially when exposed to air.
3. Shall readily caulk or adhere to clean surfaces of material with which it is designed to be used.
4. Shall have no injurious effects upon workmen or upon materials.

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2.15 SOURCE QUALITY CONTROL

A. Pole Mounted Transformer Factory Tests:

1. IEEE C57.12.00 and IEEE C57.12.90.
2. Performed by manufacturer on [each] transformer prepared for this Project to ensure that design performance is maintained in production.
3. Required tests shall be as follows:
   a. Polarity.
   b. Ratio.
   c. No-load losses (NLL) and excitation current.
   d. Load losses (LL) and impedance voltage.
   e. Dielectric:
      1) Impulse.
      2) Applied voltage.
      3) Induced voltage.
   f. Leak.

PART 3 EXECUTION

3.01 INSTALLATION

A. General: Provide overhead pole line installation conforming to requirements of NEMA C2 for Grade C construction of overhead lines in medium loading districts. Pole configuration shall be as indicated on Drawings.

B. Pole Setting: Provide pole holes at least as large at top as at bottom and large enough to provide 4-inch clearance between pole and side of hole. Provide 6-inch band of soil treated with 2 to 3 gallons of one percent dursban termiticide solution around and down to base of pole.

1. Setting Depth of Pole:

Pole Setting Depths		
Length of Pole (feet)	**Setting in Soil (feet)**	**Setting in Solid Rock (feet)**
20	5.0	3.0
25	5.5	3.5
30	5.5	3.5
35	6.0	4.0
40	6.0	4.0
45	6.5	4.5

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Pole Setting Depths		
Length of Pole (feet)	**Setting in Soil (feet)**	**Setting in Solid Rock (feet)**
50	7.0	4.5
55	7.5	5.0
60	8.0	5.0

2. Setting in Soil, Sand, and Gravel: Applying where the following occurs:
   a. Where pole holes are in soil, sand, or gravel or any combination of these.
   b. Where soil layer over solid rock is more than 2-feet deep.
   c. Where hole in solid rock is not substantially vertical.
   d. Where diameter of hole at surface of rock exceeds twice the diameter of pole at same level. At corners, dead ends, and other points of extra strain, poles 40 feet or more long shall be set 6 inches deeper.
3. Setting in Solid Rock: Applies where poles are to be set in solid rock and where hole is substantially vertical, approximately uniform in diameter and large enough to permit use of tamping bars full depth of hole.
4. Setting With Soil Over Solid Rock: Where a layer of soil 2 feet or less in depth over solid rock exists, depth of hole shall be depth of soil in addition to depth specified under Setting in Solid Rock in paragraph entitled Setting Depth of Pole, provided, however, that such depth shall not exceed depth specified under Setting in Soil.
5. Setting on Sloping Ground: Measure hole depth from low side of hole.
6. Backfill: Thoroughly tamp pole backfill for full depth of hole and mound excess fill around pole.
7. Setting Poles: Set poles so that alternate crossarm gains face in opposite directions, except at terminals and dead ends where gains of last two poles shall be on side facing terminal or dead end. On unusually long spans, set poles so that crossarm comes on side of pole away from long span. Where pole top pins are used, they shall be on opposite side of pole from gain, with flat side against pole.
8. Alignment of Poles: Set poles in alignment and plumb except at corners, terminals, angles, junctions, or other points of strain, where they shall be set and raked against strain. Set not less than 2 inches for each 10 feet of pole length above grade, nor more than 4 inches for each 10 feet of pole length after conductors are installed at required tension. When average ground run is level, consecutive poles shall not vary more than 5 feet in height. When ground is uneven, poles differing in length shall be kept to a minimum by locating poles to avoid highest and lowest ground points. If it becomes necessary to shorten pole, a piece shall be sawed off top and shall be treated and capped. Holes shall be dug large enough to permit proper use of tampers to full depth of hole.

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C. Cutting of Wood Poles: Where new gains or holes are required, paint gains with preservative compound as recommended by the pole manufacturer. Plug unused or abandoned holes using treated wood dowel pins.

D. Do not cut the tops of wood poles, except under very exceptional conditions, and only upon approval of Engineer. If cutting is deemed necessary, pole top shall be capped. Do not cut butt of wood poles.

E. Anchor and Guy: Place anchor in line with strain. Length of guy lead (distance from base of pole to top of anchor rod) shall be as indicated.

1. Setting Anchor: Set anchor in-place with anchor rod aligned with, and pointing directly at, guy attachment on pole with anchor rod projecting 6 to 9 inches out of ground to prevent burial of rod eye.
2. Backfill plate anchor with tightly tamped earth for full depth of hole.
3. Screw Anchor: Install by torquing with boring machine.
4. Swamp Anchor: Install by torquing with boring machine or wrenches, adding sections of pipe as required until anchor helix is fully engaged in firm soil.
5. Setting Guy Strand:
    a. Complete anchor and guy installation, dead end to dead end, and tighten guy before wire stringing and sagging is begun on that line section.
    b. Where indicated in Drawings, provide strain insulator at a point on guy strand 8 feet, minimum, from ground and 6 feet, minimum, from surface of pole.
    c. Otherwise effectively ground and bond guys to system neutral.

F. Hardware: Provide hardware with washer against wood and with nut and lock nut applied wrench tight. Provide locknut on threaded hardware connection. Locknut shall be M-F style and not palnut style.

G. Grounding:

1. Conform to NEMA C2.
2. Ground Rod Connection:
    a. On pole lines by exothermic weld or by using compression connector for ground wire or wire to rod connection.
    b. Exothermic welds strictly in accordance with manufacturer’s written recommendations.
    c. Welds which have puffed up or which show convex surfaces indicating improper cleaning, are not acceptable.
    d. No mechanical connectors are required at exothermic weldments.
    e. Compression connector shall be type that uses hydraulic compression tool to provide correct pressure.

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f. Provide tools and dies recommended by compression connector manufacturer.
g. Embossing die code or similar method shall provide visible indication that connector has been fully compressed on ground wire.

3. Grounding and Grounded Connections:
   a. Where no primary or common neutral exists, surge arrestors and frames of equipment operating at over 750 volts shall be bonded together and connected to a dedicated grounding electrode.
   b. Where no primary or common neutral exists, transformer secondary neutral bushing, secondary neutral conductor, and frames of equipment operating at under 750 volts shall be bonded together and connected to a dedicated grounding electrode.
   c. When a primary or common neutral exists, connect all grounding and grounded conductors to common grounding electrode.
4. Protective Molding: Protect grounding conductors that are run on surface of wood poles by wood molding, or plastic molding of equal mechanical strength, extending from ground line throughout communication and transformer spaces.

H. Conductors: Prevent nicking, kinking, gouging, flattening, or otherwise deforming or weakening conductor or impairing its conductivity. Remove damaged sections of conductor and splice conductor.

1. Splices: Conductor splices, as installed, shall exceed ultimate rated strength of conductor and shall be of type recommended by conductor manufacturer. No splice shall be permitted within 10 feet of a support.
2. Ties: Provide ties on pin insulators tight against conductor and insulator and ends turned down flat against conductor so that no wire ends project.
3. New Installation: String new conductors to “initial” sag table values indicated for conductor type and size of conductor and ruling span indicated.
4. Aluminum Protection: Protect ACSR conductors by armor rod at pin insulators and by flat aluminum wire at attachments made of galvanized or coated iron or steel.
5. Fittings: Dead end fittings, compression type, shall conform to written recommendations of conductor manufacturer and shall develop full ultimate strength of conductor.
6. Aluminum Connections: To copper or other material using only splices, connectors, lugs, or fittings designed for that specific purpose.

I. Riser: Secure conduit on pole by two-hole galvanized steel pipe straps spaced no more than 10 feet apart and within 3 feet of any outlet or termination. Ground metallic conduit.

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3.02 FIELD QUALITY CONTROL

A. Wood Crossarm Inspection: Furnish inspection report from independent inspection agency, approved by Owner, stating that offered products comply with applicable AWPA and RUS standards. The RUS approved Quality Mark “WQC” on each crossarm will be accepted, in lieu of inspection reports, as evidence of compliance with applicable AWPA treatment standards.

B. Acceptance Checks and Tests:

1. Notify Engineer 5 working days prior to start of checking and testing.
2. Perform in accordance with manufacturer’s recommendations and include the following visual and mechanical inspections, and electrical tests, performed in accordance with NETA ATS.
3. Overhead-Type Distribution Transformers:
    a. Visual and Mechanical Inspection:
        1) Compare equipment nameplate information with specifications and approved shop drawings.
        2) Inspect physical and mechanical condition.
        3) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method. Thermographic survey is not required.
        4) Perform inspections and mechanical tests as recommended by manufacturer.
        5) Verify correct equipment grounding.
4. Grounding System:
    a. Visual and Mechanical Inspection: Inspect ground system for compliance with Drawings and Specifications.
    b. Electrical Tests: Perform ground-impedance measurements utilizing fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of single ground rod, perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with manufacturer’s instructions to test each ground or group of grounds. Instrument shall be equipped with a meter reading directly in ohms or fractions thereof to indicate ground value of ground rod or grounding systems under test.
    c. Report:
        1) Before energizing electrical equipment, submit the measured ground resistance of grounding system.
        2) Include the test method and test setup (i.e., pin location) used to determine ground resistance and soil conditions at time measurements were made.

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C. Devices Subject to Manual Operation: Operate at least three times, demonstrating satisfactory operation each time.

D. Follow-Up Verification: Upon completion of acceptance checks and tests, show, by demonstration in service, that circuits and devices are in operating condition and properly performing intended function.

END OF SECTION

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