60% Design Deliverable

San José-Santa Clara Regional Wastewater Facility

7477/7701 – Headworks Project

Volume 2 of 5

Specifications

(Division 21 through Division 32)

San José-Santa Clara Regional Wastewater Facility

August 2019

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The City of San José, California

San José – Santa Clara Regional Wastewater Facility

SPECIFICATIONS

for the Construction of the

HEADWORKS PROJECT

Project No. CIP 7477/7701

VOLUME 2
DIVISION 21 THROUGH DIVISION 32

August 2019

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Jacobs Engineering Group

San José, California

Project No. 706370 Copy No. ____

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

B. 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.

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

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 seismic 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.

F. Seismic Design:
   1. Seismic component importance factor Ip equals 1.5.
   2. Seismic loads as shown on the General Structural Notes on Drawings.
   3. Seismic certification shall be conducted in accordance with 2016 California Building Code, Chapter 17.
   4. Component is required to remain operable following the design earthquake ground motion. Active parts or energized components shall be certified on basis of approved shake table testing or experience only unless demonstrably similar to other equipment so qualified.

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. Contractor-Design Submittal: Sprinkler system design; include analysis data signed and sealed by qualified professional engineer. Submit for approval by 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) Process equipment and associated piping.
         2) Bridge crane.
         3) HVAC hydronic piping, plumbing and duct work.
         4) Items penetrating finished ceilings, include the following:
            a) Lighting fixtures.
            b) Air outlets and inlets.
      e. Submit anchorage and bracing drawings and cut sheets as required by Section 01 88 15, Anchorage and Bracing.

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.
   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.
   9. Submit anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
   10. Component and attachment testing seismic certificate of compliance in accordance with 2016 California Building Code. Certificate of compliance shall list method and criteria of certification.

1.05 QUALITY ASSURANCE

A. Comply with the applicable provisions of the 2016 California Fire Code as modified by local amendments.

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 2 week(s) prior to commencing work of this section.

1.06 PROJECT CONDITIONS

A. Interruption of Existing Sprinkler Service:
   1. 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:
      a. Provide notification no fewer than 2 days in advance of proposed interruption of sprinkler service.

b. Do not interrupt sprinkler service without written permission.

1.07 EXTRA MATERIALS

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

Item	Quantity
Sprinkler Cabinet	One each
Sprinklers	Six of each different size unit
Special tools required to maintain or dismantle	One sprinkler wrench for each different size 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.

B. Sprinkler System Equipment, Specialties, Accessories, Installation, and Testing: Comply with NFPA 13.

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

2.02 STEEL PIPE AND FITTINGS

A. Pipe:
   1. FM Approved Standard Weight, 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, 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 thinwall pipe, lightwall pipe and Schedule 5 pipe.

B. Fittings:
   1. 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. Uncoated, Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.

2. Grooved-Joint, Steel Pipe Appurtenances:
   a. 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.
3. Welded or segmented fittings are not acceptable.

2.03 PIPING SCHEDULE

A. Piping Between Fire Department Connections and Check Valves: As indicated in Piping Schedule on Drawings.

B. Standard-pressure, Wet-pipe Sprinkler System, 2 inches and Smaller:
1. Standard-weight or Schedule 30, black steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Standard-weight or Schedule 30, black steel pipe with plain ends; uncoated, plain-end pipe fittings; and twist-locked joints.
3. Standard-weight or Schedule 30, 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 or Schedule 30, 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 or Schedule 30, black steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Standard-weight or Schedule 30, 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.
3. Standard-weight or Schedule 30, 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 or Schedule 30, black steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Standard-weight or Schedule 30, 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.
3. Standard-weight or Schedule 30, 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. Make flanged end and wafer type valves compatible for installation with flanges as specified.

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 or flanged.
   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: 250 psig minimum.
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: 250 psig minimum.
3. Body Material: Cast or ductile iron.
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: 250 psig minimum.
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.

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.
   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 main drain piping.
   6. Manufacturers and Products:
      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: 6 inches.

13. Manufacturers:
    a. Elkhart Brass Mfg. Company, Inc.
    b. Guardian Fire Equipment, Inc.
    c. Potter-Roemer.
    d. Tyco.

B. Yard Type:
1. Standard: UL 405.
2. Type: Exposed, freestanding.
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: Round, brass, floor type.
8. Outlet: Bottom, with pipe threads.
9. Number of Inlets: Two.
10. Sleeve: Not required.
11. Escutcheon Plate Marking: Similar to “AUTO SPKR.”
12. Finish: Rough brass or bronze.
13. Outlet Size: 6 inches.
14. Manufacturers:
    a. Elkhart Brass Mfg. Company, Inc.
    b. Guardian Fire Equipment, Inc.
    c. Potter-Roemer.
    d. Tyco.

C. 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.

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.

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.

B. Sprinkler Schedule:
   1. Use sprinkler types below for the following applications:
      a. Rooms without Ceilings: Upright sprinklers.
      b. Rooms with Suspended Ceilings: Pendent 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. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
    b. Flush Sprinklers: Bright chrome, with painted white escutcheon.
    c. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
    d. Upright Pendent 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: Corrosion-resistant paint.
6. Sprinkler Escutcheons:
    a. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
    b. Ceiling Mounting: Chrome-plated steel, one piece, flat.
    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. Electrically Operated Alarm Bell:
1. Standard: UL 464.
2. Type: Vibrating, metal alarm bell.
3. Size: Minimum 10-inch 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.

C. 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.

D. 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.

E. 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.
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 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 250 psig minimum.
4. Water System Piping Gauge: Include “WATER” or “AIR/WATER” label on dial face.
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.

2.14 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 PipeSeal. 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.
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 WATER SUPPLY CONNECTIONS

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

3.03 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 Jacobs' 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. Based on the SDC, seismic bracing is required for this Project.

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

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

G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, sized and located according to NFPA 13.

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

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

J. 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.

K. Install alarm devices in piping systems.

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

M. 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.

N. Fill sprinkler system piping with water.

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

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

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

3.04 JOINT CONSTRUCTION

A. Steel Piping:
   1. Pressure-Sealed Joints: Where permitted, 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.
   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.

3.05 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.

3.06 SPRINKLER INSTALLATION

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

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

C. 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.

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

3.07 FIRE DEPARTMENT CONNECTION INSTALLATION

A. Install yard-type, fire department connections in concrete slab support. Comply with requirements for concrete in Section 03 30 00, Cast-in-Place Concrete.
   1. Install protective pipe bollards as shown on Drawings for each fire department connection.

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

3.08 IDENTIFICATION

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

B. Identify system components.

3.09 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."

3.10 MANUFACTURER'S SERVICES

A. Manufacturer's Representative:

1. Present at Site or classroom designated for minimum person-days listed below, travel time excluded:
   a. 2 person-days for installation assistance and inspection.
   b. 1 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.
   c. 1 person-day for prestartup classroom or Site training.
   d. 1 person-day for facility startup.
   e. 2 person-days for post-startup training.

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

3.11 CLEANING

A. Clean dirt and debris from sprinklers.

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

END OF SECTION

SECTION 22 10 01
PLUMBING PIPING AND ACCESSORIES

PART 1 GENERAL

1.01 SUMMARY

A. Includes pipe and accessories not described in Section 40 27 00, Process Piping – General, and related sections.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American National Standards Institute (ANSI).
   2. American Society of Sanitary Engineering (ASSE): 1010, Performance Requirements for Water Hammer Arresters.
   3. 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, 3-In. Through 48-In. (76 mm Through 1219 mm) for Water.
      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, for Water.
      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.
   4. 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. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
e. A179/A179M, Standard Specification for Seamless Cold-Drawn Low-Carbon Steel Heat-Exchanger and Condenser Tubes.
f. A181/A181M, Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.
g. A197/A197M, Standard Specification for Cupola Malleable Iron.
h. A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
i. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
j. A518/A518M, Standard Specification for Corrosion-Resistant High-Silicon Iron Castings.
k. A536, Standard Specification for Ductile Iron Castings.
l. A563, Standard Specification for Carbon and Alloy Steel Nuts.
m. A888, Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
n. B32, Standard Specification for Solder Metal.
o. B61, Standard Specification for Steam or Valve Bronze Castings.
p. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
q. B75, Standard Specification for Seamless Copper Tube.
r. B88, Standard Specification for Seamless Copper Water Tube.
s. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.
t. B127, Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip.
u. B139/B139M, Standard Specification for Phosphor Bronze Rod, Bar, and Shapes.
v. B164, Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire.
w. B194, Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar.
x. C564, Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
y. C1277, Standard Specification for Shielded Couplings Joining Hubless Cast Iron Soil Pipe and Fittings.

z. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.

aa. D1785, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.

bb. D2000, Standard Classification System for Rubber Products in Automotive Applications.

cc. D2239, Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.

dd. D2466, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.

ee. D2564, Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.

ff. D2855, Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.

gg. D2683, Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.

hh. D3035, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.

ii. D3261, Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.

jj. D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.

kk. F656, Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings.

ll. F714, Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.

mm. F1924, Standard Specification for Plastic Mechanical Fittings for Use on Outside Diameter Controlled Polyethylene Gas Distribution Pipe and Tubing.

nn. 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.

5. Cast Iron Soil Pipe Institute (CISPI): 301, Standard Specification for Hubless Cast Iron Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
6. Plumbing and Drainage Institute (PDI): WH 201, Water Hammer Arrester Standard.
7. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

1.03 DESIGN REQUIREMENTS

A. Where pipe diameter, thickness, pressure class, pressure rating, or thrust restraint is not shown or specified, design piping system in accordance with the California Plumbing Code.
   1. Sanitary Building Drainage and Vent Systems: California Plumbing Code, San José Amendments.
   2. Fire Protection Riser: California Fire and Building Codes, San José Amendments.

1.04 SUBMITTALS

A. Action Submittals:
   1. Product data sheets.
   2. Shop Drawings:
      a. Showing changes in location of fixtures or equipment that are advisable in the opinion of Contractor.
      b. Submit anchorage and bracing drawings and data sheets as required by Section 01 88 15, Anchorage and Bracing.
   3. Isometric riser diagrams.

B. Informational Submittals:
   1. Submit 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.

PART 2 PRODUCTS

2.01 PIPING

A. Piping Schedule: Refer to Drawings.

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

2.02 PIPE HANGERS AND SUPPORTS

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

2.03 INSULATION

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

2.04 VALVES

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

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

C. 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.
   3. Manufacturers:
      a. Ernst Gage Co.
      b. Lunkenheimer.
      c. “Or-equal.”

D. Manual Air Vent Valves:
   1. With coin-operated air vent.
   2. Manufacturers and Products:
      a. Bell & Gossett; No. 4V.
      b. Dole; No. 9.
      c. “Or-equal.”

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

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

F. Safety Shower Thermostatic Mixing Valve Assembly:

1. Function: Provide 85 degree tempered water at 3 gpm to 56 gpm at maximum 45 psig pressure drop in compliance with ANSI Z358.1.
2. Components:
    a. Pressure gauge.
    b. Isolation valves.
    c. Thermometer.
    d. Pipe fittings.
    e. Bare assembly, with top inlets and outlet, wall mount bracket.
    f. Option: Heavy-gauge steel cabinet with access door and manufacturer's standard baked enamel finish.
3. Inlets: One each, 1-1/4-inch NPT, cold and hot water.
4. Outlet: 1-1/4 inch NPT.
5. Self-contained; no electrical requirements.
6. Performance:
    a. Maximum hot inlet temperature, 180 degrees F.
    b. Automatic bypass prevents discharge from exceeding 90 degrees F.
    c. With 140 degrees F hot inlet and 60 degrees F cold inlet, deliver 100 degrees F at inlet pressures between 30 psig and 100 psig. Set outlet at 85 degrees F unless otherwise noted.
7. Manufacturers and Products:
    a. Leonard; Model TM 850.
    b. Equal by Powers Process Controls.

2.05 MISCELLANEOUS PIPING SPECIALTIES

A. 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. 751.
      c. “Or-equal.”

B. Vacuum Breakers 2 Inches and Smaller:
   1. Angle type, as required.
   2. Manufacturers:
      a. Febco.
      b. Watts.
      c. “Or-equal.”

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

D. Water Hose:
   1. Furnish 1 each 50-foot length of 3/4-inch and 1 each 50-foot length of 1-1/2-inch, EPDM black cover and EPDM tube, reinforced with two textile braids. Furnish each length with brass male and female NST hose thread couplings to fit hose nozzle(s) and hose valve(s) specified.
   2. Rated minimum working pressure of 200 psi.
   3. Manufacturers:
      a. Goodyear.
      b. Boston.
      c. “Or-equal.”

E. Hose Nozzles:
   1. Furnish 3/4-inch or 1-1/2-inch cast brass satin finish nozzle as appropriate for each hose, with adjustable fog, straight-stream, and shut-off features and rubber bumper. Provide nozzle(s) with female NST hose thread.
   2. Manufacturers:
      a. Croker.
      b. Elkhart.
      c. "Or-equal."

F. Sleeves:
   1. Manufacturers and Products:
      a. J. R. Smith; Figure 1720.
      b. Josam; No. 26400.
      c. "Or-equal."

G. Flashing Sleeves for Roof Penetrations: See Architectural.

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.
      c. "Or-equal."

I. Joint Solder: 95-5 lead free wire solder, ASTM B32, Grade 95 TA. 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.

PART 3 EXECUTION

3.01 GENERAL

A. Install plumbing systems to meet the 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 Jacobs' 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 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. 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, Copper Tubing: See section 40 27 00, Process Piping—General.

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

7. Use strap wrenches only for tightening threaded plastic joints. Do not over tighten fittings.

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

D. Water Hammer Arresters:
   1. Install in piping systems where 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 Plumbing and Drainage Institute Standard 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.

3.03 SANITARY AND WASTE DRAINS AND VENTS PIPING

A. Installation:
   1. Set piping above floor slab true and plumb.
   2. Set exposed risers as close to walls as possible.
   3. Where vent stacks pass through roof slab, fit with flashing sleeve secured to roof.
   4. Extend vents minimum 1 foot above roof.
   5. Provide cleanouts where shown and where required by code.
   6. Confirm final rough-in locations for plumbing fixtures and piping with the final plumbing design.
   7. For early works package, test in accordance with the Plumbing Code, and cap for future.

3.04 HVAC CONDENSATE PIPING

A. Set piping true and plumb.

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

3.05 WATER SUPPLY PIPING

A. Water supply piping includes potable WTR1, domestic hot water (DHW), Tepid water (TW)] systems and nonpotable WTR1 where indicated.

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

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

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

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

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

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

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

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

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

3.06 INSULATION

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

3.07 HANGERS AND SUPPORTS

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

3.08 INTERIM CLEANING

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

3.09 TESTING

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

3.10 CLEANING AND DISINFECTION

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

3.11 CORROSION PROTECTION

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

3.12 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.

3.13 FIELD FINISHING

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

3.14 PIPING IDENTIFICATION

A. Refer to Section 40 27 00, Process Piping—General, and Piping Schedule as shown on Drawings.

3.15 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
22 10 01.03	Cast Iron Soil Pipe (CISP) and Fittings

END OF SECTION

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

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, 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

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 Society of Mechanical Engineers (ASME).
   2. American Society of Sanitary Engineering (ASSE): 1013, Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Fire Protection Backflow Preventers.
   3. American Water Works Association (AWWA):
      a. C511, Reduced-Pressure Principle Backflow Prevention Assembly.
      b. C550, Protective Interior Coatings for Valves and Hydrants.
   4. ASTM International (ASTM):
      a. A48/A48M, Standard Specification for Gray Iron Castings.
      b. D4101, Standard Specification for Polypropylene Injection and Extrusion Materials.
   5. California Energy Code, 2016 (CEC).
   6. FM Global (FM).
   7. Food and Drug Administration (FDA).
   8. Foundation for Cross-Connection Control and Hydraulic Research at University of Southern California (FCCHR): Manual of Cross-Connection Control.
   9. International Code Council (ICC): International Plumbing Code (IPC).
   10. National Electrical Code (NEC).
   11. National Electrical Manufacturers Association, (NEMA): MG 1, Motors and Generators.
   12. NSF International (NSF).
   13. UL.

1.02 SUBMITTALS

A. Action Submittals:
   1. Manufacturer's product data.
   2. Submit anchorage and bracing drawings and cut sheets as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Submit 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. Performance test report for submersible pump.

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 WATER HEATERS

A. Electric Water Heater (Commercial):

1. Description:
   a. Automatic, vertical, electric storage type.
   b. Regulatory Compliance: UL listed, ASME, CEC, and NSF.
   c. Tank: Steel, glass-lined, 150 psig working pressure, and ASME rate.
   d. Insulation: Foam or fiberglass type with minimum R value per ASHRAE 90.1.
   e. Dip Tube: Required on inlet connection down to bottom section of tank.
   f. Anode: Heavy-duty, tank-mounted, screw-in type, two each.
   g. Pressure/Temperature Relief Valve: ASME rated.
   h. Connections: Inlet and outlet with factory-installed dielectric unions and brass drain valve with hose thread.
   i. Heating Element: Watt-density (maximum of 75 watts per square inch) incoloy sheath; immersion type.
   j. Controls: Fully automatic, house in hinged control panel, and including the following:
      1) Terminal block.
      2) Close differential immersion-type thermostat.
      3) Control transformer for 120-volt circuit and fusing.
      4) Magnetic contactors for each stage.

5) Manual reset high-limit switch.
6) Set to 140 degrees F.
7) Power circuit fusing as required by NEC and UL.

k. Guarantee: 3 years.

2. Capacity: See schedule at end of section.
3. Manufacturers:
   a. AO Smith.
   b. Bradford White Corporation.
   c. Lochinvar Corporation.
   d. “Or-equal.”

2.02 DOMESTIC WATER EXPANSION TANK

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

B. Capacity: See schedule on Drawings.

C. Manufacturer and Product:
   1. AMTROL, Inc.; Model AST.
   2. “Or-equal.”

2.03 SUBMERSIBLE CENTRIFUGAL SUMP PUMPS

A. Simplex, Submersible Sump Pump:
   1. Description:
      a. Type: Simplex, heavy-duty, nonclog, close-coupled submersible centrifugal sewage ejector pump.
      b. Volute: Cast iron, foot mounted.
      c. Impeller: Cast iron, vortex.
      d. Motor Enclosure: Cast iron, Buna-N O-ring seals with corrosion-resistant exterior finish.

e. Motor: Continuous-duty, built-in thermal overload protection.
f. Shaft Seals: Tandem, mechanical type.
g. Shaft: Cold rolled steel AISI 1215.
h. Bearings: Sleeve type, upper and lower.

2. Oil filled pump cooling.
3. Quick Removal System:
   a. Fittings: Steel baseplate with cast iron stationary fitting, removable discharge fitting, and gasket material for positive locking.
   b. Rails: Galvanized steel guide rails and base plate with stainless steel lifting rope.
4. Capacity: See data sheet at end of section.
5. Manufacturers:
   a. Zoeller.
   b. Hydromatic Pumps.
   c. Paco Pump.
   d. Weil Pump Company, Inc.

B. Controller:
1. Controller:
   a. Control Panel: Fabricated steel, NEMA 4 enclosure, door disconnect switch, and bear UL listing mark. Components shall bear UL recognized marking. Wiring, schematics, and workmanship shall comply with NEC and UL.
   b. Wiring and Conduit: Minimum of MTH, 600V rated, 18-gauge with 90 degrees C rating, in accordance with NEC standards. Wire sized in accordance with NEC standards.
   c. Motor Protection: Magnetic motor starter, across the line type, UL listing mark, under voltage and over voltage protection with manual reset button mounted in panel door.
   d. Level Sensors: Automatic pump cycle and high alarm. Polypropylene encapsulated mechanical level sensors for pump on, pump off. Additional level sensor shall activate audible-visual panel mounted light and horn. Panel mount, push-to-silence button for deactivating audible alarm.
   e. Provide dry contacts for connection to Plant PLC system for high level alarm.
2. Manufacturers:
   a. Zoeller.
   b. Hydromatic Pumps.

c. Paco Pump.

d. Weil Pump Company, Inc.

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, and Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.
2. Piping Systems: Verify that flushing, cleaning, and testing has been completed prior to startup.

3.03 SUPPLEMENTS

A. Supplements listed below, following "End of Section," are a part of this specification.

1. Data Sheets:
   a. Electric Water Heater (Commercial).
   b. Domestic Water Expansion Tank.
   c. Simplex, Submersible Sump Pump.

END OF SECTION

Electric Water Heater (Commercial)								
Tag Number	Storage Capacity (gallons)	Total Input (kW)	No. of Elements	Simultaneous Element Operation	Voltage	Diameter (inches)	Height (inches)	Manufacturer, Model No.
14-WH-01	119	18.0	3	Yes	460/3	30	68	AO Smith, Model DRE-120
Notes: 1. FLA= 21.7 Amps, 3 elements at 6 kW each.								

Domestic Water Expansion Tank							
Tag Number	Configuration (horiz/vert)	Total Volume (gallons)	Acceptance Volume (gallons)	Air Pre-charge (psi)	Diameter (inches)	Height (inches)	Manufacturer, Model No.
14-ET-01	Vertical	2.1	0.9	12	10	9	Amtrol, Model AST-5

Simplex, Submersible Sump Pump						
Tag Number	Flow Rate (gpm)	Pressure (feet head)	Motor (hp)	Motor Speed (rpm)	Power (volts/phase)	Manufacturer, Model No.
14-SP-01	40	19	1/2	1,750	120V/1ph	Zoeller Model 137

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

B. California Plumbing Code (CPC).

C. California Energy Code, 2016 (CEC).

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Fixture Trim:
   1. Supply Stops and Traps:
      a. McGuire.
      b. American Standard.
      c. Kohler.
      d. “Or-equal.”
   2. Flush Valves:
      a. Sloan.
      b. “Or-equal.”
   3. Water Closet Seats:
      a. Bemis.
      b. Church.
      c. Olsonite.
      d. “Or-equal.”
   4. Lavatory Supply, Tailpiece, and Trap Insulation:
      a. McGuire.
      b. Trap Wrap.
      c. Truebro.
      d. “Or-equal.”

B. Plumbing Fixtures:
   1. Water Closets, Lavatories, and Urinals:
      a. American Standard.
      b. Kohler.
      c. Eljer.
      d. “Or-equal.”
   2. Service Sinks:
      a. Kohler.
      b. Eljer.
      c. “Or-equal.”

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

C. Emergency Showers and Eyewashes:
    1. Haws.
    2. Bradley Corp.
    3. Guardian Equipment.
    4. "Or-equal."

D. Drainage Products:
   1. General:
      a. Smith.
      b. Wade.
      c. Zurn.
      d. “Or-equal.”

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

2.02 GENERAL

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

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

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

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

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

2.03 MATERIALS

A. 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:
         1) McGuire Manufacturing Company, Inc.
         2) "Or-equal."
   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:
         1) McGuire Manufacturing Company, Inc.
         2) "Or-equal."
   3. Water Closet and Urinal Flush Valves: Sloan Valve Co., Royal Continental, low flush, quiet action with screwdriver stop and vacuum breaker.

B. Plumbing Fixtures:
   1. 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.; Model 2200-4CP with 0.5-gpm flow restricter.
      c. Trim: 3/8-inch supply stop with loose key, 17-gauge chrome-plated cast brass P-trap.

d. Insulation: McGuire Manufacturing Company, Inc., Prowrap antimicrobial PVC resin seamless insulation for trap, tailpiece, and hot and cold water supply piping.

e. Strainer: McGuire Manufacturing Company, Inc.; Model 155A chrome-plated grid strainer with tailpiece.

f. Carrier: Jay R. Smith Mfg. Co.; 700 series concealed arm.

2. MS-1, Mop Sink (Floor Mounted):

a. Fixture: Molded stone, corner set, 24 inches by 24 inches by 12 inches deep with stainless steel bumper guard, back panels and chrome-plated brass drain. Stern-Williams Co. Inc.; Model SBC-1700-BP.

b. Faucet: Chicago Faucet Co.; Model 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.; Model T-35 hose and T-40 stainless steel mop hanger.

3. WC-1, Water Closet (Flush Valve, Wall Mounted, ADA Compliant):

a. Fixture: Vitreous china, siphon jet action, top spud, elongated bowl. American Standard Companies, Inc.; Afwall 1.28 gpf Toilet with Exposed Manual Flush Valve System Model 2859.128.

b. Seat: American Standard Companies, Inc.; Model 5901.100; white open front.

C. Safety Equipment:

1. SSH-1, Safety Shower/Eyewash Combination:

a. Model: Haws Drinking Faucet Co.; Model 8320CRP.

b. Shower: ABS plastic deluge.

c. Eyewash: Stainless steel bowl with aerated eye/face wash.

d. Valve: Stay open.

e. Support: Freestanding, 1-1/4-inch galvanized pipe standard, stanchion, and floor flange.

f. Extended height with 8 feet-0-inch clear from bottom of shower head to floor.

g. Alarms: Flow switch with 120V ac rated contacts for connection to alarm system.

h. Factory applied CRP (corrosive atmospheres coating).

D. Drainage Products:

1. CO-1, Cleanout (Exterior):
   a. Material: Taper thread, bronze plug, heavy-duty, scoriated cast-iron top.
   b. Manufacturer and Product:
      1) Jay R. Smith Mfg. Co.; Model 4263.
      2) "Or-equal."
2. CO-2, Cleanout:
   a. Material: Taper thread, bronze plug, scoriated nickel bronze top.
   b. Manufacturer and Product:
      1) Jay R. Smith Mfg. Co.; Model 4023.
      2) "Or-equal."
3. FCO-1, Floor Cleanout (Finished Areas):
   a. Material: Tapered thread, bronze plug with round adjustable scoriated secured nickel bronze top.
   b. Manufacturer and Product:
      1) Jay R. Smith Mfg. Co.; Model 4103S.
      2) "Or-equal."
4. FCO-2, Floor Cleanout (Unfinished Areas):
   a. Material: Tapered thread, bronze plug with round adjustable scoriated secured cast-iron top.
   b. Manufacturer and Product:
      1) Jay R. Smith Mfg. Co.; Model 4243S.
      2) "Or-equal."
5. 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 where indicated as primed.
   c. Manufacturer and Product:
      1) Jay R. Smith Mfg. Co.; Model 2005T-U-round.
      2) "Or-equal."
6. 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 where indicated as primed.

c. Manufacturer and Product:
   1) Jay R. Smith Mfg. Co.; Model 2210T-U.
   2) "Or-equal."

7. 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 where indicated as primed.
   c. Manufacturer and Product:
      1) Jay R. Smith Mfg. Co.; Model 2233T-U.
      2) "Or-equal."
8. FD-5, Floor Drain (Indirect Receptor):
   a. Materials: Cast-iron body and strainer.
   b. Options: Round top, antiflood rim strainer, Jay R. Smith Mfg. Co.; with integral trap primer connection where indicated as primed.
   c. Manufacturer and Product:
      1) Jay R. Smith Mfg. Co.; Model 2010T-U-F37.
      2) "Or-equal."
9. RD-1, Roof Drain:
   a. Materials: Cast-iron body with combined flashing clamp and gravel stop, and cast-iron dome.
   b. Options: Extension collar, sump receiver, underdeck clamp.
   c. Manufacturer and Product:
      1) Jay R. Smith Mfg. Co.; Model 1010Y-E-R-C-CID.
      2) "Or-equal."
10. RD-2, Roof Drain (Small Roof Areas):
   a. Materials: Cast-iron body with combined flashing clamp and gravel stop, and cast-iron dome.
   b. Options: Extension collar, sump receiver, underdeck clamp.
   c. Manufacturer and Product:
      1) Jay R. Smith Mfg. Co.; Model 1330Y-E-R-C.
      2) "Or-equal."
11. OD-1, Overflow Drain:
   a. Materials: Cast-iron body with combined flashing clamp and gravel stop, and cast-iron dome.
   b. Options: Extension collar, sump receiver, underdeck clamp, and 2-inch-high cast-iron standpipe.

c. Manufacturer and Product:
   1) Jay R. Smith Mfg. Co.; Model 1070Y-E-R-C-CID-CIS.
   2) "Or-equal."

12. OD-2, Overflow Drain (Small Roof Areas):
    a. Materials: Cast-iron body with combined flashing clamp and gravel stop, and cast-iron dome.
    b. Options: Extension collar, sump receiver, underdeck clamp, and 2-inch-high water dam.
    c. Manufacturer and Product:
       1) Jay R. Smith Mfg. Co.; Model 1330Y-E-R-C-WD.
       2) "Or-equal."
13. ON-1, Overflow Nozzle:
    a. Material: Cast bronze body and flange.
    b. For wall discharge of roof drains.
    c. Manufacturer and Product:
       1) Jay R. Smith Mfg. Co.; Model 1770.
       2) "Or-equal."
14. HD-1, Hub Drain:
    a. Coated cast-iron reducing hub adapter with standard cast-iron hub.
    b. Hub: Two pipe sizes larger than outlet.
15. WCO, Wall Cleanout:
    a. Material: Stainless steel cover and screw.
    b. Manufacturer and Product:
       1) Jay R. Smith Mfg. Co.; Model 4472.
       2) "Or-equal."

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:
         1) Sioux Chief Mfg. Co., Inc.; Series 650 and 660.
         2) "Or-equal."
   2. TP-1, Trap Priming Valve:
      a. Materials: Cast bronze, line pressure drop activated, antisiphon port, 1/2-inch connection.

b. Manufacturer and Product:
   1) Precision Plumbing Products, Inc.; Model P-1 trap priming valve and Model DU-4, distribution unit.
   2) "Or-equal."

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:
      1) Watts Industries, Inc.; Series 40.
      2) "Or-equal."
4. Pressure Gauge (Potable):
   a. Materials: 3-1/2-inch gauge size, 0 psi to 120 psi range, steel case, glass crystal, brass movement, and 1/4-inch NPT lower connection.
   b. Manufacturer and Product:
      1) Ashcroft Dresser Instrument Division, Dresser Industries, Inc.; Type 1008.
      2) "Or-equal."
5. Pressure Gauge (Wastewater):
   a. Weather-proof, vibration resistant, glycerin fill w/ diaphragm seal, isolation ball valve.
   b. Materials: 3-1/2-inch gauge size, 0 psi to 30 psi range, all stainless steel construction, polycarbonate crystal, and 1/4-inch NPT lower connection.
   c. Accuracy, plus or minus 2 percent of span, with traceable calibration chart.
   d. Threaded Diaphragm Seal:
      1) Capsule diaphragm.
      2) 1/2 NPT Process Connection.
      3) Stainless Steel diaphragm and bottom housing.
      4) Cadmium plated upper housing.
      5) Flushing connection.
   e. Manufacturer and Product (Gauge):
      1) Ashcroft Industries, Inc.; Type 1008, Model 101008-S-L-02-L-C4-30#.
      2) "Or-equal."

f. Manufacturer and Product (Diaphragm):
1) Ashcroft Industries, Inc.; Type 101, Model 50100CC02T.
2) "Or-equal."

6. Thermometer:
a. Materials: Adjustable angle, bimetallic 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:
1) H.O. Trerice Co.
2) "Or-equal."

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

PART 3 EXECUTION

3.01 PREPARATION

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

3.02 INSTALLATION

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

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

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

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

E. 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. Tempered water shall be temperature indicated on Drawings.

F. Drainage Products:
1. Floor Drains: Set top flush with floor. Provide membrane clamps where required.
2. Cleanouts: Install where shown or required for purposes intended. Set cover flush with finished floor.
3. Hub Drains: Set top of hub 2 inches above finished floor.

G. 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. Drain P-Trap Priming:
    a. Pipe: Type K, soft copper.
    b. Trap and prime floor drains and hub drains, unless shown otherwise on Drawings. No attempt has been made to show trap primer valve locations or trap primer pipe routing.
    c. Field route trap primer piping during installation of floor drains and hub drains, and install trap primer valves in mechanical rooms, janitor rooms, or other locations acceptable to Jacobs' Engineer.

d. Priming System: Complete with connection to serving cold water system.

3. Trap Priming Valves:
   a. Floor drain traps primed with priming valves, 1/2-inch copper to floor drain.
   b. Two traps maximum primed from one priming valve or as recommended by manufacturer. Locate in mechanical spaces or janitor's rooms and as indicated on Drawings.
   c. Provide shutoff valve ahead of priming valves.
4. 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.

H. Caulk penetrations of exterior walls with weatherproof sealant.

I. 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 Jacobs' Engineer 48 hours prior to shower testing. Owner and Jacobs' 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.

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

END OF SECTION

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

PART 1 GENERAL

1.01 SUMMARY

A. Test and Balance air and water systems.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. Air Movement and Conditioning Association, Inc. (AMCA): 203, Field Performance Measurement of Fan Systems.
   2. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE): HVAC Applications Handbook.
   3. National Environmental Balancing Bureau (NEBB):
      a. Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.
      b. Procedural Standards for Measuring Sound and Vibration.
   4. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): HVAC Testing, Adjusting, and Balancing Manual.
   5. Testing and Balancing Bureau (TABB).

1.03 SUBMITTALS

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

1.04 QUALITY ASSURANCE

A. Air Balancing and Test Agency Qualifications:
   1. Certification by NEBB or TABB for testing, adjusting and balancing of HVAC systems.
   2. Corporately and financially independent organization functioning as an unbiased testing authority.
   3. Professionally independent of manufacturers, suppliers, and installers of HVAC equipment being tested.
   4. Have a proven record of at least five similar projects.
   5. Employer of engineers and technicians regularly engaged at least 40 percent of their time in testing, adjusting and balancing of HVAC equipment and systems.

PART 2 PRODUCTS

2.01 MATERIALS

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

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

C. Drives for Belt-Driven Fans:
   1. Furnish cast iron or flanged steel sheaves.
   2. Sheaves and belt combination shall be capable of providing 150 percent of motor horsepower.

PART 3 EXECUTION

3.01 GENERAL—BALANCING

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

B. Adjust and balance the following systems:
   1. Supply, return and exhaust air systems.
   2. Foul Air Systems.

3.02 ADJUSTING AND BALANCING AIR SIDE

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

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

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

D. Fan Systems:
   1. Measure fan system performance in accordance with AMCA 203.

2. In each system at least one airpath from fan to final branch duct termination shall have dampers fully open. Achieve final air quantities by adjusting fan speed.
3. Adjust Fan Air Volumes:
    a. Adjust fan speeds and motor drives for required equipment air volumes, with allowable variation of plus 10 percent minus 0 percent.
    b. After final adjustments, do not operate motor above nameplate amperage on any phase.
    c. After final adjustments, do not operate fan above maximum rated speed.
    d. Perform airflow test readings under simulated or actual conditions of full cooling, full heating, minimum outside air, full outside air and exhaust, and full return air.
    e. Provide and make drive and belt changes on motors or fans as required to adjust equipment to specified conditions. Drives shall be able to deliver 150 percent of motor horsepower. Provide written notice to air handling unit manufacturer and Jacobs' Engineer if drive or belt changes were made.
4. Adjust outside air dampers, return air dampers, relief air dampers, exhaust air dampers, and motorized louvers for maximum and minimum air requirements.
5. Read and record static pressures at unit inlet and discharge, each filter set, coils, dampers, plenums, and mixing dual-duct or adjustable-volume boxes, on every supply, return, and exhaust fan for each test condition.
6. Test fans with filters at mid-point of filter life. Simulate filter dirt by partially blocking filter racks until mid-point filter pressure drop is achieved.
7. Read and record motor amperage on all phases for each test condition.

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

F. Building Static Pressure:

1. Measure building static pressure relative to outside in perimeter entrances during normal system conditions that would yield widest range in internal building pressure.
2. Adjust building static pressure control parameters to ensure perimeter entrances are positive or negative to outdoors as indicated with entrance doors closed.

G. Zone Differential Pressure:

1. Test and adjust differential pressures by setting design flows to meet required flow direction and pressure differential during worst case conditions of systems serving zone being adjusted and of adjacent zones.
2. Zone differentials for this project are indicated on the air flow schematics.
3. Provide written notice to Jacobs' Engineer of zone leakage conditions preventing design differential requirements to be met.

3.03 FIELD QUALITY CONTROL

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

B. Performance Testing:

1. Electric Heating Coil Testing:
   a. Adjust system as required to achieve full output from coil.
   b. Read and record amperages and voltages for all phases.
2. Packaged Heating / Cooling Equipment Testing: At full output for both heating and cooling, measure and record airflow rate, entering and leaving air dry bulb and wet bulb temperatures.
3. Indirect Evaporative Cooler Testing:
   a. Adjust system as required to achieve design flow conditions for both air and water sides of cooler.
   b. For both primary and secondary air, measure and record air flows, entering air dry bulb and wet bulb temperatures, leaving air dry bulb and wet bulb.
   c. For secondary air, measure and record entering and leaving water temperature.
   d. Inside the Electrical room, measure and record air dry bulb and wet bulb temperatures at representative supply and return grilles.

C. Balancing Log Report Requirements:

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

D. Quality Control Verification:

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

END OF SECTION

SECTION 23 07 00
HVAC INSULATION

PART 1 GENERAL

1.01 SUMMARY

A. Provides requirements for HVAC ductwork and Equipment insulation. For pipe insulation, see Section 40 42 13, Process Piping Insulation.

1.02 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. UL.

1.03 DEFINITIONS

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

B. Cooled Air Ductwork: Designed to convey non-mechanically cooled supply or return air ducts in such systems.

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

1.04 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.

1.05 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.

1.06 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."

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.

G. No asbestos content allowed in any product or material.

2.02 PIPE INSULATION

A. Type P1—Fiberglass (ASTM C547, Type 1:

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

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

B. Type P3—Elastomeric (ASTM C534, Minus 40 Degrees F to 220 Degrees F):
1. Flexible, closed cell elastomeric.
2. Nominal 6 pcf density, K factor 0.27 maximum at 75 degrees F mean.
3. Water vapor transmission 0.1 perm-inch, or less.
4. Manufacturers and Products:
    a. Armacell; AP Armaflex.
    b. Nomaco; K-Flex LS.

2.03 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.
    a. “Or-equal.”

B. Type D2—Board:
1. Fiberglass, minimum 2.25 pcf density board, K factor 0.24 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.

e. "Or-equal."

C. Type D3—Liner (ASTM C1071, Type 1):

1. Fiberglass, nominal 1.5 pcf density liner, K factor 0.25 maximum at 75 degrees F mean, black composite coated surface exposed to airstream to prevent erosion of glass fibers, for temperatures to 250 degrees F.
2. Liquid water repellency rating not less than 4 when tested in accordance with INDA IST 80.6.
3. Potential heat value not exceeding 3,500 Btu/lb when tested in accordance with NFPA 259 and meeting the classification of "Limited Combustible" as defined by NFPA 90A.
4. Maximum rated velocity not less than 6,000 fpm when tested in accordance with ASTM C1071.
5. Resistant to microbial growth using a "no growth criteria" when tested in accordance with ASTM C1139, ASTM G21, and ASTM G22.
6. Manufacturers and Products:
   a. CertainTeed; Toughgard.
   b. Johns Manville; Linacoustic (rectangular), Spinacoustic (Round).
   c. Knauf; Acoustic Duct Liner.
   d. "Or-equal."

D. Type D5—Flexible Elastomeric (ASTM 534, Type I for tubular materials and Type II for sheet materials):

1. Closed-cell, sponge- or expanded-rubber materials.
2. Manufacturers and Products:
   a. Aeroflex USA, Inc.; Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.
   d. "Or-equal."

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.
   c. "Or-equal."

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. "Or-equal."

C. Type F3—Aluminum:
   1. Aluminum Roll Jacketing: For straight run piping, wrought aluminum Alloy 3003, 5005, 1100 or 3105 to ASTM B209 with H-14 temper, minimum 0.016-inch thickness, with smooth mill finish.
   2. Moisture Barrier: Provide factory applied moisture barrier, consisting of 40-pound kraft paper with 1-mil-thick low-density polyethylene film, heat and pressure bonded to inner surface of the aluminum jacketing.
   3. Fitting Covers: Material as for aluminum roll jacketing, premolded, one or two piece covers, which includes elbows, tee/valves, end caps, mechanical line couplings, specialty fittings, etc.
   4. Manufacturer and Product:
      a. RPR Products; INSUL-MATE.
      b. "Or-equal."

PART 3 EXECUTION

3.01 APPLICATION OF PIPING INSULATION

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

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

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

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

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

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

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

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

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

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

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

L. 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.

3.02 INSTALLATION OF DUCTWORK INSULATION

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

B. Install insulation materials with smooth and even surfaces.

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

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

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

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

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

H. Refer to Section 23 31 13, Metal Ducts and Accessories, for installation of internal duct liner.

3.03 INSTALLATION OF INSULATION FINISH SYSTEMS

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

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

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

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

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

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

3.04 PIPING INSULATION REQUIREMENTS

A. Domestic Hot and Cold Water, and Tempered Water:
   1. Type P1, fiberglass.
   2. 1-inch thickness for hot water.
   3. 1/2-inch thickness for domestic cold water and tempered water.

B. Refrigeration Suction:
   1. Type P3, elastomeric.
   2. 1/2-inch thickness for pipe sizes up to 1 inch.
   3. 3/4-inch thickness for pipe sizes over 1 inch.

C. 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.

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

3.05 DUCTWORK INSULATION REQUIREMENTS

A. Mechanically Cooled and Heated Supply and Return Air (Concealed but Inside Building Envelope):
   1. Type D1, blanket.
   2. Min R-4.2

B. Supply and Return Air (Outdoors):
   1. Type D2, board.
   2. 2-inch thickness.

C. Outside Air Intake:
   1. Type D1, blanket.
   2. Min R-8

D. Transfer Air:
   1. Type D3, liner.
   2. 1/2-inch thickness.

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

3.06 INSULATION FINISH REQUIREMENTS

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

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

C. Duct and Equipment Insulation (Outdoors): Type F3, aluminum jacked, lapped and sealed weatherproof with band clamps on 24-inch centers.

D. Piping Insulation (Outdoors):
   1. Type F2, paint (for use with Type P3, elastomeric).
   2. Type F3, aluminum.

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

3.07 FIELD QUALITY CONTROL

A. Inspect factory-applied materials as assembled. Field-applied materials may be inspected individually.

B. Jacobs' Engineer will specify inspection to be conducted in order to meet material performance standards.

END OF SECTION

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. 135, Data Communication Protocol for Building Automation and Control Networks.
   3. California Energy Code 2016 (CEC).
   4. 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.
   5. Federal Communications Commission (FCC).
   6. 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.
   7. National Electrical Manufacturers' Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   8. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code.
      b. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
   9. UL: 916, Standard for Safety Energy Management Equipment.

1.02 DEFINITIONS

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

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

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

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

E. Control Wiring:

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

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

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

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

I. Point: Electronic representation of value or signal. Type can be Digital or Analog, Virtual or Real.

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

K. Abbreviations that may be used in this section:
   1. AC: Air Conditioning.
   2. ATC: Automatic Temperature Control.
   3. BAS: Building Automation System.
   4. DDC: Direct Digital Control.
   5. DX: Direct Expansion.
   6. EMCS: Environmental Management and Control System.
   7. HCP: HVAC Control Panel.
   8. HMI: Human-Machine Interface.
   9. HOA: Hand-Off-Auto (Switch).
   10. HVAC: Heating, Ventilation, and Air Conditioning.
   11. IP: Current (I) - Pressure (P), as in IP transducer.
   12. LCD: Liquid Crystal Display.
   13. LCP: Local Control Panel.
   14. PLC: Programmable Logic Controller.
   15. RAM: Random Access Memory.
   16. RTD: Resistance Temperature Detectors.
   17. VAV: Variable Air Volume.

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. Electric/Electronic Control System (ELECTRIC):
      1) System using simple electric or electronic control devices such as timers or manual switches.
      2) User interface at control device.
      3) Alarms if required are separate devices wired to the Plant SCADA system or Fire Alarm system if exists.
   b. DDC Control System (DDC):
      1) Microprocessor-based DDC Control System utilizing DDC controllers.
      2) Information sharing between controllers as required to achieve indicated sequence of operation.
      3) User interface at DDC controller with local HMI.
      4) Alarms if required are wired from the DDC to the Plant SCADA system or Fire Alarm system as indicated.
      5) Information within control system can be utilized by computer workstation and/or portable terminal via ethernet connection.
2. Provide control system(s) of architecture defined in Control Type Schedule, below:

Control Types Electrical Building		
Location	**System**	**Control Type**
Electrical Room Cooling	14AHU9800-01 14AHU9800-02	DDC
Control Room	14ACU9804-01 14ACU9804-02	DDC
Battery Room Exhaust	14FAN9801-01	ELECTRIC
Restroom Exhaust	14FAN9805-01	ELECTRIC
Cable Room Ventilation	14FAN9802-01 14FAN9803-01	ELECTRIC

Control Types Grit Building		
Location	System	Control Type
Grit Pump Room Ventilation	14FAN9808-01 14FAN9809-01	ELECTRIC

C. Performance Requirements: See equipment schedules, air flow schematics, and Section 23 09 13, HVAC Controls, Field Components, and Instruments, and supplement to this section, for additional details.

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.
   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.
   8. Damper actuator sizing calculations, in schedule form.

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. Certificates, in accordance with Section 01 43 33, Manufacturers' Field Services:
    a. Manufacturer's Certificate of Compliance.
    b. Manufacturer's Certificate of Proper Installation.
4. Performance test plan and schedule.
5. Test Results: Functional and performance test documentation.
6. Anchorage and bracing data sheets and drawings as required by Section 01 88 15, Anchorage and Bracing.
7. 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.

1.05 QUALITY ASSURANCE

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

B. Codes and Standards: Meet requirements of applicable standards and codes, except when more detailed or stringent requirements are indicated by Contract Documents, including requirements of this section.
    1. UL: Products shall be UL 916-PAZX listed.
    2. National Electrical Code NFPA 70.
    3. Federal Communications Commission Part J.
    4. Networked DDC Control Systems shall comply with ASHRAE 135 (BACnet).

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

D. 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. Spare parts shall be available for at least 5 years after Substantial Completion.

B. 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.

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.
11. "Or-equal."

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.
   3. Coordinate interfaces with electrical work as necessary.
   4. Provide electric, electronic, and mechanical devices as required to properly interface with prewired control panels furnished with HVAC equipment and with other mechanical and electrical components.

2.03 LABELING

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

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

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

2.04 SERVICE CONDITIONS

A. Refer to Materials Selection Table on the General Drawings for materials requirements and classification of areas as hazardous, corrosive, wet, indoor dry, and dust-tight.

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

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

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

2.05 ELECTRICAL COMPONENTS AND ACCESSORIES

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

B. Wiring:

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

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

D. Provide commercial grade surge suppressors on each power connection.

2.06 FIELD COMPONENTS AND INSTRUMENTS

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

2.07 ACCESSORIES

A. Corrosion-inhibiting vapor capsules as manufactured by:

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

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

C. Equipment Identification Plates:

1. Provide 16-gauge 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.
2. Provide adjacent to the following control devices, and for equipment whose function is not readily apparent.
    a. START/STOP switches.
    b. Emergency STOP switches.
    c. Special purpose devices.
    d. HVAC control panels.

2.08 EQUIPMENT FINISH

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

PART 3 EXECUTION

3.01 SEQUENCES OF OPERATION

A. Reference Article Supplement, located after "End of Section," and 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 Jacobs' Engineer before proceeding with the Work.
3. Mount devices requiring manual reset and all other user serviceable control devices in readily accessible locations.

B. Corrosion Protection:

1. Protect control equipment in control cabinets as follows:
    a. Use corrosion-inhibiting vapor capsules inside control equipment enclosures and HCP.
    b. Replace capsules prior to Owner's acceptance of equipment.

C. Wiring:

1. General:

a. Install electric wire, cable, fittings, and conduit associated with systems specified in this section, in accordance with requirements of NFPA 70.

b. Install control and interlock wiring separate from power wiring.

c. Number code or color code conductors, excluding those used for individual zone controls, appropriately for future identification and servicing of control system.

d. Provide wire markers on each conductor in panel and at load connections. Identify circuit with control wire number.

e. Restrain wiring in control panels by plastic ties or ducts.

f. Hinge wiring shall be secured at each end so that any bending or twisting will be around longitudinal axis of wire and bend area shall be protected with sleeve.

g. Arrange wiring neatly, cut to length, and remove surplus wiring. Provide abrasion protection for any wire bundles that pass through holes or across edges of sheet metal.

h. Use manufacturer's recommended tool with proper sized anvil for crimp terminations. No more than two wires may be terminated in single crimp lug and no more than two lugs may be installed on single screw terminal.

i. Wiring shall not be spliced or tapped except at device terminals or terminal blocks.

j. Properly support and run wiring in a neat manner.

k. Run wiring parallel or at right angles to building structure.

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. Plenum rated low voltage control wiring system may be used without conduit in concealed, but accessible areas in Building 46. In Building 45, install exposed and concealed low voltage control wiring systems in conduit.

d. Wiring within enclosures shall be neatly bundled and anchored to prevent obstruction to devices and terminals.

e. Conduit shall be sized to suit the number, type, and size of conductors as specified in Section 26 05 05, Conductors.

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

E. Control Dampers:
1. Verify correctness of installation.
2. Verify proper control action.
3. Adjust limit switch settings.
4. Adjust opening and closing speeds, and travel stops.
5. Stroke control dampers by means of associated control output.

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

G. 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.

H. 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 (e.g., terminal blocks, power supplies, relays, PLC racks).

3.03 FIELD QUALITY CONTROL

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

3.04 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.

3.05 ADJUSTING AND CALIBRATING

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

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

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

3.06 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.

3.07 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this Specification:
   1. HVAC Controls Sequence of Operation.

END OF SECTION

HVAC CONTROLS SEQUENCE OF OPERATION

1.01 GENERAL

A. Includes control sequences for equipment vendor provided, and controls contractor provided systems. Contractor shall provide complete and operable systems.

B. The term LCP (Local Control Panel) shall refer to vendor provided panel which shall be unit mounted and contain the following items:
   1. Single point power connection and disconnect.
   2. Controls compartment containing labeled terminal block connections for vendor provided instrumentation and controls.

C. The term HCP (HVAC Control Panel), or ECP (Environmental Control Panel) shall be the central panel responsible for lead-lag-alternating, room temperature monitoring and control, and alarms logging of vendor provided equipment. There shall be 1 HCP for this project, tag 14CP101.

D. Temperatures, alarm conditions, filter and equipment status shall be available for monitoring, trend logging and changing of setpoints at the local HCP display.

E. General fault alarm signal shall be sent to the Plant DCS when an alarm is issued by the HCP. When the alarm is cleared at the HCP, cancel the alarm to the Plant DCS.

F. The Electrical building is equipped with area smoke detectors. When called upon by the Fire Alarm system, any active IDEC units shall be deactivated. The HCP shall issue an alarm to the Plant DCS.

1.02 ELECTRICAL BUILDING – CONTROL ROOM HVAC

A. General Control:
   1. The lead Heat Pump system shall operate as required to cool or heat the control room. Initial room temperature setpoints shall be 68 degrees F heating, and 75 degrees F cooling, user adjustable.
   2. The lead heat pump shall change weekly.
   3. If lead heat pump cannot maintain space temperature, the lag heat pump shall be activated, and an alarm signal shall be issued to the HCP.

B. Via BACNET or MODBUS the following Commandable Points shall be communicated to and from each heat pump:
   1. On/Off.
   2. Mode.

3. Setpoint.
4. Fan Speed.

C. Via BACNET or MODBUS the following Monitoring Points shall be communicated to the HCP from each heat pump:
   1. Fault Codes.
   2. Room Temperature.

D. Filter Differential Pressure Monitor:
   1. The HCP controller shall monitor the differential pressure across the lead heat pump filter and display this information locally at the HCP.
   2. Issue a maintenance warning at the HCP when filter differential pressure exceeds a user definable limit (adj.) on the unit.
   3. Initial setpoint 0.5-inch w.c.

1.03 BATTERY ROOM, JANITORS, RESTROOM, GRIT BUILDING

A. The Battery room exhaust fan shall operate continuously and shall alarm directly to the Fire Alarm System and Plant DCS on fan failure. Receive supply air from the main Electrical room units.

B. Restroom/Janitor Room exhaust fan shall operate as needed based on a wall timer. Receive supply air from the main Electrical room units.

C. A wall unit heater shall heat the Restroom as required using local control.

D. Grit room supply and exhaust fan shall operate continuously. Alarm to Plant DCS on fan failure.

E. Grit room supply filter differential pressure shall be monitored and displayed at the HCP.
   1. Issue a maintenance warning at the HCP when filter differential pressure exceeds a user definable limit (adj.) on the unit.
   2. Initial setpoint 0.5-inch w.c.

1.04 ELECTRICAL ROOM COOLING

A. Provide controls for Indirect Evaporative Cooling (IDEC) units described here and in the next section below. IDEC unit vendor to provide spray pumps, piping, valves, transformers, variable frequency drives, and single point electrical connection. Controls contractor to provide additional controls as necessary to provide a complete and operable system.

B. General Control:

1. The lead IDEC unit shall change weekly.
2. Air flow from the lead IDEC unit shall be continuous, but supply air flow rate shall vary according to load.
3. Evaporative cooling shall be staged on load.
4. A bleed valve on the evaporative sump shall be adjusted to discharge approximately 9 gallons of water per hour to the drain when the sump pump is operating. This will result in about 4 cycles of concentration.

C. IDEC Change-over sequence:

1. Isolation dampers on supply and return ducts shall prevent flow through the inactive unit.
2. Changeover shall not occur until water sump is filled if there is demand for cooling.
3. If there is no demand for cooling, change-over will occur with a dry sump.
4. IDEC ramp-down signal and isolation damper change-over shall initiate simultaneously. If the lead IDEC unit is providing evaporative cooling, the lag IDEC unit shall not start until the sump is filled per below.
5. Change-over Sequence:
    a. Change-over shall start with a change-over signal displayed at the HCP.
    b. If there is cooling demand, fill the sump on lag evaporative cooler by opening the fill valve.
    c. When the level sensor indicates the sump is full and closes the fill valve, a sump full signal shall be displayed at the HCP.
    d. The circulation pump and scavenger fans on the lag unit shall be activated to pre-cool the heat exchanger for 30 seconds (adj).
    e. When pump and fan have successfully operated for 30 seconds, initiate the change-over. Simultaneously close the isolation dampers on the lead unit and open the isolation dampers on the lag unit, while ramping up the lag unit supply fan, and ramp down the lead unit supply fan.
    f. Time the change-over so the new lead supply fan reaches operating speed at the same amount of time the isolation dampers complete their movement.
    g. Transition shall be complete when the new lead equipment has confirmed operation at the HCP and isolation damper end-switches have proved on all 4 dampers. Then the transition signal indications shall be removed from the HCP display.
    h. If the transition sequence does not complete in a set amount of time, 5 minutes adj, issue an alarm to the Plant DCS.

i. When the supply fan is off and the isolation dampers are closed, new lag unit sump pump shall initiate a drain-down cycle where the sump pump operates to drain the sump. Motorized valves shall divert the pump discharge to drain. Sump pump shall operate until the level sensor indicates the sump is empty. Then an empty sump signal shall be displayed at the HCP.

D. Filter Differential Pressure Monitor:

1. The controller shall monitor and display the differential pressure across the lead unit filter(s).
2. Issue a maintenance warning at the HCP when filter differential pressure exceeds a user definable limit (adj.) on the lead unit. Initial setpoint 0.5-inch w.c.

E. IDEC Heating-cooling Sequence:

1. Heating mode shall occur when Electrical room temperature equals 65 degrees F and below. IDEC unit shall operate at minimum recirculation air flow as indicated on Drawings. The sump shall be empty and the scavenger fan(s) shall remain off.
2. At room temperature equals 68 degrees F, fill sump and activate cooling water pump. Scavenger fan(s) to remain off.
3. At room temperature equals 72 degrees F, activate scavenger air cooling fans.
4. If room temperature increases to 74 degrees F, increase supply fan airflow so that at 78 degrees F room temperature the supply fan is operating at full air flow while the evaporative cooling system continues to operate.
5. If room temperature exceeds 85 degrees F, issue an alert to the HCP.
6. If room temperature exceeds 95 degrees F, issue an alarm to the Plant DCS and activate the second IDEC.
7. As room cools, reverse the sequence above.

1.05 GENERAL CONTROL TYPES (PROVIDE WHERE INDICATED)

A. Fan Failure and Ventilation Failure Alarms:

1. Work of Division 26, Electrical, includes provision of starter ON/OFF status signal to HCP for each fan motor controlled.
2. For controlled motors, initiate Fan Failure Alarm signal when motor is commanded to START and starter ON/OFF status indicates it is OFF.
3. For ventilation failure, provide differential pressure switch for each fan to determine actual flow failure. On lack of pressure differential, initiate Ventilation Failure Alarm. Include dual contacts at each differential pressure switch, one set for connection by Division 26, Electrical.

B. Common Alarm Output:

1. Initiate common alarm signal to Plant DCS process control system when alarm condition exists.
2. Provide terminals for connection by Division 26, Electrical, of alarm contact closure output signals.
3. Contacts shall be rated for minimum of 2 amps at 120V ac.
4. Coordinate with work of Division 26, Electrical, and Section 40 90 00, Instrumentation and Control for Process Systems.

C. Occupied/Unoccupied Control:

1. Modes shall be determined by 7-day schedule with holiday calendar.
2. Provide momentary contact manual after-hours override switch at room temperature sensor.
3. Initially set after-hours override duration for 4 hours.

END OF SECTION

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

PART 1 GENERAL

1.01 SUMMARY

A. Control components for HVAC.

1.02 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.

1.03 SUBMITTALS

A. Action Submittals:
   1. Shop Drawings: Submit anchorage and bracing drawings and data sheets, as required by Section 01 88 15, Anchorage and Bracing.
   2. Informational Submittals: Submit anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.

PART 2 PRODUCTS

2.01 HVAC CONTROL PANEL (HCP)

A. For this project HVAC control panel shall be 14CP101, located in the Headworks 3 Electrical room.

B. Provide as shown on Drawings for convenient operator interface with control system.

C. A single 120-volt, 20-amp feeder shall serve each HCP, unless otherwise indicated. HCP cabinet shall include microprocessor control modules, control switches, transformers, and other devices necessary for system operation.

D. HCP shall include a graphical user interface displaying equipment setpoints, operating status, scheduling, and alarms, for each piece of equipment controlled.

E. Set points for these items shall be locally adjustable using the display screens and keypads provided.

F. Dry contacts shall be provided for a common alarm output to the Plant DCS. Additional information on the alarm shall be available locally including type, source, duration and history.

G. Datalogging shall be downloadable using ethernet or USB output. Programming shall be available via laptop connection.

H. HCP Construction:
   1. Construct each HCP to NEMA 250 rating.
   2. Metal enclosure to accommodate secure conduit fittings and protect against electrical transients.
   3. Hinged front door with locking handle.
   4. Flush-mount display and keypad shall allow visual status of all controlled variables, sensors, and alarms 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.

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

J. 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.

K. Terminal Blocks:
   1. One-piece molded plastic blocks with screw type terminals and barriers rated for 600 volts.
   2. Double sided and supplied with removable covers to prevent accidental contact with live circuits.
   3. Furnish permanent, legible identification, clearly visible with protective cover removed.

4. Terminate wires at terminal blocks with crimp type, preinsulated, ring-tongue lugs.
5. Size lugs for terminal block screws and for the number and size of wires terminated.
6. Provide screwdriver access for blade width of a minimum of 3/16 inch or Klein 601 Series screwdrivers. Terminals requiring use of special screwdrivers are not acceptable.

L. Schematic Diagrams:
1. Furnish black and white graphic of smooth or engraved laminated plastic.
2. Mount on front face of HCP showing equipment within respective systems.
3. Show pilot lights, pressure gauges, and temperature-indicating dials on schematic in locations that correspond to actual system location.
4. Locate manual selector switches directly below equipment symbol being controlled.

M. 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 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 (M):
1. 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: Extruded neoprene type Mechanically attached to blade edge.
    b. Jamb Seals: Flexible metal compression type.
5. Linkage: Concealed in frame.
6. Axles:
    a. Minimum 1/2 inch (13 mm) diameter, hex-shaped, mechanically attached to blade.
    b. Material: Type 304 stainless steel.
7. Performance Data:
    a. Temperature Rating: Withstand minus 72 degrees F to 275 degrees F.
    b. Capacity: Demonstrate capacity of damper to withstand HVAC system operating conditions.
    c. Closed Position: Maximum pressure of 13 inches w.g. at 12-inch blade length.
    d. Open Position: Maximum air velocity of 6,000 feet per minute.
    e. Pressure Drop: Maximum 0.03 inch w.g. at 1,500 feet per minute across 24-inch by 24-inch damper.
8. Accessories:
    a. Actuator: Refer to Article Control Damper Operators, for requirements.
    b. Switch Package: Two-position indicator switches linked directly to damper blade to remotely indicate damper blade position.
    c. Flange Frame: 1-1/2 inches, roll formed as part of frame.
9. Manufacturers and Products:
    a. Ruskin; Model CD-50.
    b. American Warming and Ventilating.
    c. TAMCO.
    d. “Or-equal.”

2.03 CONTROL DAMPER OPERATORS

A. General:
    1. Drawings and Control Diagrams indicate only one damper motor for each motorized damper (M).
    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:
      a. 120V, 60-Hz, two-position.
      b. 24V, 60-Hz, modulating.
      c. Fail Position: As indicated.
   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.
      f. “Or-equal.”

2.04 ELECTRIC THERMOSTATS (ET)

A. General Thermostat:
   1. Modulating electric type, except where two-position action is required.
   2. Temperature Scale.
   3. External adjustments.
   4. Insulating back, where exterior wall mounting is indicated.
   5. Adjustable dead band.
   6. For any particular dead band selected, thermostat shall react to temperatures above and below that band, while within that band it shall maintain signal that produces neither cooling nor heating.

2.05 ELECTRONIC SENSORS

A. Temperature (TS):
   1. General Requirements:
      a. Sensors and transmitters shall be provided, as outlined in input/output summary and sequence of operations.
      b. Temperature sensor shall resistance type, and shall be either two-wire 1,000-ohm nickel RTD or two-wire 1,000-ohm platinum RTD.
      c. Accuracy plus or minus 0.5 degrees F.
   2. Room Temperature Sensors with Integral Display:
      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 degrees F to 140 degrees F.

2) Cooling: 30 degrees F to 100 degrees F.

c. Element:

1) Rigid insertion, 12 inch length, through sealed opening in center of duct.

2) Averaging, for ducts or plenums with any dimension greater than 36 inches. Sealed opening in duct. Sensing element incorporated in copper capillary a minimum of 20 feet long, serpentined across full area of airflow.

4. Outdoor Temperature:

a. Accuracy: Plus or minus 1 degree F.

b. Range: Minus 40 degrees F to 140 degrees F.

c. Cover: Weathertight, with sealed conduit connection and sun shield.

B. Pressure (PS):

1. Air Pressure:

a. Accuracy: 5 percent of range.

b. Range: 150 percent of measured variable.

c. Mount nonvibrating.

d. Cover: NEMA 250 Type, suitable for area classification; in accordance with NFPA 70.

C. Differential Pressure (DP):

1. General:

a. Temperature compensated.

b. Vary output voltage with change in differential pressure. Voltage shall vary linearly from 0V dc to 10V dc according to differential pressure between high and low pressure ports.

c. Sensing range shall be suitable for application with linearity of 1.5 percent of full scale and offset of less than 1 percent of full scale.

d. Capable of withstanding up to 150 percent of rated pressure without damage.

e. Compatible with 14V dc to 30V dc supply voltage range.

2. Duct Air Static Differential Pressure:

a. MAMAC transmitter.

b. Dwyer A302 duct probe.

c. Install static pressure fittings for differential pressure sensors and switches at a right angle to the flow.

D. Position Indicator:
   1. 0 percent to 100 percent open, for damper, inlet vane, or similar.
   2. Potentiometer, 0 ohm to 2,000 ohm equals 0 percent to 100 percent.

E. 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:
         1) Veris; Hawkeye 600/800.
         2) "Or-equal."
   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:
         1) Veris; Hawkeye 708/908.
         2) "Or-equal."
   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:
         1) Veris; Hawkeye 904.
         2) "Or-equal."

2.06 MISCELLANEOUS DEVICES

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

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

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

D. Duct Mounted Ionization Detection (I):
   1. Refer to Section 28 31 00, Fire Detection and Alarm, for requirements.
   2. Furnish duct smoke detectors for air handling systems, number and location as shown on Drawings.
   3. Type: Duct mounted, suitable for airstream sensing.
   4. Voltage: 120V ac.
   5. Detector Type: Ionization.
   6. Furnish with remote reset button or key switch.
   7. Include mounting bracket for installation on the ductwork.
   8. Coordinate with other trades to accomplish specified Automatic Smoke Detection shutoff control sequence.
   9. Manufacturers and Products:
      a. BRK Electronics; Model DH1851AC.
      b. Pyrotronics; Pyr-Alarm.
      c. “Or-equal.”

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

SECTION 23 23 00
REFRIGERANT PIPING

PART 1 GENERAL

1.01 REFERENCES

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

1.02 DEFINITIONS

A. ACR: Air conditioning and refrigeration.

B. NRTL: National Recognized Testing Laboratory.

1.03 SUBMITTALS

A. Action Submittals:
   1. Shop Drawings in 1/4-inch scale for refrigerant piping showing pipe and tube sizes, flow capacities location, elevations, fittings, accessories, and piping connections.
   2. Manufacturer's data on refrigerant piping, piping products, thermostatic expansion valves, solenoid valves, hot-gas bypass valves, filter dryers, strainers, pressure regulating valves and accessories.

B. Informational Submittals:
   1. Welding certificates.
   2. Field quality control; test report.
   3. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

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

1.04 QUALITY ASSURANCE

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

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

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

1.05 DELIVERY, STORAGE, AND HANDLING

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

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

PART 2 PRODUCTS

2.01 MATERIALS

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

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

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

D. Pipe Insulation: Refer to Section 40 42 13, Process Piping Insulation.

2.02 MISCELLANEOUS PIPING PRODUCTS

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

B. Refrigerant Specialties:
   1. Refrigerant Suction Line Filter-Dryer:
      a. Provide steel shell, corrosion-resistant finish filter-dryer, with molded felt core with 10-micron particle retention, in size and working pressure indicated, with copper connectors, and access valve (not applicable for heat pump system).
      b. Operating Temperature Rating: 240 degrees F.

c. Working Pressure: 500 psi.
d. Provide size recommended by refrigeration equipment manufacturer.

2. Refrigerant Liquid Line Dryer:
a. Provide refrigerant liquid line filter-dryer for all units.
b. Operating Temperature Rating: 240 degrees F.
c. Working Pressure: 500 psi.
d. For heat pumps, provide biflow directional types (not required if included with air-conditioning equipment).
e. Provide size recommended by refrigeration equipment manufacturer.

C. Refrigerant Valves:
1. Globe and Check Valves: Listed and labeled by an NRTL.
a. Shutoff Valves:
1) Forged brass, packed, back seating winged seal cap, 300 degrees F (140 degrees C) temperature rating 500 psi working pressure.
2) Maximum Opening Pressure: 0.5 psig.
3) Valve required only if shutoff service valves are not included with package air-conditioning equipment.
b. Manufacturers:
1) Henry Technologies.
2) Parker Hannifin Corp.
2. Solenoid Valve: Listed and labeled by an NRTL.
a. Two-Way Solenoid Valves: Forged brass, designed to conform to AHRI 760, normally closed, Teflon valve seat, NEMA 1 solenoid enclosure, 24 volts, 60-Hz, UL Listed, 1/2-inch conduit adapter, 250 degrees F (121 degrees C) temperature rating 500 psi working pressure.
b. Provide valve only if recommended by air-conditioning equipment manufacturer.
c. Manual Operator: Provide optional manual operator to open valve.
d. Manufacturers:
1) Alco Controls Div.; Emerson Electric Co.
2) Automatic Switch Co.
3) Parker Hannifin Corp.
3. Thermostatic Expansion Valve:
a. Body Bonnet and Seal Cap: Forged brass or steel.
b. Diaphragm, Piston, Closing Spring and Seat Insert: Stainless steel.
c. Capillary and Bulb: Copper tubing filled with refrigerant.
d. Suction Temperature: 40 degrees F.
e. End Connections: Socket or flare.
f. Working Pressure: 700 psig.

g. Manufacturers:
   1) Henry Technologies.
   2) Parker Hannifin Corp.
   3) Danfoss Group Global.

4. Safety Relief Valve:
   a. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
   b. Seat Disk: Polytetrafluoroethylene.
   c. Working Pressure: 500 psig.
   d. Operating Temperature: 240 degrees F, maximum.
   e. Manufacturers:
      1) Henry Technologies.
      2) Parker Hannifin Corp.
      3) Danfoss Group Global.

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

PART 3 EXECUTION

3.01 INSTALLATION OF PIPING SYSTEM

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

B. Install dryers on liquid and suction lines.

C. Refrigerant Piping:
   1. Cut pipe accurately to measurements established at Site and work into place without springing or forcing.
   2. Install piping with sufficient flexibility to adequately provide for expansion and contraction as a result of temperature fluctuation inherent in its operation.
   3. Where pipe passes through building structure, pipe joints shall not be concealed, but located where they may be readily inspected.
   4. Run pipe to be insulated as shown and as required with sufficient clearance to permit application of insulation.
   5. Run piping as shown on Drawings, taking care to avoid interference with other piping, conduit or equipment. Except where specifically indicated otherwise, run piping plumb, and straight and parallel to walls and ceilings.
   6. Trapping of lines shall not be permitted, except where indicated.
   7. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
   8. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

9. Install piping free of sags and bends.
10. Install fittings for changes in direction and branch connections.
11. Install accumulator in suction line near condensing unit.
12. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
13. Slope refrigerant piping as follows:
    a. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
    b. Install horizontal suction lines with a uniform slope downward to compressor.
    c. Install traps and double risers to entrain oil in vertical runs.
    d. Liquid lines may be installed level.

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

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

3.02 SOLDER JOINTS

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

3.03 BRAZED JOINTS

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

B. Brazed Joints:
1. Construct joints according to AWS *Brazing Handbook* Chapter “Pipe and Tube”.
2. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.

3. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

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

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

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

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

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

3.04 PIPE HANGERS

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

3.05 EQUIPMENT CONNECTIONS

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

3.06 FIELD QUALITY CONTROL

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

B. Leak Test:
   1. Prior to initial operation, clean and test refrigerant piping in accordance with ASME B31.5.
   2. Perform initial test with dry nitrogen to 300 psig minimum using soap solution to test joints.
   3. Evacuate system after initial test and charge system with refrigerant or dry nitrogen, 20 percent refrigeration mixture to 600 psig minimum.

4. Upon completion of initial system test, test factory, as well as field, refrigerant piping joints with electronic-type leak detector to acquire a leak-tight refrigerant system.
    a. If leaks are detected, remove entire refrigerant charge for the system, replace defective pipe or fitting, and retest entire system as specified above.

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

3.07 ADJUSTING

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

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

END OF SECTION

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-Conditioning, Heating, and Refrigeration Institute (AHRI): 880, Air Terminals.
   2. Air Movement and Control Association (AMCA): 500, Test Methods for Louvers, Dampers and Shutters.
   3. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Handbook.
   4. American Society of Mechanical Engineers (ASME): A13.1, Scheme for the Identification of Piping Systems.
   5. Association of the Nonwoven Fabrics Industry (INDA): IST 80.6, Water Resistance (Hydrostatic Pressure).
   6. 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. C636/C636M, Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels.
      i. A653/A653M, Standard Specifications for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

j. A700, Standard Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment.

k. A924/A924M, Specification for General Requirements for Sheet Steel, Metallic-Coated by the Hot-Dip Process.

l. 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.

m. 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.

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

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

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

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

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

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

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

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

8. 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. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.

d. 259, Standard Test Method for Potential Heat of Building Materials.

e. 701, Standard Methods of Fire Tests for Flame Propagation of Textiles and Films.

9. 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.
10. 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. NC: Noise Criteria; background sound rating method for indoor sound.
    4. PCF: Pounds per cubic foot.
    5. VAV: Variable air volume.
    6. WC: Water column.

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

1.03 SUBMITTALS

A. Action Submittals:

1. Product Data:

a. Rectangular, Rigid Round, and Oval Ductwork:

1) Schedules of duct systems, materials, joints, sealing, gage and reinforcement.

2) SMACNA Figure Numbers for each shop fabricated item.

3) Reinforcing details and spacing.

4) Seam and joint construction details.

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

b. Ductwork Accessories:

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

a) Fittings and volume control damper installation (both manual and automatic) details.

b) Duct liner.

c) Sealing materials.

d) Dampers; include leakage, pressure drop, and maximum back pressure data.

e) Duct-mounted access panels and doors.

f) Flexible ducts.

g) Sheet metal fasteners.

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

3. 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.

B. Informational Submittals:

1. Submit 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. Sound Attenuators Certified Test Data:
    a. Dynamic insertion loss.
    b. Self-noise power levels.
    c. Static pressure loss.
    d. Dimensions and weights.
4. Record Drawings: Include duct systems routing, fittings details, and installed accessories and devices.

1.04 QUALITY ASSURANCE

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

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

C. Suppliers of duct and fitting components shall provide on request the following information:
    1. Laboratory performance data for duct, including leakage rate, bursting strength, collapse strength, seam strength, and pressure loss.
    2. Laboratory performance data for fittings, including zero-length dynamic losses.

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

E. Changes or alterations to layout or configuration of duct system shall be:
    1. Specifically approved in writing by Jacobs' Engineer.
    2. Proposed layout shall provide original design results, without increasing system total pressure.

1.05 DELIVERY, STORAGE, AND HANDLING

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

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

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

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

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

PART 2 PRODUCTS

2.01 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.

C. 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.

2.02 SHEET METAL MATERIALS

A. See Materials Table on Drawings.

B. Construct metal duct systems from galvanized steel or aluminum. Exhaust systems serving bathrooms with showers shall be aluminum.

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

D. Galvanized Steel Ductwork (where indicated):
   1. Comply with ASTM A653/A653M and ASTM A924/924M.
   2. Product Name: Steel Sheet, Zinc Coated (Galvanized Steel).
   3. Sheet Designation: CS Type B.
   4. Applicable Specification: ASTM A653/A653M.
   5. (Zinc) Coating Designation: G90.
   6. Coating designation in accordance with Test Method A, ASTM A90/A90M and ASTM A924/A924M.
   7. Provide mill-phosphatized finish for ducts exposed to view and for ducts scheduled to be painted.
   8. Provide sheet metal packaged and marked as specified in ASTM A700.

E. Aluminum Ductwork (unless otherwise noted):
   1. Comply with ASTM B209.
   2. Aluminum Sheet: Alloy 5052-H32, unless indicated otherwise.
   3. Aluminum Connectors and Bar Stock: Alloy 6061-T6 or equivalent.

F. 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.

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

2.03 DUCT SEALING MATERIALS

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

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

C. 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.
      d. "Or-equal."

2.04 DUCTWORK FASTENERS

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

B. Self-Drilling Screws:
   1. Galvanized Steel Ductwork System: Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated carbon steel with zinc electroplated finish.
   2. Aluminum Ductwork System:
      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.
         3) "Or-equal."

2.05 DUCTWORK PRESSURE CLASS

A. Construct duct systems to pressure classifications indicated as follows:
   1. Supply Ducts: 3-inch WC.
   2. Return Ducts: 2-inch WC, negative pressure.
   3. Exhaust Ducts: 2-inch WC, negative pressure.

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

2.06 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.

2.07 RECTANGULAR DUCTWORK FITTINGS

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

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

C. Turning Vanes:
   1. Double thickness, 4-inch radius except that 2-inch radius may be used on ducts 12 inches and smaller.
   2. Airfoil vanes minimum 3.5-inch radius.
   3. Vane metal thickness shall be minimum 24-gauge steel, and minimum G60 galvanized or equivalent. Vane material to be same as duct material.
   4. Vane rails on 20-inch and larger ducts shall be 22-gauge or heavier.
   5. Acoustic turning vans shall be provided on acoustically lined elbows, and elsewhere as indicated.
   6. Acoustic vanes shall be dimpled with slotted perforations and filled with 1.3-pound minimum density insulation. Factory designed for sound attenuation.

7. Manufacturers:
    a. Aero-Dyne HEP.
    b. Ductmate.
    c. EZ Rail.

2.08 RECTANGULAR DUCTWORK BRANCH CONNECTIONS

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

2.09 RECTANGULAR DUCTWORK INSULATION LINER

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

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.
        d. “Or-equal.”

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

D. R-Value: Minimum 4.2 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.

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.

2.10 RIGID ROUND DUCTWORK

A. Construct rigid round ducts in accordance with SMACNA unless specified otherwise.

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

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

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

2.11 RIGID ROUND DUCTWORK FITTINGS

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

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

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

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

b. Fabricate nonstandard bend angle configurations or nonstandard sized (for example, 9-1/2 inches and 10-1/2 inches) elbows with segmented construction.

2.12 ROUND DUCTWORK BRANCH CONNECTIONS

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

2.13 INSULATED FLEXIBLE DUCT

A. Fabricate in accordance with:
   1. UL 181, Class 1.
   2. NFPA 90A and NFPA 90B.

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

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

D. Manufacturers and Products:
   1. Flex-Master; Type 5M.
   2. Thermaflex; Type M-KC.
   3. Hart & Cooley; Type F216.
   4. “Or-equal.”

2.14 DUCTWORK HANGERS AND SUPPORTS

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

B. Construction Materials: Supporting devices including, but not limited to, angles used for support and bracing, baseplates, rods, hangers, straps, screws, bolts shall be as follows:
   1. Galvanized Steel Ductwork:
      a. Indoors: Carbon steel, zinc electroplated.
      b. Outdoors: Carbon steel, hot-dipped galvanized after fabrication.
   2. Aluminum Ductwork Indoors and Outdoors:
      a. Carbon steel, hot-dipped galvanized after fabrication.
      b. Nonmetallic 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.

2.15 DUCTWORK FLEXIBLE CONNECTIONS

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

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

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

D. Manufacturers and Products
   1. Ductmate; PROflex, Commercial.
   2. Ventfabrics.
   3. Duro-Dyne.
   4. “Or-equal.”

2.16 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 than 16 inches, furnish inspection doors at least 8 inches by 8 inches.
   3. Complete with necessary hardware and either Amerlock 10 or Ventlock No. 100 latches, and Ventlock Series No. 100 hinges.
   4. Fabricated of same material as ductwork.

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

2.17 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.
      c. “Or-equal.”
   5. Operator Manufacturers and Products:
      a. Accessible Ductwork: Ventlok; Type 620 or Type 635.
      b. Accessible Insulated Ductwork: Ventlok; Type 639.
      c. Concealed Ductwork: Ventlok; Type 677 with extended operating rod and concealed regulator with plain cover.
      d. “Or-equal.”

B. Manual Opposed-Blade Balancing Dampers (for Rectangular Ducts):
   1. Externally operated gang single thickness, V-groove blades, 5-inch blade width.
   2. Suitable for up to 2,000 feet per minute air velocity, or 5-inch w.c. differential air pressure when closed. Up to 240 degrees F air temperature without seals.
   3. AMCA 500 leakage at 1,500 fpm shall be maximum 10 CFM/sf (with seals), or 40 CFM/sf (without seals)
   4. Seals shall be flexible metal compression.
   5. Fabricate from minimum 16-gauge thickness, heavier where indicated.
   6. Construct of galvanized steel, or stainless steel if ductwork is aluminum.
   7. Nylon sleeve bearings.
   8. Construction shall have interlocking edges and maximum 6-inch blade width.
   9. Manufacturers and Products:
      a. Ruskin; CD35.
      b. American Warming and Ventilating; Model VC-20.

2.18 BACK DRAFT DAMPERS

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

B. Aluminum, Counterbalanced, Standard Duty:
   1. Fabrication:
      a. Frame: 2 inches by minimum 0.06 inch (51 mm by minimum 1.5 mm), 6063-T5 extruded aluminum channel with mitered corners.
      b. Blades:
         1) Style: Single piece, overlap frame.
         2) Action: Parallel.
         3) Material: Minimum 0.025-inch (0.6 mm) 6063-T5 formed aluminum.
         4) Width: Maximum 6 inches (152 mm).
      c. Bearings: Corrosion-resistant, long-life, synthetic, formed as single piece with axles.
      d. Blade Seals: Extruded vinyl, mechanically attached to blade edge.
      e. Linkage: Concealed in frame.
      f. Axles: Corrosion-resistant, long-life, synthetic, locked to blade and formed as single piece with bearings.

g. Counterbalances: Adjustable zinc plated steel weights mechanically attached to blade enabling damper to operate over wide range of pressures.

h. Mounting: Suitable for mounting in vertical, horizontal airflow up, and horizontal airflow down positions.

i. Finish: Factory applied air-dried epoxy paint on all damper parts.

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.

c. “Or-equal.”

C. Aluminum, Counterbalanced, Heavy Duty:

1. Fabrication:

a. Frame: 2-1/4 inches by minimum 0.125 inch (57 mm by minimum 3.2 mm) 6063-T5 extruded aluminum channel with front flange and rear flange and galvanized steel braces at mitered corners.

b. Blades:

1) Style: Single piece, overlap frame.

2) Action: Parallel.

3) Orientation: Horizontal.

4) Material: Minimum 0.070-inch (1.8 mm) 6063-T5 extruded aluminum.

5) 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: Minimum 1/2-inch (13 mm) aluminum tie bar with stainless steel pivot pins mounted on blades.

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: Suitable for mounting in vertical, horizontal airflow up, and horizontal airflow down positions.

i. Finish: Factory applied anodizing on all aluminum damper parts.

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: 16-inch WC (4 kPa).

c. Maximum Air Velocity: 2,500 fpm (12.7 mps).

d. Operation of Blades:

1) Start to Open: 0.01-inch WC (2 Pa).

2) Fully Open: 0.05-inch WC (10 Pa).

e. Pressure Drop: Maximum 0.15-inch WC (30 Pa) at 1,500 fpm (7.6 mps) through 24-inch by 24-inch (610 mm by 610 mm) damper.

3. Manufacturer and Product:

a. Ruskin; Model CBD6.

b. "Or-equal."

2.19 CONTROL DAMPERS

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

2.20 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. Auxiliary Drain Pans:

1. Dimensions: Minimum 6 inches larger in both dimensions than equipment it is serving and 2 inches high, minimum.

2. Construction: 16-gauge stainless steel with welded joints. Pans shall be watertight and have hemmed edges.

3. Drain Connection:
    a. Minimum 1-inch IPS or as shown on Drawings.
    b. Locate at lowest point of drain pan.
    c. In lieu of drain connection, float switch may be installed. Float switch shall shut down air handling equipment upon sensing water.

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

B. Ductwork Location:
1. Locate ductwork runs vertically and horizontally, unless otherwise indicated.
2. Avoid diagonal runs wherever possible.

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

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

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

E. Coordination with Other Trades:

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

F. Shower Room and Toilet Room Exhaust Ductwork:

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

3.02 RECTANGULAR DUCTWORK

A. General:

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

B. Low Pressure Taps:

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

C. Fittings:

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

D. Rectangular Ductwork Transverse Joints:
   1. Install each run with a minimum of joints.
   2. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.
   3. Mechanical Joint Option:
      a. Construct transverse joints with Ductmate 25/35 duct connector systems, Ductmate W.D.C.I. Heavy/Lite duct connector systems, or Ductlok J/E duct connector system. 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 RIGID ROUND OR OVAL DUCTWORK

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

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

3.04 INSULATED FLEXIBLE DUCT

A. Installation:
   1. Where shown, between branch duct and ceiling diffusers and grilles.
   2. Without sags, kinks, sharp offsets, or elbows.

3. As straight and taut as possible.

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

C. Length:
   1. Maximum length of low-pressure flexible duct (construction pressure class up to 2-inch WC) to be 5 feet.
   2. Maximum length of medium pressure flexible duct (construction pressure class up to 4-inch WC) to be 5 feet.

D. Flexible ductwork shall not pass through wall, floor, or fire resistant rated assembly.

3.05 DUCTWORK HANGERS AND SUPPORTS

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

B. Support ducts rigidly with 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.

3.06 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.

3.07 DAMPERS

A. General:
   1. Inspection:
      a. Inspect areas to receive dampers.
      b. Notify Jacobs' 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 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.

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.

3.08 ACCESS DOORS

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

B. 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. Booster coil.
   4. Motorized damper.
   5. Sail switch.
   6. Turning vane.
   7. Volume damper.
   8. Automatic damper.
   9. Temperature controller.

3.09 EXTERNAL DUCT INSULATION

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

3.10 MISCELLANEOUS ACCESSORIES

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

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

C. Inspection Plates and Test Holes:
   1. Where required in ductwork for balance measurements.
   2. Test holes shall be airtight and noncorrosive with screw cap and gasket.

3. Extend cap through insulation.

3.11 DUCT SEALING

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

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

C. Seal externally insulated ducts prior to insulation installation.

D. Provide additional duct sealing as required to comply with Article Ductwork Leakage Testing.

E. Seal all audible leaks.

3.12 BALANCING OF AIR SYSTEMS

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

3.13 PROTECTION OF INSTALLED WORK

A. 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.

3.14 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

SECTION 23 31 16.16
FOUL AIR DUCTWORK AND ACCESSORIES

PART 1 GENERAL

1.01 RELATED SECTIONS

A. Related sections include the following:
   1. Division 01, General Requirements.
   2. Section 05 50 00, Metal Fabrications.
   3. Section 09 90 00, Painting and Coating.
   4. Section 09 96 35, Chemical-Resistant Coatings.
   5. Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.
   6. Section 23 31 13, Metal Ducts and Accessories.
   7. Section 31 23 23.15, Trench Backfill.
   8. Section 40 05 15, Piping Support Systems.
   9. Section 40 27 00, Process Piping – General.

1.02 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. C581, Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service.

d. C582, Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion Resistant Equipment.
e. D3299, Standard Specification for Filament-Wound Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks.
f. D3982, Standard Specification for Contact Molded "Fiberglass" (Glass Fiber Reinforced Thermosetting Resin) Duct and Hoods.
g. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.

5. Sheet Metal and Air Conditioning Contractors' National Association, Inc. (SMACNA):
   a. Thermoset FRP Duct Construction Manual.
   b. Round Industrial Duct Construction Standards.
   c. Rectangular Industrial Duct Construction Standards.

1.03 DEFINITIONS

A. H_2S: Hydrogen sulfide.

B. FRP: Fiberglass reinforced plastic.

C. WC: Water-column.

D. ppmV: Parts per million (volume).

1.04 SUBMITTALS

A. Action Submittals:
   1. Duct:
      a. Statement of resins and reinforcing proposed for use (where applicable).
      b. Pressure, vacuum, and temperature rating of duct.
      c. Dimensions of subassemblies to be shipped.
      d. Manufacturer's data and descriptive literature for duct accessories.
      e. Drawings showing layout, support, and joint details.
      f. Stamped and signed structural engineering design calculations.
      g. Information, details, and requirements for installation and support of duct and torque values for flange bolting.
      h. Name of manufacturer.

2. Supports: Comply with Section 40 05 15, Piping Support Systems.
    a. Submit anchorage and bracing drawings, load criteria, and cutsheets, as required by Section 01 88 15, Anchorage and Bracing, for ducting systems and 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:
    a. Statement of resins and reinforcing proposed for use (where applicable).
    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. Acoustical Insulation and Jacketing:
    a. Type and Model.
    b. Material.
    c. Name of manufacturer.

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 factory inspection report.
3. Manufacturer's installation instructions.
4. Damper: AMCA 500-D leakage test results by AMCA-approved laboratory.
5. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
6. Submit anchorage and bracing calculations or loading information as required in Section 01 88 15, Anchoring and Bracing, for ducting systems and supports.

1.05 QUALITY ASSURANCE

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

1.06 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.
   6. Inspect shipments upon delivery. Note damages and discrepancies on bill of lading and notify manufacturer within 24 hours.
   7. Store coated ductwork on cardboard, Styrofoam, or similar material, out of traffic areas. Where possible, store ductwork indoors and protect from dirt and debris. Where necessary to store outdoors, store abovegrade and enclose with waterproof wrapping to protect from dirt and debris.
   8. If coating is scratched, contact manufacturer for repair instructions. Repair or replace ductwork as determined by the manufacturer.

1.07 SERVICE CONDITIONS

A. Ductwork shall convey humid foul air containing up to 25 ppmV of H_2S and trace amounts of organic reduced sulfur compounds. Ductwork material shall be suitable for handling low concentrations (less than 20 percent) of sulfuric acid condensate.

B. System Maximum Pressure: 12 inches of water column.

C. System Maximum Vacuum: 12 inches of water column.

D. Location: As specified on Drawings. Most ductwork will be installed outdoors exposed. However, some limited ductwork may be direct buried as shown on Drawings.

E. Ambient Temperature: Plus 20 degrees F to 122 degrees F.

F. Wind and Snow Loads: As listed on the General Structural Note Sheets on Drawings.

1.08 ENVIRONMENTAL REQUIREMENTS

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

PART 2 PRODUCTS

2.01 FIBERGLASS REINFORCED PLASTIC DUCTWORK

A. Materials:
   1. Resin:
      a. Resin System: Premium corrosion-resistant, fire-retardant vinylester, such as Ashland Chemical Hetron FR 992, Dow Chemical Derakane 510-A, “or-equal.” Resin to be selected by fabricator, subject to approval of Jacobs, and suitable for intended service with no fillers or thixotropic agents.
      b. Liner Resin: Premium grade and corrosion resistant.
      c. Structural wall resin may be of different chemical resistance, subject to conditions of service and approval of Jacobs.
      d. Flame Spread Index: ASTM E84, less than 25; fire retardant additives used only in structural layer.
      e. Smoke Developed Index: ASTM E84, rating of less than 50 or less.
      f. Structural wall resin shall contain a minimum of 3 percent antimony trioxide to achieve required flame spread index.
      g. Add ultraviolet absorbers to surfacing resin to improve weather resistance.
      h. Color: Use no dyes, pigments, or colorants, except in exterior gel coat. Exterior gel coat shall match Sherwin-Williams SW-6081 Down Home. Final color selection by Jacobs.
      i. For interior duct, final coat shall be factory applied intumescent coating to achieve designated results for low smoke development.
   2. Reinforcement:
      a. Veil: Chemical surfacing mat, Type C (chemical) glass, 10 mils thick, with finish and binder compatible with lay-up resin.

b. Corrosion Barrier: Resin-rich interior surface of nominal 100 mills to 120 mils thick, using chopped strand mat backing the veil. Use no antimony trioxide or other additive that could inhibit visual inspection or corrosion performance in corrosion barrier.

c. Chopped Strand Mat: Type E glass, minimum 1-1/2 ounces per square foot, with silane finish and styrene soluble binder.

d. Continuous Roving for Chopper Gun Spray-Up: Type E glass.

e. Woven Roving: Type E glass, nominal 24 ounces per square yard, 4 by 5 weave, with silane type finish. Chop hoop winding and woven roving reinforcement will be allowed only with the addition of one layer of weft unidirectional glass reinforcement overlapped 1-inch and added to structural wall. Minimum of 0.020-inch thicker than the total specified wall thickness herein.

f. Continuous Roving for Filament Winding: Type E glass with silane type finish.

3. Fasteners:

a. Bolts: ASTM A193/A193M, Type 316 stainless steel, ANSI coarse thread series, Grade B 8M hex head.

b. Nuts: ASTM A194/A194M, Type 316 stainless steel, Grade 8M.

c. Washers: ASME B18.22.1, flat, Type 316 stainless steel.

B. Ductwork:

1. Design Requirements:

a. Conform to ASTM D3982 and/or SMACNA Thermoset FRP Duct Construction Manual.

b. Duct manufacturer's design for round section, including duct wall thickness and stiffeners. Wall thickness per SMACNA Thermoset FRP Manual to be a minimum 0.140-inch for 4-inch through 12-inch diameter, 0.180-inch for 14-inch through 42-inch diameter, and 0.220-inch for 43-inch through 72-inch diameter. Round duct to be fabricated per SMACNA filament wound (Type X) composites laminate Table 5-6.

c. Take into account expansion from seasonal temperature variations.

d. For direct burial applications, wall thickness as required to resist associated loadings. Provide calculations per Article Submittals, Paragraph Action Submittals, Subparagraph Duct, substantiating wall thicknesses.

C. Fabrication:

1. Physical Properties: Meet or exceed requirements of ASTM D3982 and ASTM C582.
2. Squareness of ends, fittings, elbows, and butt joints shall meet or exceed requirements of ASTM D3982.
3. Keep use of flanges to a minimum; butt joints are preferred method of joining sections of duct when inside overlay is possible.
4. Butt joints shall only be permitted in duct sections that are accessible for inside overlay (24-inch diameter and larger) unless bell-and-spigot type wrapped joints are provided. 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. At bell-and-spigot type wrapped joints, provide excess resin at joint interior to maintain corrosion barrier and install exterior overlay per manufacturer's recommendations.
5. Flanges for Duct to Duct Connections and Duct Wall Thicknesses: ASTM D3982 or SMACNA Thermoset FRP Duct Construction Manual, rated for specified pressure and vacuum. At buried applications wall thickness as required to resist applicable loadings. All flanges to be factory drilled unless connecting to valves or dampers that have factory drilled flanges that would allow template field drilling.
6. Flange dimensions (except thickness) and drilling patterns for flanges that connect to valves, or dampers are to correspond to NBS PS 15-69, Table 2. Flange dimensions (except thickness) and drilling patterns for flanges that connect to equipment, enclosures, or covers are to correspond to ASME B16.5, Class 150 or ASME B16.1, Class 125. Flange thickness to comply with ASTM D3982 or SMACNA Thermoset FRP Duct Construction Manual.
7. Furnish gussets on flanged nozzles from ducts.
8. 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.
9. Laminate:
    a. Reinforce inner surface of ducts with resin-rich surfacing veil 10 mils to 20 mils thick.
    b. Construct interior layer of resin reinforced with at least two plies of chopped strand mat; thickness at least 100 mils. Post-cure prior to filament winding or adding structural layer.
    c. Glass content of combined inner surface and interior layer shall be 27 percent plus or minus 5 percent.
10. Duct and Fittings:
    a. Type: Contact molded or filament wound, meeting requirements of ASTM D3982 or SMACNA Thermoset FRP Duct Construction Manual.

b. Joints: Butt wrapped except flanged at connections to expansion joints, butterfly valves, or mechanical equipment or at duct-to-duct connections where inside overlay is not possible.

c. Fittings: Plain end, bell and spigot, or flanged, manufacturer's standard sizes.

d. Gaskets: Hypalon, 3/16-inch thick, full-face, Type A Durometer of 50-60.

11. Manufacturers:

a. Spundstrand.

b. Daniel Mechanical.

c. Composites USA.

12. Supports:

a. Supports for FRP ductwork shall be provided per Section 40 05 15, Piping Support Systems.

b. Maximum Duct Deflection: 1/2-inch, including any stiffened sections or at stacks as called out on Drawings or otherwise required.

13. Marking:

a. Identify each duct component with fabricator's name, resin, minimum thickness, and date of manufacture.

b. Use permanent marking. Seal decals and labels into laminate exterior with resin.

c. For piece marking used for installation, use oil-based paint for easy removal.

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

D. Extra Tappings:

1. Test port tappings shall be positioned as indicated on Drawings. Supplier shall ensure tapping points are accessible for measurement.

2. Sample port tappings shall be positioned as indicated on Drawings. Sample port shall include isolation valve, hose barb, and interior 90-degree elbow with increaser turned turned into the foul air flow for improved sample flows.

3. Instrumentation Tappings: Meet requirements set forth in Instrumentation and Controls specifications and details.

4. Condensate drain tappings shall be positioned at duct invert as indicated on Drawings. Provide drip leg as detailed on Drawings.

2.02 STACKS

A. Stacks shall be free-standing and sized as shown on Drawings.

B. Stacks shall be welded steel, A283/A283M, Grade C, A285/A285M Grade C, A501, or A53/A53M, Type E or S, Grade B, in compliance with Section 40 27 00.04, Welded Steel Pipe and Fittings Data Sheet. Stack accessories shall comply with Section 05 50 00, Metal Fabrications. Interior of stack shall be coated in compliance with Section 09 96 35, Chemical-Resistant Coatings, chemical resistant coating 2 (CRC-2). Exterior of stack shall be coated in compliance with Section 09 90 00, Painting and Coating, System No. 5.

2.03 HIGH DENSITY POLYETHYLENE PLASTIC DUCTWORK

A. Application: Buried locations where called out in Piping Schedule as shown on Drawings.

B. As specified in Section 40 27 00, Process Piping – General.

2.04 ALUMINUM AND STAINLESS STEEL DUCTWORK

A. Application: Interior locations where called out in Piping Schedule as shown on Drawings.

B. As specified in Section 23 31 13, Metal Ducts and Accessories.

2.05 EXPANSION JOINTS/FLEXIBLE CONNECTIONS

A. Provide where indicated on Drawings or as required for proper duct installation. Expansion joints and flexible connections shall be flanged type unless specifically indicated to be plain end (slip-on) type on Drawings.

B. Type: W-design configuration with integral flanges suitable for service with FRP duct.

C. Material: Fabric-reinforced Hypalon or EPDM resistant to UV light.

D. Backing Rings: 3/8-inch thick, 1-1/2 inches wide, Type 316 stainless steel. NBS PS 15-69, Table 2 bolt pattern.

E. Length: 12 inches, flange-to-flange (sizes 24-inch diameter and larger).
   1. Extension: 1 inch.
   2. Compression: 4 inches.
   3. Lateral Offset: 3 inches.

F. Length: 6 inches, flange-to-flange (sizes 22-inch diameter and smaller).
   1. Extension: 1/2 inch.
   2. Compression: 2 inches.
   3. Lateral Offset: 1 inch.

G. Thickness: 3/8-inch, minimum.

H. Slip-on type expansion joints and flexible connections shall be sized to fit tightly on the outside diameter of the duct, secured in place by Type 316 stainless steel worm screw type adjustable clamps to provide gas-tight connection.

I. Manufacturer and Product: Holz Rubber Company, Inc.; Style 945; "or-equal."

2.06 FIBERGLASS REINFORCED PLASTIC BUTTERFLY DAMPERS

A. Dampers:
   1. Single-blade type, complete with channel-type frame, close-fitting axle, and bearings.
   2. Same inside diameter as connecting ductwork.
   3. Axles not less than 3/4-inch in diameter and shall be continuous through damper.
   4. When used for isolation service, shall be furnished with blade seal and shaft seal.
   5. When used for balancing only, shall be furnished with full circumference molded in blade stop.
   6. Isolation dampers shall have maximum leakage rate of 5.25 cubic feet per minute per square foot of damper area, at a differential pressure of 30 inches WC.
   7. Color: Exterior gel coat shall match Sherwin-Williams SW-6081 Down Home. Final color selection by Jacobs.

B. Design Requirements:
   1. Each damper shall be designed for the following conditions:
      a. Air Temperature Range: Plus 20 to 122 degrees F.
      b. Differential Pressure: 12-inch WC.

C. Materials:
   1. FRP materials for dampers shall be same resin as used in ductwork.
   2. Requirements for flame spread and smoke development shall be same as required for ductwork.

D. Construction:
   1. Frames: Fiberglass reinforced plastic with resin as described herein.
   2. Blades: Fiberglass reinforced plastic with resin as described herein. Blade thickness and stiffeners as required to meet design conditions.
   3. Axles: Continuous FRP rod with resin as described herein. Axle to extend 6 inches beyond frame.
   4. Bearings: Molded PTFE.
   5. Blade Stops: FRP with resin as described herein.
   6. Blade Seals: Neoprene.
   7. Shaft Seals: Neoprene.
   8. Flanges: As specified to match ductwork flanges.

E. Manufacturer and Product:
   1. Swartwout; Model 914.
   2. "Or-equal."

F. Lever Actuators: Provide for dampers 24-inch diameter and smaller.
   1. Hand quadrant type.
   2. Constructed of Type 316 stainless steel.
   3. Locking quadrant suitable for positioning the blade at intermediate position.

G. Hand Actuators: Provide for dampers larger than 24-inch diameter.
   1. Hand actuators shall be worm geared driven.
   2. Actuators shall be totally enclosed, weather-proof, and permanently lubricated in a die-cast aluminum housing.
      a. Housing shall be epoxy coated in the factory with a minimum dry film thickness of 8 mils.
   3. Hand wheel sizes shall be computed assuming a maximum rim effort of 80 pounds.
   4. Actuator shall be bolted to damper with stainless steel bolts as required.
   5. Number of turns of hand wheel in order to rotate blade 90 degrees: Minimum of 4 and maximum of 12.
   6. Provide indicating arrows identifying direction of rotation for correct operation of dampers with "Open" and "Close" clearly marked. Indication shall be legible and of substantial durability.
   7. Chain Wheels:
      a. Dampers installed with shaft centerlines more than 5 feet 6 inches above the floor shall be provided with chain wheels and operating chains.

b. Chain wheels shall be equipped with a chain guide, which will permit rapid handling of the operating chain without "gagging" of the wheel.

c. Reasonable side pull on the chain shall be permitted by the chain wheel without "gagging" of the wheel.

d. Provide suitable actuator extensions, if necessary, to prevent interference of chain and adjacent piping or facilities below.

e. Operating chains shall be hot-dip galvanized carbon steel. Loop and extend within 4 feet of the floor below damper.

f. Provide and install galvanized tie-back hooks on adjacent pipe supports or structures to hold operating chains out of walkways or access areas when damper is not in operation.

8. Hand actuators shall be Swartwout Dyna-Torque; Model DT2, "or-equal."

2.07 FIBERGLASS REINFORCED PLASTIC BACKDRAFT DAMPERS

A. Backdraft Dampers:

1. Backdraft dampers shall be of the multi-blade rectangular type complete with channel-type frame, blades, linkage, full-length axles, adjustable counterbalance assembly, and bearings.
2. Same inside dimensions as connecting fan discharge size or connecting ductwork.
3. Axles not less than 3/4-inch in diameter.
4. Backdraft dampers shall have a maximum leakage rate of 15 cubic feet per minute per square foot of damper area, at a differential pressure of 5 inches WC. AMCA leakage tests shall be furnished as part of the submittal.
5. Color: Exterior gel coat shall match Sherwin-Williams SW-6081 Down Home. Final color selection by Jacobs.

B. Design Requirements:

1. Each backdraft damper shall be designed for the following conditions:
   a. Air Temperature Range: Plus 20 degrees F to 122 degrees F.
   b. Maintained Differential Pressure Across Blades: 0.1-inch WC.
   c. Design for a differential pressure of 10 inches WC minimum when closed.

C. Materials:

1. FRP materials for backdraft dampers shall be same resin as used in ductwork.
2. Requirements for flame spread and smoke development shall be same as required for ductwork.

D. Construction:
   1. Frames: Fiberglass reinforced plastic with resin as described herein.
   2. Blades: Fiberglass reinforced plastic with resin as described herein. Airfoil shape.
   3. Axles: Continuous FRP rod with resin as described herein. Axle to extend 6 inches beyond frame.
   4. Bearings: Molded PTFE.
   5. Blade Seals: Neoprene.
   6. Shaft Seals: Neoprene.
   7. Flanges: As specified to match ductwork flanges or where connected to fan discharge match bolt pattern and flange dimensions of fan discharge.
   8. All hardware to be Type 316 stainless steel.
   9. Linkage: Fiberglass reinforced plastic with vinylester resin as described herein with monel rivets.
   10. Adjustable Counterbalance Assembly: Type 316 stainless steel.

E. Manufacturer and Product:
   1. Swartwout; Model 426AF.
   2. "Or-equal."

2.08 FLUOROPOLYMER-COATED STAINLESS STEEL DUCT SYSTEM

A. Materials:
   1. Stainless Steel (SS), Type 304L or Type 316L:
      a. Stainless Steel Sheet: No. 2B finish conforming to ASTM A167 and ASTM A480, thickness as required per SMACNA Industrial Duct Standards.
      b. Structural Members: Matching type conforming to ASTM A666.
      c. Fasteners: Type 316 stainless steel.

B. Ductwork:
   1. Acceptable Manufacturers and Products:
      a. Fab-Tech Inc.; Perma Shield Pipe.
      b. Composites USA; PureGuard SS.
      c. CorGuard; PrimeGuard.
   2. Fluoropolymer-Coated Stainless Steel Ductwork:
      a. General: Factory-fabricated system approved by Factory Mutual is fume/smoke exhaust duct without sprinklers when tested in accordance with ASTM E84, with flame-spread rating of less than 25 and smoke-developed rating of less than 50.

b. Base Metal:
   1) Material: Type 304 or Type 316 stainless steel with 2B exterior finish fabricated with gauges and reinforcing in accordance with the SMACNA Industrial Duct Construction Standards to meet designated system class and pressure class.
   2) Longitudinal Seams: Fusion-welded using no filler rod.
   3) Transverse Seams: Continuously welded.
   4) Seam Finishing: Ground/polish smooth.

c. Coating System:
   1) Manufacturers and Products:
      a) ETFE fluoropolymer 532-6005 primer, 532-6012 top coat by E.I. DuPont DeNemours and Company, Wilmington, Delaware, “or-equal.”
      b) HALAR-ECTFE Fluoropolymer by Ausimont, USA, Inc., Morristown, NJ, “or-equal.”
   2) Description:
      a) Electrostatically applied thermoplastic resin powder coating system. Ductwork interior applications shall be a minimum of 10 mils to 12 mils thick to provide complete and spark-free coverage.
      b) Prepare base metal surfaces and apply coating in accordance with coating manufacturer’s requirements to ensure proper and complete adhesion of coating to base metal.
   3) Accessories: Prep and coat duct accessories, such as dampers and blast gates, in the same manner as the duct n which they are to be installed.
   4) Testing: Wet test the entire coated surface inside and out (where applicable) and edges, using a dc spark tester used at 250 volts per mil to detect flaws. Repair flaws and retest until all flaws are repaired.

d. Fabrication:
   1) Fittings:
      a) Elbows: Minimum centerline radius of 1-1/2 times the duct diameter whenever possible.
      b) Transitions: Limit taper angle to 30 degrees for contracting and to 20 degrees for expanding transitions.
      c) Branch Takeoff Connections: Unless specifically detailed otherwise, provide 45-degree laterals and 45-degree elbows.
      d) 90-Degree Branch Takeoffs: Shoe-tap-type tees.

2) Flanged Joints:
   a) Coating Only on Inside: Use companion flange (Van Stone) duct joints consisting of rolled or pressed steel angle rings, and GoreTex or envelope-style gaskets.
   b) Flange Ring Materials: Type 304 stainless steel.
3) Slip Joints: Make small diameter field joints using Raychem TWDB heat shrink warp on slip joints on sizes 10 inches and smaller diameter. Install slip joints only when absolutely necessary. Apply heat shrink bands around the perimeter of the joint after properly aligning.
4) Dampers: Heavy-duty industrial butterfly dampers provided by the selected duct system manufacturer, unless otherwise shown on Drawings, meeting the same design conditions as the FRP dampers described herein. Dampers shall be coated same as duct.

3. Miscellaneous Materials:
   a. General: Provide miscellaneous materials and products of the types and sizes indicated and, where not otherwise indicated, provide type and size required to comply with ductwork system requirements, including proper connection of ductwork and equipment.
   b. Nuts and Bolts: Type 316 stainless steel.
   c. Gasket Material:
      1) Manufacturer: W.L. Gore and Associates, Inc., Elkton, Maryland.
      2) Description: Form in place, fully expanded 100 percent PTFE gasket material, size as recommended by the manufacturer.
   d. Drains:
      1) Prior to coating, weld stainless steel couplings to the bottom of main and branch ducts that are trapped and/or where shown on Drawings, to allow removal of condensed liquids.
      2) Predetermine locations of duct drains prior to manufacturer's fabrication.
   e. Pitot Ports:
      1) Bulkhead fittings configured to prevent exposure of metal, located on the side or top of the duct. Bottom locations are prohibited.
      2) Predetermine locations of pitot ports prior to manufacturer's fabrication. At minimum, provide pitot ports in each branch duct to tools, in each major main duct, at each fan and scrubber inlet and outlet, and where shown on Drawings.

f. Duct Support Materials: Unless otherwise noted, provide stainless steel materials with finish to match flange rings.

2.09 ACOUSTICAL INSULATION AND JACKETING

A. Insulation for FRP or stainless steel lined duct to be jacketed with special acoustic covering shall be provided in the density recommended by the manufacturer to support the acoustic jacketing with compression limited to 3 percent of the normal thickness. Duct 10 inches and larger may be insulated with "pipe wrap" type insulation meeting all requirements of this Specification, designed for application to round duct.

B. Jacketing: Acoustical jacketing shall be a laminated construction of lead or barium sulfate loaded vinyl bonded to aluminum. The composite shall be corrugated approximately 3/16-inch pitch and shall weigh not less than 1 pound per square foot. The aluminum jacket shall be 0.016-inch thick, minimum.

C. Manufacturer and Product:
   1. Childers Products Company; Muffl-Jac.
   2. "Or-equal."

2.10 HUMIDIFIER

A. Fabricate of same material and criteria as FRP ductwork per Article Fiberglass Reinforced Plastic Ductwork herein, except ASTM D3299 shall apply.

B. Service conditions identical to ductwork per Article Service Conditions herein.

C. Humidifier shall be designed to humidify incoming foul air per criteria as follows:
   1. Air Flow: 26,000 cfm.
   2. Incoming Foul Air Characteristics:
      a. Up to 25 ppmv hydrogen sulfide.
      b. Extremes: 115 degrees F at 50 percent relative humidity (maximum); 35 degrees F at 90 percent relative humidity (minimum).
   3. Performance: Outlet air at near saturated conditions at all temperatures.

D. Configuration: As indicated on Drawings.

E. Appurtenances:

1. Piping (Interior): Stainless steel tubing; ASTM A312, Type 316, seamless, soft annealed, 0.065-inch wall minimum.
    a. Fittings (Compression Type): Stainless steel, ASTM A182 forged bodies or ASTM A276 barstock bodies, Type 316, flareless. Parker Flodar, BA Series; Swagelok tube fittings; "or-equal."
    b. Fittings (Socket Weld Type): Stainless steel, ASTM A182 forged bodies or ASTM A276 barstock bodies, Type 316 for 3,000 psi maximum working pressure, safety factor 4:1. Cajon, Swagelok, "or-equal."
2. Spray Nozzles: As indicated on Drawings.
3. Hardware Material: Refer to Area Classification Table in the General Section of Drawings.

2.11 ORIFICE PLATE ASSEMBLY

A. Orifice plate assembly shall consist of minimum 1/4-inch, Type 316 stainless steel orifice plate sandwiched between two FRP flanges, pressure differential taps, tubing, valves, pressure gauge, and modulating damper. Comply with detail provided on Drawings.

B. Pressure Gauge: Capsuhelic type differential pressure gauge with Cole Parmer gauge guard, reading 0 inch to 1.0 inch WC, with all associated stainless steel sample tubing with valves and connections.

2.12 PORTABLE FLEXIBLE DUCTING

A. Provide double-ply neoprene coated black polyester fabric hose reinforced with spring steel helix and external PVC coated polyester wearstrip.

B. Listed UL 94 V-0 flame retardant.

C. Temperature Range: Minus 40 degrees F to 250 degrees F.

D. Size: Match maintenance air duct size shown on Drawings.

E. Length: Provide 200 lineal feet.

F. End Connections: Provide steel flange with all Type 316 stainless steel hardware, attached to plain cut end of duct, for connecting to flanges provided at DAF deck floor pipes and FRP duct end. Match bolt hole pattern and flange size to ensure proper fit.

G. Manufacturer and Product:
   1. Rubber-Cal Company; Model CWC-W.
   2. "Or-equal."

2.13 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 Jacobs.

C. Notify Jacobs 1 week prior to estimated date of inspection.

D. Repairs authorized by Jacobs shall be reinspected 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.

3.02 FRP DUCTWORK 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. Cut edges to be butt-joined shall be true with a maximum gap of 1/8-inch for bridging of overlay.
   3. Ductwork shall be free of vibration when in operation. Vibration isolation devices shall be provided and installed by Subcontractor.
   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.

8. Unless otherwise indicated on Drawings, slope horizontal ductwork at 1/8-inch per foot in direction of airflow or 1/4-inch per foot in opposite direction of airflow.

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. Made by manufacturer certified installer.

C. Dampers: Unless otherwise necessary for proper operation of damper, axles shall be installed in horizontal position.
   1. Locate backdraft dampers and butterfly dampers to allow full blade movement without obstructions due to adjacent fittings.

D. Buried Applications:
   1. Keep trench dry until pipe laying and joining completed.
   2. Pipe Base and Pipe Zone: As specified in Section 31 23 23.15, Trench Backfill.
   3. Exercise care when lowering pipe into trench to prevent twisting or damage to pipe.
   4. Unless otherwise indicated on Drawings, slope horizontal ductwork at 1/8-inch per foot in direction of airflow or 1/4-inch per foot in opposite direction of airflow.
   5. Prevent foreign material from entering pipe during placement.
   6. Close and block open end of last laid pipe section when placement operations are not in progress and at close of day's work.
   7. After joint has been made, check pipe alignment and grade.
   8. Place sufficient pipe zone material to secure pipe from movement before next joint is installed.
   9. Prevent uplift and floating of pipe prior to backfilling.
   10. Pipe Cover: Minimum 3 feet, unless otherwise shown.

3.03 ACOUSTICAL INSULATION AND JACKETING INSULATION

A. Install to limits indicated on Drawings.

B. Install insulation over clean, dry surfaces with all joints butted firmly together. Subcontractor shall coordinate installation of insulation with testing and balancing requirements under Section 23 05 93, Testing, Adjusting, and Balancing for HVAC. Any damage to insulation and jacketing caused by testing process shall be replaced at Subcontractor's expense. Jacketing shall be installed

over duct where shown. Longitudinal and circumferential joints shall be staggered and overlapped a minimum of 2 inches. Provide joints with silicone sealant per the manufacturer's recommended sealant.

3.04 HUMIDIFIER INSTALLATION

A. Install humidifier vessel and accessories per manufacturer's instructions.

3.05 EXPANSION JOINTS INSTALLATION

A. Install such that flexible molded boot is not concave or otherwise twisted or deformed during normal operating conditions.

3.06 INSTALLATION, FLUOROPOLYMER-COATED DUCTWORK

A. Inspection:
   1. Examine areas and conditions under which coated ductwork is to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.
   2. Prior to assembling, examine components to determine that coatings have not been damaged.
   3. Repair of Scratches: Contact the manufacturer for repair instructions. Coat all scratches, chips, and other damage to the coating with a field-applied coating patch to cover an area 2 inches on each side of the damaged area. Clean and prepare the affected area as described in the manufacturer's instructions. Spare test repairs prior to installation.
   4. Holes and Dents: Replace parts with holes or dents.

B. Installation:
   1. Assemble and install coated stainless steel ductwork using extreme care not to scratch surface of coatings, and in accordance with manufacturer's recommendations and recognized industry practices which will achieve airtight and liquid tight systems.
   2. Do not penetrate the coating for any reason. No fastening devices, such as Tek screws, rivets, etc., are to be used on any part of a coated ductwork application. Test holes and slots for monitoring must be predetermined before fabrication and coating. Discuss air balance options with air balance Subcontractor.
   3. Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal space between construction openings and ductwork with sheet metal flanges of the same material and gauge as the duct. Overlap the opening on all sides by at least 1-1/2 inches.

4. Unless otherwise indicated on Drawings, slope horizontal ductwork at 1/8-inch per foot in direction of airflow or 1/4-inch per foot in opposite direction of airflow.

3.07 FIELD TESTING

A. Field test ductwork after installation and before concealment or burying, with air test as called out in the Piping Schedule as shown on Drawings. Leaks shall be corrected and duct retested until no further leaks appear.

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 and Odor Control.

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

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. 210, Laboratory Methods of Testing Fans for Rating.
      e. 211, Certified Rating Program for Air Moving Devices.
      f. 300, Reverberant Room Method for Sound Testing of Fans.
      g. 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
      h. 330, Laboratory Methods of Testing In-Duct Sound Power Measurement Procedure for Fans.
   3. 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.
   4. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
      a. 52.1, Gravimetric and Dust Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
      b. 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
      c. HVAC Applications Handbook.
   5. ASTM International (ASTM):
      a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
      b. C582, Specification for Reinforced Laminates for Self-Supporting Structures for Use in a Chemical Environment.
      c. D2247, Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity.

d. D2563, Recommended Practice for Classifying Visual Defects in Glass-Reinforced Laminate Parts.
e. D2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
f. D3363, Standard Test Method for Film Hardness by Pencil Test.
g. D4167, Standard Specification for Fiber-Reinforced Plastic Fans and Blowers.
h. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.

6. National Electric Code (NEC).
7. National Electrical Manufacturers Association (NEMA).
8. National Fire Protection Association (NFPA):
   a. 90A, Installation of Air Conditioning and Ventilating Systems.
   b. 820, Fire Protection in Waste Water Treatment and Collection Facilities.
9. National Roofing Contractors Association (NRCA).
10. Occupational Safety and Health Act (OSHA).
11. 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.
12. UL: 507, Electric Fans.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:
   1. AC: Alternating Current.
   2. CISD: Chemical Industry, Severe-Duty.
   3. dB: Decibel.
   4. DWDI: Double Width, Double Inlet.
   5. FRP: Fiberglass Reinforced Plastic.
   6. hp: Horsepower.
   7. ODP: Open Drip Proof.
   8. SWSI: Single Width, Single Inlet.
   9. TEFC: Totally Enclosed, Fan Cooled.
   10. UV: Ultraviolet.
   11. XP: Explosion Proof.

1.03 SUBMITTALS

A. Action Submittals:

1. Provide for all products specified, as follows:
    a. Identification as referenced in Contract Documents.
    b. Manufacturer's name and model number.
    c. Descriptive specifications, literature and drawings.
    d. Dimensions and weights.
    e. Fan sound power level data (reference 10 to power minus 12 Watts) at design operating point.
    f. Fan Curves:
        1) Performance Curves 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, etc.).
            d) Static pressure, capacity, horsepower demand and overall efficiency required at the duty point, including drive losses.
        2) For variable air volume applications, indicate operating points at 100, 80, 60 and 40 percent of design capacity on fan curves including data to indicate effect of capacity control devices such as inlet vanes on flow, pressure and brake horsepower.
    g. Capacities and ratings.
    h. Construction materials.
    i. Fan type, size, class, drive arrangement, discharge, rotation, and bearings.
    j. Wheel type, diameter, revolutions per minute, and tip speed.
    k. Motor data.
    l. Power and control wiring diagrams, including terminals and numbers.
    m. Vibration isolation.
    n. Factory finish system.
    o. Color selection charts where applicable.
    p. Corrosion protection coating product data.
2. Submit anchorage and bracing drawings and cut sheets as required by Section 01 88 15, Anchorage and Bracing.

3. "Or-Equal" Equipment:
    a. Where submitted equipment results in change to fan inlet or outlet ductwork configuration shown on 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.
4. Positive Pressurization Unit: Documentation that media filter modules are UL rated Class 1.

B. Informational Submittals:
1. Submit anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Recommended procedures for protection and handling of products prior to installation.
3. Manufacturer's installation instructions.
4. Manufacturer's Certificate of Compliance in accordance with Section 01 43 33, Manufacturers' Field Services, for premium efficient motors.
5. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
6. Test reports.
7. 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.

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

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

2.02 SPARK RESISTANT CONSTRUCTION

A. Fans required to be spark resistant shall comply with requirements of AMCA 99-0401.

2.03 NAMEPLATES

A. All units shall include factory installed permanently attached nameplate displaying unit model and serial number.

2.04 OPERATING LIMITS

A. Fans designated to meet a specified fan class shall comply with requirements of AMCA 99-2408-69.

2.05 ACOUSTICAL LEVELS

A. Equipment selections shall produce sound power levels no greater than shown in Equipment Schedule.

2.06 FAN DRIVES

A. Furnish multiple drive belts where motor horsepower is 2 hp or larger.

B. Drive assembly shall be sized for a minimum 140 percent of fan motor horsepower rating.

C. Sheaves shall be capable of providing 150 percent of motor horsepower.

D. Fan Shafts: First critical speed of at least 125 percent of fan maximum operating speed.

E. Belts: Oil and heat resistant, nonstatic type.

F. Furnish motors for V-belt drives with adjustable rails or bases.

G. Unless otherwise noted, furnish belt-driven fans with cast iron or flanged steel sheaves.

H. 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.

I. Motors Larger than 20 hp: Fixed-pitch sheaves.

J. 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.

K. Weather Cover: For outdoor applications, factory fabricated drive assembly of same material as fan housing, unless specified otherwise.

L. Belt and Shaft Guards:
   1. Easily removable and to enclose entire drive assembly, meeting federal, OSHA, and State of California requirements.
   2. Guard faces of expanded metal having minimum 60 percent free area for ventilation.
   3. Bright yellow finish.

M. Provide speed test openings at shaft locations.

2.07 FINISHES

A. Carbon Steel Parts: Factory finish 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.

2.08 INLINE FAN, CENTRIFUGAL, SQUARE

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: Minimum 18-gauge galvanized steel.
   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 belt and bearings separated from air steam by enclosure.

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.

E. Accessories:
   1. Gravity Backdraft Damper: Galvanized steel frame, aluminum blades, brass pivot pins, neoprene seals on damper blade edges, gravity operation, and adjustable counterweight.
   2. Motorized Damper (where indicated): Galvanized steel frame, aluminum blades, neoprene seals on damper blade edges, ELECTRIC operator.
   3. Insulated Housing: Fiberglass insulation, 1-inch thick, neoprene coated, on interior of housing.
   4. Inlet Screen: Removable 1-inch mesh screen, aluminum construction, overexposed inlets.
   5. Single Side Discharge (where indicated): Package consisting of side duct connection collar and rear-discharge blank-off panel.

6. Dual Side Discharge: Package consisting of side duct connection collars and rear-discharge blank-off panel.
7. Bearing Lubrication Lines:
    a. Extended to outside of fan housing.
    b. Terminate with zerk fittings.
8. Corrosion Protection Coating:
    a. Provide factory-applied corrosion protection coating on the following:
        1) Wheel.
        2) Housing.
        3) Accessories.
        4) Interior surfaces in contact with airstream.
    b. In accordance with Article Corrosion Protection Coating.
9. Electronically commutated motor (where indicated) with external adjustment where indicated.

F. Manufacturers and Products:
1. Greenheck; Model SQ (Direct), or BSQ (Belt).
2. Loren Cook; Model SQND (Direct), or BSQND (Belt).
3. ACME; Centri-Master Model XD.
4. Twin City Fan (Aerovent); Model ISD.
5. "Or-equal."

2.09 INLINE FAN, TUBULAR CENTRIFUGAL UPBLAST

A. General:
1. Factory-assembled spark resistant tubular centrifugal fan, belt drive; including housing, fan wheel, drive assembly, motor, and accessories.
2. Fan Performance: AMCA 99-2408 Class 1.
3. Bearing AMCA Certified Ratings Seal for sound and air performance.

B. Housings:
1. Material: Steel.
2. Construction:
    a. Heavy-gauge rolled metal casing, with continuous seam welding.
    b. Air straightening vanes at fan outlet, integral with shaft, bearing support, and outer casing, fully welded.
    c. Bearing and drive components isolated from air stream within continuously welded tunnel.
    d. Lifting lugs welded to housing.

e. Mounting brackets, welded to housing, as required for indicated fan arrangement.

3. Bearing Lubrication Lines:
   a. Extended to outside of fan housing.
   b. Type 316 stainless steel construction.
   c. Terminate with zerk fittings.
4. Inlets: Die-formed bell mouth, matched to fan wheel inlet shroud.
5. Motor Base Plate: Minimum of 3/16-inch metal plate, welded to fan housing, to provide belt tensioning and adjustment.
6. Duct Flanges: Angle ring flanges, same diameter as housing, at fan inlet and outlet, heavy construction, factory drilled.

C. Wheel:
1. Material: Aluminum construction.
2. Centrifugal, one-piece, nonoverloading, backwardly inclined blades.
3. Blades continuously welded to inlet shroud and backplate.
4. Attached to fan shaft with split taper lock bushing.

D. Shaft, Bearings, Drive:
1. Shafts:
   a. Turned, ground and polished hot-rolled carbon steel.
   b. Keyed for sheave installation.
   c. Corrosion protection coating.
2. Bearings:
   a. Grease lubricated, precision antifriction ball, self-aligning type.
   b. Mounted in cast iron pillow block housing.
   c. Selected for average life (ABMA 9 L_{10}) of not less than 40,000 hours operation at maximum cataloged operating speed.
   d. Suitable for fan operation in vertical configuration.
3. Drives:
   a. In accordance with Paragraph Fan Drives.
   b. Factory set to the specified fan revolutions per minute.
   c. Type: Belt.
   d. Arrangement: Vertical.

E. Roof Mount Accessories:
1. Motor and Drive Cover:
   a. Factory fabricated; OSHA type.

b. Sheet metal construction, same material as fan housing.
c. Vented, openings sufficient size for proper motor cooling.

2. Stack Cap:
   a. Factory fabricated.
   b. Same material as fan housing.
   c. Integral backdraft dampers.
3. Curb Base:
   a. Factory fabricated.
   b. Sized to adapt fan inlet to roof curb.
   c. Same material as fan housing.

F. Accessories:
1. Provide as follows:
   a. Roof Curb:
      1) Factory fabricated.
      2) Sloped to match roof pitch and to provide level top.
      3) Height Above Finished Roof: 12 inches.
      4) Galvanized steel construction.
      5) Mitered continuous welded corner seams.
      6) Pressure-treated wood nailer.
      7) Insulation: Minimum 1-1/2 inches thick, 3 pounds per cubic foot density, rigid mineral fiberboard insulation with metal liner.
   b. Housing Access Doors: Bolted and gasketed.
   c. Motor and Drive Cover:
      1) Factory fabricated; OSHA type.
      2) Sheet metal construction, same material as fan housing.
      3) Vented, openings sufficient size for proper motor cooling.
   d. Belt Guard: Sheet metal construction, OSHA type.
   e. Inlet Vanes: Variable position, for manual or automatic operation.
   f. Housing Access Doors: Bolted and gasketed.
   g. Shaft Seal: Labyrinth type.
   h. Outlet Screen: Metal, spiral wire type, OSHA approved, removable.
   i. Support Base: Welded metal, for standard platform or floor mounting.
   j. Spark Resistant Construction: AMCA 99-0401 Type B.

k. Corrosion Protection Coating:

1) Provide factory-applied corrosion protection coating on these fan components:
   a) Wheel.
   b) Housing.
   c) Accessories.
   d) Interior surfaces in contact with airstream.

2) In accordance with Article Corrosion Protection Coating.

G. Manufacturers and Products:

1. Aerovent; Model CBD.
2. Cook; Model TCNH-B.
3. Greenheck; Model TCB.

2.10 ROOF FAN, LOUVERED CENTRIFUGAL, FILTERED SUPPLY

A. General:

1. Factory-assembled roof mounted supply air fan; including housing, louvered penthouse, filters, centrifugal fan wheel, drive assembly, motor, and accessories.
2. Bearing AMCA Certified Ratings Seal for sound and air performance.

B. Penthouse:

1. Aluminum construction with extruded aluminum louvers.
2. Louvers and filters on four sides.
3. Sized to allow no more than 500 fpm air intake face velocity.
4. Insulation: Fiberglass, 1-inch thickness, attached to underside of top.

C. Filters and Frames:

1. Metal Mesh Type:
   a. Washable, 4-mesh stainless steel screen media.
   b. Thickness: 2 inches.
   c. Minimum 25 percent dust spot efficiency in accordance with ASHRAE 52.2, or as indicated.
   d. Aluminum holding frame, retainer, and sealer frame.
   e. To allow removal of filters without removal of hood.

D. Wheel:

1. Centrifugal forward curved galvanized steel.
2. Factory corrosion coating.

3. Belt driven motor mounted on vibration isolation.
4. Drive in accordance with Paragraph Fan Drives.

E. Accessories:
1. Provide:
a. Bird Screens: Aluminum construction.
b. Roof Curb:
1) Factory fabricated, aluminum construction.
2) Sloped to match roof pitch, and to provide level top.
3) Height Above Finished Roof: 12 inches.
4) Mitered continuous welded corner seams.
5) Pressure-treated wood nailer.
6) Insulation: Minimum 1-1/2 inches thick, 3 pounds per cubic foot density, rigid mineral fiberboard insulation with metal liner.
c. Bearing Lubrication Lines:
1) Extended to outside of fan housing.
2) Type 316 stainless steel construction.
3) Terminate with zerk fittings.
d. Corrosion Protection Coating:
1) Provide factory-applied corrosion protection coating on these fan components:
a) Wheel.
b) Housing.
c) Accessories.
d) Interior surfaces in contact with airstream.
2) Shall be in accordance with Article Corrosion Protection Coating.

F. Manufacturers:
1. Greenheck RSFP.
2. Loren Cook.
3. Ruskin.

2.11 ROOF FAN, CENTRIFUGAL UPBLAST

A. General:
1. Factory-assembled centrifugal upblast roof fan; including housing, fan wheel, drive assembly, motor, and accessories.
2. Bearing AMCA Certified Ratings Seal for sound and air performance.

B. Housing:
   1. Construction: Spun-formed aluminum, minimum 16-gauge marine alloy.
   2. Windband: Finish with rolled bead.
   3. Top Cap: Motor access via quick release latches.
   4. Motor completely sealed from exhaust air stream.
   5. Motor cooling via air breather tubes.
   6. Integral conduit chase for wiring.
   7. Drain trough at lowest point of housing.
   8. Fan Inlet:
      a. Full inlet cone of aluminum construction.
      b. Match inlet shroud.

C. Wheel:
   1. Aluminum construction, backward inclined centrifugal, nonoverloading type.
   2. Machined, cast aluminum hub.
   3. Matched to deep spun inlet venturi.

D. Shaft, Bearings, Drive:
   1. Shaft:
      a. Turned, ground, and polished carbon steel.
      b. Keyed for sheave installation.
      c. Zinc-phosphate coated and oil emulsion-dipped.
   2. Bearings:
      a. Grease lubricated, precision antifriction ball, self-aligning, pillow block style.
      b. Selected for average life (ABMA 9 L_{10}) of not less than 40,000 hours operation at maximum cataloged operating speed.
      c. Terminate with zerk fittings.
   3. Drives:
      a. In accordance with Paragraph Fan Drives.
      b. Factory set to specified fan revolutions per minute.
      c. Type: Belt.

E. Accessories:
   1. Roof Curb:
      a. Factory fabricated.
      b. Sloped to match roof pitch, and to provide level top.

c. Height Above Finished Roof: 12 inches.
d. Mitered continuous welded corner seams.
e. Pressure-treated wood nailer.
f. Insulation: Minimum 1-1/2 inches thick, 3 pounds per cubic foot density, rigid mineral fiberboard insulation with metal liner.

2. Bearing Lubrication Lines:
a. Extended to outside of fan housing.
b. Type 316 stainless steel construction.
c. Terminate with zerk fittings.

3. Corrosion Protection Coating:
a. Provide factory-applied corrosion protection coating on these fan components:
1) Wheel.
2) Housing.
3) Accessories.
4) Interior surfaces in contact with airstream.
b. Coating system shall in accordance with Article Corrosion Protection Coating.

F. Manufacturers and Products:
1. Aerovent: Model ATB.
2. Cook; Model ACRUD (Direct Drive); ACRUB (Belt Drive).
3. Greenheck; Model CUE (Direct Drive); CUBE (Belt Drive).
4. ACME, Model PDU (Direct Drive); PNU (Belt Drive).
5. Twin City Fan; BCRU.

2.12 POSITIVE PRESSURIZATION UNIT

A. General:
1. Positive air pressurization unit, designed for the removal of both organic and inorganic contaminants from ambient outside and recirculated air, and for building pressurization with clean air.
2. Indoor mounted, free standing, vertical configuration, draw-through, packaged unit consisting of fan, motor and drive assembly, variable frequency motor controller, particulate and chemical scrubbing filters.
3. Arranged for horizontal or vertical airflow and shall deliver designed combined airflow (pressurization air plus recirculation air).

B. Unit Cabinet:
   1. Heavy gauge galvanized steel sheets, seam welded. Phosphatized and factory finished in manufacturer's standard enamel paint.
   2. Gasketed front access door(s) for servicing components.
      a. Latches: Positive locking action.
      b. Seals:
         1) Attached by mechanical means and designed for replacement.
         2) Glued in conjunction with mechanical attachment.
   3. Housing with base support.
   4. Hinges and Draw Latches: Constructed of Type 316 stainless steel.
   5. Nameplate:
      a. Type 316 stainless steel permanently attached to unit.
      b. Engraved with scrubber type, order number, and serial number.
   6. Manually controlled damper located at outside air intake for optimization of pressurization air.
   7. Return and discharge openings shall include grilles with four-way deflection louvers.

C. Blower Fan:
   1. Located in housing between second and third stages of air cleaning.
   2. Backward curved, centrifugal, glass-reinforced polyamine (GRP) wheel.
   3. Drives Type: Direct.
   4. Fan Motor:
      a. Totally enclosed and permanently lubricated with inherent protection.
      b. Variable frequency drive integral to unit.

D. Prefilter:
   1. Filters UL 900 listed and labeled.
   2. Disposable 1-inch thick strainer type with pleated nonwoven fabric media.
   3. Efficiency: 20 percent to 25 percent efficient.
   4. Maximum filter face velocity across filters when in service: 500 fpm.
   5. Clean filter resistance shall not exceed 0.20-inch WC based on a face velocity of 500 feet per minute.

E. Chemical Scrubbing Filters:
   1. Housing shall contain two chemical media sections, designed to accommodate 12-inch modular media containment devices.
   2. Dimensions: 24-inch-wide by 12-inch-high by 12-inch-deep, in direction of airflow.

3. Medium Bed Depth: Minimum of 3 inches.
4. Completely recyclable or disposable.
5. Constructed of 0.125-inch thick, black, high-impact polystyrene.
6. Module shall be factory filled with selected chemical media.
7. Pressure drop through each chemical media section shall not exceed 1.3-inch WC, at 250 fpm face velocity.
8. Maximum filter face velocity through chemical media section when in service: 250 fpm.
9. Residence time through chemical media section shall not be less than 0.24 second total; 0.12 second per media bed in direction of airflow.
10. Media Filter Modules: Filters UL 900 listed and labeled.
11. Media:
    a. High removal capacity for sewerage gases, including hydrogen sulfide, aldehydes, and sulfur dioxide.
    b. Composition: Manufactured, generally spherical, porous pellets. Pellets shall be formed from a combination of activated alumina and other binders, suitably impregnated with potassium permanganate.
    c. Potassium Permanganate Content: 8 percent minimum. To be applied during pellet formation, such that impregnant is uniformly distributed throughout pellet volume.
    d. Landfill disposable.
    e. UL Classified Class 1.
    f. New and spent media shall be nontoxic.
    g. Will not support bacterial or fungal growth.
    h. Removal Capacity:
        1) Hydrogen Sulfide: 18 percent minimum by weight.
        2) Sulfur Dioxide: 7 percent minimum by weight.
    i. Operating Conditions:
        1) Temperature: Minus 4 degrees F to 125 degrees F.
        2) Humidity: 10 percent to 95 percent relative humidity.
    j. Products: Purafil ESD Odoroxidant.

F. Final Filter:
1. Filters UL 900 listed and labeled.
2. Disposable 5-inch thick cartridge type with pleated nonwoven fabric media.
3. Efficiency: 85 percent to 90 percent efficient.
4. Maximum filter face velocity across filters when in service: 500 fpm.

5. Clean filter resistance shall not exceed 0.30-inch WC based on face velocity of 500 feet per minute.

G. Controls:
1. Meet requirements of Section 40 99 90, Package Control Systems.
2. Continuous fan operation.
3. Fan speed control by built-in variable frequency drive (VFD).
4. Airflow monitoring station, for feedback to VFD.

H. Manufacturer and Product: Purafil; Positive Pressurization Unit.

2.13 CORROSION PROTECTION COATING

A. General:
1. Factory-applied corrosion protection coating for application to fan components and accessories, where required by this section.
2. Quality Control:
a. Verify dry film thickness before final baking.
b. Finished coating system shall be free from voids, checks, cracks and blisters.
3. Surface Cleaning:
a. Clean parts to be coated as follows:
1) Immerse parts in heated cleaning solution to remove lubricants, machining oils, and residual factory contamination.
2) Follow with immersion in potable water bath to neutralize and remove cleaning solution.
3) Chemical Pretreatment: Immerse parts in heated chemical solution, iron phosphate for steel, clear/yellow chromate for aluminum.

B. Baked Polyester:
1. Material: Polyester-Urethane, equal to Greenheck Hi-Pro Polyester.
2. Surface Preparation: Sandblast surface to SSPC-SP 5.
3. Application: Electrostatic spray.
4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
5. Finished Thickness: 1.5-mil to 2.5-mil dry film thickness.
6. Performance:
a. Coating shall meet or exceed following criteria:
1) Salt Spray Test: Minimum 2,000-hour duration, ASTM B117 test method.

2) Humidity Resistance: Minimum 2,000-hour duration, ASTM D2247 test method.
3) Impact Resistance: 100 inch pounds, ASTM D2794 test method.
4) Pencil Hardness: 2H, ASTM D3363 test method.
5) Service Temperature: Maximum 230 degrees F, continuous.

2.14 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.

2.15 ACCESSORIES

A. Equipment Identification Plates: Furnish 16-gauge stainless steel identification plate securely mounted on each separate equipment. Plate shall bear 1/4-inch high engraved block type black enamel filled equipment identification number indicated on Drawings.

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

2.16 SOURCE QUALITY CONTROL

A. General:
   1. Fan shall operate at single stable point as indicated by fan curve. Fans having two potential operating points are not acceptable.
   2. Fan and motor combination shall be capable of delivering 110 percent of scheduled air quantity and static pressure. Motor shall not operate into motor service factor in any listed case.
   3. Consider drive efficiency in motor selection according to manufacturer's published recommendation or according to AMCA 203, Appendix L.

B. Testing Provisions:
   1. Provide tachometer access holes large enough to accept standard tachometer drive shaft.
   2. Center punch fan shaft to accommodate tachometer readings.

C. Acoustical Levels:
   1. Perform noise tests in accordance with AMCA 300 and AMCA 301.
   2. Fan sound power levels (dB, Reference 10^{-12} Watts) shall be no greater than scheduled values.

D. Balancing:
   1. Unless noted otherwise, each fan wheel shall be statically and dynamically balanced to ASA S2.19 Grade G6.3.
   2. Fans controlled by variable frequency drives shall be dynamically balanced at speeds 25 percent, 50 percent, 75 percent, and 100 percent of design revolutions per minute.

E. Vibration Test:
   1. Each fan furnished with a 5-hp or larger motor shall have factory run vibration test, including vibration signatures taken on each bearing in horizontal, vertical, and axial direction.
   2. Vibration reading as measured at scheduled rotational speed shall not exceed the following values when fan is rigidly mounted:
      a. Belt Drive (except Vane Axial): 0.15 inch per second peak velocity.
      b. Belt Drive Vane Axial: 0.08 inch per second peak velocity.
      c. Direct Drive: 0.08 inch per second peak velocity.
   3. Written records of run test and vibration test shall be made available upon request.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install fans level and plumb.

B. Secure roof-mounted fans to roof curbs with Type 316 stainless steel hardware.

C. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

D. Scroll Drains: Pipe drain connection through running trap to floor drain.

E. Labeling:
   1. Label fans in accordance with Article Accessories.
   2. Mark exhaust fans serving fume hoods with arrows to indicate proper direction of rotation, in accordance with NFPA 45.

F. Service Access: Locate units to provide access spaces required for motor, drive, bearing servicing, and fan shaft removal.

G. Equipment Support and Restraints:
   1. Refer to Section 01 88 15, Anchorage and Bracing.
   2. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.
   3. Seismic Restraint Snubbers: Install with sufficient clearance so unit isolators are not restricted for proper free isolation, but do limit movement in all directions.

H. Connections:
   1. Refer to Section 23 31 13, Metal Ducts and Accessories
   2. Isolate duct connections to fans.
   3. Install ductwork adjacent to fans to allow proper service and maintenance.

3.02 FIELD QUALITY CONTROL

A. Functional Tests:
   1. Verify blocking and bracing used during shipping are removed.
   2. Verify fan is secure on mountings and supporting devices, and connections to ducts and electrical components are complete.
   3. Verify proper thermal-overload protection is installed in motors, starters, and disconnect switches.
   4. Verify that cleaning and adjusting are complete.

5. Disconnect fan drive from motor; verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation.
6. Reconnect fan drive system; align and adjust belts and install belt guards.
7. Verify lubrication for bearings and other moving parts.
8. Verify manual and automatic volume control and fire and smoke dampers in connected ductwork are in fully open position.

B. Performance Tests:
1. Starting Procedures:
a. Energize motor and adjust fan to indicated revolutions per minute.
b. Measure and record motor voltage and amperage.
2. Operational Test:
a. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
b. Repair or replace malfunctioning units; retest as specified after repairs or replacement is made.
c. Test and adjust control safeties.
d. Replace damaged and malfunctioning controls and equipment.

3.03 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.

3.04 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

SECTION 23 37 00
AIR OUTLETS AND INLETS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 880, Air Terminals.
   2. ASTM International (ASTM): C636/C636M, Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels.
   3. UL.

1.02 DEFINITIONS

A. NC: Noise Criteria; background sound rating method for indoor sound.

B. VAV: Variable air volume.

C. WC: Water column.

1.03 SUBMITTALS

A. Action Submittals:
   1. Shop Drawings:
      a. Manufacturer's data and descriptive literature.
      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 CEILING DIFFUSERS

A. Premium Louvered Face Diffusers (CD1):
   1. Construction:
      a. Material: Welded aluminum.
      b. Finish: Baked white enamel. Flat black interior.

c. Neck: Round or rectangular as indicated.

2. Removable core section of louvers.
3. For hard ceilings, provide Type 1 surface mount border, size as required for indicated neck size. For T-bar type suspended ceilings, provide Type 3 lay-in border to match ceiling module size, typically 24-inch square.
4. Continuous sponge rubber gasket at face flange.
5. Performance:
   a. Distribution Pattern: Four-way unless shown otherwise.
   b. Maximum Pressure Drop: 0.1 inch WC.
   c. Sound: Maximum NC 30.
6. Manufacturers and Products:
   a. Krueger; Model 5SHR (aluminum).
   b. Carnes; Type SE (aluminum).
   c. Titus; Model TDCA-AA (aluminum).

2.02 SUPPLY GRILLES AND REGISTERS

A. Supply Grilles and Registers (SG1):
   1. Construction
   2. Material: Aluminum.
   3. Finish: Baked white enamel.
   4. Accessories:
      a. Gang-operated opposed-blade volume control damper.
      b. Material to match grille.
   5. Adjustable front horizontal and rear vertical vanes on 3/4-inch centers.
   6. Continuous sponge rubber gasket at face flange.
   7. 1-inch minimum flat rectangular frame.
   8. Manufacturers and Products:
      a. Krueger; 880/5880 Series.
      b. Titus; 300 Series.

2.03 RETURN, EXHAUST AND TRANSFER GRILLES AND REGISTERS

A. Louvered Return, Exhaust and Transfer Grilles and Registers (RG1, EG1, TG1):
   1. Construction:
      a. Material: Aluminum.
      b. Finish: Baked white enamel.

c. Accessories:
   1) RG1, EG1: Gang-operated opposed-blade volume control damper if no damper in branch duct material to match grille.
   2) TG-1: No volume damper required.

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.
   d. Krueger; Model 6500 Series.
   e. Carnes; Type SLRB (aluminum).

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to architectural reflected ceiling plans for coordination of locations of ceiling-mounted air outlets and inlets with ceiling grids and lighting. Where locations of devices shown on mechanical drawings do not agree with locations that are shown on architectural reflected ceiling plans, reflected ceiling plans shall take precedence. If air outlets or inlets are shown on mechanical drawings, but are not shown on architectural reflected ceiling plans, devices shall be located as near as possible to locations shown on mechanical drawings when coordinating with ceiling.

B. Install diffusers, grilles, and registers tight on their respective mounting surfaces, level, plumb, and true with room dimensions.

C. Provide appropriate frame to adapt to mounting surface. Provide a 24-inch by 24-inch lay-in ceiling module for diffusers, registers, and grilles in lay-in ceilings.

D. Support air inlets and outlets where installed in metal suspension systems for acoustical tile and lay-in panel ceilings as specified in ASTM C636/C636M.

END OF SECTION

SECTION 23 77 00
AIR HANDLING UNITS

PART 1 GENERAL

1.01 SUMMARY

A. Covers custom fabricated indirect evaporative cooling variable volume air handling units for Electrical room cooling.

1.02 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. 52.1, Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
      b. 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
      c. 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. 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).

7. International Standards Organization (ISO): 9001, Quality Management Systems – Requirements.
8. National Electrical Manufacturers Association (NEMA).
9. 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.
10. Occupational Safety and Health Act (OSHA).
11. 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.
12. 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.

1.03 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. CISD: Chemical Industry, Severe-Duty.
   6. dB: Decibel.
   7. DX: Direct Expansion.
   8. DWDI: Double Width, Double Inlet.
   9. ETL: ETL Testing Laboratories, Inc.
   10. FM: Factory Mutual Insurance.
   11. fpm: feet per minute.
   12. hp: Horsepower.
   13. IAQ: Indoor Air Quality.
   14. IEC: International Electro-technical Commission.
   15. IRI: Industrial Risk Insurance.
   16. MAU: Make-Up Air Unit.
   17. NRC: Noise Reduction Coefficient.
   18. OD: Outside Diameter.

19. ODP: Open Drip Proof.
20. O&M: Operations and Maintenance.
21. psi: pounds per square inch.
22. PVC: Polyvinyl Chloride.
23. rpm: revolutions per minute.
24. SWSI: Single Width, Single Inlet.
25. TEFC: Totally Enclosed, Fan Cooled.
26. UV: Ultraviolet.
27. VFD: Variable Frequency Drive.
28. WC: Water Column.
29. XP: Explosion Proof.

1.04 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:
         1) 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.
         2) Additional requirements (including by others) to achieve specified sound performance levels.
      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.
         4) Indicate operating points at 100, 80, 60, and 40 percent of design capacity on fan curves including data to indicate effect of capacity control devices such as inlet vanes on flow, pressure and brake horsepower.

g. Coils:
   1) Type, quantity, dimensions, material of construction, coatings, if applicable, energy transfer capacity, air pressure drop, air inlet, and discharge temperature at design conditions.
   2) Evaporative Coolers: Media air pressure drop at design conditions, make-up water consumption, air discharge temperature and humidity at design conditions, piping connection data.
   3) Drain pan details.
   4) Coil pull details and dimensions for service.
h. Motor(s) type, quantity, and performance data.
i. Air filter(s) type, quantity, and performance data.
j. Unit capacities and ratings, including airflow and static pressure summary.
k. Construction materials.
l. Power and control wiring diagrams, including terminals and numbers.
m. Vibration Isolation:
   1) Vibration isolation methods with maximum deflection data.
   2) Additional requirements (including by others) to achieve specified vibration isolation levels.
n. Factory finish system, with color selection charts where applicable.
o. Corrosion protection coating product data.
p. Submit anchorage and bracing drawings and data sheets as required by Section 01 88 15, Anchorage and Bracing.

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. Submit anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
   2. Manufacturer's Certificate of Compliance in accordance with Section 01 43 33, Manufacturers' Field Services.
   3. Sample copy of guarantee.
   4. Manufacturer's Test Reports for the following:
      a. Acoustical tests.

b. Evaporative Cooler.

5. Recommended procedures for protection and handling of products prior to installation.
6. Manufacturer's installation instructions, including component spacing requirements.
7. Operation and Maintenance Data:
   a. In conformance with Section 01 78 23, Operation and Maintenance Data.
   b. Include as-built version of equipment schedules.
   c. Methods for accessing components for maintenance with required service clearances.
8. Manufacturers certificate of installation.

1.05 QUALITY ASSURANCE

A. Fans: Licensed to bear AMCA seal for air flow and sound performance.

B. Manufacturer's Qualifications:
   1. The air handling 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/Jacobs' 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.

D. Acoustical 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).

1.06 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.

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Refer to Drawings and Details for construction requirements.

2.02 OPERATING LIMITS

A. Fans designated to meet a specified Fan Class shall comply with requirements of AMCA 99-2408.

2.03 ACOUSTICAL LEVELS

A. Equipment selections shall produce sound power levels no greater than shown in fan equipment schedule.

B. Units shall be heavy, rigid construction with sound deadening materials to impede break-out.

2.04 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.

2.05 AIR HANDLING UNITS—14AHU9800-01, 14AHU9800-02—INDIRECT EVAPORATIVE COOLING

A. General:
   1. Custom or semi-custom air handling unit, constructed by assembly of factory-fabricated components such as fan units, motor and drive assembly, dampers, plenums, filters, condensate pans, 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.
   5. Controls shall be coordinated between equipment vendor and HVAC controls contractor for a complete and functioning unit.

B. Unit Casing:
   1. General:
      a. Fully enclosed housing, with casing consisting of sheet metal side, floor and roof panels.
      b. Lifting lugs and unit support frames, factory installed, to facilitate installation.
      c. All casing insulated, formed and reinforced sheet metal panels; flat panel design not acceptable.
      d. Weathertight and rated for outdoor use.
      e. Cross broken and sloped roof cap system.
      f. Drip shield/overhang provided on all four sides of unit.
      g. Caulked/sealed standing top seams to assure waterproofing.
   2. Material: Panels, and structural metal frame members G-90 galvanized steel, fasteners shall be corrosion resistant.
   3. Outer Panels: Minimum 18-gauge thickness sheet metal.
   4. Inner Panels:
      a. Wet Areas: Minimum 22-gauge thickness Type 304 stainless steel.
      b. Dry Areas: Minimum 20-gauge thickness galvanized.
      c. Floor Plate: Minimum 14-gauge thickness sheet metal.
   5. Insulation:
      a. Insulation fully encased between outside and inside panels.
      b. Minimum 2-inch thickness, minimum 1.5-pounds per cubic foot density.
   6. Access Doors:
      a. Heavy-gauge, oversized access doors insulated, double wall construction, internal sheet metal skin.
      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 sides of each unit as indicated.
      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.
      f. Tool operated safety latch fan section access doors in compliance with Title 8 CAL-OSHA, ETL, and the mechanical protection requirements of UL 1995.

C. Sump:
   1. Location: Under evaporative cooler.
   2. IAQ style, complying with requirements of ASHRAE 62.
   3. Formed sections of minimum 16-gauge stainless steel.
   4. Triple pitched for complete drainage.
   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. 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. Fan Performance: AMCA 99-2408 class rating corresponding to the static pressure at which the fan is designed to operate.
      d. Fan Assemblies: Statically and dynamically balanced, designed for continuous operation at maximum rated fan speed and motor horsepower.
   2. Fan Wheel:
      a. Centrifugal, one-piece, airfoil blade type, Class II or better construction.
      b. Attached to fan shaft with split taper lock bushing.
   3. Fan Shaft, Bearings, Drive:
      a. Shafts:
         1) Turned, ground, and polished Type 304 stainless 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) Arrangement 4, SWSI plug fan.

2) Impeller overhung on and supported by motor shaft. No bearings on fan. Motor mounted on base.

4. Internal Vibration Isolation:

a. Fan/Motor Base: Internally spring isolated with flex connections and minimum 1-inch deflection.

b. Isolators shall be Amber/Booth seismically restrained, SWSR type or equal.

c. Spring isolators shall be certified for California seismic level 4 applications.

d. Flexible Connectors: Install flexible neoprene coated canvas ducts between fan and unit casing.

5. Accessories:

a. Extended Lubrication Lines: For any bearing requiring lubrication, grease lines shall be extended to exterior of unit casing.

b. Plenum Fan Guard Screen: Plenum-type fan section shall be provided with an expanded-metal guard screen for access door.

F. Indirect Evaporative Cooling Section:

1. General:

a. Self-contained indirect evaporative cooling section consisting of housing with sump, sides and top, rigid cooling media with support channel, water distribution system, make-up water, drain and overflow fittings and accessories.

b. Casing constructed in accordance with Article Unit Casing.

c. Metal in wet section shall be Type 304 stainless steel.

2. Housing:

a. Outer housing consisting of a sump, sides and top.

b. Construction as for unit casing, in accordance with Article Unit Casing.

c. Access Panel:

1) Access to and adjustment of float valve assembly.

2) Access to and adjustment of balancing valve to control water flow to header pipe.

3) Cooling media access and removal.

3. Sump:

a. Type 304 stainless steel construction, with fusion welded corners and joints.

b. Leak proof without use of fillers, sealants or coatings.

c. Media support channel to extend across full width of media.

d. Channel shall provide a minimum of 50 percent open area for water to flow freely from media into sump.

e. Air bypass inhibitor plate from bottom of media, extending into water to preclude any untreated air flow under media.

4. Internal Plumbing:

a. Piping Material: PVC Schedule 80.

b. A balancing valve provided in riser pipe between the source and header to regulate water flow over the media.

c. Header pipe with spray nozzles sized to assure proper water flow over media.

d. Brass spray nozzles.

e. Stainless steel deflector to redirect water from header pipe back onto media, evenly across full width.

f. PVC union in riser pipe below header to facilitate removal of header pipe.

g. Stainless steel couplers with female pipe thread welded into the sump and side to provide for make-up water, overflow and drain.

5. Water Distribution:

a. Pump Type: Recirculating system with float valve type make-up water assembly.

b. Pump Duty:

1) Water Flow Rate: At least three times the unit evaporation rate.

2) Sized to deliver water flow rate at required head and pressure.

c. Pump Construction:

1) Glass-filled thermoplastic or polypropylene construction with cast bronze or polypropylene impeller and shaft.

2) With inlet strainer and pressure gauge.

d. Blow-Down System: Sump flushing type. Shall automatically drain and flush sump after a fixed operating time period. See sequence of operation and schematics.

e. Bleed System: Adjustable manual bleed for when pump is in operation.

6. Cooling Media:

a. UV and corrosion resistant.

b. Media access and removal accomplished through a removable side or top panel or removable rails.

7. Electrical/Controls: Electrical/control components housed in Unit Main Control Panel mounted on the outside of the unit.

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 sides of unit.

H. Filters:
1. General:
a. Air filtration section, complete with filter media and stainless steel filter racks with intermediate supports.
b. Casing constructed in accordance with Article Unit Casing.
c. Double wall, hinged, removable access doors.
d. Maximum 400 fpm face velocity across filters.
2. Frame and Filter Assembly:
a. Suitable for space indicated.
b. Each holding frame shall be formed with an integral sealing flange along all four sides to provide a mating surface for the front of the filter unit.
c. Sealing gasket attached to the holding frame sealing flange shall be provided to assure an airtight seal between holding frame and filter.
d. Each filter shall be pressure clamped to a holding frame with removable fasteners in such a manner that the filter can be removed and replaced without disturbing the adjoining filters and frames.
e. Filter blank-offs to prevent air bypass around filters, same material as frame.
f. Side-access cabinet type enclosures shall be provided.
3. Accessories:
a. Filter Pressure Gauge:
1) Each Filter bank shall be furnished with Magnehelic filter gage (Dwyer Series 2000).
2) With adjustable signal flag.
4. Manufacturers:
a. Farr.
b. Flanders.
c. Tri-Dim.
d. American Air Filter.
e. “Or-equal.”

I. Isolation Dampers:
1. Internally mounted ultra-low leak dampers at inlet and outlet of each unit.
2. Construction:
a. Extruded aluminum blades.
b. Galvanized steel frame, U-shaped galvanized metal 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.

3. 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.

4. Damper actuators shall factory installed and tested.

J. Unit Electrical and Controls:

1. General:

a. See Section 23 09 00, Instrumentation and Control Devices for HVAC, and supplement Section 23 09 00.01, HVAC Control Devices for HVAC, and Section 23 09 13, HVAC Controls, Field Components, and Instruments, for equipment vendor and controls, Contractor provided controls, and controls sequences.

b. All electrical and control components shall meet requirements of Division 26, Electrical.

c. Electrical and controls components and assemblies UL or ETL listed and labeled.

d. Factory wired units shall bear an ETL or UL label with necessary identification marks, electrical data, and cautions, as required by NEC.

e. 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.

f. Provide permanent labels on wiring and controls conforming to the tagging conventions shown on Drawings, disconnects, VFDs, instrumentation.

2. Main Power Connection: Provide single point power connection to unit, serving both primary unit voltage and unit control voltage.

3. Main Control Panel:

a. Provide unit main control panel, with electrical and control components housed in a single enclosure, integral to unit.

b. NEMA Type 4X enclosure.

c. Recessed enclosure, exterior flush with unit cabinet, located on unit end.

d. Compartment ventilated with supply air from unit to provide adequate cooling of components mounted within.

e. Adequate spare space for field installation of additional electrical and control components.

f. Access Doors:

1) Heavy-gauge, insulated, double wall construction, internal sheet metal skin.

2) Sized and located to provide easy access to unit internal components.

3) Hinged, latched, and gasketed to provide a weatherproof seal.

4. Factory Installed Motor Starters:
   a. Provide for each constant speed motor.
   b. Magnetic type, combination starter/disconnect, for fan motor control.
   c. NEMA Type 4x enclosure.
   d. Factory installed in unit Main Control Panel.
   e. Factory wired to motor terminal box.
   f. Comply with requirements of Section 26 24 19, Low-Voltage Motor Control.
5. Factory Installed Adjustable Frequency Drives:
   a. Provide for each motor indicated to be controlled by AFD.
   b. Factory installed in unit Main Control Panel.
   c. Factory wired to motor terminal box.
   d. NEMA Type 4X enclosure.
   e. Comply with requirements of Section 26 29 23, Low-Voltage Variable Frequency Drive System.
6. Factory Installed Disconnects:
   a. Provide main electric power disconnect for unit.
   b. Provide electric power disconnect for each section containing electrical components.
   c. NEMA Type 4X enclosure.
   d. Nonfused type.
   e. Factory installed on outside of unit cabinet, and factory wired to electrical component terminals.
7. Lighting:
   a. Vapor proof Marine light in each section.
   b. Factory installed and wired.
   c. Wired to a junction box, with separate on/off switch for each light, mounted on outside of unit, adjacent to unit access door.
8. Integral Motor Control System:
   a. Provide a complete system of motor control for unit motors, including but not limited to:
      1) Terminal blocks.
      2) Motor contactors.
      3) Motor overload protection.
      4) Grounding lugs.
      5) Control transformers.
      6) Auxiliary contactors and terminals for connection of external control devices or relays.
   b. Components located in unit Main Control Panel.

K. Accessories:
   1. Corrosion Protection Coating:
      a. Provide factory applied corrosion protection coating on these unit components:
         1) Fan wheel (or propeller).
         2) Fan housing.
         3) Fan accessories.
         4) Interior surfaces in contact with air stream.
         5) Exterior cabinet.
      b. Coating systems for dry metallic components exposed to ambient air may be factory standard but shall meet Salt Spray Test minimum 3,000-hour duration or better per ASTM B117 test method.
      c. Coating systems for wetted metallic components shall meet Salt Spray Test minimum 4,000-hour duration or better per ASTM B117 test method.
      d. Nonmetallic components exposed to sunlight shall be UV resistant or have UV resistant coating.

L. Manufacturers:
   1. Energy Labs.
   2. United Metal Products.
   3. Air20.
   4. Engineered Air.
   5. “Or-equal.”

2.06 MOTORS

A. General:
   1. Fan motors shall comply with provisions of Section 26 20 00, Low-Voltage AC Induction Motors.
   2. Motors for fans specified for use with variable frequency drives shall be inverter duty type.
   3. 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.

2.07 ACCESSORIES

A. Equipment Identification Plates: Furnish 16-gauge stainless steel engraved.

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

2.08 SOURCE QUALITY CONTROL

A. Testing Provisions:
   1. Provide tachometer access holes large enough to accept standard tachometer drive shaft.
   2. Center punch fan shaft to accommodate tachometer readings.

B. Manufacturer's Tests:
   1. Water Coil Test: No leaks when tested underwater with 200 psi air.
   2. Electrical Circuits:
      a. Tested and checked as to proper function.
      b. Perform dielectric strength test.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install units level and plumb.

B. For roof curbs, see Section 07 70 01, Roof Specialties and Accessories.

C. Secure vibration and seismic controls to bases using Type 316 stainless steel bolts.

D. Inspect internal casing insulation, seal all exposed edges, and butt joints with mastic to ensure insulation will not be loosened during operation.

E. All condensate drain connections piped and trapped separately for proper drainage.

F. Labeling: In accordance with Article Accessories.

G. Service Access: Locate units to provide access spaces required for filter changing; motor, drive, and bearing servicing; and fan shaft and coil removal.

H. Equipment Restraints:
   1. Restrain equipment against seismic forces as required by Section 01 88 15, Anchorage and Bracing.

2. Restrain equipment against wind loads as required by California Building Code.
3. Refer to Section 01 88 15, Anchorage and Bracing.
4. 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.

I. 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. Lubricate nonsealed bearings prior to startup.

C. 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.

D. Vibration Testing:
   1. Perform field testing on rotating equipment, where specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC, to determine actual operating vibration.
   2. If vibration limits described therein are exceeded, rebalance equipment in-place until design tolerances are met.

3.04 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. 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 City's personnel for specified component, subsystem, equipment, or system.

B. Manufacturer's Representative: Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:
   1. 3 person-days for installation assistance and inspection.
   2. 3 person-days for functional testing and startup.
   3. 2 person-days for prestartup classroom or site training.
   4. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by Owner.

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

3.06 SUPPLEMENTS

A. See Equipment Schedules and Drawing Details.

END OF SECTION

SECTION 23 81 00
UNITARY AIR-CONDITIONING EQUIPMENT

PART 1 GENERAL

1.01 SUMMARY

A. This section covers packaged direct expansion air conditioners and heat pumps.

1.02 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. 210/240, Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
      b. 360, Commercial and Industrial Unitary Air-Conditioning Equipment.
   2. Air Moving and Conditioning Association (AMCA):
      a. 210, Laboratory Methods for Testing Fans for Rating.
      b. Bulletin 300, Setup No. 1.
   3. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
      a. 15, Mechanical Refrigeration Safety Code.
      b. 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
      c. 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
   4. American Society of Mechanical Engineers (ASME): Section IX, Welding and Brazing Qualifications.
   5. 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.
   6. ETL Testing Laboratories (ETL).
   7. 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.
   8. National Electric Code (NEC).

9. National Electrical Manufacturers Association (NEMA).
10. National Fire Protection Association (NFPA):
    a. 90A, Installation of Air Conditioning and Ventilating Systems.
    b. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
11. National Roofing Contractors Association (NRCA).
12. Title 24 of the California Code of Regulations (Title 24).
13. UL: 94-5V, Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.03 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. EER: Energy Efficiency Ratio.
    4. DX: Direct Expansion.
    5. HP: Heat Pump.
    6. IR: Infrared.
    7. LED: Light Emitting Diode.
    8. PSC: Permanent Split Capacitor.
    9. SPST: Single Pole, Single Throw.
    10. TXV: Thermostatic Expansion Valve.
    11. UV: Ultraviolet.

1.04 SUBMITTALS

A. Action Submittals:
    1. Shop Drawings: Submit anchorage and bracing drawings and data sheets as required by Section 01 88 15, Anchorage and Bracing.
    2. 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.
    3. Manufacturer's standard finish color selection for enclosure finishes.
    4. Complete performance data that will indicate full compliance with the specifications:
        a. Include fan sound power level data (ref. 10 to 12 watts) at design operating point, based on AMCA Bulletin 300, Setup No. 1.
        b. Include heating and cooling performance data at design operating conditions.
    5. Factory dip-applied protective coating product data.

B. Informational Submittals:

1. Submit anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's Certificate of Compliance in accordance with Section 01 43 33, Manufacturers' Field Services, for heat pumps, air-conditioning units, and motors.
3. Component and attachment seismic qualification certificate of compliance as required by Section 01 45 36, Equipment Seismic Certification.
4. Detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement or details shown to equipment furnished.
5. Sample copy of guarantee.
6. Test reports.
7. Operation and Maintenance Data in conformance with Section 01 78 23, Operation and Maintenance Data.
    a. Include wiring and control diagrams for equipment.
    b. Include as-built version of equipment schedules.

1.05 QUALITY ASSURANCE

A. Heating and Cooling Equipment: Minimum operating efficiencies, defined as COP and EER, as specified in California Title 24.

B. Unit shall be rated (when matched with appropriate outdoor unit) per AHRI 210/240.

C. Units shall be certified by UL and CSA, and shall be UL or ETL listed and labeled.

D. Cooling performance rated in accordance with AHRI testing procedures.

1.06 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 anti-friction 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.

1.07 EXTRA MATERIALS

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

Item	Quantity
Filters	Two complete sets per unit.

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.

B. Multiple Compressor Units:
   1. Provide completely independent refrigeration circuits and controls.
   2. Indoor unit air coils shall have intermingled circuits, unless specified otherwise.

2.02 EQUIPMENT SCHEDULES

A. Refer to Drawings.

2.03 SPLIT SYSTEM AC INDOOR UNIT, DUCTED (UP TO 5 NOMINAL TONS)

A. General:
   1. Indoor mounted, draw-through, packaged air-handling unit consisting of forward-curved centrifugal fan(s), motor and drive assembly, prewired fan motor contactor, factory-installed refrigerant metering devices, cooling coil, disposable air filters, and condensate drain pan.
   2. Suitable for use with air conditioner or heat pump outdoor unit.
   3. Indoor unit shall be of the same manufacturer as the associated outdoor unit.
   4. Modular design horizontal flow.

B. Unit Cabinet:
   1. Heavy gauge galvanized steel sheets.
   2. Phosphatized and factory finished in manufacturer’s standard enamel paint.
   3. Sufficient removable panels for access to all internal components.
   4. Interior of casing insulated with 1-inch, 1-pound density coated glass fiber insulation attached with adhesive material.

5. Duct flanges for connection of supply ductwork and filter racks.
6. Knockouts for unit electrical power and condensate piping connections.

C. Evaporator Fan:
1. Double-inlet, double-width, forward-curved fans mounted on rubber isolators.
2. Direct-drive or belt-drive as standard with the unit furnished.
3. Fan Motor:
a. Totally enclosed and permanently lubricated with inherent protection.
b. Minimum three-speed, or variable speed.

D. DX Evaporator Coil:
1. Copper tube with aluminum fins and galvanized steel tube sheets.
2. Fins bonded to tubes by mechanical expansion.
3. Condensate Drain Pan: High-impact thermoplastic, insulated, sloped in two planes, with primary and secondary brass drain fittings.
4. Refrigerant piping sweat connections.

E. Controls:
1. Refrigerant Metering:
a. Factory installed refrigerant metering device.
b. Heat Pump Applications: Reverse flow bypass refrigerant metering device with internal check valves.
2. Magnetic contactor for fan.
3. Overload protection in each leg.
4. Control voltage transformer.
5. Terminal strip for connection of remote controls.
6. Control board fusing.

F. Air Filters: Disposable 2-inch-thick MERV8 with maximum filter velocity 500 feet per minute.

G. Internal Condensate Pump:
1. To remove condensate from drain pan when gravity drainage cannot be used.
2. Lift capability of condensate pump shall be 18 inches.
3. Accessories: Filter Box.

H. Manufacturers:
1. Trane.
2. Mitsubishi.
3. Carrier.

4. Rheem.
5. Lennox International.
6. York Air Conditioning.
7. "Or-equal."

2.04 SPLIT SYSTEM AC/HP OUTDOOR UNITS

A. General:
   1. Factory assembled, single piece, air-cooled heat pump air conditioner outdoor unit.
   2. Contained within the unit enclosure shall be all factory wiring, piping, controls, compressor, and holding charge of refrigerant accepted by the State of California.
   3. Outdoor unit shall be of the same manufacturer as the associated indoor unit.

B. Unit Cabinet:
   1. Constructed of galvanized steel, phosphatized and coated with a baked finish. Finish shall pass the 3,000-hour salt spray test.
   2. Removable access panels for access to all internal components.
   3. Outdoor Compartment: Isolated, with acoustic lining to assure quiet operation.
   4. Knockouts for unit electrical power.

C. Condenser Fans:
   1. Direct-drive propeller type.
   2. Motors:
      a. Totally enclosed, with Class B insulation and permanently lubricated bearings.
      b. Thermal overload protection.
   3. Shaft of galvanized or stainless steel construction.
   4. Fan blades shall be corrosion-resistant and shall be statically and dynamically balanced.
   5. Equip openings with PVC-coated protection grille over fan and coil.

D. Compressor:
   1. Fully hermetic reciprocating or scroll type.
   2. Equipped with oil system, operating oil charge, and motor.
   3. Internal overloads shall protect compressor from overtemperature and overcurrent.
   4. Motor: NEMA rated, Class F, suitable for operation in a refrigerant atmosphere.
   5. Scroll compressors shall have high discharge gas temperature protection.

6. Reciprocating compressors shall be equipped with crankcase heaters to minimize liquid refrigerant accumulation in compressor during shutdown and to prevent refrigerant dilution of oil.
7. Installed on rubber vibration isolators and shall have internal spring isolation.

E. Condenser Coil:
1. Constructed of aluminum fins mechanically bonded to internally enhanced seamless copper tubes that are cleaned, dehydrated, and sealed.
2. Coat entire coil with anti-corrosion protective coating.
3. Finish shall pass the 4,000-hour salt spray test.

F. Refrigeration Components:
1. Brass external liquid line service valve with service gauge port connections.
2. Suction line service valve with service gauge connection port.
3. Service gauge port connections on compressor suction and discharge lines with Schrader-type fittings with brass caps.
4. Suction Line: Accumulator.
5. Pressure relief.
6. See Section 23 23 00, Refrigerant Piping, for refrigerant piping.

G. Controls:
1. Factory selected, assembled, and tested.
2. Refrigerant Metering:
   a. Reversing valve for heat pump units.
   b. Heating mode metering device for heat pump units.
3. Automatic restart on power failure.
4. Three-pole contactors.
5. Time delay control sequence shall be provided standard through control board on indoor units.
6. High pressure and liquid line low pressure switches.
7. Automatic outdoor fan motor protection.
8. Start capacitor and relay (single-phase units without scroll compressors).
9. Defrost board to provide defrost control.
10. Safeties:
    a. Time delay restart to prevent compressor reverse rotation on single-phase scroll compressors.
    b. Safety lockout if any outdoor unit safety is open.
    c. High condensing temperature protection.
    d. System diagnostics.
    e. Compressor motor current and temperature overload protection.
    f. High pressure relief.

g. Outdoor fan failure protection.

H. Manufacturers:
1. Trane.
2. Carrier.
3. Rheem.
4. Lennox International.
5. Mitsubishi.
6. "Or-equal."

2.05 HARSH ENVIRONMENT CORROSION PROTECTION SYSTEM

A. General:
1. Corrosion protection system below shall be provided for outdoor equipment.
2. Exterior and interior surfaces of outdoor unit cabinet/casing shall be coated with an anticorrosion protection coating as described below.
3. Protective coating to be applied to unit after factory assembly of equipment.

B. Coating Material: Use one of the following materials.
1. Epoxy modified phenolic. Straight phenolic materials are not acceptable.
2. Epoxy or epoxy urethane.
3. Complex chain linked polyelastomer material.

C. Cabinet Coating Process:
1. Unit Disassembly:
a. Disassemble unit.
b. Remove condenser fan motor.
c. Mask or pull back all exterior wires.
2. Cabinet Cleaning:
a. Clean surfaces by residue-free solvent wipe down or steam cleaner/pressure washer with soap to remove lubricants, machining oils, and residual factory contamination. Do not soak or damage unit insulation.
b. Rinse with clean potable water to remove cleaning solution.
3. Coating Application:
a. Etch bare interior and exterior surfaces including: compressor/condenser section, base rails, and underside of unit. Rinse etched surfaces to remove etching solution and residue.
b. Previously painted surfaces to be scuff sanded with 220-grit to 320-grit abrasive to remove gloss on original coating. Sanded surfaces to be cleaned with a residue-free solvent wipe down.
c. Surfaces should be clean and allowed to dry.

d. Base Coat: When cabinet is dry, apply primer to interior and exterior surfaces. Allow to dry minimum of 12 hours.

e. Top Coat: When primer is dry, apply final protective coating to interior and exterior surfaces. Apply two coats for optimum protection.

f. Allow coating to dry completely before reassembling the unit.

4. Quality Control: Free from voids, checks, cracks, and blisters.

D. Performance: Cabinet finish shall meet or exceed the following criteria.

1. Salt Spray Test: In accordance with ASTM B117, minimum 3,000-hour duration, with no corrosion or degradation.

2. Exposure to UV Light: UV inhibited life of minimum 10 years when exposed to sun.

E. Refrigerant Coils: Condenser and evaporator coil(s) shall be coated with a corrosion protection coating in accordance with Article Factory Dip-Applied Protective Coating.

F. Fasteners: Replace factory fasteners with stainless steel components.

2.06 UNITARY EQUIPMENT CONTROLS

A. Electronic Thermostat:

1. Compatible with controller.

2. Hard wired.

3. Insulating back, where exterior mounting is indicated.

B. Electronic Heat Pump Unit Controller:

1. Control by third party building management system via BACnet® MSTP (RS-485) protocol.

2. Commandable Points:

a. Unit on/off.

b. Mode.

c. Setpoint.

d. Fan Speed.

3. Monitor Points:

a. Fault Codes.

b. Room Temperature.

4. Wired thermostat with room temperature display and visual indication of unit status and mode for heating and cooling.

5. Power loss memory for restoration of sequence of operation in the event of loss of power.

6. Refer to Section 23 09 00, Instrumentation and Control Devices for HVAC, for additional controller requirements.

2.07 FACTORY DIP-APPLIED PROTECTIVE COATING

A. General:
   1. Factory dip-applied protective coating for application to plate fin and tube coils exposed to ambient air.
   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.

B. Coating Material:
   1. Use one of the following materials:
      a. Epoxy Modified Phenolic: Straight phenolic materials are not acceptable.
      b. Epoxy or epoxy urethane.
      c. Polyelastomer: Complex chain linked polyelastomer material.

C. Coating Process:
   1. Coil Inspection and Sealing:
      a. Inspect coil for open tubes, headers, capillary tubes; repair as necessary.
      b. Fill with dry nitrogen, cap and seal, to prevent contamination of internal coil surfaces with cleaning or coating solutions.
   2. Coil Cleaning:
      a. Immerse coil in heated alkaline cleaning solution to remove lubricants, machining oils, and residual factory contamination.
      b. Followed with immersion in potable water bath to neutralize and remove cleaning solution.
   3. Coating Application:
      a. Immerse coil assembly in coating bath, including headers, casing, and heat exchange surfaces.
      b. Coil shall be completely removed from equipment during coating application.
      c. Spray-on coatings are not acceptable.
   4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
   5. Quality Control: Free from voids, checks, cracks and blisters.

D. Performance:
   1. Coil finish shall meet or exceed the following criteria:
      a. Salt Spray Test: In accordance with ASTM B117, minimum 4,000-hour duration, with no fin corrosion or degradation.
      b. Thermal Efficiency: Loss no greater than 1 percent after coating application.
      c. Exposure to UV Light: UV inhibited life of minimum 10 years when exposed to sun in the State of Florida.

2.08 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.

2.09 SOURCE QUALITY CONTROL

A. Factory Tests:
   1. Direct expansion coils leak tested underwater with 200-psig air. Pressure tested to 450 psig.
   2. Electric heating coils tested with 2,000-volt dielectric test.

PART 3 EXECUTION

3.01 INSTALLATION

A. Set and install equipment so that equipment is level and properly supported.

B. Make certain that piping connections to equipment do not cause any strain on equipment.

C. Make certain that vibration isolation has been installed per manufacturer's instructions and isolation devices are performing satisfactorily.

D. Install equipment in accordance with manufacturer's recommendations, and these Specifications. Condensate drains to be installed to project plumbing standards.

E. Install all safety devices as recommended by manufacturer and/or required by code in these Specifications.

F. Initial equipment startup shall be made by an authorized representative of the unit manufacturer.

G. Air-cooled outdoor unit shall not be started without complete prestart checkout of entire refrigerant piping system and charging of system with refrigerant as recommended by equipment manufacturer.

H. Startup: Manufacturer shall provide a factory-trained representative employed by the 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).
   6. See Section 23 23 00, Refrigerant Piping.

I. Factory Checkout:
   1. Contractor shall secure the services of a factory trained and qualified service engineer employed by the equipment manufacturer who shall inspect the 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. This service engineer shall forward a report in three copies to Jacobs' Engineer when the unit is in safe and proper operating condition. This report shall contain all pressure and control settings, meg readings, voltage readings per phase during START and RUN, suction temperature and pressure, liquid temperature and pressure, and shall list minor

discrepancies to be corrected which do not affect safe and reliable operation.

3. One additional copy of report shall be left in unit control panel. 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 the unit control panel at the time of starting.

J. Locate units to provide access for filter changing; motor, drive, and bearing servicing; and fan shaft and coil removal.

K. Seal outside air intake watertight to roof curb.

L. Isolate sheet metal duct connections from all portions of the unit not internally spring-isolated from fans, or other vibrating or rotating equipment.

M. Inspect internal casing insulation, seal all exposed edges, and butt joints with mastic to ensure insulation will not be loosened during operation.

3.02 ADJUSTING AND CLEANING

A. Air System Balancing: As specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

B. Lubricate unsealed bearings prior to startup.

C. Do not operate units until filters are installed. If operated without filters, completely clean ductwork, coils, and interior of units.

3.03 FILTERS

A. Install a complete set of filters in each unit before operating, and leave in place during startup and testing to keep the equipment and ductwork clean.

B. Install a complete set of filters at the time of final cleaning as defined in Section 01 77 00, Closeout Procedures.

3.04 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 City's personnel for specified equipment.

END OF SECTION

SECTION 23 82 00
UNIT HEATER

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): 90.1 IP/SI, Energy Standard for Buildings, Except Low-Rise Residential Buildings.
   2. Electrical Test Laboratories (ETL).
   3. National Electrical Manufacturer's Association (NEMA).
   4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
   5. 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. dB: Decibel.
   3. hp: Horsepower.
   4. ODP: Open Drip Proof.
   5. PSC: Permanent Split Capacitor.
   6. SWSI: Single Width, Single Inlet.

1.03 SUBMITTALS

A. Action Submittals:
   1. Shop Drawings.
   2. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature which shall include make, model, dimensions, weight of equipment, and electrical schematics.
   3. Manufacturer's standard finish color selection for cabinet finishes.
   4. Performance data, including sound power level data (reference 10 to minus 12 power watts) at design operating point, shall be based on AMCA 300.
   5. Factory dip-applied protective coating product data.

B. Informational Submittals:
   1. Recommended procedures for protection and handling of equipment and materials prior to installation.

2. Detailed information on structural, mechanical, electrical, or other modifications necessary to adapt the arrangement or details shown to the equipment furnished.
3. 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 the State of California Energy Code.

PART 2 PRODUCTS

2.01 EQUIPMENT

A. Equipment Schedules: Refer to Drawings.

2.02 UNIT HEATER, ELECTRIC, WALL

A. Characteristics:
   1. Horizontal air delivery, suspended electric unit heater.
   2. UL listed and CSA certified.
   3. Cabinet Casing:
      a. Corrosion-resistant drawn-formed steel finished with baked on polyester powder paint finish.
      b. Top: Two threaded holes for threaded rod suspension.
      c. Bottom: Hinged panel for service access to wiring and controls.
   4. Elements:
      a. Nickel-chromium resistance wire surrounded with magnesium oxide and sheathed in steel spiral-finned tubes.
      b. Kilowatt rating as specified.
   5. Motor and Fan:
      a. Motor shall be totally enclosed, continuous-duty, with automatic resetting, thermal overload protection.
      b. Fan shall be directly connected to motor shaft and be statically balanced.
      c. Mount motor to unit with rubber vibration absorbing material.
   6. Electrical:
      a. Built-in control circuit transformer (where required) to provide a single-source power connection.
      b. Enclose electrical control components in separate junction box.
   7. Controls: Operated by wall or unit mounted line-voltage thermostat as specified.

B. Manufacturers:
   1. Cadet.
   2. Modine.
   3. Chromalox.
   4. Markel.

2.03 ELECTRICAL

A. General:
   1. Units shall include high and low voltage terminal block connections.
   2. Motor Starters/Contactors: Factory installed with unitary equipment, unless otherwise noted.
   3. 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.

2.04 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 3/8-inch high engraved block type black enamel filled equipment identification number and letters indicated.

2.05 SOURCE QUALITY CONTROL

A. Functional Test: Perform manufacturer's standard factory test on equipment.

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.

END OF SECTION

SECTION 26 05 02
BASIC ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Supplemental requirements to all specification sections for all phases of work concerning electrical distribution and utilization equipment.

1.02 RELATED SECTIONS

A. Division 26, Electrical, covers Work necessary for the complete electrical system. Furnish materials, labor, and equipment in accordance with these specifications and the accompanying Drawings.

B. Requirements specified within this section apply to all sections in Division 26, Electrical. Work specified herein shall be performed as if specified in the individual sections.

C. The requirements of Division 26, Electrical, in their entirety apply to all electrical work and equipment furnished on this Project, whether furnished or specified under this or other Divisions of these specifications.

1.03 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. Institute of Electrical and Electronics Engineers (IEEE): 1584, Guide for Performing Arc-Flash Calculations.
   2. National Electrical Contractors Association (NECA).
   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, Electrical Safety Requirements for Employee Workplaces

1.04 DESIGN REQUIREMENTS

A. See Division 01, General Requirements, specification sections, which contain additional information and requirements that apply to the Work specified herein and are required for this Project.

B. Submit anchorage and bracing drawings and cut sheets as required in Section 01 88 15, Anchorage and Bracing.

C. Contractor shall provide conduit routing plan drawings for all conduit at each facility location. Drawings shall show final chosen equipment sizes, pad sizes, orientations, and detail conduit routes and fills as to be installed. Drawing shall be in the latest AutoCAD format and based on full size sheet (24-1/2-inch by 36-1/2-inch). Text font shall be 1/8-inch minimum on full size Drawings. Submit for review and approval prior to conduit installation and again at the end of the Project as "as-built Drawings."

D. As part of the "as-built Drawings", all electronic AutoCAD drawings generated by the Contractor or equipment vendors shall be provided to the City.

1.05 ELECTRICAL COORDINATION

A. Work provided outside this Contract:
   1. Existing electrical power system.
   2. Provide materials, labor, and coordination to interface with existing power system.

1.06 INTENT OF DRAWINGS

A. Electrical plan drawings are diagrammatic and show only general locations of equipment, devices, and raceway, unless specifically dimensioned. The Contractor shall be responsible for a complete raceway system, provide as a minimum what is shown on Drawings, and provide additional trenching, raceway, devices, fittings, boxes, cables, and the like, needed to fit the equipment size and configuration as supplied subject to the approval of the Design-Builder.

B. In general, where the background on Drawings has been screened, the area screened is existing, or future, or other than electrical, unless otherwise noted. Work under this Division 26, Electrical, is shown heavier by contrast.

C. Standard and/or other details are typical for all locations which apply, regardless of whether a callout is shown on the Plan or not.

D. Number and size of wires which shall be installed in runs of conduit, where not shown on Drawings, shall be determined from the site plan, one-line and control diagrams.

E. Cables shown with a raceway callout or number shall be cables in conduit (see Cable Block Diagrams with Circuit Schedules shown on Drawings).

1.07 SYSTEM DESCRIPTION

A. Furnish and install a tested and working electrical system, as indicated on Drawings and as specified. System includes all items not specifically mentioned in these Specifications or indicated on Drawings or accepted Shop Drawings, but which are necessary to make a complete working installation, and shall be deemed to be included herein.

B. Notify Jacobs of discrepancies within the Contract Documents and discrepancies between the Contract Document and actual field conditions.

C. The Contract Documents indicate or specify minimum sizes of equipment, electric devices, and other components of electrical system, but the Contract Documents do not indicate every offset and fitting, or every structural or mechanical difficulty that may be encountered during the execution of the Work.

D. Install equipment at locations indicated on Contract Documents as closely as field conditions permit. Obtain accepted equipment submittal dimensions prior to installing pads and conduits.

E. Make minor variations to alignment of equipment and/or installation of raceway systems to avoid conflict with other portions of the Work.

F. One Line Diagrams: One line diagrams indicate circuit voltage, circuit I.D., equipment number, equipment rating, circuit protection rating, and other pertinent data.

G. Temporary Power:
   1. Provide and maintain temporary power and communications to existing EBOS and Ferric Chloride Facilities during construction.
   2. Provide and maintain temporary power, lighting, and telephone systems as needed for construction. Include weatherproof panel(s) for main breakers and electrical power distribution system.
   3. Install temporary wiring in accordance with NEC Article 305 with Type SO portable cable, watertight connections, and ground fault interrupting equipment. After construction is completed, remove temporary systems. Other styles of cable are allowable, such as tray cables.
   4. Install temporary wiring in accordance with NEC Article 305 with 2,000V rated power cable, watertight connections, and ground fault interrupting equipment. After construction is completed, remove temporary systems. Other styles of cable are allowable, such as tray cables.

5. Provide and maintain temporary power and communications to existing equipment and services located near C Street as needed to facilitate installation new pipework and rework of existing power and communications.

1.08 PERFORMANCE REQUIREMENTS

A. Operate electrical equipment successfully at full-rated load, without failure, at an ambient air temperature of 40 degrees C, and rated for an altitude of 10 feet.

B. Coordination of Electrical Equipment Rating: Verify actual equipment, motor full-load, and locked-rotor current ratings. When providing equipment with different motor full-load and locked-rotor current ratings than indicated on Contract Documents, coordinate branch circuit conductor sizes, motor overload protection, motor controllers, control power transformers, and branch circuit overcurrent protection required for equipment provided.

C. Branch Circuit Conductor Current Carrying Capacity: Minimum 125 percent of the full-load current rating of equipment.

D. Branch Circuit Conductor Size: Adequate to prevent voltage drop greater than 2 percent from branch circuit protection device to equipment with equipment running at full-load and rated voltage. Include conductor derating in accordance with ambient temperature and conduit fill requirements.

E. Motor Running Overload Protection Devices:
   1. Rated or selected to trip at no more than the following percent of motor nameplate full-load current rating:
      a. 125 percent for motors with marked service factor not less than 1.15.
      b. 125 percent for motors with marked temperature rise not over 40 degrees C.
      c. 115 percent for all other motors.
   2. Size and provide upon verification of actual motor or nameplate data.

F. Overload Heaters Required for Motors with Temperature Rise of 50 Degrees C: As selected from motor controller manufacturer's overload heater selection tables.

G. Motor Controller Size: Coordinated with full load amp and horsepower size of motor.

H. Motor-Branch-Circuit Short Circuit and Ground Fault Protections Device: Capable of tripping open in 30 seconds or less on locked-rotor current of motor. This device shall also protect the motor-branch-circuit conductors and the motor

control apparatus against overcurrent due to short-circuit or ground faults. Protect motor control circuits with device type specified or as indicated on Drawings.

I. Environmental conditions should be considered such as condensing and gaseous environments. Machines should be tested within the condition it resides.

1.09 DEPARTURE FROM CONTRACT DOCUMENTS

A. Submit to Jacobs, in writing, details of any necessary, proposed departures from these Contract Documents, and the reasons therefor. Submit such requests as soon as practicable and within 15 calendar days after Notice to Proceed. Make no such departures without written approval of Jacobs.

1.10 SUBMITTALS

A. Action Submittals:
   1. Shop Drawings and Product Data such as control devices, fixtures, wire, cables, raceways, and other equipment specified or indicated on the Contract Documents.
   2. Studies such as short circuit studies, protective device and coordination studies, arc flash studies, harmonic studies, and other studies as specified.
      a. See Section 26 05 70, Electrical System Analysis.
   3. Conduit routing plans as specified in this section.
   4. Test reports as specified in Section 26 08 00, Commissioning of Electrical Systems.
   5. Protect Record Documents such as revised Shop Drawings and operations and maintenance manuals.

B. Informational Submittals: Calculations.

1.11 AUTHORITY HAVING JURISDICTION APPROVAL

A. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC) and other codes specified herein. Where required by the Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ, in order to provide a basis for approval under the NEC.

B. Materials and equipment manufactured within the scope of standards published by 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.

1.12 CODES AND PERMITS

A. All Work shall be performed in strict accordance with the Local Laws and Ordinances, National Electrical Code (NEC), and National Electrical Safety Codes (NESC), California Administrative Code 2016—Title 8, Chapter 4, Subpart 5, Electrical Safety Orders and Title 24, Energy Conservation Standards (CAC), UL, Occupational Health and Safety Administration (OSHA), American National Standards Institute (ANSI), National Electrical Manufacturer's Association (NEMA), National Electrical Testing Association (NETA), ASTM International (ASTM), Institute of Electrical and Electronics Engineers (IEEE), Uniform Building Code (UBC). Conflicts, if any, that may exist will be resolved at the discretion of the Jacobs.

B. Wherever the requirements of the Contract Documents exceed those of these codes, the requirements of the Contract Documents shall govern. Code compliance shall be mandatory. Nothing in these Contract Documents shall be construed as permitting work not in accordance with these laws and codes.

C. Obtain all permits and pay all fees required by any utility or governmental agency having jurisdiction over this Work. Arrange all inspections required by these utilities or agencies. Upon completion of Work, furnish satisfactory evidence to Jacobs that the Work is acceptable to the regulatory authorities having jurisdiction.

1.13 ENVIRONMENTAL CONDITIONS

A. As indicated in the Area Classification and Material Selection Table on the Contract Documents.

1.14 SEQUENCING AND SCHEDULING

A. Sequencing and scheduling shall be in accordance with Section 01 31 13, Project Coordination.

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 of 50 degrees C direct sun.

D. Equip panels installed outdoors in direct sun with sun shields.

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, light gray color finish as approved by Jacobs.

2.03 NAMEPLATES

A. Material:
   1. Indoor Locations: Laminated plastic.
   2. Outdoor Locations: Type 316 stainless steel.
      a. Engraving to be enamel filled with a high contrasting color for visibility.

B. Color (Laminated Plastic Only):
   1. White, engraved to a black core.
   2. Red, engraved to a white core.

C. Letter Height:
   1. Pushbuttons/Selector Switches: 1/8-inch.
   2. Other Electrical Equipment: 3/8-inch.

D. Attachment Screws: Type 316 stainless steel.

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 Jacobs'' Engineer.

B. Check approximate locations of light fixtures, switches, electrical outlets, equipment, and other electrical system components shown on the Contract Documents for conflicts with openings, structural members, and components of other systems and equipment having fixed locations. In the event of conflicts, notify Jacobs' 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 Jacobs. 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 AND MOUNTING

A. Submit anchorage and bracing calculations as required in Section 01 88 15, Anchorage and Bracing. All concrete anchors, strut, and strut clamps are to be stainless steel.

3.03 COMBINING CIRCUITS INTO COMMON RACEWAY

A. Circuits shown on the Contract Documents indicate functional wiring requirements for power and control circuits. Circuits may be combined into common raceways with approval by Jacobs' Engineer.

3.04 NAMEPLATES, SIGNS, AND LABELS

A. Arc Flash Protection Warning Signs:

1. Field mark all electrical equipment and devices to warn qualified persons of potential arc-flash hazards based on the study performed under Section 26 05 70, Electrical Systems Analysis. Locate marking so to be clearly visible to persons before working on energized equipment.
2. Arc flash signs to be provided by the Subcontractor.

B. Multiple Power Supply Sign: Install permanent plaque or directory at each panelboard, control panel, or electrical panel indicating other services, feeders, and branch circuits supplying the cabinet.

C. Equipment Nameplates:

1. Provide a nameplate to label electrical equipment including switchgear, standalone drives, motor control centers, panelboards, motor starters, transformers, automatic transfer switches, terminal junction boxes, pull boxes, disconnect switches, switches and control stations.
2. Switchgear, motor control center, standalone drives, 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. Panelboard and automatic transfers switch nameplates shall include equipment designation, service voltage, and phases.

3.05 LOAD BALANCE

A. Contract Documents 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 the Contract Documents, and is acceptable to Jacobs.

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 Subcontractor'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 Jacobs.

END OF SECTION

SECTION 26 05 04
LOW-VOLTAGE BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Basic low voltage electrical materials and methods.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. ASTM International (ASTM):
      a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
      b. A1011/A1011M, Standard Specification for Steel, Sheet, and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low Alloy and High-Strength Low Alloy Formability.
      c. E814, Method of Fire Tests of Through-Penetration Fire Stops.
   2. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 18, Standard for Shunt Power Capacitors.
   3. Instrumentation, Systems, and Automation Society (ISA): RP12.06.01, Wiring Practices for Hazardous (Classified) Locations Instrumentation–Part 1: Intrinsic Safety.
   4. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
      b. AB 1, Molded Case Circuit Breakers, Molded Case Switches, and Circuit-Breaker Enclosures.
      c. C12.1 Code for Electricity Metering.
      d. C12.6 Phase-Shifting Devices Used in Metering, Marking and Arrangement of, Terminals for.
      e. CP 1, Shunt Capacitors.
      f. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts.
      g. ICS 5, Industrial Control and Systems: Control Circuit and Pilot Devices.
      h. KS 1, Enclosed and Miscellaneous Distribution Switches (600 Volts Maximum).
   5. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
   6. UL:
      a. 98, Standard for Enclosed and Dead-Front Switches.
      b. 248, Standard for Low Voltage Fuses.

c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
d. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
e. 508, Standard for Industrial Control Equipment.
f. 810, Standard for Capacitors.
g. 943, Standard for Ground-Fault Circuit-Interrupters.
h. 1059, Standard for Terminal Blocks.
i. 1479, Fire Tests of Through-Penetration Fire Stops.

1.03 SUBMITTALS

A. Action Submittals:
1. Provide manufacturers' data for the following:
a. Control devices.
b. Control relays.
c. Circuit breakers.
d. Fused switches.
e. Intrinsic safety barriers and relays.
f. Enclosures: Include enclosure data for products having enclosures.
g. Support and framing channel.
h. CCTV Cameras and accessories.
i. Security Cameras and accessories.
2. Submit anchorage and bracing drawings and cut sheets as required by Section 01 88 15, Anchorage and Bracing.

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

1.04 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 GENERAL

A. Manufacturers: Unless specified otherwise indicated on Drawings, the fabricator of major electrical equipment, such as switchgear, switchboards, variable frequency drives, motor control centers, and lighting and distribution panelboards shall also be the manufacturer of the major devices herein.

B. Miscellaneous: Materials, equipment, and parts comprising any unit or part thereof specified or indicated on Drawings shall be new and unused, of current manufacture, and of highest grade consistent with the industrial industry standards. Damaged materials, equipment, and parts are not considered to be new and unused and will not be accepted.

2.02 MOLDED CASE CIRCUIT BREAKER THERMAL MAGNETIC, LOW VOLTAGE

A. General:
   1. Type: Molded case.
   2. Trip Ratings: 15 amps to 800 amps.
   3. Voltage Ratings: 120, 240, 277, 480, and 600V ac.
   4. Suitable for mounting and operating in any position.
   5. NEMA AB 1 and 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.
   8. Short Circuit Interrupting Ratings: Greater than or equal to, available fault current or interrupting rating shown. Where fault current is not shown, provide rating greater than or equal to the rating of the upstream electrical equipment.

D. 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.

E. 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.
   5. Use bolted bus connections, except where bolt-on is not compatible with existing breaker provisions.

F. 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.

2.03 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.
   4. No mechanical locks on push-buttons.

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. Auxiliary contact indicating switch position open rated for 24V dc, 2 amp.

H. Enclosures: See Article Enclosures.

I. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.04 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 indicating switch position open, rated 24V dc, 2 amps.

E. 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.

F. Enclosures: See Article Enclosures.

G. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

H. Manufacturer:
   1. WPCP to advise.
   2. “Or-equal.”

2.05 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. “Or-equal.”

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.
      c. "Or-equal."

D. Cable Limiters:
   1. 600V or less; crimp to copper cable, bolt to bus or terminal pad.
   2. Manufacturer and Product:
      a. Bussmann; K Series.
      b. "Or-equal."

E. Ferrule:
   1. 600V or less, rated for applied voltage, small dimension.
   2. Ampere Ratings: 1/10 amp to 30 amps.
   3. Dual-element time-delay, time-delay, or nontime-delay as required.
   4. Provide with blocks or holders as indicated and suitable for location and use.
   5. Manufacturers:
      a. Bussmann.
      b. Littlefuse, Inc.
      c. "Or-equal."

2.06 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Size: 30.5 mm.

B. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.

C. Selector Switch Operating Lever: Standard.

D. Indicating Light: Push-to-test. LED, full voltage.

E. Pushbutton Color:
   1. ON or START: Green.
   2. OFF or STOP: Red.

F. Legend Plate:
   1. Material: Aluminum for outdoor usage and plastic for indoor usage.
   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. Allen-Bradley; 1-7/32-inch 4X is the preferred primary option. Type 800H.
b. General Electric Co.; Type CR 104P.
c. Square D Co.; Type T.
d. Eaton/Cutler-Hammer; Type 10250T.
e. "Or-equal."
2. Heavy-Duty, Watertight, and Corrosion-Resistant Type:
a. Allen-Bradley; 1-7/32-inch 4X is the preferred primary option. Type 800H.
b. Square D Co.; Type SK.
c. General Electric Co.; Type CR 104P.
d. Eaton/Cutler-Hammer; Type E34.
e. Crouse-Hinds; Type NCS.
f. "Or-equal."

2.07 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. Allen-Bradley (1492 W4).
2. Weidmuller, Inc.
3. Ideal.
4. Electrovert USA Corp.
5. "Or-equal."

2.08 MAGNETIC CONTROL RELAY

A. Industrial control with field convertible contacts rated 10 amps continuous, 7,200VA make, 720VA break.

B. NEMA ICS 2, Designation: A300 (300 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.

D. Latching Attachment: Mechanical latch, having unlatching coil and coil clearing contacts.

E. Manufacturers and Products:
1. Eaton/Cutler-Hammer; Type M-30.
2. General Electric Co.; Type CR120A.
3. "Or-equal."

2.09 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. Idec (preferred manufacturer).
2. Square D Co.; Type F.

3. Eaton/Cutler-Hammer.
4. General Electric Co.
5. “Or-equal.”

2.10 RESET TIMER

A. Drive: Synchronous motor, solenoid-operated clutch.

B. Mounting: Semiflush panel.

C. Contacts: 10 amps, 120 volts.

D. Manufacturers and Products:
1. Idec (preferred manufacturer).
2. Eagle Signal Controls; Bulletin 125.
3. Automatic Timing and Controls; Bulletin 305.
4. “Or-equal.”

2.11 TWENTY-FOUR HOUR TIMERS

A. Heavy-duty industrial, 120 volts, 60 hertz alternating current operating power, electronic type; amperes at 120 volts alternating current output, single channel type; lithium battery-backed; single pole double throw.

B. Housed in adequate NEMA enclosure. Plug-in or non-industrial timers shall be prohibited unless accepted in writing. The timers shall be 2 series.

C. Manufacturers:
1. Paragon.
2. Tork, equivalent model.
3. “Or-equal.”

2.12 BUZZERS

A. Capable of producing an adjustable audible sound which shall be minimum 70 decibels at 10 feet from the buzzers.

B. Manufacturers:
1. Edwards Signaling.
2. Federal Signal.
3. “Or-equal.”

2.13 ALARM HORNS

A. Capable of producing an adjustable audible sound which shall be minimum 100 decibels at 10 feet from the horn, accepting up to eight different plug-in tone modules, and having distinct tones so no two horns have the same tone; receiving power from its respective control panel as specified or as indicated on Drawings.

B. Manufacturers:
   1. Edwards Signaling.
   2. Federal Signal.
   3. “Or-equal.”

2.14 THERMOSTATS

A. Unless otherwise specified elsewhere in the Contract Documents, the thermostats shall be:
   1. Heavy-duty type with full load rating of 120 volts, 16 amps.
   2. Provided with a clear plastic splash-proof protective thermostat cover to inhibit corrosion and moisture damage.

B. Manufacturers and Products:
   1. Honeywell; T6051 Series.
   2. Rockwell; equivalent.
   3. “Or-equal.”

2.15 WARNING LIGHTS

A. Warning rotating lights, 40-watt, LED, suitable for indoor or outdoor use, corrosive environment.

B. Red color lens.

C. Shall direct light in a 360-degree pattern.

D. With all necessary accessories for wall-mounting or as specified otherwise elsewhere in these Contract Documents.

E. Voltage: 24V dc and 120V ac, see Contract Documents.

F. Manufacturers and Products:
   1. Federal Signal; Model 121.
   2. Edwards Signaling equivalent.
   3. “Or-equal.”

2.16 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 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.
   4. “Or-equal.”

2.17 INTRINSICALLY SAFE RELAYS

A. Factory Mutual approved to allow the use of every type of remote pilot device located in Class 1, Division 1 or 2, hazardous areas by providing a pilot circuit incapable of releasing sufficient electrical energy to ignite gases and vapors classified in Groups A, B, C, and D.

B. Output relay with double pole, double throw contacts rated 5 amperes continuous minimum at 120 volts alternating current, capable of operating on the voltage indicated.

C. Manufacturers and Products:
   1. B/W; Controls Series 53.
   2. Cutler-Hammer; Powered Relay.
   3. “Or-equal.”

2.18 MAGNETIC LIGHTING CONTACTOR

A. Comply with NEMA ICS 2; provide UL 508 listing.

B. Electrically operated by dual-acting, single coil mechanism.

C. Inherently interlocked and electrically held in CLOSED position.

D. Main Contacts:
   1. Double-break, continuous-duty, rated 20 amperes, 600 volts, withstand rating of 22,000 amps rms symmetrical at 250 volts.
   2. Marked for electric discharge lamps, tungsten, and general purpose loads.
   3. Position not dependent on gravity, hooks, latches, or semipermanent magnets.
   4. Capable of operating in any position.
   5. Visual indication for each contact.

E. Auxiliary contact relay for two-wire control.

F. Fully rated neutral terminal.

G. Provision for remote pilot lamp with use of auxiliary contacts.

H. Clamp type, self-rising terminal plates for solderless connections.

I. Enclosures: See Article Enclosures.

J. Manufacturers and Products:
   1. ASCO.
   2. Eaton/Cutler-Hammer; Class A202.
   3. General Electric Co.; Class 360 (electrically held).
   4. Square D; Class 8903, Type L (electrically held).
   5. “Or-equal.”

2.19 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, ASTM A167, 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. Support Channel Bolts: Type 316 stainless steel.

H. Manufacturers:
   1. B-Line Systems, Inc.
   2. Unistrut Corp.
   3. Aickinstrut.
   4. "Or-equal."

2.20 INTRINSIC SAFETY BARRIER

A. Provides a safe energy level for exposed wiring in a Class I, Division 1 or Division 2 hazardous area when circuit is connected to power source in nonhazardous area.

B. Rating: Power source shall be rated 24V dc, nominal, with not more than 250 volts available under fault conditions.

C. Contact Rating: 5 amps, 250V ac.

D. Mounting: Rail or surface.

E. Manufacturers and Products:
   1. MTL, Inc.; Series 2000 or Series 3000.
   2. R. Stahl, Inc.
   3. "Or-equal."

2.21 CAMERAS

A. CCTV Cameras for Process Systems.
   1. Ethernet/IP communications, POE.
   2. Locations as shown on the Contract Documents.
   3. PTZ, 30X zoom.
   4. Low Light tolerant down to 0.03 lux.
   5. Outdoor rated.
   6. Pole or ceiling mount adaptors.

7. Compatible with Owner's existing CCTV communications system and software.
8. Accessories: Mounting components specific to the installation as well as component needed for a complete system and as shown on the Contract Documents, including but not limited to media converters and power supplies.
9. Manufacturer: Pelco Spectra Enhanced.

B. Cameras for Site Security:
1. Ethernet/IP communications, POE.
2. Locations as shown on the Contract Documents.
3. PTZ, 30X zoom.
4. IR illuminator with long range capability, greater than 200 meters.
5. Outdoor rated.
6. Pole or ceiling mount adaptors.
7. Compatible with Owner's existing security communications system and security software.
8. Accessories: Mounting components specific to the installation as well as component needed for a complete system and as shown on the Contract Documents, including but not limited to media converters and power supplies.
9. Manufacturer: Pelco Esprit.

2.22 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 barriers within enclosures to separate wiring of different systems and voltage.

D. Enclosure Selections: As shown in the Area Classification and Material Selection Table located on Contract Documents.

PART 3 EXECUTION

3.01 GENERAL

A. Install equipment in accordance with manufacturer's recommendations.

3.02 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Unless otherwise shown, install heavy-duty, oil-tight type in nonhazardous, indoor, dry locations, including motor control centers, control panels, and individual stations.

B. Unless otherwise shown, install heavy-duty, watertight and corrosion-resistant type in nonhazardous, outdoor, or normally wet areas.

3.03 SUPPORT AND FRAMING CHANNEL

A. Install where required for mounting and supporting electrical equipment and raceway.

B. Channel Type: See Area Classification and Material Selection Table on the Contract Documents.

3.04 INTRINSIC SAFETY BARRIERS OR RELAYS

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.

END OF SECTION

SECTION 26 05 05
CONDUCTORS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes:
   1. Low voltage class wire and cable.
   2. Instrumentation class wire and cable.
   3. Fire alarm wire and cable.
   4. Communication wire and cable.
   5. Date wire and cable.
   6. Special wires and cables.
   7. Medium voltage class wire and cable.

1.02 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. B263, Standard Test Method for Determination of Cross-Sectional Area of Stranded Conductors.
   3. Electronic Industries Alliance (EIA), Telecommunications Industry Association (TIA): TIA-568-B, Commercial Building Telecommunications Cabling Standard.
   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 Cables.
      c. T-29-520, Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input of 210,000 Btu/hour.

5. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
    a. 48, Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminations 2.5 kV through 765 kV.
    b. 386, Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
    c. 404, Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500000 V.
6. National Electrical Manufacturers' Association (NEMA):
    a. CC 1, Electric Power Connectors for Substations.
    b. WC 55, Instrumentation Cables and Thermocouple Wire.
    c. WC 70, Standard for Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
    d. WC 71, Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy.
7. National Fire Protection Association (NFPA):
    a. 70, National Electrical Code (NEC).
    b. 262, Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
8. UL:
    a. 13, Standard for Safety Power-Limited Circuit Cables.
    b. 44, Standard for Safety Thermoset-Insulated Wires and Cables.
    c. 62, Standard for Safety Flexible Cord and Cables.
    d. 486A-486B, Wire Connectors.
    e. 486C, Standard for Splicing Wire Connections.
    f. 510, Standard for Safety Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
    g. 1072, Standard for Safety Medium-Voltage Power Cables.
    h. 1277, Standard for Safety Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
    i. 1581, Standard for Safety Reference Standard for Electrical Wires, Cables, and Flexible Cords.

1.03 SUBMITTALS

A. Action Submittals:
    1. Wire and cable descriptive product information.
    2. Wire and cable accessories descriptive product information.

3. Cable Pulling Calculations:
    a. Calculations shall be submitted and reviewed before cable installation.
    b. Provide cable pulling calculations for the following cable installations:
        1) Medium voltage cable runs that cannot be hand pulled.
        2) Multi-conductor 600-volt cable sizes larger than #2 AWG that cannot be hand pulled.
        3) Feeder circuits, single conductors #4/0 and larger.
4. Certified Factory test report per AEIC CS6, including AEIC qualifications report for conductors above 600 volts, for each cable reel length.

B. Informational Submittals:
1. Journeyman Lineman splicing credentials.
2. Certified Factory Test Report for conductors 600 volts and below.

1.04 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 UL 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.

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: Stranded tin-plated copper.
2. 120-Volt Receptacle Circuits, 10 AWG and Smaller: Stranded tin-plated copper.
3. All Other Circuits: Stranded tin-plated copper.

C. Insulation: XHHW-2, except for general purpose, discrete control, receptacle, and lighting circuits which shall be Type THHN/THWN-2.

D. 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.

E. Fabrication:

1. Permanently mark American Wire Gauge (AWG) size, grade of insulation, voltage, and manufacturer's name on outer covering at maximum 24-inch intervals.
2. Identify and mark conductors in accordance with NEC Article 310.
3. Fabricate cable ends with provisions for field testing.

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: 8 kV, shielded, UL 1072, Type MV-105.
3. Conductors: Copper, concentric lay Class B stranded in accordance with ASTM B3, ASTM B8, and ASTM B263.
4. Conductor Screen: Extruded, semiconducting ethylene-propylene rubber in accordance with NEMA WC 71 and AEIC CS 6.
5. Insulation: 133 percent insulation level, ethylene-propylene rubber (EPR), containing no polyethylene in accordance with NEMA WC 71, and AEIC CS 6.
6. Insulation Thickness: 140-mil, 8 kV, nominal.
7. Insulation Screen: Thermosetting, semiconducting ethylene-propylene rubber (EPR), extruded directly over insulation in accordance with NEMA WC 74 and AEIC CS 6.
8. Metallic Shield: Uncoated, 5-mil, copper shielding tape, helically applied with 17-1/2 percent minimum overlap.
9. Jacket: Extruded polyvinyl chloride (PVC) compound applied over the metallic shield in accordance with NEMA WC 71.
10. Operating Temperature: 105 degrees C continuous normal operations, 130 degrees C emergency operating conditions, and 250 degrees C short-circuit conditions.

11. Manufacturers:
    a. Okonite Co.
    b. Pirelli Wire and Cable.
    c. General Cable.
    d. Southwire Co.
    e. "Or-equal."

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 minimum, 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

No. of Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
12	0.72	60
19	0.83	60
25	1.00	60
37	1.15	80

4. Manufacturers:
   a. Okonite Co.
   b. Southwire.
   c. "Or-equal."

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	0.42	45
		3	0.45	45
		4	0.49	45

Conductor Size	Minimum Ground Wire Size	No. of Current Carrying Conductors	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
10	10	2 3 4	0.54 0.58 0.63	60 60 60
8	10	3 4	0.66 0.75	60
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.
   c. “Or-equal.”

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 55 requirements.
   1. Outer Jacket: 45-mil nominal thickness.
   2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
   3. Dimension: 0.31-inch nominal OD.

4. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
    b. 20 AWG, seven-strand tinned copper drain wire.
    c. Insulation: 15-mil nominal PVC.
    d. Jacket: 4-mil nominal nylon.
    e. Color Code: Pair conductors, black and red.
5. Manufacturers:
    a. Okonite Co.
    b. Alpha Wire Corp.
    c. Belden.
    d. “Or-equal.”

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 55 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.
    d. “Or-equal.”

F. Type 8, Multi-Conductor Adjustable Frequency Drive Power Cable:
1. Conductors:
    a. Class B, stranded coated copper.
    b. Insulation: 600-volt cross-linked polyethylene, UL Type XHHW-2.
    c. Grounding Conductors: Insulated stranded copper.

2. Sheath:
   a. UL 1277 Type TC, 90 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)	Jacket Thickness (Mils)
12 AWG	12	4	0.610	50
10 AWG	10	4	0.670	50
8 AWG	8	4	0.910	50
6 AWG	6	4	1.010	50
4 AWG	4	4	1.150	50
2 AWG	2	4	1.310	50

5. Manufacturers and Products:
   a. Alpha Wire, Series V.
   b. Belden, Series 29500.
   c. LAPP USA, OLFLEX VFD Slim.
   d. "Or-equal."

2.04 300-VOLT RATED CABLE

A. General:
1. Type PLTC, meeting requirements of UL 13 and 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: 105 degrees C.
5. Passes Vertical Tray Flame Test.
6. Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.

B. Type 23, 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 55 requirements.

1. Outer Jacket: 37-mil nominal thickness.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
3. Dimension: 0.264-inch nominal OD.
4. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
    b. 18 AWG, tinned copper drain wire.
    c. Insulation: 15-mil nominal PVC.
    d. Jacket: 4-mil nominal nylon.
    e. Color Code: Pair conductors, black and red.
5. Manufacturers:
    a. Belden 9316.
    b. Okonite Co.
    c. Alpha Wire Corp.
    d. "Or-equal."

C. Type 24, Twisted Pair Fire Alarm Cable Nonshielded: Power limited fire protective signaling circuit cable meeting requirements of NFPA 70, Article 760.

1. Cable: Pass NFPA 262, 70,000 Btu flame test and listed by California State Fire Marshall.
2. Outer Jacket: Red in color, identified along its entire length as fire protective signaling circuit cable.
3. Conductors:
    a. Solid, tinned, or bare copper.
    b. Insulation: 15-mil PVC.
4. Cable Sizes:

Wire Size	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Inches)
12	0.36	0.042
14	0.32	0.042
16	0.26	0.037
18	0.23	0.037

5. Manufacturers:
   a. West Penn Wire.
   b. Coleman Cable, Inc.
   c. "Or-equal."

2.05 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-B.2-1 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:
      a. Belden; 7852A.
      b. "Or-equal."

B. Type 31, Shielded Twisted Pair Telephone and Data Cable, 300V:
   1. Category 6, UL listed, and third party verified to comply with TIA/EIA 568-B.2-1 Category 6 requirements and tested up to 250MHz.
   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:
      a. Belden; 1352A.
      b. "Or-equal."

C. Type 32, Gel-filled Unshielded Twisted Pair Telephone and Data Cable, 300V:
   1. Category 6 UTP, UL listed, and third party verified to comply with TIA/EIA 568-B.2-1 Category 6 requirements.
   2. Cable is rated for use in underground ductbanks.
   3. 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.
   4. Provide four each individually twisted pair, 23 AWG conductors, with FEP insulation and black PVC jacket.
   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:
      a. Belden; 2143A.
      b. “Or-equal.”

D. Type 33, EIA RS-232 Shielded Computer Cable, 300V.
   1. UL Listed, CMG approval. Meets UL 1685 flammability test.
   2. Conductors: Tinned copper, 7 - 22AWG.
   3. Insulation: Semi-rigid PVC.
   4. Overall Shield:
      a. Tape: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
      b. Braid: Tinned copper, 70 percent coverage.
   5. Manufacturer and Product:
      a. Belden; 9943.
      b. “Or-equal.”

2.06 GROUNDING CONDUCTORS

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

B. Direct Buried: Bare stranded copper.

2.07 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

A. Tape:
   1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33+, rated for 90 degrees C minimum, meeting requirements of UL 510.

2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.
3. Arc and Fireproofing:
    a. 30-mil, elastomer.
    b. Manufacturers and Products:
        1) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.
        2) Plymouth; 53 Plyarc, with 77 Plyglas glass cloth tapebinder.
        3) "Or-equal."

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.
        3) "Or-equal."
2. Heat Bond Marker:
    a. Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive.
    b. Machine printed black text.
    c. Manufacturer and Product:
        1) 3M Co.; Type SCS-HB.
        2) "Or-equal."
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:
        1) Raychem; Type CM-SCE.
        2) "Or-equal."
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.
         4) "Or-equal."
   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.
         4) "Or-equal."
   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.
         3) "Or-equal."
   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.
         4) "Or-equal."

D. Cable Lugs:
   1. In accordance with NEMA CC 1.
   2. Rated 600 volts of same material as conductor metal.

3. Uninsulated Crimp Connectors and Terminators:
    a. Suitable for use with 75 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) "Or-equal."
4. Uninsulated, Bolted, Two-Way Connectors and Terminators:
    a. Manufacturers and Products:
        1) Thomas & Betts; Locktite.
        2) Burndy; Quiklug.
        3) ILSCO.
        4) "Or-equal."

E. Cable Ties:
    1. Nylon, adjustable, self-locking, and reusable.
    2. Manufacturer and Product:
        a. Thomas & Betts; TY-RAP.
        b. "Or-equal."

F. Heat Shrinkable Insulation:
    1. Thermally stabilized cross-linked polyolefin.
    2. Single wall for insulation and strain relief.
    3. Dual Wall, adhesive sealant lined, for sealing and corrosion resistance.
    4. Manufacturers and Products:
        a. Thomas & Betts; SHRINK-KON.
        b. Raychem; RNF-100 and ES-2000.
        c. "Or-equal."

2.08 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 the cable ampacity, conforming to IEEE 404.

3. Class 5 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.
    c. "Or-equal."

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 the cable ampacity, conforming to IEEE 404.
3. Class 5 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. "Or-equal."

C. Termination Kits:
1. Capable of terminating 8 kV, single-conductor, polymeric-insulated shielded cables plus a shield ground clamp.
2. Capable of producing a termination with a current rating equal to, or greater than, the cable ampacity, meeting Class 1 requirements of IEEE 48.
3. Capable of accommodating any form of cable shielding or construction without the need for special adapters or accessories.
4. Manufacturers:
    a. Raychem.
    b. 3M Co.
    c. "Or-equal."

D. Bus Connection Insulation:
1. Heat shrinkable tubing, tape, and sheets of flexible cross-linked polymeric material formulated for high dielectric strength.

2. Tape and sheet products to have coating to prevent adhesion to metal surfaces.
3. Manufacturer:
    a. Raychem.
    b. “Or-equal.”

E. Elbow Connector Systems:
1. Molded, peroxide-cured, EPDM-insulated, Class 15 kV, 95 kV BIL, 600A, 40,000 rms nonload-break elbows having all copper current-carrying parts in accordance with IEEE 386.
2. Protective Caps: Class 15 kV, 95 kV BIL, 600 amperes, with molded EPDM insulated body.
3. Insulated Standoff Bushings: Class 15 kV, 95 kV BIL, 600 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, 600A, nonload-break with EPDM rubber body and all-copper, current-carrying parts.
5. Junctions: Class 15 kV, 95 kV two-way, 600A, 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.
    c. “Or-equal.”

F. Cable Lugs:
1. In accordance with NEMA CC1.
2. Rated 5 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.
    d. “Or-equal.”

4. Manufacturers and Products, Uninsulated, Bolted, Two-Way Connectors and Terminators:
   a. Thomas & Betts; Locktite.
   b. ILSCO.
   c. "Or-equal."

2.09 PULLING COMPOUND

A. Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant; UL listed.

B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.

C. Approved for intended use by cable manufacturer.

D. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.

E. Manufacturers:
   1. Ideal Co.
   2. Polywater, Inc.
   3. Cable Grip Co.
   4. "Or-equal."

2.10 WARNING TAPE

A. As specified in Section 26 05 33, Raceway and Boxes.

2.11 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 6 partial discharge level test for EPR insulated cable.

C. Test full lengths in accordance with ASTM and ICEA standards.

PART 3 EXECUTION

3.01 GENERAL

A. Test conductors and cables post installation per Section 26 08 00, Commissioning of Electrical Systems.

B. Conductor installation shall be in accordance with manufacturer's recommendations.

C. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.

D. Do not exceed cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii.

E. Terminate conductors and cables, unless otherwise indicated.

F. Tighten screws and terminal bolts in accordance with UL 486A-486B for copper conductors.

G. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.

H. Bundling: Where single conductors and cables in manholes, handholes, vaults, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 18 inches on center.

I. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.

J. 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 an area 1-1/2 inches to 2 inches wide.
2. 8 AWG and Smaller: Provide colored conductors.
3. Colors:

System	Conductor	Color
All Systems	Equipment Grounding	Green
240/120 Volts Single-Phase, Three-Wire	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red

System	Conductor	Color
208Y/120 Volts Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Black Red Blue
480Y Volts Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	Gray Brown Orange or Yellow
NOTE: Phase A, B, C implies direction of positive phase rotation.		

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

B. Conductors Above 600 Volts: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering an area 1-1/2 inches to 2 inches wide.

1. 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 circuit schedule format.
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 continuous circuit conductors from source to load without splices or terminations in intermediate manholes or pull boxes, except for 10 AWG and smaller conductors for lighting and receptacles.

B. Size power conductors in accordance with National Electrical Code when sizes are not indicated on Drawings.

C. Install minimum 12 AWG wiring for power circuits unless otherwise specified or indicated on Drawings, and minimum 14 AWG for control wiring unless otherwise specified.

D. Install minimum 14 AWG for internal panel control wiring with type MTW or SIS insulation.

E. Do not exceed cable manufacturer's pulling tension and side-wall pressures.

F. Terminations and Splices (600 Volt or Less):
   1. Terminations: Terminate control and instrument conductors on terminal boards with set-screw pressure connectors with spade, ring lug connections or ferrules.
   2. Splicing: Join conductors mechanically with splice connectors and install heat-shrink type insulation. Splice conductors in accordance with manufacturer's instructions. Make waterproof heat shrink type splices in wet and below grade locations. Control and instrument conductors shall not be spliced.
   3. Splice or weld grounding conductors of different sizes.
   4. Conductor 10 AWG and smaller for lighting and receptacle circuits may be spliced in junction boxes with wire nuts.

G. All conductors for installation in underground duct banks, in sizes 10 AWG and smaller shall be of the multi-conductor type with overall jacket.

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

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

J. Connections and Terminations:

1. Install wire nuts on solid or stranded conductors. Silicon impregnated wire nuts are acceptable.
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 8 AWG or larger. 10 AWG motor circuit conductors may terminated using wire nuts.
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.

K. Do not use soldered mechanical joints.

L. Splices and Terminations:

1. Where splices are necessary because of extremely long wire or cable lengths that exceed standard manufactured lengths, install and label junction boxes for power conductors or termination cabinets for control and instrument conductors.
2. Power and control conductors routed in common raceways may be spliced in common junction boxes.
3. Install NEMA 4X junction and terminal boxes in wet and outdoor locations. Clearly label junction and terminal boxes containing splices with the word "SPLICE".

4. Leave sufficient slack at junction boxes and termination boxes to make proper splices and connections. Do not pull splices into conduit.
5. Insulate all uninsulated connections.
6. Indoors: Use general purpose, flame retardant tape or single wall heat shrink.
7. Outdoors, Dry Locations: Use flame retardant, cold- and weather-resistant tape or single wall heat shrink.
8. Below Grade and Wet or Damp Locations: Use dual wall heat shrink.

M. Cap spare conductors with UL listed end caps.

N. 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.

O. Control and Instrumentation Wiring:
1. Install instrumentation class cables in separate raceway systems.
   a. Install instrument cable in metallic conduit within non-dedicated manholes or pull boxes.
   b. Install cable without splices between instruments or between field devices and instrument enclosures or panels.
2. Do not make intermediate terminations, except in designated terminal boxes indicated on Contract Documents.
3. Ground cable shields at only one location, typically at panels, not at field instruments.
4. Install communication cables in dedicated raceways, including through ductbanks, manholes, and pull boxes.
5. Separate and isolate electrical signal cables from sources of electrical noise and power cables by minimum 12 inches.
6. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
7. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer’s instructions.
8. Manufacturer supplied instrument cables shall be cut down to fit the installation with an excess of 3 feet.
9. Splices are not allowed.

10. 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 the shield.

P. 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 Jacobs' Engineer or Owner.

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 shield termination and grounding for terminations.

G. Provide necessary mounting hardware, covers, and connectors.

H. Where elbow connectors are specified, install in accordance with manufacturer's instructions.

I. Connections and Terminations:
    1. Install uninsulated crimp connectors and terminators for power circuit conductors 4 AWG through 2/0 AWG.
    2. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors 4/0 AWG and larger.
    3. Install uninsulated, bolted, two-way connectors for motor circuit conductors No. 12 and larger.

4. Insulate bus connections with heat shrinking tubing, tape, and sheets.

J. Give 2 working days' notice to Design-Builder prior to making splices or terminations.

3.06 CONDUCTOR ARC AND FIREPROOFING

A. Install arc and fireproofing tape on 8 kV cables throughout their entire exposed length at splices in manholes, handholes, vaults, cable trays, and other indicated locations.

B. Wrap conductors of same circuit entering from separate conduit together as a single cable.

C. Follow tape manufacturer's installation instructions.

D. Secure tape at intervals of 5 feet with bands of tapebinder. Each band to consist of a minimum of two wraps directly over each other.

3.07 FIELD CONDITIONS AND RELATED REQUIREMENTS

A. Existing underground water table is near or above the location of new ductbanks.

B. Existing underground pull boxes, handholes, ductbanks, and manholes contain excessive amounts of water, conductors, and debris.

C. Contractor shall include cost for necessary dewatering, equipment cost to identify raceways, and cleaning equipment to perform the work required for new underground ductbanks, manholes, and pull boxes.

D. Contractor shall include necessary cost to clean all underground ductbanks and pull boxes prior to installation of required new conductors.

3.08 WIRING ALLOWANCES

A. Subcontractor shall include allowance of necessary conductors and terminations to provide any and all motorized equipment, electrical outlets, fixtures, communication outlets, instruments, and devices within 10 linear feet of location shown on Contract Documents.

B. Subcontractor shall include allowance of necessary conductors and related materials to provide any and all pull boxes, manholes, and ductbanks within 20 linear feet of location shown on Contract Documents.

C. Prior to installation of any raceway or related items identified in Paragraphs A and B above, the Owner shall have the right to make changes related to preferred location, at no additional cost.

D. Subcontractor shall include allowance to provide necessary conductors for all equipment specified, identified in wiring/raceway schedule, equipment schedules, panelboards schedules, electrical single line diagrams, block diagrams, process and instrumentation diagrams (P&IDs), fixture schedules, and devices. Said necessary conductors may not be shown on the plan drawings, but they shall be sized by Subcontractor in accordance with requirements of the National Electrical Code, and included in this allowance if the conductor are necessary for the complete operation of the included device or equipment.

E. Include cost allowance to provide the following wiring for potential extra items not included in Contract Documents:

1. 5,000 linear feet of 12 AWG-THWN-2 copper single conductor for installation in conduit.
2. 8,000 linear feet of 14 AWG-THWN-2 for installation in conduit.
3. 3,000 linear feet of 16 AWG shielded one pair cable for installation in conduit.
4. 3,000 linear feet of No. 12-2 with Ground AWG-XHHW with jacket for installation in conduit.

3.09 RESTRAINING DEVICES FOR SUSPENDED CONDUCTORS

A. Submersible Cables in Wet Wells: Provide kellem's grip or stainless steel wire mesh to support cable weight and avoid stress on insulation.

B. Cable Fasteners: Provide black plastic tie-wraps or alike cable fasteners to attach exposed or suspended cables to cabinets, building, or structure. All plastic tie-wraps must be outdoor and UV rated.

END OF SECTION

SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes: Grounding electrode system, consisting of bare or insulated conductors and ground rods and also includes insulated equipment and system ground wires in conduits.

1.02 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).

1.03 SUBMITTALS

A. Action Submittals: Shop Drawings.

1.04 QUALITY ASSURANCE

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

PART 2 PRODUCTS

2.01 GROUND ROD

A. Material: Copper-clad.

B. Diameter: Minimum 3/4 inch.

C. Length: 10 feet.

2.02 GROUND CONDUCTORS

A. As specified in Section 26 05 05, Conductors.

2.03 CONNECTORS

A. Exothermic Weld Type:
   1. Outdoor Weld: Suitable for exposure to elements or direct burial.
   2. Indoor Weld: Utilize low-smoke, low-emission process.
   3. Manufacturers and Products:
      a. Erico Products, Inc.; Cadweld and Cadweld Exolon.
      b. Thermoweld.
      c. "Or-equal."

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.
      b. Thomas and Betts Co.
      c. ILSCO.
      d. "Or-equal."

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.
   3. "Or-equal."

PART 3 EXECUTION

3.01 GENERAL

A. Grounding shall be in compliance with NFPA 70 and IEEE C2.

B. Ground electrical service neutral at service entrance equipment to supplementary grounding electrodes.

C. Ground each separately derived system neutral to nearest effectively grounded building structural steel member or separate grounding electrode.

D. Bond together system neutrals, service equipment enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways, ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.

E. Shielded Power Cables: Ground shields at each splice or termination in accordance with recommendations of splice or termination manufacturer.

F. 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.

G. Install concrete encased bare ground conductor in each duct bank. Run grounding electrode system conductors continuously in duct banks, through manholes, handholes, other raceway boxes, and cable tray exteriors. Connect conductors to grounding plate at main switchgear. All UFER grounding plates must be brought to a single plate and not equipment ground. Do not use bimetallic terminals. Use Navy style or compression ring terminals. structure ground ring or grounding system to provide a continuous grounding electrode system.

H. Bond electrical enclosures, including metallic raceways, panels, switchboards, and other similar metallic panels, cases, and devices associated with power, instrumentation, and control systems to the grounding electrode system.

I. Drive ground rods and install grounding conductors prior to construction of concrete slabs and duct banks.
   1. Extend grounding conductors through concrete to accessible points for grounding equipment and electrical enclosures.

2. Install grounding system at each structure where switchgear, motor control centers, switchboards, panelboards, panels, or other electrical equipment are installed.

J. Provide exothermic welded for grounding cable to rods or cable.

K. When size is not indicated on Contract Documents, size grounding conductors in accordance with NEC Table 250-66 and Table 250-122.

L. Install a green insulated equipment grounding conductor, or multi-conductor cable with integral green insulated grounding conductor, with each feeder and branch circuit from the power source grounding means to the load equipment or device.

M. Install ground bushings at both ends of rigid conduit runs. Do not use locknuts. Bond ground bushings to the grounding system.

N. When not indicated on Contract Documents, install grounding electrode systems in compliance with NEC-250, Part C.

O. Furnish and install precast ground well boxes as specified herein.

3.02 WIRE CONNECTIONS

A. Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.

B. Nonmetallic Raceways and Flexible Tubing: Install equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.

C. Connect ground conductors to raceway grounding bushings.

D. Extend and connect ground conductors to ground bus in all equipment containing a ground bus.

E. Connect enclosure of equipment containing ground bus to that bus.

F. Bolt connections to equipment ground bus.

G. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.

H. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding clips mounted directly on box, or with 3/8-inch machine screws.

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: Furnish compression, spade-type terminal connected to conduit box mounting screw.

D. Motors 10 hp and Above: 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.

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.

3.05 GROUNDING WELLS

A. Install inside buildings, asphalt, and paved areas.

B. Install riser ring and cover flush with surface.

C. Place 6 inches of crushed rock in bottom of each well.

3.06 CONNECTIONS

A. General:
   1. Provide exothermic weld for exterior connections.
      a. Abovegrade Connections: Install exothermic weld as standard. Mechanical, or compression-type connectors provided where exothermic welds are not suitable or recommended by the manufacturer.
      b. Belowgrade Connections: Install exothermic weld only. Compression type connectors are not allowed.

2. Compression or exothermic weld may be used for building interior connections.
3. Remove paint, dirt, or other surface coverings at connection points to allow good metal-to-metal contact.
4. Notify Design-Builder 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.

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.

3.07 METAL STRUCTURE GROUNDING

A. Ground 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.

B. Ground Rod Floor Protrusion: 4 inches to 6 inches above floor.

C. Make connections of grounding conductors fully visible and accessible.

D. Connect all noncurrent-carrying metal parts, and any metallic raceway grounding bushings to ground rod with 6 AWG copper conductor.

3.09 TRANSFORMER GROUNDING

A. Bond neutrals of transformers within buildings to system ground network, and to any additional indicated grounding electrodes.

B. Bond neutrals of pad-mounted transformers to locally driven ground rods and buried ground wire encircling transformer and system ground network.

3.10 SURGE PROTECTION EQUIPMENT GROUNDING

A. Connect surge arrestor ground terminals to equipment ground bus.

3.11 FIELD QUALITY CONTROL

A. Test ground resistance, as specified in Section 26 08 00, Commissioning of Electrical System, of entire system and at each building/structure where electrical equipment is installed.

B. Invite Jacobs to witness ground resistance testing.

C. Where maximum allowable ground resistance of 5 ohms is exceeded, install additional grounding mats or ground rods until ground resistance is equal to or below maximum allowable ground resistance.

END OF SECTION

SECTION 26 05 33
RACEWAY AND BOXES

PART 1 GENERAL

1.01 SUMMARY

A. This section includes conduit, tubing, fittings, boxes, cabinets, surface raceways, wireways, manholes, handholes, and accessories.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American Association of State Highway and Transportation Officials (AASHTO): HB, Standard Specifications for Highway Bridges, Sixteenth Edition.
   2. American Concrete Institute (ACI): 318, Building Code Requirements for Structural Concrete
   3. 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, Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
   4. Electronic Industry Alliance (EIA) and Telecommunications Industry Association (TIA): 569, Commercial Building Standard for Telecommunications Pathways and Spaces.
   5. National Electrical Contractor's Association, Inc. (NECA):
      a. 101, Standard for Installing Steel Conduit (Rigid, EMT).
      b. 111, Standard for Installing Nonmetallic Raceway (RNC, ENT, LFNC).
   6. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. C80.1, Specification for Rigid Steel Conduit, Zinc Coated.
      c. C80.3, Specification for Electrical Metallic Tubing, Zinc Coated.
      d. C80.5, Specification for Rigid A Conduit.
      e. C80.6, Intermediate Metal Conduit (IMC) – Zinc Coated.

f. RN 1, Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
g. TC 2, Electrical Polyvinyl Chloride (PVC) Plastic Tubing and Conduit.
h. TC 3, Polyvinyl-Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
i. TC 6, PVC Plastic Utilities Duct for Underground Installation.

7. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
8. UL:
   a. 1, Standard for Flexible Metal Conduit.
   b. 5, Standard for Surface Metal Raceways and Fittings.
   c. 6, Standard for Electrical Rigid Metal Conduit – Steel.
   d. 50, Standard for Enclosures for Electrical Equipment.
   e. 360, Standard for Liquid-Tight Flexible Steel Conduit.
   f. 514B, Standard for Conduit, Tubing, and Cable Fittings.
   g. 514C, Standard for Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers.
   h. 651, Standard for Schedule 40 and 80 Rigid PVC Conduit.
   i. 651A, Standard for Type EB and A Rigid PVC Conduit and HDPE Conduit.
   j. 797, Standard for Electrical Metallic Tubing.
   k. 870, Standard for Wireways, Auxiliary Gutters, and Associated Fittings.
   l. 1242, Standard for Intermediate Metal Conduit.
   m. 1660, Standard for Liquid-Tight Flexible Nonmetallic Conduit.
   n. 1684, Standard for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
   o. Standard for Optical Fiber and Communication Cable Raceway.

1.03 SUBMITTALS

A. Action Submittals:
   1. Manufacturer's Literature:
      a. PVC coated rigid galvanized steel conduit.
      b. PVC-Coated conduit fittings.
      c. Device boxes for use in hazardous areas.
      d. Junction and pull boxes used at or below grade.
      e. Large junction and pull boxes.
      f. Terminal junction boxes.

2. Precast Manholes and Handholes:
   a. Dimensional drawings and descriptive literature.
   b. Traffic loading calculations.
   c. Accessory information.
3. Submit anchorage and bracing drawings and cut sheets as required by Section 01 88 15, Anchorage and Bracing.
4. Conduit Layout:
   a. Provide drawings for underground and concealed conduits including, but not limited to ductbanks, those under floor slabs, concealed in floor slabs and concealed in walls.
   b. Provide plans 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.
   d. Indicate spacing between conduit and size of conduit with circuit id.
   e. Provide section arrangement for conduit entering structures below grade.

B. Informational Submittals:
   1. Submit anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
   2. PVC-Coated Rigid Conduit Installer Certification.

1.04 QUALITY ASSURANCE

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

B. PVC-Coated, Rigid Steel Conduit Installer: Certified by conduit manufacturer as having received minimum 2 hours of training on installation procedures.

PART 2 PRODUCTS

2.01 CONDUIT AND TUBING

A. Rigid Galvanized Steel Conduit (RGS):
   1. Meet requirements of NEMA C80.1 and UL 6.
   2. Material: Hot-dip galvanized, with chromated protective layer.
   3. Manufacturers:
      a. LTV Steel Tubular Products Company.
      b. Triangle PWC Inc.
      c. Allied Tube and Conduit Corporation.

B. Electric Metallic Tubing (EMT):
   1. Meet requirements of NEMA C80.3 and UL 797.
   2. Material: Hot-dip galvanized, with chromated and lacquered protective layer.
   3. Manufacturers:
      a. LTV Steel Tubular Products Company.
      b. Triangle PWC Inc.
      c. Allied Tube and Conduit Corporation.

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. Manufacturers:
      a. Carlon.
      b. Triangle Conduit and Cable.

D. PVC-Coated Rigid Galvanized Steel Conduit:
   1. Meet requirements of NEMA RN 1.
   2. Material:
      a. Meet requirements of NEMA C80.1 and UL 6.
      b. Exterior Finish: PVC coating, 40 mils nominal thickness, bond to metal shall have tensile strength greater than PVC.
      c. Interior Finish: Urethane coating, 2 mils nominal thickness.
   3. Threads: Hot-dipped galvanized and factory coated with urethane.
   4. Bendable without damage to either interior or exterior coating.
   5. Manufacturers:
      a. Robroy Industries; Perma-Cote.
      b. Ocal Inc.
      c. “Or-equal.”

E. Flexible Metal, Liquid-Tight Conduit:
   1. UL 360 listed for 105 degrees C insulated conductors.
   2. Material: Galvanized steel, with an extruded PVC jacket.
   3. Manufacturers:
      a. American Brass.
      b. General Electric.

F. Flexible Metal, Nonliquid-Tight Conduit:
   1. Meet requirements of UL 1.
   2. Material: Galvanized steel.
   3. Manufacturers:
      a. American Brass.
      b. General Electric.

G. Innerduct:
   1. Resistant to spread of fire, per requirements of UL 2024.
   2. Smooth or corrugated HDPE.
   3. Textile:
      a. Manufacturer: Maxcell.

2.02 FITTINGS

A. Rigid Galvanized Steel:
   1. General:
      a. Meet requirements of UL 514B.
      b. Type: Threaded, galvanized. Set screw and threadless compression fittings not permitted.
   2. Bushing:
      a. Material: Malleable iron with integral insulated throat, rated for 150 degrees C.
      b. Manufacturers and Products:
         1) Appleton; Series BU-I.
         2) O-Z/Gedney; Type HB.
   3. Grounding Bushing:
      a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs.
      b. Manufacturers and Products:
         1) Appleton; Series GIB.
         2) O-Z/Gedney; Type HBLG.
   4. Conduit Hub:
      a. Material: Malleable iron with insulated throat with bonding screw.
      b. UL listed for use in wet locations.

c. Manufacturers and Products:
   1) Appleton, Series HUB-B.
   2) O-Z/Gedney; Series CH.
   3) Meyers; ST Series.

5. Conduit Bodies:
   a. Sized as required by NFPA 70.
   b. Malleable iron.
   c. Manufacturers and Products (For Normal Conditions):
      1) Appleton; Form 7.
      2) Crouse-Hinds; Form 7 threaded condulets.
      3) Killark; Form 7.
      4) Thomas & Betts; Form 7.
   d. Manufacturers (For Hazardous Locations):
      1) Appleton.
      2) Crouse-Hinds.
      3) Killark.
6. Couplings: As supplied by conduit manufacturer.
7. Unions:
   a. Concrete tight, hot-dip galvanized malleable iron.
   b. Manufacturers and Products:
      1) Appleton; Series SCC Bolt-On Coupling or Series EC Three-Piece Union.
      2) O-Z/Gedney; Type SSP split coupling or Type 4 Series, three-piece coupling.
8. Conduit Sealing Fitting Manufacturers and Products:
   a. Appleton; Type EYF, EYM, or ESU.
   b. Crouse-Hinds; Type EYS or EZS.
   c. Killark; Type EY or EYS.
9. Drain Seal Manufacturers and Products:
   a. Appleton; Type EYD.
   b. Crouse-Hinds; Type EYD or EZD.
10. Drain/Breather Fitting Manufacturers and Products:
   a. Appleton; Type ECDB.
   b. Crouse-Hinds; ECD.
11. Expansion Fitting Manufacturers and Products:
   a. Deflection/Expansion Movement:
      1) Appleton; Type DF.
      2) Crouse-Hinds; Type XD.

b. Expansion Movement Only:
   1) Appleton; Type XJ.
   2) Crouse-Hinds; Type XJ.
   3) Thomas & Betts; XJG-TP.

12. Cable Sealing Fittings:
   a. To form watertight nonslip cord or cable connection to conduit.
   b. For Conductors with OD of 1/2 inch or Less: Neoprene bushing at connector entry.
   c. Manufacturers and Products:
      1) Appleton; CG-S.
      2) Crouse-Hinds; CGBS.

B. Electric Metallic Tubing:
   1. Meet requirements of UL 514B.
   2. Type: Steel body and locknuts with steel or malleable iron compression nuts. Set screw and drive-on fittings not permitted.
   3. Electro zinc-plated inside and out.
   4. Raintight.
   5. Coupling Manufacturers and Products:
      a. Appleton; Type 95T.
      b. Crouse-Hinds.
      c. Thomas & Betts.
   6. Connector Manufacturers and Products:
      a. Appleton; Type ETP.
      b. Crouse-Hinds.
      c. Thomas & Betts.

C. PVC Conduit and Tubing:
   1. Meet requirements of NEMA TC-3.
   2. Type: PVC, slip-on.

D. PVC-Coated Rigid Galvanized Steel Conduit:
   1. Meet requirements of UL 514B.
   2. Fittings: Rigid galvanized steel type, PVC coated by conduit manufacturer.
   3. Conduit Bodies: Form 7, cast metal hot-dipped galvanized or urethane finish. Cover shall be of same material as conduit body. PVC coated by conduit manufacturer.
   4. Finish: 40-mil PVC exterior, 2-mil urethane interior.
   5. Overlapping pressure-sealing sleeves.
   6. Conduit Hangers, Attachments, and Accessories: PVC-coated.

7. Manufacturers:
    a. Robroy Industries.
    b. Ocal.

E. 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.

F. Flexible Metal, Nonliquid-Tight Conduit:
1. Meet requirements of UL 514B.
2. Body: Galvanized steel.
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.

G. Flexible Coupling, Hazardous Locations:
1. Approved for use in the 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 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 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. Sheet Steel: One-piece drawn type, zinc- or cadmium-plated.

B. Cast Metal:
   1. Box: Malleable iron.
   2. Cover: Gasketed, weatherproof, malleable iron, with stainless steel screws.
   3. Hubs: Threaded.
   4. Lugs: Cast mounting.
   5. Manufacturers and Products, Nonhazardous Locations:
      a. Crouse-Hinds; Type FS or FD.
      b. Appleton; Type FS or FD.
   6. Manufacturers and Products, Hazardous Locations:
      a. Crouse-Hinds; Type GUA or EAJ.
      b. Appleton; Type GR.

C. PVC-Coated Cast Metal:

   1. Type: One-piece.
   2. Material: Malleable iron, cast ferrous metal.
   3. Coating:
      a. Exterior Surfaces: 40-mil PVC.
      b. Interior Surfaces: 2-mil urethane.
   4. Manufacturers:
      a. Robroy Industries.
      b. Ocal.
      c. “Or-equal.”

D. Nonmetallic:
   1. Box: PVC.
   2. Cover: PVC, weatherproof, with stainless steel screws.
   3. Manufacturers and Products:
      a. Carlon; Type FS or FD, with Type E98 or E96 covers.
      b. “Or-equal.”

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 Sheet Steel Box:
   1. NEMA 250, Type 1.
   2. Box: Code-gauge, galvanized steel.
   3. Cover: Full access, screw type.
   4. Machine Screws: Corrosion-resistant.

D. Large Cast Metal Box, Hazardous Locations:
   1. NEMA 250 Type 7 or Type 9 as required for Class, Division, and Group involved.
   2. Box: Cast ferrous metal, electro-galvanize finished or copper-free aluminum with drilled and tapped conduit entrances.
   3. Cover: Hinged with screws.
   4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
   5. Manufacturers and Products:
      a. Crouse-Hinds; Type EJB.
      b. Appleton; Type AJBEW.

E. Large Stainless Steel Box:
   1. NEMA 250 Type 4X.
   2. Box: 14-gauge, ASTM A240/A240M, Type 304 stainless steel, with white enamel painted interior mounting panel.
   3. Cover: Hinged with clamps.
   4. Hardware and Machine Screws: ASTM A167, Type 304 stainless steel.
   5. Manufacturers:
      a. Hoffman Engineering Co.
      b. Robroy Industries.
      c. Wiegman.

F. Concrete Box, Nontraffic Areas:
   1. Box: Reinforced, cast concrete with extension.
   2. Cover:
      a. Steel diamond plate with locking latch.
      b. Locking bolts are NOT acceptable.
   3. Cover Marking: ELECTRICAL, TELEPHONE, or as shown in addition to tag shown on Contract Documents.
   4. Size: 10 inches by 17 inches, minimum.
   5. Manufacturers and Products:
      a. Utility Vault Co.; Series 36-1017.
      b. Christy, Concrete Products, Inc.; N9.
      c. Quazite; “PG” Style.

G. Concrete Box, Traffic Areas:
   1. Box: Reinforced, cast concrete with extension and bottom slab.
   2. Cover: Steel checker plate; H/20 loading with latch.
      a. Locking bolts are NOT acceptable.
   3. Cover Marking: ELECTRICAL, TELEPHONE, or as shown in addition to tag shown on Contract Documents.
   4. Manufacturers and Products:
      a. Christy, Concrete Products, Inc.; B1017BOX.
      b. Utility Vault Co.; 3030 SB.

2.05 TELEPHONE AND DATA OUTLET

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

2.06 TERMINAL JUNCTION BOX

A. Cover: Hinged, unless otherwise shown.

B. Interior Finish: Paint with white enamel or lacquer.

C. Terminal Blocks:
   1. Separate connection point for each conductor entering or leaving box.
   2. Spare Terminal Points: 25 percent, minimum.

2.07 PRECAST MANHOLES AND HANDHOLES

A. Concrete Strength: Minimum, 4,000 psi compressive, in 28 days.
   1. Strength: Minimum 4,000 psi compressive, in 28 days.
   2. Concrete Sulfate Exposure Class: S2.
      a. Provide Type V cement or Type II cement with fly ash or slag as required to meet sulfate exposure class.
   3. Concrete Chloride Exposure Class: C1.

B. Loading: AASHTO, H-20 in accordance with ASTM C857.

C. Access: Provide cast concrete 6-inch or 12-inch risers between top of manhole and finished grade at required elevations.

D. Drainage:
   1. Slope floors toward drain points, leaving no pockets or other nondraining areas.
   2. Provide drainage outlet or sump at low point of floor constructed with a heavy, cast iron, slotted or perforated hinged cover, and a minimum 4-inch outlet and outlet pipe.
   3. Minimum of one handhole in a single run shall have a sump pump, see Contract Documents.

E. Raceway Entrances:
   1. Provide on all four sides.
   2. For raceways to be installed under this Contract, provide knockout panels or precast individual raceway openings.
   3. At entrances where raceways are to be installed by others, provide minimum 12-inch high by 24-inch wide knockout panels for future raceway installation.

F. Embedded Pulling Iron:
   1. Material: 3/4-inch diameter stock, fastened to overall steel reinforcement before concrete is placed.
   2. Location:
      a. Wall: Opposite each raceway entrance and knockout panel for future raceway entrance.
      b. Floor: Centered below manhole or handhole cover.

G. Cable Racks:
   1. Arms and Insulators: Adjustable, of sufficient number to accommodate cables for each raceway entering or leaving manhole, including spares.
   2. Material: Fiberglass.
   3. Anchorage: Stainless steel.
   4. Wall Attachment:
      a. Adjustable inserts in concrete walls. Bolts or embedded studs not permitted.
      b. Insert Spacing: Maximum 3 feet on center for entire inside perimeter of manhole.
      c. Arrange so 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, with equipment label ID shown on Contract Documents in addition to the following appropriate titles:
      a. Above 600 Volts: ELECTRIC HV
      b. 600 Volts and Below: ELECTRIC LV.
      c. TELEPHONE.

I. Handhole Frames and Covers:
   1. Material: Steel, hot-dipped galvanized.
   2. Cover Type: Solid, torsion spring, of checkered design.

3. Cover Loading: Nontraffic or AASHTO H-20 for locations in roadways.
4. Cover Designation: Burn by welder, on upper side in integral letters, minimum 2 inches in height, with equipment label ID shown on Contract Documents in addition to the following appropriate titles:
    a. 600 Volts and Below: ELECTRIC LV.
    b. COMMUNICATIONS.

J. Hardware: Stainless steel.

K. Manhole Sump Pumps:
1. Provide permanently installed sump pump for every manhole.
2. Electrical: 1/2 hp, 208/230V, single-phase,
3. Material: Stainless steel.
4. Manufacturer and Product:
    a. Myers; DSW50M2.
    b. “Or-equal.”

L. Manufacturers:
1. Utility Vault Co.
2. Penn-Cast Products, Inc.
3. Concrete Conduit Co.
4. Associated Concrete Products, Inc.
5. Pipe, Inc.

2.08 ACCESSORIES

A. Duct Bank Spacers:
1. Type: Nonmetallic, interlocking, for multiple conduit sizes.
2. Suitable for all types of conduit.
3. Manufacturers:
    a. Underground Device, Inc.
    b. Carlon.

B. Identification Devices:
1. Raceway Tags:
    a. Material: Permanent, nonferrous metal.
    b. Shape: Round.
    c. Raceway Designation: Pressure stamped, embossed, or engraved.
    d. Tags relying on adhesives or taped-on markers not permitted.
2. Warning Tape:
    a. Material: Polyethylene, 4-mil gauge with detectable strip.
    b. Color: Red.
    c. Width: Minimum 3 inches.

d. Designation: Warning on tape that electric circuit is located below tape.
e. Identifying Letters: Minimum 1-inch high permanent black lettering imprinted continuously over entire length.
f. Manufacturers and Products:
1) Panduit; Type HTDU.
2) Reef Industries; Terra Tape.

3. Buried Raceway Marker:
a. Material: Sheet bronze, consisting of double-ended arrows, straight for straight runs and bent at locations where runs change direction.
b. Designation: Incise 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. Raceway Thread Compound:
1. Anti-seize and anti-corrosion properties.
2. Manufacturer and Product:
a. Thomas and Betts; CP8 KOPR-SHIELD.
b. “Or-equal.”

E. 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.

F. 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.

G. Fasteners: Electroplated or stainless steel in boxes with wiring devices.
1. Screws, nuts, bolts, and other threaded fasteners are Type 316 stainless steel.

PART 3 EXECUTION

3.01 GENERAL

A. Install conduit runs in accordance with schematic representation as indicated on Contract Documents. Modify conduit runs to suit field conditions, as accepted by the Jacobs' Engineer.

B. Install conduit runs for lighting and receptacle circuits, whether or not indicated on Drawings, for circuit numbers indicated on Contract Documents.

C. Install straight and true conduit runs with uniform and symmetrical elbows, offsets, and bends. Make changes in direction with long radius bends or with condulet fittings.

D. Install conduit runs so that runs do not interfere with proper and safe operation of equipment and not block or interfere with ingress or egress, including equipment removal hatches.

E. Minimize exposed conduit runs in buildings and structures, unless otherwise indicated on Contract Documents.

F. Securely fasten exposed conduits with clamps or straps. Run exposed conduit on walls and ceilings only, parallel to planes of walls or ceilings. Do not run conduit diagonally. Securely fasten exposed polyvinyl chloride-coated rigid steel conduits with Type 316 stainless steel clamps or straps.

G. Use flexible conduit for short lengths required to facilitate connections between rigid conduit and motors, vibrating equipment, or control equipment.

H. Support conduit runs on water-bearing walls at 7/8 inch for shallow mounting and 1-5/8 inch for deep mounting away from wall on an accepted channel. A combination of depths is acceptable. Use stainless steel channels, consistent with type of conduit being installed. Do not run conduit in water-bearing walls unless otherwise indicated on Contract Documents.

I. Encase underground conduit runs, including conduit runs below slabs-on-grade, in concrete envelope as specified in Section 03 30 00, Cast-in-Place Concrete, and as indicated on Contract Documents.

J. Install underground installations of direct buried cable, conduit, or other raceways to meet minimum cover requirements of NEC Table 300-5 and Table 710-4(b). Exceed minimum NEC requirements where indicated on Contract Documents.

K. Thoroughly ream conduit after threads have been cut to remove burrs. Seal joints with accepted conductive sealant compound and make watertight. Set up joints tight. Use bushings or conduit fittings at conduit terminations. Exposed male threads on rigid steel conduit shall be coated with zinc-rich paint.

L. Install runs between pull boxes or junction boxes with total bends equaling not more than 270 degrees. Install NEC required pull boxes at locations acceptable to Jacobs' Engineer. Plug conduits brought into pull boxes, manholes, handholes, and other openings until used to prevent entrance of moisture. Cap spare conduits and provide plastic pulling tape below threaded cap. Provide bonding bushing and bond wire.

M. Provide appropriate hangers, supports, fasteners, and seismic restraints to suit applications.

N. After complete installation of 2-inch and larger conduit runs, snake conduits with conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of nominal diameter of conduit. Remove and replace conduits through which mandrel will not pass.

O. Clean and ensure that new and existing conduit runs are not crushed or creased. Verify internal dimensions of existing conduit prior to installation of conductors. Verify that no foreign objects or obstructions are present in conduit prior to installing conductors.

P. Install conduit system to provide firm mechanical assemblies with electrical conductivity throughout.

Q. Install expansion/deflection fittings across expansion joints and at other locations where necessary to compensate for thermal or mechanical expansion and contraction as indicated on Contract Documents. Provide ground connection at expansion joints.

R. Install conduits compete between outlets, boxes, and circuit source before conductors are installed.

S. Install minimum 2-inch ductbank raceways, unless otherwise indicated on Contract Documents.

T. Make ductbank raceway to external conduit size transitions at pullboxes and manholes.

U. Install spare conduits in underground duct banks towards top center of runs to allow for ease of installation of future cables as conduits enter underground manholes and pullboxes. All spare conduits shall be installed with a pull string.

V. Install conduit thruwall seals where indicated on Contract Documents.

3.02 INSTALLATION

A. Conduit and Tubing sizes shown are based on the use of copper conductors.

B. All installed Work shall comply with NECA Installation Standards.

C. Crushed or deformed raceways not permitted.

D. Maintain raceway entirely free of obstructions and moisture.

E. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.

F. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.

G. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.

H. Group raceways installed in same area.

I. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.

J. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.

K. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.

L. Block Walls: Do not stall raceways in same horizontal course or vertical cell with reinforcing steel. Consult with Jacobs' Engineer prior to installation.

M. Install watertight fittings in outdoor, underground, or wet locations.

N. Apply conductive compound to all threaded conduit and conduit fittings.

O. Paint threads and cut ends, before assembly of fittings, galvanized conduit, or PVC-coated galvanized 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. Install raceways in concrete equipment pads, foundations, or beams. Consult with Jacobs' Engineer prior to installation.

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 EIA/TIA 596-A.

3.03 REUSE OF EXISTING CONDUITS

A. Where Contract Documents 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 the 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.

3.04 INSTALLATION IN CAST-IN-PLACE STRUCTURAL CONCRETE

A. Minimum Cover: 2 inches, including all 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 Jacobs' Engineer or shown on Contract Documents.

E. Slabs and Walls:
   1. Trade size of conduit not to exceed one-fourth of the slab or wall thickness.
   2. Install within middle one-third of slab or wall.
   3. Separate conduit less than 2-inch trade size by a minimum three times conduit trade size, center-to-center, unless otherwise shown.
   4. Separate conduit 2-inch and greater trade size by a minimum three 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 three times the outside dimension of expansion/deflection fittings at expansion joints.

3.05 CONDUIT APPLICATION

A. Diameter: Minimum 3/4 inch.

B. Exterior, Exposed: Reference Area Classification and Materials Selection table on Contract Documents.

C. Interior, Exposed: Reference Area Classification and Materials Selection table on Contract Documents.

D. Interior, Concealed (Not Embedded in Concrete): Electric metallic tubing.

E. Direct Earth Burial: PVC Schedule 40 for ac circuits, PVC coated RGS for dc circuits.

F. Concrete-Encased Raceways: PVC Schedule 40.

G. Under Slabs-on-Grade: PVC Schedule 40.

H. Transition from Underground or Concrete Embedded to Exposed: PVC-coated rigid steel conduit, extending a minimum of 6 inches above slab, floor or equipment pad.

I. Under Equipment Mounting Pads: PVC-coated rigid steel conduit.

J. Exterior Light Pole Foundations: Schedule 40 PVC.

K. Corrosive Areas: Reference Area Classification and Materials Selection table on Contract Documents.

L. Hazardous Gas Areas: Reference Area Classification and Materials Selection table on Contract Documents.

3.06 POLYVINYL CHLORIDE-COATED RIGID STEEL

A. Attach cover to conduit body with Type 316 stainless steel screws.

B. Where patching is required, apply 40-mil-thick polyvinyl chloride coating in accordance with manufacturer's instructions.

C. Polyvinyl chloride-coated conduit may be buried in earth without concrete encasement where indicated on Contract Documents.

3.07 RIGID NONMETALLIC POLYVINYL CHLORIDE

A. Reinforce encasement as indicated on Contract Documents. Install conduit supports at 30-inch intervals.

3.08 ELECTRIC METALLIC TUBING

A. Install electrical metallic tubing in office and conference room areas of operation and maintenance building.

B. Provide supports spaced at minimum 10-foot on center within 3 feet of each outlet box, junction box, pull box, cabinet, or other enclosure.

C. Use and install electrical metallic tubing in accordance with NEC Article 348.

3.09 CONDUIT SEALS

A. Install conduit entering or leaving NEC Article 500 hazardous areas with conduit seals.

B. Install conduit entering or leaving chlorination facilities or areas of buildings in which chlorine storage or distribution equipment is located with conduit seals.

C. Install conduit seals in other hazardous locations as required by NEC.

D. Provide drains on conduit seals in locations where water accumulation is likely to enter a device or enclosure.

3.10 ELECTRICAL METALLIC TUBING FITTINGS

A. Fittings shall be compression type steel and plastic threaded.

3.11 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 Jacobs' 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, 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.
   6. Length: 18-inch minimum, 60-inch maximum, sufficient to allow movement or adjustment of equipment.

B. Suspended Lighting Fixtures in Dry Areas: Flexible steel, nonliquid-tight conduit.

C. Suspended Lighting Fixtures in Outdoor Areas, Process Areas Exposed to Moisture, and Areas Required to be Oiltight and Dust-Tight: Flexible metal, liquid-tight conduit.

3.12 PENETRATIONS

A. Make at right angles, unless otherwise shown.

B. Notching or penetration of structural members, including footings and beams, not permitted.

C. Fire-Rated Walls, Floors, or Ceilings: Firestop openings around penetrations to maintain fire-resistance rating as specified in Section 07 84 00, Firestopping (as included in Balance of Plant Project).

D. Apply 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 the first box or outlet with oakum or expandable plastic compound to prevent the 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 the 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.
      c. Seal penetration with Type 5 sealant, as specified in Section 07 92 00, Joint Sealants (as included in Balance of Plant Project).
   4. Corrosive-Sensitive Areas:
      a. Seal conduit entering equipment panel boards and field panels containing electronic equipment.
      b. Seal penetration with Type 5 sealant, as specified in Section 07 92 00, Joint Sealants (as included in Balance of Plant Project).
   5. Existing or Precast Wall (Underground): Core drill wall and install a 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.

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.
8. Provide expansion/deflection fittings unless otherwise shown.

3.13 SUPPORT

A. Support from structural members only, at intervals not exceeding NFPA 70 requirements, and in any case not exceeding 10 feet. Do not support from piping, pipe supports, or other raceways.

B. Multiple Adjacent Raceways: Provide ceiling trapeze.

C. Application/Type of Conduit Strap:
   1. Rigid Steel or EMT Conduit: Zinc coated steel, pregalvanized steel or malleable iron.
   2. PVC-Coated Rigid Steel Conduit: Stainless steel.
   3. Nonmetallic Conduit: Nonmetallic or stainless steel.

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: Galvanized.
      b. Wet, Noncorrosive Areas: Stainless steel.
      c. Corrosive Areas: Stainless steel.

E. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.

3.14 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. 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.

3.15 EXPANSION/DEFLECTION FITTINGS

A. Provide on all raceways at all structural expansion joints, and in long tangential runs.

B. Provide expansion/deflection joints for 25 degrees F maximum temperature variation.

C. Install in accordance with manufacturer's instructions.

3.16 PVC CONDUIT

A. Solvent Welding:
   1. Provide manufacturer recommended solvent; apply to all joints.
   2. Install such that joint is watertight.

B. Adapters:
   1. PVC to Metallic Fittings: PVC terminal type.
   2. PVC to Rigid Metal Conduit: PVC female adapter.

C. Belled-End Conduit: Bevel the unbelled end of the joint prior to joining.

3.17 PVC-COATED RIGID STEEL CONDUIT

A. Install in accordance with manufacturer's instructions.

B. Tools and equipment used in cutting, bending, threading and installation of PVC-coated rigid conduit shall be designed to limit damage to PVC coating.

C. Provide PVC boot to cover all exposed threading.

3.18 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.

3.19 TERMINATION AT ENCLOSURES

A. Cast Metal Enclosure: Provide manufacturer's premolded insulating sleeve inside metallic conduit terminating in threaded hubs.

B. Nonmetallic, Cabinets, and Enclosures:
   1. Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.
   2. 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.
   2. Rigid Galvanized Conduit:
      a. Provide one lock nut each on inside and outside of enclosure.
      b. Install grounding bushing at source enclosure.
      c. Provide bonding jumper from grounding bushing to equipment ground bus or ground pad.
   3. Electric Metallic Tubing: Provide gland compression, insulated connectors.
   4. Flexible Metal Conduit: Provide two screw type, insulated, malleable iron connectors.
   5. PVC-Coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector.
   6. 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 a grounding jumper extending to equipment ground bus or grounding pad.
   2. Terminate PVC conduit entering bottom with bell end fittings.

3.20 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, 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.

H. Transition from Underground to Exposed: PVC-coated rigid steel conduit. Extend minimum 6 inches above slab.

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. Provide expansion/deflection 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.

K. Provide deflectional/expansion fittings in conduit runs that exit building or structure belowgrade. Conduit from building wall to fitting shall be PVC-coated rigid steel.

L. Concrete Encasement:
   1. As specified in Section 03 30 00, Cast-in-Place Concrete.
   2. Concrete Color: Red.

M. Backfill:
   1. As specified in Section 31 23 23.15, Trench Backfill. Controlled low strength fill is an acceptable bedding and pipe zone material and backfill material to within 12 inches of the surface.
   2. Do not backfill until inspected by Jacobs' Engineer.

3.21 OUTLET AND DEVICE BOXES

A. Install suitable for conditions encountered at each outlet or device in wiring or raceway system, sized to meet NFPA 70 requirements.

B. Size:
   1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted.
      a. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.
   2. Ceiling Outlet: Minimum 4-inch octagonal 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 Jacobs' Engineer.
   3. Light Switch: Install on lock side of doors.
   4. Light Fixture: Install in symmetrical pattern according to room layout, unless otherwise shown.

D. Mounting Height:
   1. General:
      a. Dimensions given to centerline of box.
      b. Where specified heights do not suit building construction or finish, adjust up or down to avoid interference. Do not straddle CMU block or other construction joints.
   2. Light Switch: 48 inches above floor.
   3. Thermostat: 54 inches above floor.
   4. Telephone Outlet: 6 inches above counter tops or 15 inches above floor.
   5. Wall Mounted Telephone Outlet: 52 inches above floor.

6. 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 splashback, or 6 inches above counter tops without splashback.
    c. Industrial Areas, Workshops: 48 inches above floor.
    d. Outdoor, All Areas: 24 inches above finished grade.
7. Special-Purpose Receptacle: As shown on Drawings.
8. Switch, Motor Starting: 48 inches above floor, unless otherwise indicated on Drawings.

E. Install plumb and level.

F. Flush Mounted:
1. Install with concealed conduit.
2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.
3. Holes in surrounding surface shall be no larger than required to receive box.

G. Support boxes independently of conduit by attachment to building structure or structural member.

H. Install bar hangers in frame construction or fasten boxes directly as follows:
1. Wood: Wood screws.
2. Concrete or Brick: Bolts and expansion shields.
3. Hollow Masonry Units: Toggle bolts.
4. Steelwork: Machine screws.

I. Provide plaster rings where necessary.

J. Boxes embedded in concrete or masonry need not be additionally supported.

K. Install galvanized mounting hardware in industrial areas.

L. Install separate junction boxes for flush or recessed lighting fixtures where required by fixture terminal temperature.

M. Boxes Supporting Fixtures: Provide means of attachment with adequate strength to support fixture.

N. Open no more knockouts in sheet steel device boxes than are required; seal unused openings.

3.22 JUNCTION AND PULL BOXES

A. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.

B. Install pull boxes where necessary in raceway system to facilitate conductor installation.

C. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.

D. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.

E. Use conduit bodies as junction and pull boxes where no splices are required and their use is allowed by applicable codes.

F. Installed boxes shall be accessible.

G. Do not install on finished surfaces.

H. Install plumb and level.

I. Support boxes independently of conduit by attachment to building structure or structural member.

J. Install bar hangers in frame construction or fasten boxes directly as follows:
   1. Wood: Wood screws.
   2. Concrete or Brick: Bolts and expansion shields.
   3. Hollow Masonry Units: Toggle bolts.
   4. Steelwork: Machine screws.

K. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.

L. Boxes embedded in concrete or masonry need not be additionally supported.

M. 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 Design-Builder acceptance prior to installation in paved areas, roadways, or walkways.
   4. Use boxes and covers suitable to support anticipated weights.

N. 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.

O. Mounting Hardware: See Area Classification and Material Selection Table on Drawings.

3.23 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.

3.24 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.

C. Install such that raceways enter at nearly right angles and as near as possible to one 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.

3.25 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 with foot markers for length.

D. Identify, as specified in Article Identification Devices, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

3.26 IDENTIFICATION DEVICES

A. Raceway Tags:
   1. Identify Raceway Schedule designation.
   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 runs.

C. Buried Raceway Markers:
1. Install at grade to indicate direction of underground raceways.
2. Install at all 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.

3.27 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 all 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.

3.28 FIELD CONDITIONS AND RELATED REQUIREMENTS

A. Underground water table may be near or above the location of new ductbanks.

B. Subcontractor shall include cost for necessary dewatering, cleaning equipment to perform Work in underground ductbanks, pull boxes, and manholes, prior to installation of required new conductors.

3.29 RACEWAY ALLOWANCES

A. Subcontractor shall include allowance of necessary raceways and supports to provide any and all motorized equipment, electrical outlets, fixtures, communication outlets, instruments and devices within 10 linear feet of location shown on Drawings.

B. Subcontractor shall include allowance of necessary raceways, trench, excavation, backfill, and related materials to provide any and all pull boxes, manholes, and ductbanks within 30 linear feet of location shown on Drawings.

C. Prior to installation of any raceway or related items identified in Paragraphs A and B above, the Design-Builder shall have the right to make changes related to preferred location at no additional cost.

D. Subcontractor shall include allowance to provide necessary raceways for all equipment specified, identified in wiring schedules, equipment schedules, panel boards schedules, electrical single line diagrams, block diagrams, process and instrumentation diagrams (P&ID), fixtures schedules, and devices. Said necessary conduits may not be shown on the plan drawings, but they shall be sized by Subcontractor in accordance with requirements specified and the National Electrical Code, and include in this allowance, the raceways necessary for the installation of the conductors and for the complete operation of the included device or equipment.

E. In addition to the above, include the following allowance for extra items not specified or identified on the documents:
   1. 1,000 feet of 3/4-inch exposed rigid steel conduit with fittings and supports in locations up to 20 feet above finish floor.
   2. 500 feet of 1-inch exposed rigid steel conduit with fittings and supports in locations up to 20 feet above finish floor.
   3. 500 feet of 1-inch PVC coated rigid steel conduit with fittings and supports in locations up to 20 feet above finish floor.
   4. 500 feet of 2-inch PVC Schedule 40 conduit, encased in concrete, including necessary excavation.
   5. 40 equipment terminations with 3/4-inch flexible liquid tight conduit including boxes and fittings.

END OF SECTION

SECTION 26 05 70
ELECTRICAL SYSTEMS ANALYSIS

PART 1 GENERAL

1.01 SUMMARY

A. This section includes electrical short circuit, coordination studies, and arc flash hazard analysis study.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American National Standards Institute (ANSI).
   2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      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.
   3. National Fire Protection Association (NFPA):
      a. 70, National Electric Code (NEC).
      b. 70E, Standard for Electrical Safety in the Workplace.
   4. Occupational Safety and Health Standards (OSHA): 29 CFR, Part 1910 Subpart S, Electrical.

1.03 SUBMITTALS

A. Action Submittals:
   1. Provide PDF and SKM PTW electronic copy of studies, to include:
      a. Short circuit study. Submit prior to submission of major electrical equipment.
      b. Protective Device Coordination Study: Submit within 90 days after approval of the short circuit study.
      c. Arc Flash Hazard Analysis.
      d. Example Arc Flash label(s) of the design and layout to be used for this Contract.

1.04 QUALITY ASSURANCE

A. Short circuit and protective device coordination studies shall be prepared by the manufacturer furnishing the switchgear in accordance with IEEE 242 and IEEE 399.

B. Qualifications of the entity responsible for Short Circuit Fault Analysis Study and Protective Device Coordination Study:

1. The study shall be performed, stamped, and signed by a registered professional engineer in the State of California. A minimum of 10 years' experience in power system analysis is required for the individual in responsible charge of the studies. Credentials of the individual(s) performing the study shall be submitted to Jacobs upon request.
2. The short-circuit study and protective device coordination study shall be performed with the aid of a digital computer program and shall be in accordance with the latest applicable IEEE and ANSI standards.

1.05 SEQUENCING AND SCHEDULING

A. An initial, complete short circuit study must be submitted and reviewed before Jacobs' Engineer will review Shop Drawings for switchgear, standalone drives, and motor control center equipment.

B. An initial, complete protective device coordination study must be submitted with 90 days after approval of initial short circuit study.

C. The short circuit and protective device coordination studies shall be updated prior to Project Substantial Completion. Utilize characteristics of as-installed equipment and materials.

D. Recommended settings per protective device coordination and arc flash hazard studies shall be provided to third party for testing per Section 26 08 00, Commissioning of Electrical Systems.

1.06 GENERAL

A. Equipment and component titles used in the studies shall be identical to the equipment and component titles shown on the Contract Documents.

B. The entity conducting the electrical systems analysis shall request and receive from the City, a PTW, by SKM, a copy of the plant electrical system, not including new work provided under this contract. The entity providing the electrical systems analysis shall confirm in the PTW model, all interconnections, components, and ratings of the equipment being installed as part of the project. The model shall reflect all circuit breakers and equipment installed as part of this contract.

C. Perform complete fault calculations for each ultimate source combination.

D. Source combination may include utility company supply circuits, large motors, or generators.

E. Utilize proposed and existing load data for the study provided by Jacobs and the Owner.

F. Final studies shall utilize submitted product date for motors, and electrical equipment used for this Contract.

G. Existing Equipment: Obtain required existing equipment data from the Owner.

H. Device coordination time-current curves for medium and low voltage distribution system(s).

I. Individual protective device time-current characteristics on transparencies.

1.07 SHORT CIRCUIT STUDY

A. General:
   1. Use the ANSI fault analysis model, “A-Fault”.
   2. Use cable impedances based on copper conductors.
   3. Use bus impedances based on copper bus bars.
   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 XHHW 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. Selected base per unit quantities.
   3. One-line diagrams.
   4. Source impedance data, including electric utility system and motor fault contribution characteristics.
   5. Impedance diagrams.
   6. Zero sequence impedance diagrams.
   7. Typical calculation.

8. Tabulations of calculated quantities.
9. Results, conclusions, and recommendations.

C. Calculate short circuit interrupting and momentary (when applicable) duties for an assumed three-phase bolted fault at each:
   1. Switchgear.
   2. Standalone VFDs.
   3. Motor control centers.
   4. All branch circuit panelboards.
   5. Automatic transfer switch.
   6. Other significant locations throughout the system.
   7. Future load contributions as shown on one-line diagram.

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 and motor control center 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, besides normal load currents.

1.08 PROTECTIVE DEVICE COORDINATION STUDY

A. Proposed protective device coordination time-current curves for distribution system, graphically displayed on conventional log-log curve sheets.

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.

C. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.

D. Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

E. Plot Characteristics on Curve Sheets:
   1. Medium voltage equipment relays.
   2. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
   3. Low voltage equipment circuit breaker trip devices, including manufacturers tolerance bands.
   4. Pertinent transformer full-load currents at 100 percent and 600 percent.
   5. Transformer magnetizing inrush currents.
   6. Transformer damage curves.
   7. ANSI transformer withstand parameters.
   8. Significant symmetrical and asymmetrical fault currents.
   9. Ground fault protective device settings.
   10. Other system load protective devices for largest branch circuit and feeder circuit breaker in each motor control center.

F. Multifunction Protective Relay Settings:
   1. Provide the recommended settings for the following protective relays:
      a. Transformer Protection Relays:
         1) 50, Overcurrent on Primary Side of Transformer.
         2) 51, Time Overcurrent on Primary Side of Transformer.
         3) 50, Overcurrent on Secondary Side of Transformer.
         4) 51, Time Overcurrent on Secondary Side of Transformer.
         5) 87, Current Differential.
         6) Unrestrained and restrained elements to allow for transformer inrush.

G. Primary Protective Device Settings for Delta-Wye Connected Transformer:
   1. Secondary Line-to-Ground Fault Protection: Primary protective device operating band within the 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.

H. Separate medium voltage relay characteristics curves from curves for other devices by at least 0.4-second time margin.

1.09 TABULATIONS

A. General Data:
   1. Short circuit reactances of rotating machines.
   2. Cable and conduit material data.
   3. Bus data.
   4. Transformer data.
   5. Circuit resistance and reactance values.

B. Short Circuit Data:
   1. Fault impedances.
   2. X to R ratios.
   3. Asymmetry factors.
   4. Motor contributions.
   5. Short circuit kVA.
   6. Symmetrical and asymmetrical fault currents.
   7. Bus evaluation.
   8. Device evaluation.

C. Recommended Protective Device Settings:
   1. Relays:
      a. Current tap.
      b. Time dial.
      c. Instantaneous pickup.
   2. Circuit Breakers:
      a. Adjustable pickup.
      b. Adjustable time-current characteristic.
      c. Adjustable instantaneous pickup.

1.10 ARC FLASH HAZARD ANALYSIS STUDY

A. Perform arc flash hazard study after short circuit and protective device coordination study have 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. Provide calculations for equipment including but not limited to the following:
   1. Switchgear.
   2. Panelboards,

3. Motor Control Center Main and load side bus.
4. Disconnects.
5. Automatic transfer switches.
6. Standalone drives.
7. Starter enclosures.
8. Battery charger.
9. Any equipment likely to be worked on while energized.

D. Base Calculation:
1. For each major part of electrical power system, determine the following:
a. Flash hazard protection boundary.
b. Limited approach boundary.
c. Restricted approach boundary.
d. Incident energy level.
e. Glove class required.

E. Produce arc flash hazard labels that list items in Paragraph Base Calculation and the following additional items.
1. Bus name.
2. Bus voltage.

F. 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.

G. 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.

H. Analyze short circuit, protective device coordination, and arc flash calculations and highlight equipment that is determined to be underrated or causes incident energy values greater than 8 cal/cm^2. Propose approaches to reduce energy levels.
   1. Coordinate with items required in paragraph Tabulations.

I. 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. PDF copies of all arc flash hazard labels. Template for arc flash label to designed by entity providing electrical system analysis. Design to be approved by Owner.

1.11 STUDY ANALYSES

A. 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 and coordination studies.
   6. Comments or suggestions.

B. Suggest changes and additions to equipment rating and/or characteristics.

C. Notify Jacobs' Engineer in writing of existing circuit protective devices improperly rated for new fault conditions.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Adjust relay and protective device settings according to values established by coordination study prior to startup. Coordinate with Section 26 08 00, Commissioning of Electrical Systems.

B. Make minor modifications to equipment as required to accomplish conformance with the short circuit and protective device coordination studies prior to fabrication of equipment.

C. Notify Jacobs' Engineer in writing of any required major equipment modifications.

END OF SECTION

SECTION 26 08 00
COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. This section includes acceptance testing of electrical system equipment, wiring, and grounding.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. ASTM International (ASTM):
      a. D665, Standard Test Method for Rust-Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water.
      b. D877, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
      c. D923, Standard Practices for Sampling Electrical Insulating Liquids.
      d. D924, Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
      e. D971, Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
      f. D974, Standard Test Method for Acid and Base Number by Color-Indicator Titration.
      g. D1298, Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
      h. D1500, Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
      i. D1524, Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.
      j. D1533, Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration.
      k. D1816, Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes.
      l. D2285, Standard Test Method for Interfacial Tension of Electrical Insulating Oils of Petroleum Origin Against Water by the Drop-Weight Method.

2. Insulated Cable Engineers Association (ICEA):
   a. S-93-639, Shielded Power Cables 5000V-4600V.
   b. S-94-649, Concentric Neutral Cables Rated 5 through 46 kV.
   c. S-97-682, Utility Shielded Power Cables Rated 5 through 46 kV.
3. Institute of Electrical and Electronics Engineers (IEEE):
   a. 43, Recommended Practice for Testing Insulating Resistance of Rotating Machinery.
   b. 48, Standard Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminators 2.5 kV through 765 kV.
   c. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System (Part 1): Normal Measurements.
   d. 95, Recommended Practice for Insulation Testing of AC Electric Machinery (2300V and Above) with High Direct Voltage.
   e. 386, Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
   f. 400, Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field.
   g. 450, Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
   h. C2, National Electrical Safety Code.
   i. C37.20.2, Standard for Metal-Clad Switchgear.
   j. C62.33, Test Specifications for Varistor Surge-Protective Devices.
4. InterNational Electrical Testing Association (NETA): Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (ATS).
5. National Electrical Manufacturers Association (NEMA):
   a. AB 4, Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
   b. ICS-2, Industrial Control and Systems.
   c. ICS-3, Industrial Control and Systems—Medium Voltage Controllers.
   d. 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. 70E, Standard for Electrical Safety Requirements for Employee Workplaces.

c. 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.

1.03 SUBMITTALS

A. Informational Submittals:

1. Submit 30 days prior to performing inspections or tests:
   a. Testing service qualifications.
   b. Test personnel qualifications (resumes).
   c. Tabulated schedule for Performing Inspection and Tests with proposed dates and time frames.
   d. List of references to be used for each test.
   e. Sample copy of equipment and materials inspection form(s).
   f. Sample copy of individual device test form.
   g. Sample copy of individual system test form.
2. Submit summary test report consisting of the following within 30 days after completion of test:
   a. Summary of testing for the Project.
   b. Description of the equipment tested.
   c. Description of the test and test procedures.
   d. Test results for each apparatus and motorized equipment.
   e. Conclusions and recommendations.
   f. Completed test forms, including witness's signatures.
   g. List of test equipment and calibration documents.
   h. Date and time.
   i. A copy of the specification section with each paragraph check marked indicating compliance or marked with explicit deviations.
3. 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 Jacobs and returned, insert a copy of each in Operation and Maintenance Manual.

1.04 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 shall be in accordance with NETA ATS.

1.05 SEQUENCING AND SCHEDULING

A. Perform inspection and electrical tests after equipment here in listed has been installed.

B. Perform tests with apparatus de-energized whenever feasible.

C. Inspection and electrical tests on energized equipment shall be:
   1. Scheduled with Jacobs prior to de-energization.
   2. Minimized to avoid extended period of interruption to the operating plant equipment.

D. Notify Jacobs at least 48 hours prior to performing tests on energized electrical equipment.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 SAFETY AND PRECAUTIONS

A. Testing firm shall perform tests following a safe practice in accordance with OSHA and accident prevention procedures by National Safety Council and applicable codes as well as Owner's safety policies.

B. Tests shall be performed with apparatus de-energized, except as necessary for equipment performance and functional test.

3.02 EXAMINATION

A. Verify that electrical work is free from improper grounds, short circuits, and overloads.

B. Verify correctness of wiring first by visual comparison of the conductor connections with connection diagrams.

C. Make individual circuit continuity checks by using electrical circuit testers.

D. Verify correctness of wiring by actual electrical operation of electrical and mechanical devices in both manual and automatic modes of operation.

3.03 IMPLEMENTATION OF POWER SYSTEMS STUDIES

A. Prior to performing acceptance testing, the testing firm shall inspect and verify adequate short circuit rating of electrical equipment as determined by the short circuit study specified in Section 26 05 70, Electrical Systems Analysis.

B. The testing firm shall implement the adequate settings and calibration of protective relays, circuit breakers, fuses and other applicable protective devices as recommended in the protective devices coordination and arc flash hazard studies in Section 26 05 70, Electrical Systems Analysis.

3.04 ACCEPTANCE TESTING

A. General Requirements:

1. Perform testing and allow Owner and Jacobs' Engineer to witness testing.
2. Perform tests to assure that electrical equipment will operate within industry and manufacturer's published tolerances and will perform safely. Record test result data to be used as a baseline for future tests.

3. Test motorized equipment to verify conformance with the Contract Documents and for acceptance.
4. Equipment for which acceptable test data has not been submitted or has been submitted but rejected, shall be deemed as not meeting Contract requirements.

B. Equipment and Materials Inspection and Test Procedures: Complete test reports for each individual piece of equipment and systems.

C. Tests specified in this section shall be performed in accordance with requirements of Section 01 91 14, Equipment Testing and Facility Startup.

D. 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.

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

F. Set, test, and calibrate protective relays, circuit breakers, fuses, power monitoring meters, and other applicable devices in accordance with values established by the short circuit, coordination and arc flash hazard studies as specified in Section 26 05 70, Electrical Systems Analysis.

G. Adjust mechanisms and moving parts of equipment for free mechanical movement.

H. Adjust and set electromechanical electronic relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

I. Verify nameplate data for conformance to Contract Documents and approved Submittals.

J. Realign equipment not properly aligned and correct unlevelness.

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

L. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench/screw driver to manufacturer's recommendations, or as otherwise specified in NETA ATS.

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

N. Provide proper lubrication of applicable moving parts.

O. Inform Jacobs of working clearances not in accordance with NFPA 70.

P. 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.

Q. 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 Jacobs door and panel sections having dented surfaces.
   5. Repair or replace, as determined by Jacobs, 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 due to extensive damage, as determined by Jacobs, refinish entire assembly.

R. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents or approved Submittals.

3.05 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. Unbalance Corrections:
    a. Make written request to power company to correct condition if balance (as defined by NEMA) exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded condition more than plus or minus 4 percent of nominal.
    b. Obtain a written certification from a responsible power company official that 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 any phase current for any piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken.

3.06 SWITCHGEAR ASSEMBLIES

A. Includes existing switchgear being modified as well as new equipment.

B. 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. Control switch.
    c. Pilot light.
    d. Control relay.
    e. Circuit breaker.
    f. Indicating meter.
    g. Protective Relays.

9. Verify that fuse and circuit breaker ratings, sizes, and types conform to those specified.
10. Check bus and cable connections for high resistance by low resistance ohmmeter and calibrated torque wrench applied to bolted joints.
    a. Ohmic value to be zero.
    b. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
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.
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.

C. 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 voltage and test procedure in accordance with IEEE C37.20.1 and NEMA PB 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.
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.

3.07 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.

3.08 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 that 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. 10-minute test duration 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.

3.09 LIQUID FILLED TRANSFORMERS

A. Visual and Mechanical Inspection:
   1. Physical and insulator damage.
   2. Proper winding connections.
   3. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
   4. Defective wiring.
   5. Proper operation of fans, indicators, and auxiliary devices.
   6. Effective core and equipment grounding.
   7. Removal of shipping brackets, fixtures, or bracing.
   8. Tank leaks and proper liquid level.
   9. Integrity and contamination of bus insulation system.
   10. Verify that 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. 10-minute test duration 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. Insulating Oil Tests:
      a. Baseline Test: Test insulating oil before transformer is energized to develop a baseline for the transformer.

b. Post-energization Test: After 1 month of continuous energization, perform the insulating oil test again.
   1) Compare test results against initial baseline test.
   2) Look for any results that would indicate arcing within the transformer or other abnormal conditions.

c. Sample insulating oil in accordance with ASTM D923 and have laboratory test for:
   1) Dielectric breakdown voltage in accordance with ASTM D877 or ASTM D1816.
   2) Acid neutralization number in accordance with ASTM D974.
   3) Interfacial tension in accordance with ASTM D971 or ASTM D2285.
   4) Color in accordance with ASTM D1500.
   5) Visual condition in accordance with ASTM D1524.
   6) Specific gravity in accordance with ASTM D1298.
   7) Water content, in parts per million, in accordance with ASTM D1533.
   8) Dielectric fluid test results in accordance with NETA ATS, Table 100.4.
   9) Power factor at 25 degrees C and at 100 degrees, in accordance with ASTM D924.
   10) Maximum power factor, corrected to 20 decrees C, in accordance with manufacturer's specifications.

3.10 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:
   1. Inspect each individual exposed power cable No. 6 and larger for:
      a. Physical damage.
      b. Proper connections in accordance with single-line diagram.
      c. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.
      d. Color coding conformance with Specifications.
      e. Proper circuit identification.
   2. Mechanical Connections for:
      a. Proper lug type for conductor material.
      b. Proper lug installation.
      c. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.

3. Shielded Instrumentation Cables for:
    a. Proper shield grounding.
    b. Proper terminations.
    c. Proper circuit identification.
4. Control Cables for:
    a. Proper termination.
    b. Proper circuit identification.
5. Cables Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests for Conductors No. 6 and Larger:
1. Insulation Resistance Tests:
    a. Utilize 1,000V dc megohmmeter for 600-volt insulated conductors and 500V dc megohmmeter for 300-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.

3.11 MEDIUM VOLTAGE CABLES, 15 KV MAXIMUM

A. Visual and Mechanical Inspection:
1. Inspect each individual exposed cable for:
    a. Physical damage plus jacket and insulation condition.
    b. Proper connections in accordance with single-line diagram or approved Submittals.
    c. Proper shield grounding.
    d. Proper cable support.
    e. Proper cable termination.
    f. Cable bends not in conformance with manufacturer’s minimum allowable bending radius.
    g. Proper arc and fireproofing in common cable areas.
    h. Proper circuit and phase identification.
2. Mechanical Connections:
    a. Proper lug type for conductor material.
    b. Proper lug installation.

c. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturers.

3. Conductors Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 5,000-volt megohmmeter for 8 kV.
   b. Test each cable individually with remaining cables and shields grounded.
   c. Test each conductor with respect to ground and to adjacent conductors.
   d. Evaluate ohmic values by comparison with conductors of same length and type.
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 400.2, ICEA S-93-639/NEMA WC 74, ICEA S-94-649, and ICEA S-97-682 for insulated conductors.
   b. Each conductor section tested with:
      1) Splices and terminations in-place but disconnected from equipment.
      2) Remaining conductors and shields grounded in accordance with IEEE 400.
   c. Apply maximum test voltage per NETA ATS Table 100.6 based on the Very Low Frequency (VLF) method used.
   d. Measure only the 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, test new conductor sections.

b. After splicing new conductors to existing conductors, disconnect the existing conductors and perform the following tests:

1) Shield continuity test.

2) Insulation resistance test.

3.12 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 interlocking system operation and sequencing.

B. Electrical Tests:

1. Insulation Resistance Tests:

a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.

b. Phase-to-phase and phase-to-ground for 1 minute on each pole.

c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.

2. Contact Resistance Tests:

a. Contact resistance in microhms across each switch blade and fuse holder.

b. Investigate deviation of 50 percent or more from adjacent poles or similar switches.

3.13 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated 100 amperes and larger and to motor circuit protector breakers rated 50 amperes and larger.

B. Visual and Mechanical Inspection:
   1. Proper mounting.
   2. Proper conductor size.
   3. Feeder designation according to nameplate and one-line diagram.
   4. Cracked casings.
   5. Connection bolt torque level in accordance with NETA ATS, Table 100.12.
   6. Operate breaker to verify smooth operation.
   7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.
   8. Verify that terminals are suitable for 75 degrees C rated insulated conductors.

C. Electrical Tests:
   1. Insulation Resistance Tests:
      a. Utilize 1,000V dc megohmmeter for 480-volt and 600-volt circuit breakers and 500V 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.
   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.

3.14 MEDIUM VOLTAGE VACUUM CIRCUIT BREAKERS

A. Visual and Mechanical Inspection:

1. Check for proper element alignment.
2. Check for proper operation of cubicle shutters and racking mechanism.
3. Bolt torque level in accordance with NETA ATS, Table 100.12.
4. Perform mechanical operational tests on breaker and it's operating mechanism in accordance with manufacturer's instructions, plus check:
   a. Pull rod adjustment.
   b. Trip latch clearance.
   c. Overtravel stops.
   d. Wipe and gap setting.
5. Perform breaker travel and velocity analysis in accordance with manufacturer's instructions; values shall be in accordance with manufacturer's acceptable limits.
6. Check contact erosion indicators in accordance with manufacturer's instructions.
7. With breaker in TEST position:
   a. Trip and close breaker with control switch.
   b. Trip breaker by manually operating each protective relay.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 2,500V dc megohmmeter for 8-kV 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. Between the line and load stab of closed contact resistance in microhms across each pole.

b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.

3. Overpotential Tests:
   a. Maximum applied ac voltage in accordance with NETA ATS, Table 100.19.
   b. Each pole-to-ground with other poles grounded and contacts closed for 1 minute.
   c. Test results evaluated on pass/fail basis.
4. Minimum pickup voltage tests on trip and close coils.
5. Control Wiring Tests:
   a. Insulation resistance test at 1,000V dc on control wiring, except that connected to solid state components.
   b. Insulation resistance to be 1 megohm minimum.
6. Vacuum bottle overpotential integrity test across each vacuum bottle with breaker in OPEN position, in accordance with manufacturer's instructions.
7. Power Factor Test (Each Phase):
   a. With breaker in both OPEN and CLOSED position.
   b. Compare power factor and arc chute watt loss with adjacent poles or manufacturer's published data.
8. Power Factor Test (Each Bushing):
   a. Utilize conductive straps and hot collar procedures if bushings are not equipped with power factor tap.
   b. Power factor and capacitance test results within nameplate rating of bushings.

3.15 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.

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.

3.16 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 1,000V dc for 30 seconds.
      b. Polarity test.
   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.
   3. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 100.5.

3.17 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.

3.18 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).

2. Two-Point Direct Method Test:

a. In accordance with IEEE 81, Section 8.2.1.1 for measurement of ground resistance between main ground system, equipment frames, and system neutral and derived neutral points.

b. Equipment ground resistance shall not exceed main ground system resistance by 0.25 ohm.

3.19 GROUND FAULT SYSTEMS

A. Inspection and testing limited to:

1. Zero sequence grounding systems.
2. Residual ground fault systems.

B. Visual and Manual Inspection:

1. Neutral main bonding connection to assure:
   a. Zero sequence sensing system is grounded ahead of neutral disconnect link.
   b. Ground strap sensing system is grounded through sensing device.
   c. Neutral ground conductor is solidly grounded.
2. Verify control power has adequate capacity for system.
3. Manually operate monitor panels for:
   a. Trip test.
   b. No trip test.
   c. Nonautomatic rest.
4. Zero sequence system for symmetrical alignment of core balance transformers about current carrying conductors.
5. Relay check for pickup and time under simulated ground fault conditions.
6. Verify nameplate identification by device operation.

C. Electrical Tests:

1. Test system neutral insulation resistance with neutral ground link removed. System neutral insulation resistance minimum 1 megohm.
2. Determine relay pickup by primary current injection at the sensor. Relay pickup current within plus or minus 10 percent of device dial or fixed setting.
3. Test relay timing by injecting 300 percent of pick-up current or as specified by manufacturer. Relay operating time in accordance with manufacturer's time-current characteristic curves.

4. Test system operation at 55 percent rated control voltage, if applicable.
5. Test zone interlock system by simultaneous sensor current injection and monitoring zone blocking functions.

3.20 AC INDUCTION MOTORS

A. General: Inspection and testing limited to motors rated 50 hp and larger.

B. Visual and Mechanical Inspection:
   1. Proper electrical and grounding connections.
   2. Shaft alignment.
   3. Blockage of ventilating air passageways.
   4. Operate motor and check for:
      a. Excessive mechanical and electrical noise.
      b. Overheating.
      c. Correct rotation.
      d. Check vibration detectors, resistance temperature detectors, or motor inherent protectors for functionability and proper operation.
      e. Excessive vibration, in excess of values in NETA ATS Table 100.10.
   5. Check operation of space heaters.

C. Electrical Tests:
   1. Insulation Resistance Tests:
      a. In accordance with IEEE 43 at test voltages established by NETA ATS, Table 100.1 for:
         1) Motors 200 hp and less for 1-minute duration with resistances tabulated at 30 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 hp. Investigate index ratios less than 1.5 for Class A insulation and 2.0 for Class B insulation.
   3. Insulation resistance test on insulated bearings in accordance with manufacturer's instructions.
   4. Measure running current and voltage, and evaluate relative to load conditions and nameplate full-load amperes.
   5. Test grounded rotors to verify ground connection.

3.21 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.
      b. Pushbuttons.
      c. Control switches.
      d. Pilot lights.
      e. Control relays.
      f. Circuit breakers.
   10. Verify fuse and circuit breaker sizes and types conform to Contract Documents.
   11. Verify current and potential transformer ratios conform to Contract Documents.
   12. Check bus connections for high resistance by low resistance ohmmeter and calibrated torque wrench applied to bolted joints:
      a. Ohmic value to be zero.
      b. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
   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 all connections.

18. Compare overload heater rating with full-load current for proper size.

19. Compare motor protector 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.

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 boards and each device terminal.
    c. Insulation resistance test at 1,000V dc on control wiring except that connected to solid state components: Insulation resistance to be 1 megohm minimum.
4. Operational test by initiating control devices to affect proper operation.

3.22 AUTOMATIC TRANSFER SWITCHES

A. Visual and Mechanical Inspection:
    1. Check doors and panels for proper interlocking.
    2. Check connections for high resistance by low resistance ohmmeter.
    3. Check positive mechanical and electrical interlock between normal and alternate sources.
    4. Check for proper operation:
        a. Manual transfer function switch.
        b. Generator under load and nonload conditions.
        c. Auto-exerciser of generator under load and no-load conditions.
    5. Verify settings and operation of control devices.

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. Set and calibrate in accordance with Specifications, Manufacturer's recommendations and Coordination Study.
        a. Voltage and frequency sensing relays.
        b. Time delay relays.

c. Engine start and shutdown relays.

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

3.23 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.
   7. All batteries are to be marked with appropriate information for inspection.

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.
      a. Provide proof of discharge testing in 3-hour test.

3.24 LOW VOLTAGE SURGE ARRESTORS

A. Visual and Mechanical Inspection:
   1. Adequate clearances between arrestors and enclosures.
   2. Ground connections to ground bus and electrode.

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, Sections 4.4 and 4.9.

3.25 MEDIUM VOLTAGE SURGE ARRESTORS AND SURGE CAPACITORS

A. Visual Inspection:
   1. Ground connections to ground electrode.
   2. Shortest practical jumper connections to line.

B. Electrical Tests:
   1. Grounding electrode resistance test in accordance with IEEE 81, Section 8.2.1.5 using three-point fall-of-potential method.
   2. Insulation power factor.
   3. Insulation resistance.
   4. RF noise test using Stoddard Noise Test set with applied voltage of 1.18 times maximum continuous operating voltage.
   5. Insulation power factor leakage current, watts loss, and insulation resistance tests in accordance with manufacturer's test values. RIV value not to exceed 10 microvolts above background noise.
   6. Leakage current and watts loss tests.

3.26 SUMMARY TEST REPORT

A. Upon completion of testing all electrical equipment, submit summary test report.

END OF SECTION

SECTION 26 09 13
POWER MEASUREMENT AND CONTROL

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 for Electrical and Electronics Engineers, Inc. (IEEE):
      a. C37.90, Standard for Relays and Relay Systems Associated with Electric Power Apparatus.
      b. C37.90.1, Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.
      c. C57.13, Standard Requirements for Instrument Transformers.
   3. International Electrotechnical Commission (IEC):
      a. 60255-5, Electrical Relays—Part 5: Insulation Coordination for Measuring Relays and Protection Equipment—Requirements and Tests.
      b. 60255-22-4, Measuring Relays and Protection Equipment — Part 22-4: Electrical Disturbance Tests—Electrical Fast Transient/Burst Immunity Tests.
      c. 60688, Electrical Measuring Transducers for Converting a.c. Electrical Quantities to Analogue or Digital Signals.
      d. 60870-5-104, Telecontrol Equipment and Systems—Part 5-104: Transmission Protocols—Network Access for IEC 60870-5-101 Using Standard Transport Profiles.
      e. 61850, Communication Network and Systems in Substations.
   4. National Electrical Manufacturers Association (NEMA):
      a. C12.1, Electric Meters Code for Electricity Metering.
      b. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   5. Telecommunications Industry Association (TIA):
      a. 232-F, Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
      b. 485-A, Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems.

1.02 DEFINITIONS

A. CT: Current Transformer.

B. DNP: Distributed Network Protocol.

C. LCD: Liquid Crystal Display.

D. LED: Light Emitting Diode.

E. MPR: Motor Protection Relay.

F. PLC: Programmable Logic Controller.

G. RTD: Resistance Temperature Detectors.

H. UCA: Utility Communications Architecture.

I. VFD: Variable Frequency Drive.

J. VT: Voltage Transformer.

1.03 SUBMITTALS

A. Action Submittals:
   1. Instruction manuals for each type of device.
   2. Special features, licensed programming software.
   3. Potential and current schematic diagrams.
   4. Control and metering schematic diagrams.
   5. Interconnection wiring diagrams.
   6. Installation and mounting requirements.
   7. Complete descriptive literature and renewal parts data.
   8. Manufacturer initial programmable settings.

B. Informational Submittals:
   1. Programming software used to configure devices, along with settings files necessary to reload or revise settings as left by Contractor.
   2. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

PART 2 PRODUCTS

2.01 MAIN MANAGEMENT RELAY (MMR)

A. MMR shall provide primary protection and management of distribution feeders. Protection shall include:
   1. Complete time overcurrent (51P, 51N, 51G), including sensitive ground.
   2. Complete instantaneous overcurrent (50P, 50N, 50G), including sensitive ground.
   3. Directional overcurrent (67P, 67N, 67G, 67_2).
   4. Bus and Line undervoltage and overvoltage (27/59).
   5. Negative sequence voltage (47).
   6. Bus under-frequency (81U) with voltage and current level monitoring.
   7. Bus over-frequency (81O) with voltage and current level monitoring.

8. Frequency rate-of-change (81D) monitoring.
9. Under-frequency automatic restoration (81/79).
10. Neutral displacement overvoltage (59N) used to give line to ground fault coverage on high impedance grounded or ungrounded systems, which are isolated.

B. Operate with either wye-connected (four-wire) or open-delta-connected (three-wire) potential transformers, and three-phase, four-wire connected current transformers.

C. Control shall include manual close control, cold load pickup control, programmable logic inputs, two breaker control relay outputs, internal failure relay output, programmable relay outputs, solid state trip output, analog transducer input, and analog transducer outputs.

D. Monitoring and metering functions shall include:
1. Current: Phase A RMS current, Phase B RMS current, Phase C RMS current.
2. Voltage: Phase A-N (A-B) voltage, Phase B-N (B-C) voltage, Phase C-N (C-A) voltage.
3. Frequency.
4. Symmetrical components.
5. Three-phase power factor.
6. Three-phase real power.
7. Three-phase reactive power.
8. Three-phase apparent power.
9. Watt-hours.
10. VAR-hours.
11. Demand Measurement: Rolling demand, time interval, programmed to 5, 10, 15, 20, 30, or 60 minutes. A fault locator with a record of last 10 faults.
12. Event Recorder: Record last 512 events, time tagged.
13. Waveform Capture: Relay shall store up to 256 cycles of data, captured for analog current and voltage inputs as well as digital data for output relays and input contact states. Amount of data to capture and trigger point shall be user configurable.
14. Data logger.
15. Latest Trip Report: Containing date and time, cause, phase, ground, sensitive ground, and neutral currents, line-line and line-ground voltages, neutral voltage, frequency, and analog Input.
16. Operation counter and accumulated interrupted currents per phase.
17. Coil (trip/close) monitoring inputs for detection of failed circuit regardless of breaker state.

E. User interfaces shall include:
   1. Large 40-character display, navigation keys, and keypad.
   2. Indicator LEDs on front panel which provide a quick visual indication of status.
   3. Front panel RS232 serial port that provides easy computer access.
   4. Two rear RS485 ports, one of which can be configured as a RS422 port.
   5. Relay programmed to communicate using DNP 3.0 Level 2 Protocol through one of its ports.
   6. RJ45 Ethernet port to allow Modbus/TCP Ethernet connectivity to local or wide area networks.
   7. Relay capable of being set by Windows-based, easy to use setup graphical terminal interface.

F. Manufacturer and Product: Basler; BE1-11T or SEL 787.

2.02 FEEDER MANAGEMENT RELAY (FMR)

A. Feeder protection shall be provided using a single static drawout relay. Protection features shall include:
   1. Three-phase (51) and ground (51G) time overcurrent.
   2. Three-phase (50) and ground (50G) instantaneous overcurrent.
   3. Independent phase and ground curves; ANSI, IAC (AC Phase and Ground Relay), or IEC/BS142 curve shapes: definite time, moderately inverse, normal inverse, very inverse, extremely inverse.
   4. Forty “time dials” for phase and ground time overcurrent curves.
   5. Separate pickup level and output relay for each protection element.
   6. Three Outputs: Trip, auxiliary trip, and service.
   7. Eight additional output relays shall be an option, one for each protection element.
   8. Trip Record: Display of last five trips.
   9. Relay 86 lockout.

B. Front Panel LED Indicators:
   1. Cause of trip, pickup, relay in service, relay malfunction.
   2. Clear key shall be available to clear cause of trip indicators.
   3. Phase current indicator shall be provided on front panel.
   4. Relay shall be able to communicate via an RS485 port. Information available over this port shall include:
      a. Settings, phase, and ground current as a percent of CT, status.
      b. Simulation of trips.

C. Relay shall comply with surge withstand capability (SWC) standards IEEE C37.90 and IEC 60255-22-4.

D. Manufacturer and Product: Basler; BE1-851.

2.03 BUS DIFFERENTIAL RELAY (BDR)

A. Type: High impedance.

B. Stabilizing Resistors: 2,000 ohm, minimum.

C. Protection Functions:
   1. Differential Overcurrent.
   2. Instantaneous Overcurrent.
   3. Time Overcurrent.

D. Bus Differential Protection:
   1. Three sensitive independent high impedance elements.
   2. Two setting levels.

E. Overcurrent Protection:
   1. Instantaneous Elements:
      a. Maximum Phase: Three.
      b. Phase Specific: Six.
      c. Negative Sequence: Two.
      d. Zero Sequence: Two.
   2. Time Overcurrent:
      a. Maximum Phase: Single.
      b. Phase Specific: Three.
      c. Negative Sequence: One.
      d. Zero Sequence: One.

F. Event Reporting:
   1. Track a minimum of 10 events in nonvolatile memory.
   2. Track a minimum of 512 sequential events in nonvolatile memory.

G. Monitoring:
   1. Open Circuit Detection: Alarm on detection of an open circuit CT.
   2. Out of Zone Fault Detection: Trip on an out of zone fault.
   3. Other Relay Monitoring: Conduct self-tests to continuously track random access memory (RAM), critical RAM, read only memory (ROM), and electrically erasable programmable read only memory (EEPROM).

H. Metering:
   1. Instantaneous.
   2. Demand.
   3. Peak Demand.

I. User Interface:
   1. LCD display with keypad.
   2. RS232 port, faceplate accessible.
   3. RS232 port, read accessible port.
   4. Two by 20 character display and keypad.
   5. Target LED indicators.

J. Manufacturer and Product: Schweitzer Engineering Laboratories; SEL 587Z.

2.04 TRANSFORMER DIFFERENTIAL RELAY (TDR)

A. Three-phase current differential function with dual slope, dual breakpoint differential/restraint characteristic, and harmonic restraint.

B. Unrestrained transformer differential protection.

C. Two restricted ground fault protection.

D. Instantaneous Overcurrent Elements: Two for phase, two for neutral, and two for ground currents.

E. Time Overcurrent Elements: Two for phase, two for neutral, and two for ground currents.

F. Two time delayed negative sequence overcurrent elements.

G. Per-phase transformer thermal protection.

H. Metering:
   1. Current:
      a. Per-phase winding current.
      b. Winding ground current.
      c. Winding neutral and negative sequence currents.
      d. Per-phase differential and restraint currents.
      e. Per-winding ground differential current.
      f. Per-phase differential 2nd and 5th harmonic currents.
      g. Per-phase percent thermal capacity.

I. Event record with record of last 256 events, time tagged with a resolution of 1 ms.

J. User Interface:
   1. LCD display with keypad.
   2. RS232 port, faceplate accessible.
   3. RJ45 Ethernet port, Modbus/TCP.
   4. Two by 20 character display and keypad.

K. Manufacturer and Product: Basler; BE1-87T.

2.05 LOCKOUT RELAY (ANSI DEVICE 86)

A. Ratings:
   1. Voltage: Up to 600 volts.
   2. Current: 30 amps continuous.
   3. Interrupt Rating: 3 amps at 125V dc.
   4. Contact Resistance: 0.01 ohm maximum.

B. Manufacturer and Product: Electroswitch; Series 24.

2.06 POWER METER (PM)

A. General:
   1. Solid state device with LED displays.
   2. Direct voltage input up to 600V ac. See Contract Documents for input voltage requirements.
   3. Current input via current transformer with 5-ampere secondary.
   4. Programmable current and potential transformer ratios.
   5. Programmable limits to activate up to four alarms.
   6. Selectable Voltage Measurements: Line-to-line or line-to-neutral and wye or delta.
   7. Ethernet capable with Modbus TCP/IP.

B. Simultaneous Display:
   1. Volts, three-phase.
   2. Amperes, three-phase.
   3. Kilowatts.
   4. Kilowatt hours.
   5. Power factor.
   6. Frequency.
   7. kVA.
   8. kVAR.
   9. kVARh.
   10. Manufacturer and Product: Electro-Industries; Shark 200 V-6.

2.07 INSTRUMENT TRANSFORMERS

A. Current Transformer (CT), 600 Volts and Below:
   1. Type: Molded bar or donut.
   2. Accuracy: 0.3 at burden imposed by meters and instruments.
   3. Shorting type terminal boards for current transformer leads.

B. Potential Transformer (PT), 600 Volts and Below:
   1. Type: Molded.
   2. Accuracy Classification: 0.3 at burden imposed by meters and instruments, including future.
   3. Primary Fuses: Two, current-limiting.
   4. Secondary Fuses: One, current-limiting.

C. Current Transformer (CT), Over 600 Volts: Reference Section 26 13 13, Medium-Voltage Circuit Breaker Switchgear.

D. Potential Transformer (PT), Over 600 Volts: Reference Section 26 13 13, Medium-Voltage Circuit Breaker Switchgear.

2.08 TEST SWITCH MODULE

A. Function: Multipole switch bank for instrument transformer testing.
   1. Allows current injection for each phase.
   2. CT inputs short when current switches are open.
   3. Ability to visually isolate (open) trip relay output circuits.
   4. Cover provided.
   5. Additional test switch position for switch open indication to plant control system.

B. Manufacturers and Products:
   1. ABB; Type FT-1 Flexitest.
   2. GE; Multilin 515.

PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with manufacturer's written instructions.

B. As defined in Section 26 08 00, Commissioning of Electrical Systems.

3.02 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at distribution equipment factory, Site, and classroom designated by Design-Builder, for the minimum person-days listed below, travel time excluded:
   1. 2 person-days to enter, confirm, and assist in testing protective relay settings and communications configuration at the distribution equipment. Device settings to be based on values generated in the device coordination study.
   2. 2 person-days for initial energization and start-up of distribution system equipment.

3. 2 person-days 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 Jacobs' Engineer.

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

END OF SECTION

SECTION 26 12 02
OIL-FILLED PAD MOUNTED TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

A. This section includes oil-filled pad mounted transformers and accessories.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American National Standards Institute (ANSI)/Institute of Electrical and Electronic Engineers (IEEE):
      a. ANSI C57.12.22, Transformers - Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers with High-Voltage Bushings, 2,500 kVA and Smaller: High Voltage, 34,500 Grd Y/19 920 Volts and Below; Low Voltage, 480 Volts and Below Requirements.
      b. ANSI C57.12.70, Terminals Markings and Connections for Distribution and Power Transformers.
      c. ANSI/IEEE C57.12.00, Distribution, Power, and Regulating Transformers, General Requirements for Liquid-Immersed.
      d. ANSI/IEEE C57.12.80, Terminology for Power and Distribution Transformers.
      e. ANSI/IEEE C57.12.90, Test Code for Liquid-Immersed Distribution, Power and Regulating Transformers and Guide for Short Circuit Testing of Distribution and Power Transformers.
   2. ASTM International (ASTM): D3487, Standard Specification for Mineral Insulating Oil Used in Electrical Apparatus.
   3. 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 Arrestors for Alternating-Current Power Circuits (>1 kV).

4. National Electrical Code (NEC): Article 450, Transformers and Transformer Vaults.

5. National Electrical Manufacturers Association (NEMA):

a. TR 1, Transformers, Regulators, Reactors.

b. TP 1, Guide for Determining Energy Efficiency for Distribution Transformers.

6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).

7. UL.

1.03 SUBMITTALS

A. Action Submittals:

1. Descriptive information.

2. Dimensional drawings.

3. Transformer nameplate data.

4. Schematic and connection diagrams.

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

B. Informational Submittals:

1. Submit 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. Component and attachment seismic qualification certificate of compliance as required by Section 01 45 36, Equipment Seismic Certification.

5. Factory test reports, certified.

1.04 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Manufacturer of specified transformers for minimum 10 years with satisfactory performance in a similar or related application.

B. 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.

1.05 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage and deliver prior to 90 percent Project completion the following spare parts 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.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Cutler-Hammer.

B. Square D Co.

C. General Electric.

D. Cooper Power System.

E. "Or-equal."

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 05 19, Anchor Bolts.

2.03 TRANSFORMER

A. kVA Rating: As shown.

B. Primary Voltage: 4.16 kV line-to-line, three-phase, 60-Hz.

C. Secondary Voltage: 480/277 volts, three-phase, 60 Hz.

D. BIL Rating:
   1. 60 BIL for 5 kV insulation class transformers.
   2. 30 BIL for secondary.

E. Temperature Rise: Dual rated for 55 degrees C and 65 degrees C above 30 degrees average ambient with maximum ambient not to exceed 40 degrees C.
   1. Full kVA rating at 55 degrees C temperature rise.
   2. Additional 12 percent capacity at 65 degrees C temperature rise.

F. Impedance: Maximum of 8 percent.

G. Efficiency: Meet or exceed values in Table 4-1 of NEMA TP 1.

H. Dielectric Coolant: Fully biodegradable, nontoxic, and nonbio-accumulating fluid, qualifying as “less flammable” per NEC 450.23; Factory Mutual Approved. FR3

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.

J. Coil Conductors: Copper windings.

K. 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. Paint: Manufacturer’s standard.

E. Color: Provide gray finish as approved by Design-Builder.

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: Hex-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 arrestors with barriers.

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. Nameplate.

2.06 BUSHINGS

A. High Voltage:
   1. Deadfront Termination:
      a. Universal bushing well rated at 5 kV in accordance with IEEE 386.
      b. Bushings externally clamped and front removable.
      c. Rated for 600 amperes continuous, 95 kV BIL.
      d. Standoff brackets located adjacent to bushings.

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 BIL, 600 volts.
   3. Internally connected neutral extending to neutral bushing.

2.07 PROTECTION

A. Transformer protection is provided by the transformer protection relay and circuit breaker located at the switchgear. Reference the one-line diagram on Drawings.

2.08 SURGE ARRESTORS

A. Metal-Oxide, Varistor Type:
   1. Insulated body, elbow type, 6 kV in accordance with IEEE C62.11.
   2. Installed in high voltage compartment.
   3. Connected to transformer high voltage terminals.

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.

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.

3.03 TRAINING

A. Training shall be by manufacturer's qualified representative and shall include instruction on complete service, operation, and maintenance of the transformer as recommended by the manufacturer

END OF SECTION

SECTION 26 13 13
MEDIUM-VOLTAGE CIRCUIT BREAKER SWITCHGEAR

PART 1 GENERAL

1.01 SUMMARY

A. This section includes indoor 5 kilovolt (kV) class metal clad switchgear with vacuum interrupter power circuit breakers.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American National Standards Institute (ANSI):
      a. C37.06, Switchgear-Rating Capabilities for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
      b. C37.09, Section 4, Test Procedures for AC High Voltage Circuit Breakers.
      c. C37.2, Standard Electrical Power System Device Function Numbers.
      d. C37.20.2, Section 5.2, Metal-Clad and Station Type Cubical Switchgear.
      e. C39.1, Requirements for Electrical Analog Indicating Instruments.
      f. C57.13, Requirements for Instrumentation Transformers.
      g. C84.1, Electrical Power Systems and Equipment-Voltage Rating.
   2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. 460, Standard for Electrical Measuring Transducer for Converting AC Electrical Quantities into DC Electrical Quantities.
      b. C37.04, Standard Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
      c. C37.06, AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis Preferred Ratings and Related Required Capabilities.
      d. C37.09, Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
      e. C37.2, Standard Electric Power Systems Device Function Numbers.
      f. C37.20.2, Metal-Clad and Station Type Cubicle Switchgear.
      g. C37.90.1, Standard Surge Withstand Capacity (SWC) Tests for Protective Relays and Relay Systems.
      h. C57.13, Standard Requirements for Instrument Transformers.
      i. C62.11, Metal-Oxide Surge Arrestors for Alternating Current Power Circuits (>1KV).

3. Instrumentation, Systems, and Automation Society (ISA):
    a. 82.02.01, Safety Standard for Electrical and Electronic Test, Measuring, Controlling, and Related Equipment – General Requirements.
    b. 82.02.02, Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use.
    c. 82.03, Safety Standard for Electrical and Electronic Test, Measuring, Controlling, and Related Equipment.
4. National Electrical Code (NEC):
    a. Article 110, Requirements for Electrical Installations, Part C: Over 600 Volts/Nominal.
    b. Article 230, Services, Part H: Services Exceeding 600 Volts, Nominal.
    c. Article 300, Wiring Methods, Part B: Requirements for Over 600 Volts, Nominal.
5. National Electrical Manufacturers Association (NEMA):
    a. LA 1, Surge Arrestors.
    b. SG 4, Alternating-Current High-Voltage Circuit Breakers.
    c. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
7. Pacific Gas and Electric (PG&E): Transmission Interconnection Handbook.

1.03 SUBMITTALS

A. Action Submittals:
    1. Descriptive product information.
    2. Dimensional and assembly drawings.
    3. Itemized bill of material.
    4. Operational description.
    5. Installation instructions.
    6. Bus data.
    7. One-line and three-line diagrams.
    8. Breaker control schematic drawings.
    9. Connection and interconnection drawings. Must show interconnections to all devices external to the switchgear.
        a. Provide a separate control diagram, schematic drawing, and connection diagram for each breaker compartment.
    10. Conduit entrance locations.
    11. Mimic bus layout.

12. Anchoring instructions and details.
13. Cable terminal sizes.
14. Nameplate schedule.
15. Master drawing list.
16. Submit anchorage and bracing drawings and cut sheets as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Submit 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. Certified factory test reports.
5. Electronic AutoCAD drawings of all Shop Drawings. AutoCAD version to match City standards. Must be submitted on or before the switchgear arriving on-site.

1.04 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

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

B. UL listing mark for Category A enclosure requirements of IEEE C37.20.2, Appendix A.

C. Manufacturer shall be ISO 9000, 9001, or 9002 certified.

1.05 PACKING AND SHIPPING

A. Shipping Splits: Established by Contractor to facilitate ingress of equipment to final installation location within the building.

1.06 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts, special tools, and materials:
   1. Two Each: Spare fuse, both power and control, of every size and type used.
   2. Two Each: Color caps of each color for indicating lamps.
   3. One breaker test cabinet for facilitation of operation of a circuit breaker out of its cubicle for test purposes.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. General Electric.

B. Russelectric.

C. Eaton.

D. Square D.

E. Siemans.

F. Powell Electric.

G. “Or-equal.”

2.02 GENERAL

A. Furnish switchgear that is the product of a single manufacturer. Assembled units with component parts of several manufacturers will not be acceptable with the exception that such minor items as terminal blocks, test switches, fuses, wiring, etc., may be manufactured by others.

B. Design, test, and assemble in accordance with IEEE C37.04, IEEE C37.06, and IEEE C37.20.2, and NEMA SG4.

C. Suitable for 4,160 volts, three-phase, three-wire low resistive grounded-wye electrical service having an available short-circuit current at line terminals as shown on Drawings.

D. Rated at 4.76 kV, 60 kV BIL.

E. Operating Conditions:
   1. Ambient Temperature: Maximum 40 degrees C.
   2. Equipment shall be fully rated without derating for the above operating conditions.

F. Equipment and devices weighing in excess of 100 pounds shall have lifting lugs.

2.03 STATIONARY STRUCTURE

A. Type: Indoor switchgear consisting of pull sections with cable terminations, metering, 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. Breaker compartments to have blocking devices to prevent installation of breaker with lower ampacity or interrupting capacity into compartment designed for a higher rated breaker.

E. Each breaker compartment shall contain:
   1. Housing for vacuum circuit breakers.
   2. Manually operated drawout mechanism with automatic shutters and safety interlocks.
   3. Hinged front panel.
   4. Primary and secondary disconnect devices.
   5. Truck Operated Contact (TOC): Changes state when circuit breaker is racked out.
   6. Control circuit cutout devices.
   7. Main bus with connections.
   8. Extended ground bus.
   9. Terminal block, small wiring, control bus, and cable supports.
   10. Door Closure: Latches or bolts that will prevent the door from opening beyond 10 degrees during an arc flash.

F. Each auxiliary compartment shall contain:
   1. Front Panel: Hinged.
   2. Door Closure: Latches or bolts that will prevent the door from opening beyond 10 degrees during an arc flash.

3. Main bus and connections.
4. Extended ground bus.
5. Drawout potential transformers and associated primary fuses.
6. Relays, meters, and instrumentation.
7. Terminal block, small wiring, control bus, and cable supports.

G. Rear accessible cable compartments shall contain:
1. Provisions for cable entry from bottom.
2. Insulated bushings for primary disconnecting devices.
3. Ground bus should be extended to front of the rear compartment near the cubicle door.
4. Clamp type cable lugs for 8 kV conductors.

H. Main bus compartment, rear accessible via removal of interior steel barriers, shall contain:
1. Insulated bus and support system.
2. Primary disconnects.
3. Provision for mounting current transformers.

I. Bus transition sections shall be isolated from main bus section.

J. Provide Modbus TCP/IP switches per Section 40 99 90, Packaged Control Systems, to connect all breakers, power monitors and relays with network communications to a central point. One switch each for for A and B sides of switchgear.

2.04 ENCLOSURE

A. Finish: Baked enamel applied over rust-inhibiting, phosphated base coating.
1. Color:
a. Exterior: Gray finish as approved by Design-Builder.
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.
4. Do not exceed space shown.

2.05 BUS BARS AND INTERCONNECTIONS

A. Continuous Current Rating: See Drawings.

B. Phase Arrangement: Phases A-B-C, left-to-right, top-to-bottom, and front-to-rear as viewed from switchgear front.

C. Buses sized for present and anticipated future loads as indicated on one-line diagram.

D. Main Bus:
   1. Totally enclosed by metal plates.
   2. Material: Bar, rounded edge, flat tin-plated copper.
   3. Braced and supported on high dielectric BIL-rated glass polyester flame-retardant and track-resistant insulators.
   4. Insulate with molded epoxy, applied by fluidized bed process.

E. Ground Bus:
   1. Material: Same as main bus.
   2. Current Rating: 25 percent of main bus rating.
   3. Length: Extend entire width of switchgear.
   4. Bolted to ground contact in each breaker compartment and auxiliary section.
   5. Pads or terminals at each end for connection to building ground grid as required by NFPA 70.
   6. Extend ground bus vertically into the rear of each breaker compartment for connection of the medium voltage cable shields to the ground bus.

F. Control Bus:
   1. 600-volt insulated copper conductors.
   2. Maximum current rating determined by application.
   3. Extend from control power source to terminal boards in each unit of grouped lineup.
   4. Provide one 125V dc rated molded-case circuit breaker in 125V dc panelboard for each breaker compartment for breaker CLOSE and breaker TRIP.

G. Potential Bus:
   1. 600-volt insulated copper conductors.
   2. Maximum current rating determined by application.
   3. Connected to terminal boards mounted inside enclosure.

H. Bus Bar Connections:
   1. Material:
      a. Joints, Splice Plates, and Bar Ends: Tin-plated copper.
      b. High Pressure Line Contacts: Tin-to-tin.
   2. Bolts: Steel, with Belleville washers for joints, splice plates, and connections.
   3. Insulate bolted connections with preformed, molded, polyvinyl boots held in place with nylon hardware.

2.06 CIRCUIT BREAKERS

A. Type: Vacuum. Interrupter equipped with contact erosion indicators.

B. Rating: 4,760 volts, 60-Hz.

C. Continuous Current Rating: As shown on Drawings.

D. Interrupting Rating: As shown on Drawings.

E. Drawout Type Breaker:
   1. Three-pole, single-throw.
   2. Electrically charged from a spring charging motor at 125V dc.
   3. Mechanically and electrically trip-free.
   4. Position indicator.
   5. Operational counter.
   6. Mechanism Operated Contact (MOC): Changes state when breaker is open.
   7. Auxiliary switches.
   8. Primary and secondary devices.
   9. Breaker Operation: 125V dc close and trip.
   10. Primary Contacts:
      a. Breaker mounted stud.
      b. Stationary sockets.
      c. Silver-plated pressure line contacts.
      d. Nonmagnetic, corrosion-resistant leaf springs.
   11. Secondary Contacts:
      a. Breaker mounted multiple plug coupler.
      b. Stationary receptacles.
      c. Silver-to-silver contacts.

12. Auxiliary Contacts:
    a. Rated 10 amperes, 125V dc.
    b. Within the Breaker:
        1) Two Type “a” contact to indicate CLOSED position.
        2) Two Type “b” contacts to indicate OPEN position and trip operation.
    c. 52STA (Mechanically Operated Contacts):
        1) Ten Type “a” contact to indicate CLOSED position.
        2) Ten Type “b” contacts to indicate OPEN position and trip operation.
    d. 52POS (Breaker Status Position):
        1) Six racked-In position indication contacts.
        2) Six racked-out position indication contacts.
13. Contacts closing speed independent of control voltage and operator.
14. Mechanically interlock to prevent breaker movement to or from operating position when primary contacts are engaged.
15. Breakers of equal rating to be completely interchangeable.

2.07 CURRENT TRANSFORMER (CT)

A. Types:
    1. Insulated dry indoor.
    2. Window type for relaying and ground sensing.
    3. Wound type for metering.

B. Transformer accuracy in accordance with IEEE C57.13:
    1. Class C20 or greater for relaying.
    2. Class 1.2 maximum for imposed burden for metering.

C. Rating: 5 kV.

D. Mechanical Rating: Equal to short-time current carrying capability of circuit breakers.

E. Thermal Rating: Maximum 55 degrees rise above 30 degrees C ambient.

F. Size to operate continuously at rated primary current without insulation damage.

G. Identify polarity with standard mark or symbol.

H. Secondary Wiring:

1. Install in conduit and wiring trough.
    a. Wire CTs to shorting terminal block for CTs not associated with bus differential relays.
    b. Wire CTs to shorting test switches for CTs associated with bus differential relays. When a shorting test switch is opened, the remaining CTs connecting to the differential relay shall NOT be shorted. Provide additional switch position to provide alarm when each test switch is open.

I. Isolate from adjacent components and circuits by removable insulating or metal barriers.

J. Window type CTs accessible for replacement without removing high voltage insulated connections.

2.08 POTENTIAL TRANSFORMER (PT)

A. Type: Insulated dry, indoor.

B. Rating: 4,200-volt to 120-volt (20:1) with 60 kV BIL rating.

C. PTs shall be connected in open Delta with grounded B phase.

D. Thermal Capacity: Minimum 55 degrees rise above 30 degrees C ambient.

E. Mechanical Rating: Equal to short-time current carrying capability of circuit breaker.

F. Accuracy classification in accordance with IEEE C57.13 for connected burden.

G. Primary Protection: Two, integral mounted current-limiting fuses.

H. Secondary Protection: Single, separately mounted current-limiting fuse.

I. Identify polarity with standard marking or symbols.

J. Mount on drawout carriage installed in separate steel compartment.

K. Primary and secondary terminals to be disconnected and the primary fuses grounded when drawout carriage is in OPEN position.

2.09 TERMINAL BLOCKS

A. Rating: 600 volts, 30-ampere minimum.

B. Type:
   1. One-piece barrier with strap screws.
   2. Shorting type for current transformer leads.
   3. Pull-apart control wiring terminal boards on drawout units.

C. Provide for:
   1. Conductors connecting to circuits external to switchgear.
   2. Internal circuits crossing shipping splits.
   3. Equipment parts requiring replacement and maintenance.

D. Spares: Minimum 20 percent spare unused terminals.

E. Grouped together terminal blocks for external circuit wiring leads.

F. 6-inch minimum space between columns of terminal blocks.

G. Permanently identify each terminal and columns of terminal blocks.

H. CTs connecting to impedance bus differential relays shall be connected to shorting test switches instead of shorting type terminal blocks.
   1. Test switches shall be States Type MTS, with arrangement #91/5/5/5/1K#

I. Manufacturer and Product:
   1. States; Type NT.
   2. “Or-equal.”

2.10 CONTROL WIRING

A. NFPA 70, Type SIS, single-conductor, Class B, stranded copper, rated 600 volts for control, instrumentation, and power circuits.

B. Individual seven-strand, copper conductors, twisted and covered with a 100 percent aluminum, polyester shield with tinned copper drain wire and overall outer jacket, rated 600 volts, 90 degrees C minimum for transducer output and analog circuits.

C. Conductor Lugs: Preinsulated, self-locking, spade type with reinforced sleeves. However, use Ringtong type on CT circuits.

D. Wire Markers: Each wire individually identified with permanent markers at each end.

E. Internal circuit wiring crossing shipping splits to have plug connectors.

F. Splices: Not permitted.

2.11 METERS AND INSTRUMENTS

A. General:
   1. Semiflush mounted.
   2. Suitable for mounting on hinged steel panels.
   3. Case: Dust-tight, enclosed, with dull black finish.
   4. Shape: Square or rectangular.
   5. Complete with resistors, reactors, and necessary auxiliaries.
   6. ANSI C39.1 Standards for 1 percent accuracy class.
   7. Zero Adjustment: External zero capability.

B. Instrument and Control Switches:
   1. Type: Rotary, cam-operated, with two contacts per stage.
   2. Silver contacts and maintained positive contact position.
   3. Wiping action closing contacts.
   4. Adjacent contacts separated by barriers.
   5. Contact assembly enclosed in removable cover.
   6. Rating: Minimum 20 amperes with 600-volt insulation.
   7. Marked escutcheon plates.
   8. Operating Handles:
      a. Power Circuit Breaker Control: Pistol grip.
   9. Circuit Breaker Switches:
      a. Momentary contact, spring-return type.
      b. Operation indicator to show last operation.
      c. Indicating Lights:
         1) LED integral to the control switch.
         2) Red to indicate closed.
         3) Green to indicate open.
         4) Amber to indicate tripped.
         5) Switchboard type.
      d. Mechanical key interlock for locking in OFF position.

10. Test Switches for Instrument and Current Sources:
    a. Test Switches for Switchgear Protective Relays:
        1) Back connected and flush door mounted with clear plastic covers.
        2) Ganged current test switches with Black handles and test jacks.
        3) Ganged potential test switches with Red handles and test jacks.
        4) Ganged trip circuit test switches with Yellow handles.
    b. Test Switches for High Impedance Differential Relays:
        1) Front connected and surface mounted with clear plastic covers.
        2) Five Ganged Pole Test Switches:
            a) Four for shorting the CTs.
            b) One for alarming to indicate the switch is open.
    c. Test jacks in phases for current test switches.
    d. Four-pole units for both current and voltage.

C. Power Meter:
    1. See Section 26 09 13, Power Measurement and Control.
    2. Solid state device with LED displays.
    3. Direct voltage input up to 600V ac.
    4. Current input via current transformer with 5-ampere secondary.
    5. Programmable current and potential transformer ratios.
    6. Programmable limits to activate up to four alarms.
    7. Selectable Voltage Measurements: Line-to-line or line-to-neutral and wye or delta.
    8. Simultaneously Display:
        a. Volts, three-phase.
        b. Amperes, three-phase.
        c. Kilowatts.
        d. Kilowatt hours.
        e. Power factor.
        f. Frequency.
        g. kVA.
    9. Voltage Rating: 125V dc.
    10. Manufacturer and Product: Electro Industries; Model Shark 200 V-6.

2.12 PROTECTIVE RELAYING

A. General:
   1. Grade: In accordance with IEEE C37.90.1.
   2. Provide all relays with conformal coating, whenever possible.
   3. Drawout type, with build-in test devices.
   4. When connecting plug is withdrawn, current transformer secondary connections to be automatically short-circuited and relay de-energized.
   5. Case: Dust-tight with dull block finish.
   6. Zero adjustments external to cases.
   7. Targets to indicate operation.
   8. Contacts: Self-aligning and visible.

B. Refer to Section 26 09 13, Power Measurement and Control.
   1. Relays for Mains: Basler; Model BE1-851 or similar.
   2. Relays for Feeders: Basler; Model BE1-851 or similar.
   3. Relays for Transformers: Basler; Model BE1-11t or similar as well as 87T.
   4. Relays for Synch-check: Basler; Model BE1-25 or similar.
   5. Relays for Miscellaneous and Auxiliary Use (IEEE C37.2 Device/Function):
      a. Lockout, Multicontact, Hand Reset: Device 86.
         1) Provide with Integrated LED Indicating Lights:
            a) Normal: White.
            b) Trip: Blue.

2.13 SURGE PROTECTION

A. In accordance with IEEE C62.11 and NEMA LA 1.

B. Nominal System Voltage: 4160V, three-phase.

C. Switchgear Surge Protection:
   1. Surge Suppressor Arrestors: Connect to line side of feeder breakers and ground directly to plant ground grid.
      a. MCOV Rating: 5.1 kV for 4.16 kV resistive grounded system.
   2. Lightning Surge Arresters: Connect to line side of main power circuit breakers and ground directly to plant ground grid.
      a. Class: Station.
      b. MCOV Rating: 5.1 kV for 4.16 kV resistive grounded system.

2.14 ACCESSORIES

A. One each, manual racking crank.

B. One each, manual spring charging crank.

C. One each, spanner nut wrench for main contact removal or replacement.

D. One set, test plugs, cables, and jumper for drawout relays, meters, and electrically operated circuit breakers.

E. One each, drawout, manual ground and test device.

F. One each, Wall mounted circuit breaker test cabinet.

G. One each, maintenance slow close lever.

H. Breaker Handling Equipment: One each, portable transfer truck with manual lifting mechanism and yoke.

2.15 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, green for breaker open, unless LED is integrated.

C. Buses: 3/8-inch wide, with red colored strips.

D. Devices: 3/8-inch wide, with red colored strips.

E. Strips: Self-sticking plastic tape, applied to face of switchgear.

F. Nameplates to identify incoming lines, protective devices, and feeder circuits.

2.16 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. Engraved metallic, riveted to each vertical section.
   2. Serial number, bus rating, and section reference number.

3. Size: Manufacturer's standard.

C. Nameplate:
1. Engraved, phenolic for each circuit breaker cubicle and door mounted device.
2. White with black block type characters.
3. Character Height: 1/4 inch.
4. Size: Manufacturer's standard.
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.

E. Metering Instruments: Meter type identified on meterface below pointer or dial.

F. Control Switches: Engraved, phenolic.

G. Relays and Devices:
1. Phenolic labels; located on the front and rear of the door.
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, phenolic.
4. Color: Red with white.
5. Inscription: DANGER/HIGH VOLTAGE/KEEPOUT.
6. Characters: Gothic type, 2 inches high.
7. Attachment: Four rivets each sign.

2.17 FACTORY TESTING

A. Switchgear assembly production tested in accordance with IEEE C37.20.2.

B. Circuit breakers production tested in accordance with IEEE C37.09.

C. Switchgear manufacturer to notify Jacobs and Owner in writing 2 weeks prior to factory testing to allow either or both parties to witness testing at factory.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install equipment in accordance with manufacturer's instructions and recommendations.

B. Secure equipment to floor with anchor bolts of sufficient size and number adequate for specified seismic conditions.

C. Install equipment plumb and in longitudinal alignment with wall.

D. Tighten current-carrying bolted bus connections and enclosure framing and panel bolts to manufacturer's recommendations.

E. Coordinate terminal connections with installation of secondary feeders.

F. Provide insulated boots for field cables terminated in rear compartments.

3.02 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by Design-Builder, for minimum person-days listed below, travel time excluded:
   1. 2 person-days for installation assistance and inspection.
   2. 5 person-days 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. 5 person-days for facility startup.
   5. 1 person-day for post-startup training of City's personnel. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by Design-Builder.

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

END OF SECTION

SECTION 26 19 00
MEDIUM-VOLTAGE INDUCTION MOTORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American Bearing Manufacturers Association (ABMA).
   2. American Petroleum Institute (API):
      a. 541, Form-Wound Squirrel-Cage Induction Motors—500 Horsepower and Larger.
      b. 670, Vibration, Axial Position, and Bearing Temperature Monitoring Systems.
   3. Institute of Electrical and Electronics Engineers (IEEE):
      a. 43, Recommended Practice for Testing Insulation Resistance of Rotating Machinery.
      b. 112, Standard Test Procedures for Polyphase Induction Motors and Generators.
   4. National Electronics Manufacturers Association (NEMA): MG 1, Motors and Generators.

1.02 RELATED SECTIONS

A. This section applies only when referenced by a motor-driven equipment specification. Application, horsepower, enclosure type, mounting, shaft type, synchronous speed, and deviations from this section will be listed in the equipment specification. Where such deviations occur, they shall take precedence over this section.

1.03 DEFINITIONS

A. CT: Current Transformer.

B. IPS RMS: Inches Per Second, Root Mean Squared.

C. PIV: Peak Inverse Voltage.

D. RTD: Resistance temperature detector.

1.04 SUBMITTALS

A. Action Submittals:
   1. Submit complete motor data with driven equipment Shop Drawings.
   2. Induction motor name and specification number of driven equipment.
   3. Rated motor horsepower.

4. Voltage, phase and frequency ratings.
5. Design full load current at rated horsepower for utilization (motor) voltage.
6. Number of poles and full-load speed.
7. Service factor.
8. Power factor at full, 3/4-load and 1/2-load.
9. Locked rotor, pull-up, breakdown, and full-load torque.
10. Guaranteed minimum full-load efficiency, include nominal efficiencies at 1/2-load and 3/4-load.
11. Maximum number of successive cold and hot starts.
12. Code letter for locked-rotor kVA/HP.
13. Locked-rotor inrush in percent of full-load current.
14. Motor Thermal Performance: Hot and cold start curves.
15. Winding insulation class and temperature rise class.
16. Frame size.
17. Enclosure.
18. Motor type/model and dimension drawing. Include motor component weights.
19. Motor terminal box and space heater box dimensions, location on motor and wiring.
20. Motor lead termination support insulators.
21. Vibration Monitoring System:
    a. Product data.
    b. Control and wiring diagrams with terminal labels for all internal and external interfaces.
22. Temperature Monitoring System:
    a. Product data.
    b. Control and wiring diagrams with terminal labels for all internal and external interfaces.
23. Schematic wiring diagram for motor.
24. Space Heater:
    a. Product data.
    b. Wiring diagrams with terminal labels for all internal and external interfaces.
25. Bearing Data:
    a. Identify type and manufacturer of bearings to be installed, suitable for thrust of pumps in equipment driven specification.
    b. Specify proposed bearing insulation materials and methods and recommended bearing lubricant(s).
    c. Bearing protection data including bearing housing vibration sensors for vertical motors, axial position probes, and resistance temperature detectors, as applicable.
26. Complete lube oil system requirements.

27. Anticipated maximum maintenance weights for rotors and removable housing elements.
28. Assembly clearances; this requirement includes, but is not limited to diametrical bearing clearances, air gap, coupling interference fit to shaft and bearing housing interference fit.
29. Shaft radial and axial runout tolerances at various lateral locations.
30. Shaft mass elastic diagram.
31. Motor rotor wk^2, added flywheel wk^2,and load wk^2, as obtained from driven machinery manufacturer.
32. Motor shaft grounding.
33. Instrumentation, including but not limited to, vibration monitoring system, RTDs. Provide detailed catalog information indicating complete model number derivation and wiring diagrams.
34. Water or oil cooling if required for motor thrust bearings.
35. Submit anchorage and bracing drawings and cut sheets as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:
1. List demonstrating manufacturer's requisite experience, as well as location of manufacturer and number of years of production.
2. Lateral and torsional analysis report.
3. Driven equipment and motor manufacturers' detailed mass elastic data.
4. Submit anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
5. Name, address, telephone number, and contact name for factory-trained and authorized service organization representing synchronous motor manufacturer.
6. Written installation, connection, and commissioning instructions for specific motor(s) to be furnished.
7. Factory test results.
8. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
9. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.05 QUALITY ASSURANCE

A. Production Facility: Motor manufacturer shall produce the medium voltage, induction motors at a facility manufacturer owns or operates under its own supervision.

B. Requisite Experience: Induction motor manufacturer shall be experienced in manufacture of medium voltage induction motors for at least 10 years. At least 10 of manufacturer's synchronous motors of comparable capacity and complexity shall have been successfully operating in similar condition as ones specified in this section for at least 5 years in the USA.

C. Service Organizations: Synchronous motor manufacturer shall have a factory-owned or authorized service organization.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Provide materials, equipment, and accessories specified in this section manufactured by:
   1. ABB Motors, Inc.
   2. Electric Machinery/Ideal Electric Company.
   3. GE Industrial Systems.
   4. National Oilwell/Louis Allis.
   5. TECO-Westinghouse Motor Company.
   6. Toshiba International Corporation.
   7. WEG Electric Motors Corp.

2.02 GENERAL

A. Provisions of this section apply to induction motors larger than 300 hp and rated 2,300 volts through 13,200 volts.

B. Electric motors driving identical machines shall be identical.

C. Maximum motor loading at any point on driven load operating curve shall not exceed 85 percent of motor nameplate horsepower rating, and as verified with approved submittal data of driven machinery. Motor shall not be required to conform to NEMA MG 1 ratings.

D. Lateral and Torsional Analysis:
   1. Driven equipment supplier with system responsibility shall perform a complete lateral and torsional analysis of each distinct equipment-coupling motor system provided on Project.
   2. Identify dry and wet lateral critical(s) plus torsional critical(s) speeds.
   3. Produce critical speed maps; no active critical speed shall be allowed within 15 percent of operating speed range.
   4. Analysis shall be performed, submitted, reviewed, and approved by Jacobs' Engineer prior to fabrication of machinery.

5. Mass Elastic Data: Used for independent evaluation of lateral and torsional natural frequency analysis. Encroachment by plus or minus 15 percent of any active critical speeds upon operating speed range must be eliminated to satisfaction of Jacobs' Engineer.

E. Motors are driven by VFDs and shall be rated and labeled as suitable for inverter duty, and rated for continuous operation at 40 degrees C ambient temperature running on VFD output at any frequency from 30 Hz to 60 Hz or other frequency range as may be provided by VFD manufacturer.

2.03 DESIGN REQUIREMENTS

A. Motors shall be in accordance with NEMA MG 1, except as indicated in equipment specifications for motors controlled for variable speed operation and other special motors, constant speed induction motors having starting torque and starting current sufficient to ramp up to speed of driven equipment. In no case shall locked rotor, pull-up or breakdown torque be less than value specified in NEMA MG 1.

B. Motor Voltage Ratings: 4,000 volts, three-phase for use on a 4,160-volt (nominal), three-phase, 60-Hz system as indicated.

C. Service Factor: 1.0 minimum.

D. Insulation: Furnish motors with Class F insulation, rated to operate at a maximum ambient temperature of 40 degrees C, minimum ambient of 0 degrees C, and at altitudes where motors will be operated, without exceeding Class B temperature rise limits stated in NEMA MG 1-20.8 at rated full load and service factor.

E. Motor Leads and Terminations:
   1. Provide six main leads fitted with solderless lug terminals with two holes minimum each.
   2. Hole spacing and size shall meet NEMA standards.
   3. Leads shall be brought out to main terminal box for all motors.

F. Rotor Bars:
   1. Copper or copper alloy or aluminum; designed to meet starting and accelerating torque characteristics of NEMA MG 1-20.4.3.2 for Variable Torque Square applications.
   2. For copper bars select materials and processes used for fabricated rotor bars to minimize hydrogen embrittlement.
   3. For copper bars, size to assure tight bar construction to eliminate bar vibration.
   4. For copper bars replaceable without damage to air passages or laminations.

G. Stator:
   1. Iron laminations shall utilize C5 core-plate minimum, on both sides, capable of withstanding 1,400 degrees F without deterioration.
   2. Brace and support to eliminate any detrimental winding movement.

H. Shafts:
   1. Material: Hot-rolled C1045, minimum.
   2. Stiff-shaft design.
   3. Shaft Dimensions: Manufacturer's standard.
   4. Provide extended shaft, tapered shaft, double shaft, or short shaft as required.
   5. Permanently mark shaft on drive end and indicate magnetic center with a pointed indicator mounted off drive-end bearing cap.
   6. Include reference measurement to locate magnetic center in the event of a broken pointer on motor outline drawing.
   7. Provide drive shaft extension with open-ended keyway and key.
   8. Provide spring-loaded contact brush on shaft and provide connection lug for external grounding connection.
      a. Motor Shaft grounding pickup shall be readily accessible.
      b. Manufacturer: Aegis Pro, "or-equal. "

I. Torque:
   1. Motor manufacturer shall review start-up load curve for driven equipment to determine minimum motor capabilities for locked-rotor torque, pull-up torque, and breakdown torque.
   2. Motor speed-torque curve shall exceed driven equipment speed-torque curve by a minimum margin of 10 percent at all points from zero speed to pull-up speed.
   3. Motor shall also be able to start and accelerate, to rated-speed of driven equipment during a 20 percent under-voltage or reduced voltage start condition.

J. wk^2: Motors shall be capable of accelerating driven equipment without excessive temperature rises.

K. Number of Starts: Each motor shall be capable of two successive cold starts or one hot start according to NEMA MG 1.

L. Motor Efficiency:
   1. Guaranteed Minimum Efficiency: 90.
   2. Stamp nameplate with tested efficiency.
   3. In accordance with IEEE 112.

M. Starting: Motors shall be suitable for starting method indicated.

N. Enclosures:
   1. Mechanical protection and method of ventilation or cooling as listed below and as defined in NEMA MG 1-25 for Open Machines and NEMA MG 1-26 for Totally Enclosed Machines.
   2. Weather Protected, Type II (WPII):
      a. Check spaces, dimensions, and arrangement to ensure heat exhaust of one motor is not fed as air intake to an adjacent motor.
      b. Provide reusable, washable, stainless steel inlet air filters and stainless steel screens.
      c. Provide differential pressure switches for indication of dirty inlet air filters.
   3. Cooling Air:
      a. Internal cooling air shall circulate from end(s) of motor towards center of rotor and stator lamination stacks, then through vents in rotor and stator laminations (symmetrical cooling) to exhaust openings or heat exchanger.
      b. Internal air shall circulate through rotor and stator in a symmetrical manner to minimize hotspots.
   4. Hardware: Corrosion-resistant hardware for screens and associated fasteners.
   5. Provide openings in stator endplates with access covers for checking motor air gap.

2.04 ACCESSORIES

A. Connection Box:
   1. Cast or fabricated steel connection box.
   2. Fabricated steel connection boxes shall have hinged covers secured by knurled screws.
   3. Gasketed and provisions for grounding.

B. Main Terminal Boxes:
   1. Size:
      a. For three main leads and neutral, incoming cable glands, and accessories.
      b. To accommodate components and accept power supply conductors, all per NEMA requirements.
   2. Construction comparable with degree of enclosure indicated for motor itself.
   3. Allot space for mounting of auxiliary devices such as stress cones and neutral bar.

C. Equipment Grounding Lugs: Provide within main terminal box, suitable to terminate equipment ground wire, sized as indicated. Ground path shall be direct to stator frame.

D. Auxiliary Terminal Boxes:
   1. Space heater terminations shall be in a terminal box that is separate from control signal terminations.
   2. Wire devices to auxiliary terminal boxes and terminate on suitable terminal blocks.
   3. Vibration and temperature sensors cables shall not be terminated at motor mounted terminal boxes, but shall extend to nearby monitoring enclosure.

E. Space Heaters:
   1. Provide to keep motor windings at least 5 degrees C to 10 degrees C above dew point during de-energized conditions.
   2. Grid type in base of stator with easy access for maintenance.
   3. Rated for 120V ac, single-phase power.
   4. Prewired to terminal junction box mounted on motor.
   5. Provide warning label on space heater junction box and motor indicating space heater wiring is energized when motor is not running.

F. Provide manufacturer's standard antireverse rotation rachet.

G. Equipment Identification Plates: Provide 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component in a readily visible location. Plate shall bear 3/8-inch high die-stamped block type equipment identification number and letters indicated in motor driven equipment specification.

H. Frame Grounding Pads: Provide two stainless steel faced grounding pads and locate on opposite sides of motor frame diagonally apart. Grounding pads shall feature a tapped 1/2-inch national coarse (NC) thread drilling into motor frame.

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

2.05 MOTOR BEARINGS

A. Antifriction bearings shall be used for vertical machines provided the following conditions are met:
   1. dN factor is less than 300,000.
   2. Antifriction bearings meet ABMA L10 rating life of 100,000 hours with continuous operation at rated conditions or 50,000 hours at maximum axial and radial loads and rated speed.
   3. Antifriction thrust bearings for vertical machines shall be rated for ABMA L10 life of 100,000 hours.

B. Vertical Motor Thrust Bearings:
   1. Provide singular angular contact thrust bearing, load-equalizing, thrust bearings located in oil reservoir at top of motor frame. Bearings shall be Kingsbury, Renk, or Waukesha.

2. Bearing Capacity: Rated for weight of pump motor rotating assembly plus maximum hydraulic down-thrust developed by pump. Capable of operating at this rating in either direction of rotation up to runaway speed.
3. Up-thrust Capacity: As required for any operating condition.
4. Oil Lubrication System:
    a. Self-contained and self-circulating.
    b. Oil Reservoir:
        1) Cooling Coils:
            a) Sized to maintain a 40 degrees C, maximum, oil temperature rise.
            b) 90/10 Cu-Ni tube.
            c) 90/10 Cu-Ni threaded pipe connections.
5. Provide oil level sight glass, and threaded oil fill and drain pipes with stainless steel ball valves and end plugs.
6. High Pressure Lift System:
    a. Provide where required to pressurize thrust bearing at startup and shutdown to reduce starting torque and minimize bearing wear.
    b. Mount oil pump, circulating piping and associated components on motor.
    c. Energize prior to motor start and stop end run for an adjustable time period.
    d. Operation of pumping unit without lift system shall not damage thrust bearing.
    e. Oil Pump: Three-phase, 460-volt, 60-Hz, no greater than 3 hp.
7. Thrust Bearing Temperature Elements:
    a. Provide thrust bearing with one 100-ohm platinum RTD each which shall be wired to a monitoring enclosure mounted nearby and provided by equipment driven specification, Section 44 42 56.03, Vertical Turbine Pumps. Provide 50-foot lead lengths, cut to suit installation with excess of 5 feet.
    b. Elements shall be installed in two opposite thrust shoes of thrust bearing.
    c. Metal of bearings and mountings shall be drilled, milled, and tapped to place element at hottest points of bearings and within 1/16 inch of bearing metal.

C. Vertical Motor Guide Bearings:
1. Lower Guide Bearing: Split sleeve type with oil reservoir, oil level sight glass, and threaded oil fill and drain plugs. Lubrication system shall be self-contained and self-circulating or antifriction type meeting performance criteria listed above.
2. Lower bearings shall have spring-loaded RTDs to sense bearing metal temperature. RTDs shall be wired to a monitoring enclosure mounted nearby and provided by equipment driven specification,

Section 44 42 56.03, Vertical Turbine Pumps. Provide 40-foot lead lengths, cut to suit installation with excess of 5 feet.

D. Bearing Insulation: Electrically insulated in a manner to prevent circulating currents from passing through bearing surfaces. Provide grounding device in bearing housing on drive end.

2.06 VIBRATION MONITORING

A. General: Provide for each medium-voltage induction motor, for installation into separately mounted enclosure located near to motor. Configure, program, test, calibrate, and place each system into operation. System shall include components and features per Section 44 42 56.03, Vertical Turbine Pumps.

B. Vibration Transducers:
   1. Bearing Housing Velocity Transducers:
      a. Use antifriction bearings and bearing housing velocity transducers permanently installed by motor manufacturer.
      b. Locate transducers at upper bearing, measuring in two directions in horizontal plane with 90-degree offset.
      c. Minimum rated operating frequency shall be less than minimum motor operating speed.
      d. Vibration element shall include shielded signal cable and enclosed in a NEMA 4X housing.
      e. Manufacturer and Product: Bently Nevada Corporation; Velomitor, piezo-velocity sensor.
      f. Provide 4- foot vibration element leads. Cut to suit installation with an excess of 5 feet.

2.07 MOTOR TEMPERATURE DETECTION

A. RTDs:
   1. 100 ohm, three-wire, platinum, and prewired to terminal junction box mounted on motor base.
   2. Provide one lower bearing RTD, one thrust bearing RTD, and six stator winding RTDs (two per phase).

2.08 FACTORY TESTING

A. General:
   1. Factory test motors in conformance with IEEE 112, IEEE 43, and NEMA MG 1.
   2. Notify Jacobs' Engineer a minimum of 5 weeks prior to test.
   3. No equipment shall be shipped until Jacobs' Engineer has approved test data.

4. See motor driven equipment specification requirements for testing with equipment.
5. Acceptance:
    a. In the event motor fails to meet above requirements or efficiencies make necessary modifications, repairs, or replace entire motor.
    b. Retest motor until found satisfactory.
6. Test Reports:
    a. Include documentation and results.
    b. Indicate test procedure and instrumentation used to measure and record data.
    c. Certified, signed, and dated by a registered Professional Engineer.

B. Tests:
1. Routine:
    a. Measurement of winding resistance.
    b. No-load motoring readings of current, power, and speed at rated voltage and frequency.
    c. Measure and record air gap during assembly.
    d. Visually inspect bearing and bearing insulation.
    e. High potential test in accordance with NEMA MG 1-20.17.
2. Surge: Test stator coils individually after insertion into stator core, but prior to coil-to-coil connection, to ensure no turn-to-turn shorts. Repeat surge test after coil-to-coil connections are complete.
3. High Potential: High pot stator coils individually after insertion into stator core, but prior to coil-to-coil connection, to ensure no turn-to-turn shorts. Repeat high potential test after all coil-to-coil connections are complete.
4. Efficiency and Loss: Use any IEEE 112 Method B only. Included the following in determining efficiency per NEMA MG 1–20.21.
    a. Stator I^2R.
    b. Rotor I^2R.
    c. Core loss+.
    d. Stray load losses.
    e. Friction and windage loss.
5. Phase Rotation:
    a. Apply phase sequence as called for on outline drawing and check for correct direction of rotation.
    b. Record direction of rotation and phase sequence.
6. Temperature:
    a. Perform heat run tests on motors via embedded detector, using either of the IEEE 112 8.2.3 methods of loading.
    b. Record stator and bearing temperatures every 30 minutes until machine reaches constant temperature.

c. Determine temperature rise for service factor loading.

7. Blocked Rotor Test: With rotor blocked, take the following readings at highest voltage possible: line voltage, current, kW, torque, and induced field current.
8. Noise:
   a. In accordance with NEMA MG 1, Part 9.
   b. Mean A-weighted sound pressure level measured at one meter from major machine surface shall not exceed 85 dB (A) with motor operating at no-load, and rated frequency and voltage applied.
9. Vibration:
   a. Radial Shaft at Full Operating Speed: 2.0 mils peak-to-peak, maximum.
   b. Take vibration data at cold and hot operating conditions, at no-load during factory testing.
   c. Transient Shaft Vibration: 3.5 mils peak-to-peak, maximum, throughout normal startup and shutdown speed range.
   d. Values shall include shaft surface runout sensed by probes.
   e. Shaft Runout: At slow roll speeds of less than 100 rpm shall be less than 0.25 mils peak-to-peak, maximum. For areas to be observed by axial-position probes, combined total electrical and mechanical runout shall not exceed 0.5 mil.
   f. Bearing Housing Vibration:
      1) At full operating speed shall be 0.15 inches per second (RMS), maximum.
      2) Take vibration data at cold and hot conditions, at no-load.
      3) Transient Vibration: 0.5 IPS RMS, maximum, throughout normal startup and shutdown speed range.
   g. Vibration Frequency:
      1) Record during vibration testing at cold and hot conditions.
      2) Record frequencies up to seven times line frequency.
      3) When operated uncoupled at rated speed, machinery shall not exhibit unusual or abnormal frequency components on either shaft or casing vibration measurements.
      4) Normal frequency components are defined as excitations such as rotational speed, synchronous and multiples of synchronous frequency, or blade passing frequency that are inherent with mechanical construction of machinery.
      5) Unusual or abnormal frequency components are excitations that are nonsynchronous or not related to known geometry of machinery.
10. Starting Characteristics: Determine speed-torque characteristics using any of the four IEEE 112-7.3.2 recommended methods.

11. Integrated Drive and Motor:
    a. A single motor and VFD, provided under Section 26 19 23, Medium-Voltage Variable Frequency Drive System, shall be shipped to pump manufacturer factory for testing as an integrated system.
    b. Additional motors and VFDs may be shipped directly to site after approval of pump factory tests with single motor and VFD. See Section 42 44 56.03, Vertical Turbine Pumps.
    c. Functional test of vibration and temperature monitoring system with VFD.
    d. Efficiency/performance:
        1) Percent efficiency test at line side of drive over 5 operational speeds for the given pump application.
        2) Record efficiency of VFD, motor and pump combined system as part of the test reports.
12. Final Factory AC High Potential Test:
    a. Perform after above tests are completed to assure no damage to insulation during setup and testing.
    b. Apply 1,000 volts plus twice rated machine voltage across stator insulation and 2,500 volts across rotor insulation for 1 minute, per NEMA MG 1, Part 3.
13. Final Insulation Resistance: Take reading of armature insulation with mega-ohmmeter for one minute after high potential test has been completed.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with motor manufacturer's written recommendations and written requirements of manufacturer of driven equipment.

B. Perform electrical work involving connections, controls, and switches in accordance with the applicable sections of Division 26, Electrical.

3.02 FIELD TESTING

A. Functional Tests:
    1. Perform the following prior to connection to driven equipment:
        a. Check electrical supply at motor feeder cable terminations for any deviation from rated voltage, phase, or frequency.
        b. Visually inspect motor mounting and coupling to driven equipment.
        c. Visually check for proper phase and ground connections. Verify multi-voltage motors are connected for proper voltage.
        d. Test insulation of all winding and bearing temperature detectors and space heaters.
        e. Bump motor to test for proper rotation.

f. Test motor insulation in accordance with NEMA MG 1.

g. Test insulation after motor has arrived at Site via an AC high potential test performed for same duration as final factory high potential test, but at 75 percent of specified voltage.

h. Take vibration data at no-load and maximum available load.

i. Test motors for proper noise, temperature, and vibratory behavior following no less than 4 hours at maximum available load and full operating speed. Noise and vibration limits used for factory testing with temporary machinery support shall also be applicable to field testing condition with proper rigid support structure below machinery.

END OF SECTION

SECTION 26 19 23
MEDIUM-VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. Each variable frequency drive shall be manufactured, assembled and tested by the supplier at a facility owned or operated by the supplier, and under its direct supervision and control.

B. The Supplier shall coordinate and provide for all requirements and features of the induction motor with the VFD supplier.

1.02 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

A. Commercial Standards:
   1. American National Standards Institute/National Fire Protection Association (ANSI/NFPA): 70, National Electrical Code (NEC).

1.03 SUBMITTALS

A. Action Submittals:
   1. Record of calculations and measurements per Article 2.1, Paragraph C, Item 1 for VFD efficiencies at 50, 75, and 100 percent speed. The system efficiency shall include power losses from the cooling system, controls, isolation transformers, line reactors, and filters.
   2. Maximum continuous current and fault current withstand ratings of drive.
   3. Complete outline description of proposed factory test procedure and sketch of test setup.
   4. VFD output pulse maximum peak voltage, pulse rise time and pulse rate of rise. Include motor Sub-supplier certification that motor insulation shall operate continuously from the VFD output waveform throughout the specified speed range without overheating.
   5. Complete system rating, including all nameplate data, continuous operation load capability throughout speed range of 10 percent to 100 percent rated speed.
   6. Complete unit lineup dimensional drawings, weight, and information on size and location of space for incoming and outgoing power and control cables or conduit.
   7. Maximum heat dissipation from enclosure, exhaust air flow requirements, location and dimensions of exhaust duct interface opening(s).
   8. Layout of controller section face showing pushbuttons, switches, instruments, indicating lights, HMI display unit, etc.
   9. Complete system operating description.

10. Complete system schematic (elementary) wiring diagrams, single and three line diagrams.
11. Complete system interconnection diagrams between controller, drive motor, pump, and all related components or controls external to system, including wire numbers and terminal board point identification.
12. One-line diagram of system, including component ratings.
13. Description of diagnostic features being provided.
14. Descriptive literature for all control devices such as relays, timers, etc.
15. Itemized bill-of-materials listing all system components.
16. Description of controller, HMI, and motor protection relay being furnished, including a description of the equipment, installation, setup, and operations manuals.
    a. List of programmable settings and their initial shipment setting.
17. Annotated and cross-referenced controller and HMI program printout.

B. Informational Submittals:
1. Listing of references.
2. Operations and Maintenance Data per Section 01 78 23, Operation and Maintenance Data.
3. Component and attachment seismic qualification certificate of compliance as required by Section 01 45 36, Equipment Seismic Certification.
4. Test Reports: Provide copies in triplicate of the required factory testing. Reports shall be stamped and signed by a professional electrical engineer licensed in the USA.

1.04 EXTRA MATERIALS

A. Spare Parts:
1. Furnish the following spare parts for each VFD:
    a. Two power modules (Cells) or 20 percent, whichever is greater, with accompanying printed circuit boards.
    b. Two spare LEDs of each type used.
    c. Three spare fuses of each type used.
    d. Two spare control relays of each type used.
    e. Two spare sets of all replacement air filters.
    f. One hoisting mechanism for removal and replacement of cells, if required.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Products of the type or model number indicated shall be manufactured by one of the following:
   1. Siemens (Robicon) Corporation.
   2. Toshiba International Corporation.
   3. ABB Automation, Inc.
   4. Alstom Power Conversion.
   5. Rockwell Automation/Allen-Bradley.

2.02 VARIABLE FREQUENCY DRIVES

A. General:
   1. Isolation Transformer Input Voltage: 4,160 volts, three-phase, 60-Hz.
   2. Drive Output Voltage: 0 volt to 4,160 volts (4,000-volt motor).

B. Service Conditions: The VFD shall be designed, manufactured, assembled and tested to operate within the following service conditions:
   1. Elevation: 0-feet to 3,300-feet, msl.
   2. Ambient Temperature Range: 0 degree C to 40 degrees C.
   3. Atmosphere: Noncondensing relative humidity to 95 percent.
   4. AC Line Voltage Variation: Minus 5 percent to plus 10 percent.
   5. AC Line Frequency Variation: Plus or minus 3-Hz.

C. Operating Conditions:
   1. Minimum guaranteed VFD system efficiency shall be 95 percent at 100 percent speed and 100 percent torque and 87 percent at 60 percent speed based on nominal 900-rpm motor with load horsepower to vary as the cube of speed. The measured VFD system efficiency shall include the input transformer, VFD power section, all auxiliary cooling systems and output filter. Efficiency verification shall be performed as part of Factory test. Efficiency of the input transformer, VFD power section and output filter shall be measured, as a minimum. The overall VFD system efficiency including the input transformer, input filter, power factor correction equipment, VFD power section, heat exchanger (if any) and output filter may be calculated.
   2. The VFD shall at no time experience any overcurrent during start-up and at any time while operating. All components shall be properly sized to avoid any premature VFD break down.

2.03 GENERAL

A. VFD shall consist of the following:
   1. Primary power cable termination section.
   2. Medium voltage surge arresters.
   3. Input disconnect switch.
   4. Multi-pulse drive phase-shifting isolation transformer.
   5. 24-pulse minimum converter section.
   6. DC bus link with reactors.
   7. Output inverter.
   8. Control logic section.
   9. Output filter to limit the output dv/dt.
   10. Panel shall contain a motor protection relay, auxiliary power sources, human-machine interface (HMI), and a controller or as shown on Contract Documents.
   11. All components listed shall be integral to the VFD lineup, factory wired and tested as a complete system.

B. The motor shall be a squirrel cage, induction design in accordance with Section 26 19 00, Medium-Voltage Induction Motors. The VFD shall be designed such that no components shall overheat and fail during start-up and shutdown and during prolonged and continuous operation of the pump. The VFD shall be rated for continuous operation at motor nameplate FLA and at no less than 110 percent of the nameplate FLA for 60 seconds for the actual motor being supplied, and 100 percent speed.

C. Construction:
   1. The input section shall contain a suitably rated, load-break disconnect switch with current-limiting, solid material power fuses, interlocked with the door. For safety, blade position shall be visible through the door. Interlock shall be provided with a defeater. The fused switch shall have a minimum short circuit interrupting capacity of 50-kA rms symmetrical. Incoming medium voltage cable terminations shall be located in this section and shall be suitable for bottom entry. NEMA 2-hole drilled bus termination pads shall be available to terminate power cables. Termination points higher than three feet above the floor shall require extra incoming cable support to maintain spacing and short-circuit withstand capability.

2. Each VFD shall be supplied with a drive phase-shifting, isolation transformer to provide phase shifting for 24-pulse or higher converter bridge. Transformers shall be designed to provide common mode voltage protection of the induction motor, allowing the use of motors with standard 5-kV class insulation systems. VFDs using input, three-phase, AC line reactors which require motors equipped with special 10-kV to 13-kV insulation systems are not acceptable and shall not be allowed as an alternate bid.
    a. Transformer design shall be a rectifier grade isolation type. Transformer shall be dry type construction, maximum 125 degrees C rise and 220 degree C insulation with over-temperature protection.
    b. Input section to transformer shall include high power surge arresters to protect input transformer and VFD against voltage surges.
3. The converter section shall be a full wave bridge, multi-phase converter (24-pulse minimum) to change the input ac power to dc power.
4. The output of the converter shall feed a dc link. dc link reactors shall be provided in positive and negative busses if required. The output of the converter/inductor combination voltage source shall be regulated and limited. The converter shall be sufficiently fast and effective to protect against a sudden or random application of a short circuit to the output terminals.
5. The inverter section shall invert the dc power of the voltage source to variable frequency power to the motor. The VFD shall not induce excessive power losses in the motor. The worst case rms motor line current measured at rated speed, torque, and voltage shall not exceed 1.03 times the rated rms motor current for pure sine wave operation. Voltage waveform dV/dt applied to motor shall not produce standing waves or overvoltage conditions requiring nonstandard motor insulation systems or ratings above the VFD output voltage rating. VFD output waveform shall be suitable for operating a squirrel cage induction motor without derating or requiring additional service factor. VFD output waveforms shall be coordinated with motor design to allow motor to operate within all specified temperature limits between 10 percent and 100 percent speed regardless of loading.
6. The VFD output shall produce no electrically induced pulsating torques to the output shaft of the mechanical system, eliminating the possibility of exciting a resonance caused by VFD-induced torque pulsations. The VFD Sub-supplier shall supply all data required by the Supplier to perform the torsional analysis. The VFD shall not cause micro-pitting of the motor shaft.
7. Fault log data storage memory shall be powered from a rechargeable source furnished with the VFD and with at least a 6-day capability or shall be nonvolatile EEPROM memory.
8. Medium voltage cables and components shall be isolated in separate compartments from the low voltage components. Sufficient space for power cable entry and termination shall be provided, all in accordance with NEC requirements.

9. VFD control power shall be from a separate external 480-volt, three-phase, 30-amp circuit. Provide lockable molded case circuit breaker operator on front panel of control section. Circuit breaker shall have auxiliary contact to notify DCS of CLOSED status.

D. Basic Features:

1. The VFD controller shall have the following basic features:
   a. See Drawings for control and one line diagram.
   b. Speed Profile: Individual adjustable settings for start, stop, entry, slope, and minimum and maximum speed points. The maximum and minimum speed set points for each VFD shall be preset to the values specified in Section 44 24 56.03, Vertical Turbine Pumps. Drives shall include “Critical Frequency Avoidance” logic. Initial acceleration setting shall be from zero to minimum speed in 15 seconds, and from minimum to maximum speed at a rate of no more than a flow increase rate of 35 cfs per minute. The deceleration rate shall be no more than a flow decrease rate of 35 cfs per minute.
   c. Provide for an external 4-mA dc to 20-mA dc speed reference input signal. Provide a signal current isolator to ensure signal and galvanic isolation of the grounded or ungrounded input speed reference signal.
   d. Status and alarm outputs each shall be SPDT electrically isolated auxiliary contacts rated 2-amps at 24V dc, 60-Hz, in addition to MODBUS/IP.
      1) Alarm outputs shall consist of two separate outputs; VFD fault, and motor fault, which shall be wired together into a common “FAIL” alarm output for each fault. VFD fault outputs shall be activated by any of the following, as a minimum and shall be displayed on the operator terminal on the door of the VFD:
         a) Output or input under-voltage or over-voltage.
         b) Power unit over-temperature.
         c) Instantaneous overcurrent.
         d) Commutation failure (if applicable).
         e) Input power loss of phase.
         f) Converter saturation.
         g) VFD output short circuit.
         h) Control power failure.
         i) Motor regeneration due to backspin.
         j) Phase shifting isolation transformer high temperature.
   e. Motor fault outputs shall be activated by any of the following as a minimum and shall be displayed on the operator terminal on the door of the VFD:
      1) Motor winding high temperature.
      2) Motor or pump bearing high temperature.
      3) Motor short circuit.
      4) Motor overload.

5) Motor ground fault.
6) Motor under voltage.
7) Motor over voltage.
8) Motor under frequency.
9) Motor over frequency.
10) Motor phase reversal.
11) Motor current unbalance.

f. VFD and motor failure alarms shall normally latch in the trip mode and shall require an operator intervention to reset the alarms. An exception to this requirement are overvoltage, undervoltage or voltage failure alarms. These alarms shall automatically reset at the motor control and allow the operator to manually restart the pump after an adjustable 0-minute to 60-minute delay period after the alarm occurs and resets. If the alarm condition still exists, the pump shall not restart.

g. Normal and emergency shutdown contacts, each consisting of a remote contact closure rated 2-amp at 24V dc maximum shall be inputs to the VFD.

h. Provide the opening of the normal shutdown input contact via either the local panel mounted switch or through the facility DCS. Opening shall cause the motor speed to ramp down to zero speed by a controlled deceleration and at the same time the pump control valve shall start to close. The starting and stopping ramp rate shall be field adjustable and locked to an equivalent pumping rate of 35 cfs per minute or an equivalent ramping rate of 14 rpm per minimum, whichever is less over a pumping capacity flow range of 10 cfs to 120 cfs.

i. Provide opening of the emergency shutdown input contact, via either the local panel mounted switch or through the facility DCS. Opening shall cause the VFD to be immediately de-energized. The motor shall continue to spin forward dissipating its inertia until the motor comes to a complete stop. The check valve shall completely close as the flow reverses. The closed status of the check valve shall initiate closure of the pump control valve.

j. Startup of the VFD shall be accomplished by the following procedure:

1) The operator shall manually reset any alarms or failures pertaining to the VFD control system. Each pump shall be started locally at the VFD panel. When the HAND/OFF/REMOTE (H/O/R) selector switch, located on the local VFD panel, is selected to the HAND position and the operator activates the local START pushbutton, the pump VFD start sequence shall begin. A run permissive must then be received from the Pump Station Master PLC. This permissive shall allow that VFD to be capable of starting. The pump shall start and begin to automatically ramp up to the minimum

speed. If a low system differential pressure is sensed at the DCS, a second control signal requiring throttling of the pump control valve will be sent to the VFD PLC. If this second control signal is received, the VFD PLC shall reference a preset differential pressure set point (30-feet of pressure) for the differential pressure controller of the pump control valve. The pump control valve shall open normally, except it will throttle its position to maintain a minimum of 30-feet of differential pressure across the pump control valve. As the pump control valve moves to its differential pressure set point, the pump VFD shall ramp up to maintain the flow set point provided by the DCS. If two pumps are brought on-line with a required throttling signal from the DCS, the differential pressure set point across the pump control valves shall be 20-feet. If the low system differential head permissive is not required, the pump control valve differential pressure set point shall be 0 feet of differential, which shall move the pump control valve to a fully open position. Each pump shall be started manually, one at a time, in the MANUAL mode. There shall be an electrical interlock to prevent more than two pumps from running at the same time in either HAND or REMOTE mode.

2) The speed of the pump shall be adjusted manually at the VFD panel when the MANUAL/REMOTE speed control selector switch is in the MANUAL position.

3) The pump can be manually shutdown, in a normal condition, by the operator pushing the STOP pushbutton, located on the VFD panel or by selecting the OFF position on the H/O/R switch. The pump shall ramp down to minimum speed while closing the pump control valve. When the pump check valve fully closes, the pump shall shutdown.

4) In the event an emergency occurs, the pump shall be shut down by placing the EMERGENCY STOP mushroom style pushbutton switch, located the motor, in the depressed position. The appropriate pump shall immediately power down. The motor shall continue to spin forward dissipating its inertia until the motor comes to a complete stop. The check valve shall completely close as the flow in the pump discharge line reverses. The closed status of the check valve shall initiate the closure of the pump's pump control valve.

5) Provisions are made for each pump to be able to be started remotely from the workstations by selecting the REMOTE position on the H/O/R selector switch.

k. Provide adjustable minimum to maximum frequency limits of 6-Hz to 60-Hz. The VFD shall be provided with a frequency limit stop to insure that the motor horsepower is not exceeded.

l. Provide independent, timed linear acceleration and deceleration functions, adjustable from 360 seconds to 700 seconds.

m. Provide terminal blocks for wires entering and leaving the VFD unit. Terminals shall be identified with alpha-numeric characters identical to the terminal identifiers indicated on the schematic and connection diagrams.

n. Frequency regulator shall operate within the following tolerances:

1) Frequency regulator span shall be 4 mA at minimum speed and 20 mA at maximum speed.

2) Frequency regulator accuracy shall be within 1.0 percent of span.

3) Frequency regulator deadband shall be within 0.5 percent of span.

4) Frequency regulator repeatability shall be within 0.5 percent of span.

5) Frequency reference signal input resistance shall be no more than 550 ohms.

2.04 ENCLOSURE

A. The enclosure shall be a dead-front, freestanding assembly with cabinet base and maximum dimensions as shown on the Contract Documents. Maximum height of any door mounted switch or indicator shall be 72 inches above the bottom of the VFD enclosure. Doors shall be minimum 12-gauge sheet steel. Removable lifting angles shall be provided.

B. The enclosure be per the Area Classification and Material Selection Table on the Contract Documents with gasketed doors and door openings. The enclosure shall be front access only. No rear or side access shall be required. The rear panel cover shall not be used for mounting of internal equipment. The enclosure shall be suitable for bottom and top cable entry and exit.

C. All VFD components, including input switch/compartment, cooling equipment, DC link, controller, motor protection relay, and isolation transformer shall be mounted and wired in a grounded continuous, multi-section enclosure meeting the following requirements without exception:

1. Power conversion and auxiliary equipment enclosure sections shall be NEMA 1 design.
2. All power conductors (bus or cable) shall be insulated, except the bus that is not accessible from VFD cabinet doors.
3. All wiring shall be located internally within the VFD enclosure.
4. It shall be the responsibility of the Sub-supplier to provide all cooling or heating equipment for the internal components of the VFD in order for it to operate satisfactorily without breakdown per the Service Conditions herein.
5. VFDs shall be furnished with redundant cooling fans (complete with motor starters), and shall be capable of operating at full load with one cooling fan out of service. Automatic switchover controls shall be provided for redundant cooling fans.

6. Ventilation exhaust from each of the VFD cabinet sections shall be ducted to adapt to one common connecting duct, installed by the Installing Contractor, from an outlet at the top of each VFD enclosure. Cooling fans shall be designed to produce the required airflow against an internal and external static pressure. External static pressure shall be calculated equivalent to a head loss for a 100 feet of ductwork, 1,500-fpm velocity plus the head loss through an acoustical louver of 1/8 inch of water column.
7. Maximum door swing clearance shall not exceed 36 inches.
8. Enclosure shall be painted Sub-supplier's standard gray color. Enclosure painting shall conform to Section 09 90 00, Painting and Coating, System 11 for exposed metals. The indicated intermediate coating may be omitted.

2.05 PROTECTIVE FEATURES AND CIRCUITS

A. The controller shall include the following protective features:
   1. Static instantaneous overcurrent and overvoltage trip.
   2. Phase sequence detector and undervoltage protection.
   3. Power unit over-temperature protection.
   4. Electronic, motor inverse time, overload protection.
   5. Responsive action to shut down the VFD on high temperature from the motor winding or bearing temperature detectors. All analog temperature signals shall be converted to contacts by the use of RTD relays or similar devices. Contacts shall open on fault condition or loss of relay power. RTD relays or similar devices shall be selected and provided in coordination with the motor Sub-supplier. RTD relays or similar devices shall be mounted within enclosure provided under Section 44 42 56.03, Vertical Turbine Pumps. Each VFD shall be supplied with a GE Multilin, SR469, motor protection relay (MPR), with MODBUS RS-485 interface to the pump station control system. All VFD and MPR alarm contacts shall be configured to be normally closed, open in alarm condition, and open on loss of power.
   6. The VFD shall be capable of transient operation with a line voltage dip of 15 percent of normal operating voltage on a variable torque load. During line dip, the VFD shall automatically provide a speed droop limiting maximum capable speed for the duration of the input voltage dip.

B. The power circuit design shall be such that the following fault conditions can occur without damage to the power circuit components:
   1. Single phase fault or three phase short circuit on VFD output terminals.
   2. Loss of three-phase input power due to opening of VFD input disconnect device or utility power failure during VFD operation.
   3. Loss of one phase of input power.

2.06 CONTROL DEVICES

A. Pilot devices and instruments shall be flush mounted on a VFD unit door. Pilot devices shall be heavy-duty type with contacts rated at 10-amps minimum at 600V ac. Indicating lights shall be LED, transformer push-to-test type. Lens colors shall be in accordance with details shown on Drawings. Door-mounted indicating lights shall be removable without removing the related wiring. The control units of the same type and size shall be made interchangeable. Relays shall be hermetically sealed and shall have energization indication.

2.07 DIAGNOSTICS

A. A door-mounted flat panel screen operator terminal shall be furnished with the VFD and be capable of controlling the VFD and setting drive parameters. The operator terminal shall include the following features:
   1. The display shall present diagnostic messages and parameter values in English engineering units when accessed, without the use of codes. Provide the ability to switch to SI units.
   2. The keypad / touch screen shall allow the operator to enter exact numerical settings in English engineering units. A plain English user menu shall be provided in software as a guide to parameter settings, (rather than codes). Drive parameters shall be factory set in EEPROM and resettable in the field through the operator terminal.
   3. Password security shall be available to protect drive parameters from unauthorized personnel. The EEPROM stored drive variables shall be able to be transferred to a new board to reprogram spare boards. Provide the ability to reset the password.
   4. Individual “Help-Screens” shall be incorporated into the display allowing operators to be “guided” through the start-up and shutdown process, along with troubleshooting the VFD when a “Failure” occurs. These screens shall be accessed directly from any operating page by pressing a “Help” button programmed into the display.
   5. The VFD shall be capable of direct communication to a compatible computer for serial link setup of parameters, fault diagnostics, trending and diagnostic log downloading. An RS-232 port shall be door-mounted for computer or printer interface. VFD parameters, fault log and diagnostic log shall be downloadable for hardcopy printout via the RS-232 port and a standard serial printer.

B. The VFD shall be provided with the following diagnostics:
   1. Lights to indicate a failure of converter or inverter power device.
   2. Lights to indicate presence of gate pulses on converter and inverter power device.
   3. Indication of the following fault conditions:
      a. No fault.
      b. Blown power fuse.

c. Control power failure.
d. Under-voltage.
e. Instantaneous overcurrent.
f. Sustained overload.
g. Over-temperature.
h. Output over-voltage.

4. Diagnostic Features and Fault Handling:
   a. A “Fault Log” shall record, store, display and print upon demand, the following 30 most recent events:
      1) VFD mode (Auto/Manual).
      2) Date and time of day (of fault).
      3) Type of fault.
      4) Reset mode (Auto/Manual).
   b. A “Historic Log” shall record, store, display and print upon demand, the following control variables at 2.7-mSec intervals for the 50 intervals immediately preceding a fault trip:
      1) VFD mode (Manual/Auto/Inhibited/Tripped, etc.).
      2) Speed demand.
      3) VFD output frequency.
      4) Demand (output) amps.
      5) Feedback (motor amps).
      6) VFD output volts.
      7) Type of fault.
      8) Drive-in (on/off).
   c. The fault log record shall be accessible via a RS-232 serial link as well as page-by-page on the terminal display.
   d. A portable battery powered printer with RS-232C serial interface and connecting cable or a data logger printer powered by a UPS, supplied and installed with VFD, shall be furnished.

2.08 POWER FACTOR CORRECTION

A. The collective power factor of the VFD and the motor, when running between 50 percent and 100 percent speed, shall not be less than 0.95 measured at the Point of Common Coupling.

2.09 FACTORY TESTING

A. Component Tests: All components (including furnished spares) shall be 100 percent tested. All printed circuit boards shall be burned-in continuously for 24 hours at 60 degrees C. The printed circuit boards shall be tested after burn-in to insure they are functioning within specification. Every thyrister, transistor or IGBT shall have the following critical parameters tested at rated current: gating,

turn-on, turn-off, high temperature, forward blocking, reverse blocking and waveform characteristics. All assembled phase cells shall be tested for cell balance at rated voltage, maximum current, maximum dV/dT and maximum dI/dT.

1. Control power shall be applied to processors, printed circuit boards, diagnostic boards, controller, LCD display, and similar devices including software to test for proper operation, sequencing, logic and diagnostics.
2. All wiring shall be checked for continuity and for functional compliance with the wiring diagrams.

B. System Tests: Testing shall proceed in the order given below.

1. Functional Test: Each VFD shall be completely functionally tested at the factory as a unit. Test results in triplicate shall be submitted to Jacobs' Engineer and no equipment shall be shipped until the test data have been approved in writing by Jacobs' Engineer. Test reports shall include the Sub-supplier's standard tests as well as HMI, and controller. The test report shall indicate the test procedure and instrumentation used to measure and record data. The test report shall be certified by the test personnel and be submitted to Jacobs' Engineer.
2. Load Tests:
    a. Each VFD shall be factory load tested at 50 percent of its maximum rating for a continuous period of three hours without overheating or shutdown. The load shall be applied as a motor (or dynamometer) load or a combination of motor and fixed resistor bank. Resistor bank shall not be greater than 25 percent of the applied load.
    b. One of the provided VFDs shall be load and efficiency tested at pump manufacturer factory. Test reports shall include Sub-supplier's standard tests as well as functional tests of the vibration and temperature monitoring system, and motor protection relays. See Section 26 19 00, Medium Voltage Induction Motors, and Section 42 44 56.03, Vertical Turbine Pumps. Drive manufacturer shall be responsible for setup of drive at pump manufacturer's facility. Drive manufacturer shall provide startup and testing services of drive with motor and pump at pump manufacturer's facility.

PART 3 EXECUTION (NOT USED)

END OF SECTION

SECTION 26 20 00
LOW-VOLTAGE AC INDUCTION MOTORS

PART 1 GENERAL

1.01 SUMMARY

A. This section includes low voltage single-phase and three-phase AC induction motors.

1.02 RELATED SECTIONS

A. This section applies only when referenced by a motor-driven equipment specification. Application, horsepower, enclosure type, mounting, shaft type, synchronous speed, and deviations from this section will be listed in the equipment specification. Where such deviations occur, they shall take precedence over this section.

1.03 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. 10, National Precision Ball.
      c. 11, Load Ratings and Fatigue Life for Roller Bearings.
   2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. 85, Test Procedure for Airborne Sound Measurements on Rotating Electric Machinery.
      b. 112, Standard Test Procedures for Polyphase Induction Motors and Generators.
      c. 114, Standard Test Procedures for Single-Phase Induction Motors.
      d. 620, Guide for the Presentation of Thermal Limit Curves for Squirrel Cage Induction Motors.
      e. 841, Standard for Petroleum and Chemical Industry—Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors—up to and Including 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.

d. MG 13, Frame Assignments for Alternating Current Integral Horsepower Induction Motors.

4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. UL:
   a. 1, Flexible Metal Conduit.
   b. 674, Standard for Safety Electric Motors and Generators for use in Division 1 Hazardous (Classified) Locations.
   c. 2111, Overheating Protection for Motors.

1.04 DEFINITIONS

A. EXP: Explosion-proof enclosure.

B. Inverter Duty Motor: Motor meeting applicable requirements of NEMA MG 1, Section IV, Parts 30 and 31.

C. 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.

D. ODP: Open drip-proof enclosure.

E. TEFC: Totally enclosed, fan cooled enclosure.

F. TENV: Totally enclosed, nonventilated enclosure.

G. WPI: Open weather protected enclosure, Type I.

H. WPII: Open weather protected enclosure, Type II.

1.05 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. Multispeed load classification (for example, variable torque).

e. Adjustable frequency drive motor load classification (for example, variable torque) and minimum allowable motor speed for that load classification.

f. Guaranteed minimum full load efficiency and power factor.

4. Enclosure type and mounting (such as, horizontal, vertical).
5. Outline drawings, dimensions, and total weight.
6. Conduit box dimensions and usable volume as defined in NEMA MG 1 and NFPA 70.
7. Bearing type.
8. Space heater voltage and watts.
9. Description, ratings, and wiring diagram of motor thermal protection.
10. Maximum brake horsepower required by the equipment driven by the motor.
11. Description and rating of submersible motor moisture sensing system.
12. Submit anchorage and bracing data sheets and drawings as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Submit anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Factory test reports, certified.
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 01 43 33, Manufacturers' Field Services.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. General Electric.

B. Reliance Electric.

C. MagneTek.

D. Siemens Energy and Automation, Inc., Motors and Drives Division.

E. Baldor.

F. U.S. Electrical Motors.

G. TECO-Westinghouse Motor Co.

H. Toshiba International Corp., Industrial Division.

I. WEG Electric Motors Corp.

J. "Or-equal."

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, utilize a single supplier to provide a drive motor, its driven equipment, and specified motor accessories.

C. Meet requirements of NEMA MG 1.

D. Frame assignments in accordance with NEMA MG 13.

E. Provide motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark.

F. Motors shall be specifically designed for the use and conditions intended, with a NEMA design letter classification to fit the application.

G. Lifting lugs on all motors weighing 100 pounds or more.

H. Operating Conditions:
   1. Maximum ambient temperature not greater than 40 degrees C.
   2. Motors shall be suitable for operating conditions without any reduction being required in the nameplate rated horsepower or exceeding the 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 specifications.

B. Constant Speed Applications: Brake horsepower of the driven equipment at any operating condition not to exceed motor nameplate horsepower rating, excluding any service factor.

C. Adjustable Frequency and Adjustable Speed Applications (Inverter Duty Motor): Driven equipment brake horsepower at any operating condition not to exceed motor nameplate horsepower rating, excluding any service factor.

2.04 SERVICE FACTOR

A. Inverter-duty Motors: 1.0 at rated ambient temperature, unless otherwise noted.

B. Other Motors: 1.15 minimum at rated ambient temperature, unless otherwise noted.

2.05 VOLTAGE AND FREQUENCY RATING

A. System Frequency: 60 Hz.

B. Voltage Rating: Run motors at highest voltage that is most efficient. Unless otherwise indicated in motor-driven equipment specifications:

Size	Voltage	Phases
1/2 hp and smaller	115 & 480	1
3/4 hp through 250 hp	460	3

C. Suitable for full voltage starting.

D. 50 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 12-11, Full-load Efficiencies of Energy Efficient Motors, or as indicated in motor-driven equipment specifications.
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 F or lower, if motor horsepower not covered by NEMA MG 1 tables.

B. Safe stall time 12 seconds or greater.

2.08 INSULATION SYSTEMS

A. Single-Phase, Fractional Horsepower Motors: Manufacturer's standard winding insulation system.

B. Three-Phase and Integral Horsepower Motors: Unless otherwise indicated in motor-driven equipment specifications, Class F with Class B rise at nameplate horsepower and designated operating conditions.

2.09 ENCLOSURES

A. Enclosures to conform to NEMA MG 1.

B. TEFC and TENV: Furnish with a drain hole with porous drain/weather plug.

C. Explosion-Proof (EXP) (does not necessarily apply to all motor styles, adjust depending upon mounting and size):

1. TEFC listed to meet UL 674 and NFPA 70 requirements for Class I, Division 1, Group D hazardous locations.
2. Drain holes with drain and breather fittings.
3. Integral thermostat opening on excessive motor temperature in accordance with UL 2111 and NFPA 70.
4. Terminate thermostat leads in terminal box separate from main terminal box.

D. Submersible: In accordance with Article Special Motors.

2.10 TERMINAL (CONDUIT) BOXES

A. Oversize main terminal boxes for all 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.

D. Minimum usable volume in percentage of that specified in NEMA MG 1, Section 1, Paragraph 4.19 and NFPA 70, Article 430 (some adjustment to following table may be needed depending upon manufacturer):

Terminal Box Usable Values	
Horsepower	Percentage (or larger)
15 through 125	500

E. Terminal for connection of equipment grounding wire in each terminal box.

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 and above: Regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
   3. Minimum 100,000 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.
      c. Minimum 50,000 hours L-10 bearing life.
   2. Guide Bearings:
      a. Manufacturer's standard bearing type.
      b. Manufacturer's standard lubrication.
      c. Minimum 100,000 hours L-10 bearing life.

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:

1. Bearing Isolation: Motors larger than 20 hp shall have electrically isolated bearings to prevent stray current damage.
2. Shaft Grounding Device: Motors larger than 1 hp shall be provided with a shaft grounding brush or conductive micro fiber shaft grounding ring. Shaft grounding device shall be solidly bonded to the grounded motor frame per manufacturer's recommendations.
    a. Manufacturers and Products:
        1) Grounding Brush; Sohre Turbomachinery, Inc.
        2) Grounding Ring; EST-Aegis.
        3) "Or-equal."

2.12 NOISE

A. Measured in accordance with IEEE 85 and NEMA MG 1.

B. Motors controlled by adjustable frequency drive systems shall not exceed sound levels of 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: Corrosion-resistant on motors with ODP, WPI, and WPII enclosures meeting requirements for Guarded Machine in NEMA MG 1, and attached with stainless steel screws.

B. Winding Thermal Protection:
   1. Thermostats:
      a. Motors for constant speed application as indicated in process equipment specifications.
      b. Bi-metal disk or rod type thermostats embedded in stator windings.
      c. Automatic reset contacts rated 120V ac, 5 amps minimum, opening on excessive temperature. (Provide manual reset at motor controller.)

C. Space Heaters:
   1. Provide winding space heaters where indicated in process equipment specifications with leads wired out to motor 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 the specified seismic conditions.

2.16 SPECIAL MOTORS

A. Requirements in this article take precedence over conflicting features specified elsewhere in this section.

B. Severe-Duty Explosion-Proof: Meet requirements for EXP enclosures and CISD-TEFC motors.

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

D. Inverter Duty Motor:
   1. Motor supplied power by adjustable voltage and adjustable frequency drives shall be inverter duty rated.
   2. Motor shall be suitable for operation over entire speed range indicated.

3. Provide forced ventilation where speed ratio is greater than published range for motor provided.
4. Motor installed in Division 1 hazardous (classified) location shall be identified as acceptable for variable speed when used in a Division 1 location.

E. Submersible Motor:

1. Manufacturers:
   a. Reliance Electric.
   b. Xylem Flygt Corp.
2. At 100 Percent Load:
   a. Motors with Speeds Less than 1,200 rpm: Manufacturer's standard.
   b. Motors with Speeds 1,200 rpm and Greater:

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

3. Insulation System: Manufacturer's standard Class B or Class F.
4. Motor capable of running dry continuously.
5. Enclosure:
   a. Hermetically sealed, watertight, for continuous submergence up to 65-foot depth.
   b. Listed to meet UL 674 and NFPA 70 requirements for Class I, Division 1, Group D hazardous atmosphere.
   c. Seals: Tandem mechanical.
6. Bearing and Lubrication:
   a. Permanently sealed and lubricated, replaceable antifriction guide and thrust bearings.
   b. Minimum 15,000 hours L-10 bearing life.
7. Inrush kVA/horsepower no greater than NEMA MG 1 and NFPA 70, Code F.

8. Winding Thermal Protection:
    a. Thermal sensor and switch assembly, one each phase, embedded in stator windings and wired in series.
    b. Switches normally closed, open upon excessive winding temperature, and automatically reclose when temperature has cooled to safe operating level.
    c. Switch contacts rated at 24V dc.
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 24V dc supply.
    c. Monitoring module with control power transformer, probe test switch and test light, and two independent 24V dc contacts, one opening and one closing when flux of moisture is detected.
10. Winding thermal protection, moisture detection, and bearing overtemperature specified above may be monitored by single device providing two independent 24V dc contacts, one closing and one opening on malfunction.
11. Connecting Cables:
    a. Two separate cables, one containing power and grounding conductors, and the other containing control and grounding conductors.
    b. Each cable suitable for hard service, submersible duty with watertight seal where cable enters motor.
    c. Length: See motor equipment driven specification. Subcontractor to cut cable to length needed for application with an excess of 60 inches.
    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 and IEEE 114 for single-phase motors.
2. Routine (production) tests on all motors 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.

4. Additional Required Tests: Provide certified test reports for all polyphase motors.

B. Test Report Forms:

1. Routine Tests: IEEE 112, Form A-1.

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.

END OF SECTION

SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.01 SUMMARY

A. This section includes single-phase and three-phase low voltage lighting and power distribution transformers.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. California Titles 20 and 24.
   2. Institute of Electrical and Electronics Engineers (IEEE): C57.96, Guide for Loading Dry Type Transformers.
   3. National Electrical Code (NEC): 450, Transformers and Transformers Vaults.
   4. National Electrical Contractor's Association (NECA): 409, Recommended Practice for Installing and Maintaining Dry-Type Transformers.
   5. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. ST 20, Dry-Type Transformers for General Applications.
      c. TP 1, Guide For Determining Energy Efficiency for Distribution Transformers.
   6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
   7. 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.

1.03 SUBMITTALS

A. Action Submittals:
   1. Descriptive information.
   2. Dimensions and weight.
   3. Transformer nameplate data.
   4. Schematic and connection diagrams.
   5. Submit anchorage and bracing drawings and cut sheets as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:
   1. Submit anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
   2. Component and attachment seismic qualification certificate of compliance as required by Section 01 45 36, Equipment Seismic Certification.
   3. Test Report: Sound test certification for dry type power transformers (0-volt to 600-volt, primary).
   4. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.

PART 2 PRODUCTS

2.01 GENERAL

A. UL 1561, NEMA ST 20, unless otherwise indicated.

B. Dry-type, self-cooled, two-winding, with copper windings.

C. Units larger than 5 kVA suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

D. Efficiency: Meet or exceed values in Table 4.2 of NEMA TP 1. In California, transformers 15 kVA and larger shall comply with Title 20 and Title 24.

E. Maximum Sound Level per NEMA ST 20:
   1. 40 decibels for 0 kVA to 9 kVA.
   2. 45 decibels for 10 kVA to 50 kVA.
   3. 50 decibels for 51 kVA to 150 kVA.

F. Overload Capability: Short-term overload per IEEE C57.96.

G. Wall Bracket: For single-phase units, 15 kVA to 37-1/2 kVA, and for three-phase units, 15 kVA to 30 kVA.

H. Vibration Isolators:
   1. Rated for transformer's weight.
   2. Isolation Efficiency: 99 percent, at fundamental frequency of sound emitted by transformer.
   3. Less Than 30 kVA: Isolate entire unit from structure with external vibration isolators.
   4. 30 kVA and Above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator.

I. Manufacturers:
   1. General Electric Co.
   2. Square D Co.
   3. Eaton/Cutler-Hammer.
   4. "Or-equal."

2.02 GENERAL PURPOSE TRANSFORMER

A. Insulation Class and Temperature Rise: Manufacturer's standard.

B. Core and Coil:
   1. Encapsulated for single-phase units 1/2 kVA to 25 kVA and for three-phase units 3 kVA to 15 kVA.
   2. Thermosetting varnish impregnated for single-phase units 37.5 kVA and above, and for three-phase units 30 kVA and above.

C. Enclosure:
   1. Single-Phase, 3 kVA to 25 kVA: NEMA 250, Type 3R, nonventilated.
   2. Single-Phase, 37-1/2 kVA and Above: NEMA 250, Type 2, ventilated.
   3. Three-Phase, 3 kVA to 15 kVA: NEMA 250, Type 3R, nonventilated.
   4. Three-Phase, 30 kVA and Above: NEMA 250, Type 2, ventilated.
   5. Outdoor Locations: NEMA 250, Type 3R.
   6. Corrosive Locations: NEMA 250, Type 3R stainless steel.

D. Voltage Taps:
   1. Single-Phase, 3 kVA to 10 kVA: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
   2. Single-Phase, 15 kVA and Above: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.
   3. Three-Phase, 3 kVA to 15 kVA: 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 112 kVA.

END OF SECTION

SECTION 26 24 16
PANELBOARDS

PART 1 GENERAL

1.01 SUMMARY

A. This section includes dead front panel boards including lighting, process, appliance, power, and distribution panelboards.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. Institute of Electrical and Electronics Engineers (IEEE):
      a. C62.1, Surge Arresters for Alternating Current Power Circuits.
      b. C62.11, Standards for Metal-Oxide Surge Arrestors for AC Power Circuits.
   2. National Electrical Contractor's Association (NECA): 407, Recommended Practice for Installing and Maintaining Panelboards.
   3. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. 289, Application Guide for Ground Fault Circuit Interrupters.
      c. AB 1, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
      d. KS 1, Enclosed Switches
      e. LA 1, Surge Arrestors.
      f. PB 1, Panelboards.
      g. PB 1.1, General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
   4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
   5. UL:
      a. 50, Cabinets and Boxes
      b. 67, Standard for Panelboards.
      c. 98, Standard for Enclosed and Dead-Front Switches.
      d. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
      e. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
      f. 508, Standard for Industrial Control Equipment.
      g. 870, Wireways, Auxiliary Gutters and Associated Fittings.
      h. 943, Standard for Ground-Fault Circuit-Interrupters.

1.03 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.
      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. Submit anchorage and bracing drawings and cut sheets as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:
   1. Submit anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
   2. Manufacturer's recommended installation instructions.
   3. Component and attachment seismic qualification certificate of compliance as required by Section 01 45 36, Equipment Seismic Certification.

1.04 QUALITY ASSURANCE

A. Listing and Labeling: Provide products specified in this section that are listed and labeled as defined in NEC Article 100.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:
   1. Eaton/Cutler-Hammer.
   2. General Electric Co.
   3. Square D Co.
   4. "Or-equal."

B. Panelboards shall be of the same manufacturer as equipment furnished under Section 26 24 19, Low-Voltage Motor Control.

2.02 GENERAL

A. In certain situations, epoxy materials are preferred for 30 kV and 40 kV.

B. Provide equipment in accordance with NEMA PB 1, NFPA 70, and UL 67.

C. Wire Terminations:
   1. Panelboard assemblies, including protective devices, shall be suitable for use with 75 degrees C or greater wire insulation systems at NEC 75 degrees C conductor ampacity.
   2. In accordance with UL 486E.

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”, “100 percent”, etc., selected components and protective devices shall be rated for continuous load current at value shown.

E. Overcurrent Protective Devices:
   1. In accordance with NEMA AB 1, NEMA KS 1, UL 98, and UL 489.
   2. Protective devices shall be adapted to panelboard installation.
      a. Capable of device replacement without disturbing adjacent devices and without removing main bus.
      b. Spaces: Cover openings with easily removable cover.
   3. Series-Connected Short Circuit Ratings: Devices shall be fully rated; series-connected ratings unacceptable.

F. Circuit Breakers:
   1. General: Thermal-magnetic unless otherwise indicated, quick-make, quick-break, molded case, of indicating type showing ON/OFF and TRIPPED positions of operating handle.
   2. Provide 20 percent spare breakers.
   3. Noninterchangeable: In accordance with NEC.
   4. Bus Connection: Bolt-on circuit breakers in all panelboards.
   5. Trip Mechanism:
      a. Individual permanent thermal and magnetic trip elements in each pole.
      b. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.

c. Two and three pole, common trip.
d. Automatically opens all poles when overcurrent occurs on one pole.
e. Test button on cover.
f. Calibrated for 40 degrees C ambient, unless shown otherwise.

6. Unacceptable Substitution:
   a. Do not substitute single-pole circuit breakers with handle ties for multi-pole breakers.
   b. Do not use tandem or dual circuit breakers in normal single-pole spaces.
7. 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).
   a. Ground fault sensor shall be rated same as circuit breaker.
   b. Push-to-test button.
   c. Reset button.
8. 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).

G. Enclosures:
1. Type: NEMA 1.
2. Material: Shall be code-gauge, hot-dip galvanized sheet steel with reinforced steel frame.
3. Finish: Rust inhibitor prime followed by manufacturer's standard gray baked enamel or lacquer.

H. Bus:
1. Material: Tin-plated copper full sized throughout length.
2. Provide for mounting of future protective devices along full length of bus regardless of number of units and spaces shown. Machine, drill, and tap as required for current and future positions.

I. Feeder Lugs: Main, feed-through, and neutral shall be replaceable, bolted mechanical or crimp compression type.

J. 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.

K. 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 shall be bolted crimp compression lugs for conductors 6 AWG and larger.

L. Provision for Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances for future protective device ampere ratings indicated.

M. Special Features: Where indicated, provide the following features:
   1. Controls:
      a. Provide controls in accordance with UL 508.
      b. Controls shall be Class I, 120V ac.
      c. Control circuits shall be protected by fuse or circuit breaker.
   2. Surge Arresters:
      a. In accordance with NEMA LA 1, IEEE C62.1, and IEEE C62.11.
      b. Comply with Section 26 43 00, Surge Protection Devices.
      c. Coordinate impulse sparkover voltage with system voltage.
      d. Provide protective device within panelboard as disconnecting means and short circuit protection per manufacturer's recommendation.

2.03 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

A. Multi-Section Panelboards: Where more than one section is indicated, provide multiple panelboards with separate fronts.
   1. Panelboard sections shall be individually installed and field interconnected to form a single electrical unit.
   2. Unless otherwise indicated, provide feed-through lugs on each section but last.
   3. Surface-mount panels shall be individually mounted and may be different sizes.
   4. Recessed-mount panels shall be individually mounted and the same size tub and flush cover.
   5. Surface-mount multi-section panelboards may be comprised of sections of unequal heights.
   6. Provide feed-through and main lugs in individual sections as required for field assembly of a complete multi-section panelboard.
   7. Provide neutral and ground terminal bars in each section.

B. NEMA 250 Type 1 Branch Panelboard Enclosure:
   1. Front trim shall be secured to box with concealed trim clamps.
   2. Surface-mount panelboard front trim shall have same dimensions as box.

3. Flush panelboards front trims shall overlap box nominal 3/4 inch on all sides.
4. Door in panelboard front trim, with concealed hinges, shall provide access to protective device operating handles.
5. Doors over 30 inches in height shall have multi-point latching.
6. Door lock shall be secure with flush catch and tumbler lock; all panelboards keyed alike, with two milled keys each lock.
7. Circuit Directory: Metal frame with transparent plastic face and enclosed card, mounted inside each panel door.
8. Hinged Front Cover (Door In Door): Entire front trim hinged to surface box with standard door within hinged trim cover.

2.04 POWER DISTRIBUTION PANELBOARDS

A. Branch Protective Devices:
   1. Locking: Furnish devices with provisions for handle padlocking.
   2. Load Connections: Wire lugs shall be mechanical or crimp compression type, removable/replaceable, and suitable for 75 degrees C rated conductors without derating switch nor conductor ampacity.
   3. Provide a nameplate for each circuit, blanks for spares.

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.

3.02 BRANCH CIRCUIT PANELBOARD

A. Mount flush panels uniformly flush with wall finish.

B. Provide typewritten circuit directory for each panelboard.

3.03 POWER DISTRIBUTION PANELBOARD

A. Provide engraved identification for each protective device.

END OF SECTION

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): C2, National Electrical Safety Code (NESC).
   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. CT: Current Transformer.

B. LCD: Liquid Crystal Display.

C. N.C.: Normally Closed.

D. N.O.: Normally Open.

E. THD: Total Harmonic Distortion.

F. VT: Voltage Transformer.

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. Anchoring instructions and details.
   9. 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. Heater model number and relay 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 heater or setting selection tables for starters provided.
   10. Control Diagrams: Provide a separate control diagram for each load and compartment. Control diagrams that are typical for a group of loads will not be acceptable.
   11. One-line diagrams.
   12. Schematic (Elementary) Diagrams: Provide a separate schematic diagram for each load and compartment. Wiring diagrams that are typical for a group of loads will not be acceptable.
   13. Outline diagrams.

B. Informational Submittals:
   1. Manufacturer's installation instructions.
   2. Factory test reports, certified.
   3. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
   4. Component and attachment seismic qualification certificate of compliance as required by Section 01 45 36, Equipment Seismic Certification.

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 Subcontractor to facilitate ingress of equipment to final installation location within building.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:
   1. Allen-Bradley.
   2. Eaton Electrical/Cutler-Hammer.
   3. GE Industrial Systems.
   4. Schneider Electric/Square D Services.
   5. ABB.

2.02 GENERAL

A. Like Items of Equipment: End product of one manufacturer.

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.
   4. Mount within starter/drive cubicle.

E. Power Supply: 120V ac input, 24V dc output.

F. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

G. Lifting lugs on equipment and devices weighing over 100 pounds.

H. Anchor Bolts: Type 316 stainless steel, sized by a licensed structural engineer registered in California in accordance with Section 01 88 15, Anchorage and Bracing, and as specified in Section 05 05 19, Anchor Bolts.

I. Seismic Zone and Importance Factor shall be as specified in Section 01 61 00, Common Product Requirements.

J. Operating Conditions:
   1. Ambient Temperature: Maximum 40 degrees C.
   2. Altitude: Zero feet above sea level.
   3. Equipment to be fully rated.

K. Enclosures: In accordance with NEMA 250.

L. Equipment Finish:
   1. Electrocoating process applied over rust-inhibiting phosphated base coating.
   2. Exterior Color: Light gray.

2.03 SEPARATELY MOUNTED MOTOR CONTROL

A. Combination Full-Voltage, Magnetic Starter:
   1. Rating: Horsepower rated at 600 volts.
   2. Short Circuit Withstand Rating: As shown on Drawings.
   3. Three-phase, nonreversing, full voltage.
   4. Control: As shown on Drawings.
   5. Disconnect Type: Motor circuit protector.
   6. Enclosure: As shown on Drawings.
   7. Padlockable operating handle, capable of up to three locks.

B. Solid State Motor Overload Protection:
   1. Control Voltage: 24V dc.
   2. Inverse-time-limit characteristic.
   3. Phase loss, phase unbalanced and Class II ground fault protection.
   4. Current operated electronic circuitry with adjustable trip.
   5. Class 10/20/30 relay trip, switch selectable.
   6. N.O. auxiliary contact for remote monitoring.
   7. Manual reset.
   8. Provide in each ungrounded phase.
   9. Mount within starter unit.
   10. Contain sufficient relay inputs and outputs as shown in motor control schematics.
   11. Voltage and current monitoring.
   12. Communications: Modbus TCP/IP.

2.04 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.
   3. Short Circuit Rating: As shown on Drawings.
   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 gasketed.
   2. Vertical Section Standard Indoor Dimensions for NEMA 1 Type:
      a. Nominal, 90 inches high, 20 inches wide, 16 inches deep.
      b. Alternative width dimensions of 24 inches and 30 inches are acceptable for oversize devices or panels.
      c. Do not exceed space shown.
   3. Construction:
      a. Sheet steel reinforced with channel or angle irons.
      b. Butt sections flush, end-to-end against similar section without bolts, nuts, or cover plates causing interference.
      c. Removable top cover plates and bottom cover plates.
      d. Removable plates on end panels for future bus extension.
   4. Section Mounting: Removable formed-steel channel sills and lifting angles.
   5. Horizontal Wiring Compartments: Accessible from front, full width, top and bottom.
   6. Vertical Wiring Compartment:
      a. Full height, isolated from unit starters with separate hinged door and tie supports.
      b. No terminal blocks allowed in vertical wireway compartment.
   7. Unit Compartment: Individual compartments separated by steel barriers for each starter, feeder, or other unit capable of being wired from front without unit removal.
   8. Compartment Doors: Separate hinged doors for each starter, feeder, or other unit.
   9. Door Interlocking: Mechanically interlock starter and feeder doors so doors cannot be opened with unit energized. Provide defeater mechanism to allow intentional access and energizing at any time by qualified individual.
   10. External disconnect handles with ON/OFF and trip positions showing, padlockable in OFF position with up to three-lock capability.

11. Cable Entrance: Main leads enter from bottom; 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. Construct to allow future extension of additional sections.
   c. Pressure type solderless lugs for each incoming line cable.
   d. Isolated from top horizontal wireway.
2. Vertical Power Bus:
   a. Three-phase tin-plated, copper, full height of section, rated 300 amperes.
   b. Sandwich type bus insulation providing deadfront construction with starter units removed except for bus stab openings.
   c. Insulated and isolated barrier, complete with shutters.
3. Neutral Bus: None.
4. Ground Bus: Copper, tin-plated, rated 300 amperes, entire width of control center.
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, Low-Voltage Basic Electrical Materials and Methods.
2. Construction:
   a. Drawout combination type with stab connections for starters NEMA ICS, Size 5 and smaller.
   b. Readily interchangeable with starters of similar size.
   c. Pull-apart unit control wiring terminal boards capable of accepting up to 2 #14 AWG wires minimum on all units.
3. Foreign Voltages: Incoming voltages to a motor starter circuit above 50V, originating outside of the MCC, shall be de-energized when the motor disconnect switch is in the OFF position.
4. Communications:
   a. Motor Control: Hardwired status signals. Control over network connection not permissible. The following signals should be communicated through hardwired status contacts (minimum):
      1) Start.
      2) Stop.
      3) Disconnect Closed.
      4) E-Stop.

b. Motor Monitoring: Over Modbus TCP/IP connection. The following signals shall have the capability of being monitored at the plant DCS level over the Modbus TCP/IP connection for each motor controller unit:
   1) On.
   2) Fault.
   3) Ready.
   4) Remote.
   5) Local.
   6) Electrical Data Monitoring:
      a) Phase Currents (Ia, Ib, Ic, In).
      b) Line-to-Line Voltages (Vab, Vbc, Vca): Monitor over motor control center power monitors.
      c) Energy and Power (Watt-Hours, Watts, Volt-Amps Reactive, Volt-Amps).
      d) Frequency.
      e) Power Factor.

5. Starters:
   a. NEMA ICS 18, standard rating, except none smaller than NEMA ICS, Size 1.
   b. Rating: Horsepower rated at 600 volt.
   c. Short Circuit Rating: As shown on Drawings to match the overall rating of the motor control center.
   d. Three-phase, nonreversing, unless specified otherwise.
   e. Disconnect Type: Motor circuit protector.
   f. Combination Full Voltage, Magnetic Starter:
      1) Control: Hardwired, as shown on Drawings.
      2) Monitoring: MODBUS TCP/IP, as shown on Drawings.
   g. Combination Reduced Voltage, Solid State Starter:
      1) Control: As shown on Drawings.
      2) Bypass contactor.
      3) Class 10/20/30 electronic overload relay, switch, or dip switch selectable.
      4) Kick start, with adjustable torque and time settings.
      5) Ramp start, selectable current or torque, and adjustable time.
      6) Smooth stop ramp, adjustable time.
      7) Phase loss unbalance and phase reversal protection.
      8) LED display or LCD of fault, N.O. contact to communicate fault condition.
   h. Combination Adjustable Frequency Drive: Drives as specified in Section 26 29 23, Low-Voltage Variable Frequency Drive System.
   i. Communications: Modbus TCP/IPt.

j. Padlockable operating handle when de-energized with up to three-lock capability.
k. Unit door interlocked to prevent opening when disconnect is in closed position.
l. Mechanical interlocked to prevent placing disconnect in ON position when unit door is open.
m. Minimum Dimensions: 12 inches high by full section width, less vertical wireway.

6. Disconnecting Device:
   a. As indicated.
   b. Padlockable in OPEN position for up to three locks.
7. 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.
8. Solid State Motor Overload Protection:
   a. Control Voltage: 24V dc.
   b. Inverse-time-limit characteristic.
   c. Phase loss, phase unbalance and Class II ground fault protection.
      1) Includes voltage and current monitoring.
   d. Current operated electronic circuitry with adjustable trip.
   e. Class 10/20/30 relay trip, switch selectable.
   f. One N.O. auxiliary contact for remote monitoring.
   g. Manual reset.
   h. Provide in each ungrounded phase.
   i. Mount within starter unit.
   j. Contain sufficient relay inputs and outputs as shown in motor control schematics.
   k. Communications: Modbus TCP/IP.
9. Ground Fault Protection: Where indicated and as specified in Paragraph Main Protective Device and Feeder Units, except provide instantaneous operation device.

E. Control Unit:
1. Disconnecting Device: Pull-apart terminal blocks capable of de-energizing external source control circuits in unit.
2. Control Devices: As indicated and as specified in Section 26 05 04, Low-Voltage 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: As shown on Drawings.

G. Main Protective Device and Feeder Unit:
    1. Construction: As specified in Paragraph Motor Controller Unit.
    2. Incoming Service Feeder: As shown.
    3. Solid State Trip Circuit Breaker:
        a. In accordance with UL 489.
        b. Main protective device.
        c. 100 percent rated.
        d. Insulated or molded case breakers with ambient insensitive solid-state trips and having current sensors and logic circuits integral in breaker frame.
        e. Solid-state current control with adjustable ampere setting, adjustable long-time delay, adjustable short-time trip and delay band, fixed or adjustable instantaneous trip, and adjustable ground fault trip and delay band.
        f. Setting adjustments to be covered by a sealable, tamper-proof, transparent cover (insulated case breakers only) or by compartment door for other breakers).
        g. Locate trip button on front cover of breaker to permit mechanical simulation overcurrent tripping for test purposes and to trip breaker quickly in emergency situation.
    4. Molded Case Circuit Breaker:
        a. In accordance with UL 489.
        b. Feeder protective device.
        c. Thermal-magnetic trip and interrupting capacity required for connection to system with short circuit capacity indicated.
        d. Indicate tripping by operating-handle position.
        e. Suitable for use with 75 degrees C wire at full NEC 75 degrees C ampacity.

5. Ground Fault Protection:
    a. Suitable for 480-volt, three-phase, three-wire, solidly grounded wye system.
    b. Ground sensors to encircle phase conductors and neutral conductor where used, and connected to ground relays with adjustable pickup settings and time-current characteristics indicated.
    c. Circuit breaker shunt trip and relay operating from fused 120V ac control source within control center.
    d. Manufacturers and Products:
        1) Cutler-Hammer; GFR.
        2) General Electric; Ground Break.
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.
7. Phase Monitoring Relay:
    a. Three-phase monitoring relay to protect against low voltage, voltage unbalance, and phase reversal.
    b. Manufacturer and Product: Schneider Electric/Square D; Class 8430 Type MPS or Class 8430 Type MPD.

H. Digital Power Meter: As specified in Section 26 09 13, Power Measurement and Control.

I. Network Switches:
1. Provide network switches within each shipping split.
2. Wire all Modbus TCP/IP connected devices to the closest network switch within the MCC.
3. Manufacturer and Product: Hirschmann; RS30.

J. 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.

K. SPD: As specified in Section 26 43 00, Surge Protection Devices.

L. Pushbuttons, Indicating Lights, Selector Switches, Elapsed Time Meters, Control Relays, Time-Delay Relays, and Reset Timers: As specified in Section 26 05 04, Low-Voltage Basic Electrical Materials and Methods.

M. Nameplates:
1. Per Section 26 05 02, Basic Electrical Requirements.
2. Provide for each motor control center and each unit.
3. Engrave with inscription shown on single-line diagram.
4. Provide blank nameplates on spaces for future units.
5. Attach with stainless steel panhead screws on face of control center.

2.05 SOURCE QUALITY CONTROL

A. Factory Testing:
1. Applicable Standards: NEMA ICS 18, UL 845, and NEC Article 430, Part VIII.
2. Perform standard factory inspection and tests in accordance with NEMA requirements to verify components have been designed to Specification, assembled in accordance with applicable standards, and each unit functions in accordance with electrical diagrams.
3. Actual operation shall be performed wherever possible. Otherwise, inspect and perform continuity checks.
4. Verify component devices operated correctly in circuits as shown on diagrams or as called for in Specification.
5. Control Circuits and Devices:
a. Energize circuit at rated voltage.
b. Operate control devices.
c. Perform continuity check.
6. Instruments, Meters, Protective Relays, and Equipment:
a. Verify devices functioned by energizing potential to rated values with connection to devices made at outgoing terminal blocks.
b. Verify protective relays operated for functional checks and trips manually initiated to verify functioning of operation for indicator and associated circuits.
7. Perform dielectric tests on primary circuits and equipment, except potential transformers. Tests shall be made 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:
    a. Provide typed, self-adhesive label attached inside each motor starter enclosure door displaying the following information:
        1) Motor served by tag number and equipment name.
        2) Nameplate horsepower.
        3) Motor code letter.
        4) Full load amperes.
        5) Service factor.
        6) Installed overload relay heater catalog number.

B. Circuit Breakers:
1. Field adjust trip settings of motor starter magnetic-trip-only circuit breakers.
2. Adjust to approximately 11 times motor rated current.
3. Determine motor rated current from motor nameplate following installation.

C. Overload Relay: Select and install overload relay settings after actual nameplate full-load current rating of motor has been determined.

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. 1 person-day for installation assistance, and inspection of installation.
2. 3 person-days for functional and performance testing.
3. 3 person-days for plant startup.
4. 1 person-day for training of Owner's personnel.

END OF SECTION

SECTION 26 27 26
WIRING DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. This section includes wiring devices such as switches, receptacles, and device plates.

1.02 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-596, General Specification for Connector, Electrical, Power.
      b. W-S-896F/GEN, Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).
   3. California Code of Regulations (CCR): Title 24, California Building Standards Code.
   4. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. WD 1, General Requirements for Wiring Devices.
   5. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
   6. UL:
      a. 498, Standard for Attachment Plugs and Receptacles.
      b. 508, Standard for Safety for Industrial Control Equipment.
      c. 924, Emergency Lighting and Power Equipment.
      d. 943, Standard for Ground-Fault Circuit-Interrupters.
      e. 1449, Standard for Transient Voltage Surge Suppressors.
      f. 2251, Standard for Plugs, Receptacles, and Couplers for Electric Vehicles.
      g. 2594, Standard for Electric Vehicle Supply Equipment.

1.03 SUBMITTALS

A. Action Submittals: Manufacturer’s product data for wiring devices.

PART 2 PRODUCTS

2.01 GENERAL

A. All light controlling devices must be compliant with California Code of Regulations (CCR) Title 24.

2.02 SWITCHES

A. Switch, General Purpose:
   1. NEMA WD 1 and FS W-S-896F/GEN.
   2. Totally enclosed, ac type, with quiet tumbler switches and screw terminals.
   3. Rivetless one-piece brass or copper alloy contact arm with silver alloy contacts.
   4. Capable of controlling 100 percent tungsten filament and fluorescent lamp loads.
   5. Rating: 20 amps, 120/277 volts.
   6. Color:
      a. Office Areas: Brown.
      b. Other Areas: Brown.
   7. Automatic grounding clip and integral grounding terminal on mounting strap.
   8. Manufacturers and Products:
      a. Arrow Hart; 1201/2221 Series.
      b. Bryant; 4801/4901 Series.
      c. Hubbell; 1202/1222 Series.
      d. Leviton; 1201/1221 Series.
      e. “Or-equal.”

B. Switch, Pushbutton:
   1. California Title 24 Compliant.
   2. 120V ac to 277V ac, 60 Hz.
   3. Two-button wired model.
   4. LED status indicators.
   5. Color: Brown.
   6. Compatible with Time Controller.
   7. Manufacturers and Products:
      a. Lutron STWD-7B.
         1) Button Kit: SKD-2B.
      b. Leviton equivalent.
      c. Wattstopper equivalent.
      d. “Or-equal.”

C. Switch, Door Controls:
   1. Americans with Disabilities Act (ADA) compliant pushbutton.
      a. Mounting Plate Heavy Duty 1/8 inch.
      b. Faceplate: 18-gauge satin stainless steel.
      c. Engraving: Blue infill.
         1) Symbol: ADA compliant wheelchair.
         2) Text: “PUSH TO OPEN”.
      d. Double pole, double throw (DPDT).
      e. ADA Type 1:
         1) Size: 4.5 inch by 4.5 inch square push plate.
         2) Manufacturer and Product: Security Door Controls; 484A4U.
      f. ADA Type 2:
         1) Size: 1-11/16 inch by 4-9/16 inch narrow push plate.
         2) Designed to install in door jamb.
         3) Manufacturer and Product: Security Door Controls; 484A1U.

D. Switch, Motor Rated:
   1. Type: Two-pole or three-pole, manual motor starting/disconnect switch without overload protection.
   2. Enclosure/Mounting and Rating:
      a. General Purpose:
         1) Totally enclosed snap-action switch. Quick-make, slow-break design with silver alloy contacts. UL 508 listed.
         2) General Purpose Rating: 30 amperes, 600V ac.
         3) Minimum Motor Ratings:
            a) 2 hp for 120V ac, single-phase, two-pole.
            b) 3 hp for 240V ac, single-phase, two-pole.
            c) 15 hp for 480V ac, three-phase, three-pole.
         4) Screw-type terminals.
      b. Explosion-Proof:
         1) Provide enclosed manual motor starter-type. Three-pole nonreversing contactor.
         2) Minimum Motor Rating: 10 hp, 480V ac, three-phase, three-pole.
         3) Enclosure: NEMA 250, Type 7.
         4) Provide lockable external handle operator.
   3. Manufacturers and Products:
      a. General Purpose:
         1) Bryant.
         2) Hubbell.
         3) “Or-equal.”

b. Explosion-Proof:
   1) Eaton; Type B101.
   2) "Or-equal."

2.03 RECEPTACLES

A. Receptacle, General Purpose:
   1. NEMA WD 1 and FS W-C-596.
   2. Duplex, two-pole, three-wire grounding type with screw type wire terminals.
   3. Impact resistant nylon cover and body.
   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.
   7. Size: For 2-inch by 4-inch outlet boxes.
   8. Industrial Grade:
      a. Color:
         1) Office Areas: Brown
         2) Other Areas: Brown.
      b. Manufacturers and Products:
         1) Arrow Hart; 5262/5362 Series.
         2) Bryant; 5262/5362 Series.
         3) Hubbell; 5262/5362 Series.
         4) Leviton; 5262/5362 Series.
         5) "Or-equal."

B. Receptacle, UPS-backup:
   1. Meet requirements of general-purpose receptacles.
   2. Color: Orange.

C. Receptacle, Ground Fault Circuit Interrupter:
   1. Meet requirements of general-purpose receptacles.
   2. Listed Class A to UL 943, tripping at 5 mA.
   3. Color: Brown.
   4. Standard Model: NEMA WD 1, with No. 12 AWG copper USE/RHH/RHW-XLPE insulated pigtails and provisions for testing.
   5. Feed-Through Model: NEMA WD 1, with No. 12 AWG copper USE/RHH/RHW-XLPE insulated pigtails and provisions for testing.
   6. Manufacturers:
      a. Bryant.
      b. Hubbell.

c. Arrow Hart.
d. Leviton.
e. “Or-equal.”

D. Receptacle, Special-Purpose: Rating and number of poles as indicated or required for anticipated purpose.

2.04 OCCUPANCY SENSOR

A. Wall Switch:
1. Description:
a. Passive-infrared type, 120-volt, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of 900 square feet (84 square meters).
b. Provide dual switch unit where indicated.
c. Color: Manufacturer’s standard white.
2. Manufacturers and Products:
a. Hubbell; WS1277.
b. Leviton; 0DS 10-ID.
c. Pass & Seymour; WS3000.

B. Ceiling Mounted:
1. Description:
a. Passive-infrared type, 120-volt, adjustable time delay up to 30 minutes, 360-degree field of view, with a minimum coverage area of 500 square feet. High density lens.
b. Color: Manufacturer’s standard white.
2. Manufacturers and Products:
a. Hubbell; ATP600C with CU control unit.
b. Leviton; 0DC0S-I1W.
c. Pass & Seymour; CS500 with PWP2120 power pack.

2.05 TIME CLOCK RELAY PANEL

A. Enclosure:
1. NEMA 1, steel enclosure.
2. Color: Black.
3. Door: Hinged, removable, locking.

B. Hardware:
1. Eight 30A (NO/NC) Relays.
2. Eight 0V dc to 10V dc programmable control inputs.

C. Functionality:
   1. Astronomical Clock:
      a. 12-hour or 24-hour display.
      b. Automatic Daylight Savings Time adjustment.
      c. View and/or edit Latitude and Longitude data.
      d. Sunrise/sunset offsets.
   2. Scheduler:
      a. 999 Date Event Engine: Events can recur by day of week, day of month, or can occur, only on a specified date or over a specified date range.
      b. Event time can be an absolute time of day, sunrise, sunset, or programmable offset before or after sunrise or sunset.
      c. Holiday Scheduling Modes:
         1) Holiday Schedule: Runs every day except for national holidays.
         2) Holidays Only: Only runs on defined holidays.
         3) Always Run: Runs on holidays and non-holidays.
         4) Holiday Designation:
            a) User defined holidays.
            b) Pre-programmed list of common US holidays.
   3. Zones and Inputs:
      a. Capable of controlling a minimum of four different lighting zones.
      b. Can accept up to eight on/off manually operated digital inputs.
         1) Inputs can extend the on/off schedule timing by no more than 2 hours.
   4. Control Description:
      a. Room 46102 (Open Office):
         1) Lights shall be on 100 percent during a set schedule of normal business hours.
         2) Lights shall automatically turn off at the end of the day, with the exception of walkthrough and egress/exit lights.
         3) Lights shall remain off on holidays and weekends.
         4) Lights shall turn on for 2-hour blocks after normal business hours via manually operated pushbutton.
         5) Time schedules shall be set in coordination with the City.
      b. Room 46104 (Hallway):
         1) Lights shall be on at 100 percent during a set schedule of normal business hours.
         2) Lights shall automatically dim to 50 percent at the end of the day.
         3) Lights shall dim to 50 percent on holidays and weekends.
         4) Lights shall turn on to 100 percent for 2 hour blocks via manually operated pushbutton.

5) Time schedules shall be set in coordination with the City.

5. Manufacturers and Products:
   a. Leviton; EZ-Max Plus 8 Cabinet.
   b. Wattstopper; LP8 Peanut.
   c. "Or-equal."

2.06 DEVICE PLATES

A. General: Sectional type plates not permitted.

B. Plastic:
   1. Material: Specification grade, 0.10-inch minimum thickness, noncombustible, thermosetting.
   2. Color: To match associated wiring device.
   3. Mounting Screw: Oval-head metal, color matched to plate.

C. Metal:
   1. Material: Specification grade, one-piece, 0.040-inch nominal thickness stainless steel.
   2. Finish: ASTM A167, Type 302/304, satin.
   3. Mounting Screw: Oval-head, finish matched to plate.

D. Cast Metal:
   1. Material: Malleable ferrous metal, 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.
      c. "Or-equal."

F. Engraved:
   1. Character Height: 1/8-inch.
   2. Filler: Black.

G. Weatherproof:
   1. Receptacles, 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.
3) "Or-equal."

2. Receptacles, Weatherproof Type 2:
a. UL listed for WET location while in use.
b. Polycarbonate cover.
c. Manufacturer and Product:
1) TayMac; Type Multi-Mac.
2) "Or-equal."

3. Switches:
a. Gasketed, cast-metal or cast-aluminum, incorporating external operator for internal switch.
b. Mounting Screw: Stainless steel.
c. Manufacturers and Products:
1) Crouse-Hinds; DS-181 or DS-185.
2) Appleton; FSK-1VTS or FSK-1VS.
3) "Or-equal."

H. Raised Sheet Metal: 1/2-inch high zinc- or cadmium-plated steel designed for one-piece drawn type sheet steel boxes.

I. Sheet Steel: Formed sheet steel or Feraloy designed for installation on cast metal boxes.

PART 3 EXECUTION

3.01 SWITCHES

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 switches so 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 so toggle is in up position when ON.
3. Install within sight of motor when used as a disconnect switch.

3.02 RECEPTACLES

A. Duplex Receptacles:
   1. Install with grounding slot down, except where horizontal mounting is shown, in which case install with neutral slot down.
   2. Weatherproof Receptacles:
      a. Install in cast metal box.
      b. Install such that hinge for protective cover is above receptacle opening.
   3. Ground Fault Interrupter: Install feed-through model at locations where ground fault protection is specified for “downstream” conventional receptacles.
   4. Special-Purpose Receptacles: Install in accordance with manufacturer’s instructions.

B. Multioutlet Surface Raceway System: Install in accordance with manufacturer’s instructions.

3.03 DEVICE PLATES

A. Securely fasten to wiring device; ensure a tight fit to box.

B. Flush Mounted: Install with all four edges in continuous contact with finished wall surfaces without use of mats or similar materials. Plaster fillings will not be acceptable.

C. Surface Mounted: Plate shall not extend beyond sides of box, unless plates have no sharp corners or edges.

D. Install with alignment tolerance to box of 1/16 inch.

E. Types (Unless Otherwise Shown):
   1. Office: Plastic.
   2. Exterior:
      a. Switch: Weatherproof.
      b. Receptacle in DAMP Location: Weatherproof Type 1.
      c. Receptacle in WET Location: Weatherproof Type 2.

F. Interior:
   1. Flush Mounted Boxes: Plastic.
   2. Surface Mounted, Metal Boxes:
      a. General Purpose Areas: Sheet steel.
      b. Other Areas: Cast.

3. Surface Mounted, Aluminum Boxes:
   a. General Purpose Areas: Stamped.
   b. Other Areas: Cast.
4. Surface Mounted, Sheet Steel Boxes: Raised sheet steel.
5. Surface Mounted, Nonmetallic Boxes: Manufacturer's standard.
6. Receptacle shown as Weatherproof on Drawings: Weatherproof Type 1.

END OF SECTION

SECTION 26 29 23
LOW-VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. This section includes complete low voltage solid state variable frequency drive (VFD) units.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. Electronic Industries Alliance (EIA), Telecommunications Industry Association (TIA): 359-1, Special Colors.
   2. 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 Electric Power Systems.
      c. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
   3. National Electrical Manufacturer's Association (NEMA):
      a. CP 1, Shunt Capacitors.
      b. MG 1, Motors and Generators.
      c. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
      d. WC-57, Control Cables.
   4. National Fire Protection Association (NFPA): Electrical Standard for Industrial Machinery.
   5. UL.

1.03 DEFINITIONS

A. Terms that may be used in this section:
   1. CMOS: Complementary metal oxide semiconductor.
   2. CSI: Current Source Inverter.
   3. EMU: Energy monitoring unit.
   4. GTO: Gate Turn-Off Thyristor.
   5. MPR: Motor protection relay.
   6. MTBF: Mean time between failure.

7. PWM: Pulse width modulation.
8. ROM: Read only memory.
9. RTD: Resistance temperature detector.
10. RTU: Remote Telemetry Unit.
11. Rated Load: Load specified for the equipment.
12. Rated Speed: Nominal rated (100 percent) speed specified for the equipment.
13. TDD: Total demand distortion.
14. THD: Total harmonic distortion.
15. TTL: Transistor transistor logic.
16. VFD: Variable frequency drive.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications:
   1. The manufacturer shall have produced the specified type of VFDs for a minimum period of 5 years.
   2. Variable frequency drive manufacturer shall maintain, as part of a national network, engineering service facilities within 150 miles of the equipment installation to provide quick responsive startup service, training of customer personnel, periodic maintenance service contracts, and emergency troubleshooting and repair service.

1.05 SYSTEM DESCRIPTION

A. The Contractor and variable frequency drive system manufacturer are cautioned regarding the review and compliance with the total Contract Documents. Typical required auxiliary drives may include harmonic filters, circuit breakers, motor circuit protectors, magnetic starters, solid-state-reduced voltage starter, relays, timers, pilot devices including pushbuttons, selector switches and pilot lights, enclosures, conduit, disconnect switches, terminal boxes, and other equipment. These auxiliary items may be provided by separate supplier; however, they shall be integrated as complete VFD working system.

B. See Division 40, Process Interconnections, for information and verify data of the motors and driven equipment including full load current, torque, speed and performance requirements and provide all supplementary equipment and services to accomplish the necessary operation.

C. Design Requirements:

1. Design and provide drive system consisting of variable frequency controller, drive motor, certain auxiliary items, and components necessary for complete operating system.
2. Other equipment is being powered from same bus as variable frequency drives. Ensure proper operation of drives and other loads under normal and emergency conditions.
3. Furnish VFDs rated on basis of actual motor full load nameplate current rating.
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 the pulse-width-modulation (PWM) technique to produce the adjustable frequency output.
5. System rated for continuous industrial duty and suitable for use with Standard NEMA MG 1, Design B motors.
6. Incoming Line Circuit Breaker: Provide positive means of disconnecting incoming power, and overcurrent protection for the drive system.
7. Incoming Line Reactor: 5 percent on incoming power feeder.
8. Dv/dt filters on the output for load distances greater than 200 feet.

1.06 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. VFD output pulse maximum peak voltage, pulse rise time and pulse rate of rise, including any justification for proposed deviation from specified values. Include motor manufacturer's certification that motor insulation will withstand long-term overvoltages caused at motor terminals due to specified output pulse data or any proposed deviation from this data.
3. Data on the shelf life of "dc link" capacitor.
4. Complete system rating, including all nameplate data, continuous operation load capability throughout speed range of 0 percent to 120 percent of rated speed.
5. Complete variable frequency controller rating coordinated with motor full load nameplate current rating; list any controller special features being supplied.
6. Controller, reactor, and isolating transformer (if applicable) dimensional drawings; information on size and location of space for incoming and outgoing conduit.

7. Maximum heat dissipation from enclosure.
8. Layout of controller face showing pushbuttons, switches, instruments, indicating lights, etc.
9. Complete system operating description.
10. Complete system schematic (elementary) wiring diagrams.
11. Complete system interconnection diagrams between controller, drive motor, and all related components or controls external to system, including wire numbers and terminal board point identification.
12. Tabulated initial programmable settings from factory.
13. One-line diagram of system, including component ratings.
14. Description of diagnostic features being provided.
15. Descriptive literature for all control devices such as relays, timers, etc.
16. Itemized bill-of-materials listing all system components.
17. Submit 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. Submit 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 Standard 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 seismic qualification certificate of compliance as required by Section 01 45 36, Equipment Seismic Certification.
9. Suggested spare parts list to maintain equipment in service for a period of 1 year. Include a 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.

1.07 WARRANTY

A. 5-year manufacturer's warranty required.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Where components and accessories are mounted in a motor control center, see Section 26 24 19, Low-Voltage Motor Control, they shall be of the same manufacturer as the motor control center.

B. Components and accessories specified in this section shall be products of:
   1. Allen-Bradley.
   2. Eaton Electrical/Cutler-Hammer.
   3. GE Industrial Systems.
   4. Schneider Electric/Square D.
   5. ABB.
   6. "Or-equal."

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 feet to 3,300 feet.

E. Frequency Stability: Plus or minus 0.1 percent of maximum frequency.

2.03 COMPONENTS

A. Drive Units:
   1. Drives shall be rated heavy duty.
   2. Incorporate a switching power supply operating from a dc bus, to produce a PWM output waveform simulating a sine wave and providing power loss ride through of 2 milliseconds at full load, full speed.
   3. Current-limiting semiconductor fuses for protection of internal power semiconductors.
   4. Employ a diode bridge rectifier providing a constant displacement power factor of 0.95 minimum at all operating speeds and loads.

5. Use transistors for output section, providing a minimum 97 percent drive efficiency at full speed, full load.
6. Employ dc power discharge circuit so that after removal of input power dc link capacitor voltage level will decay below 50V dc within 1 minute after de-energizing following NEMA CP 1 and NFPA 79. Design dc link capacitor for a MTBF of 5 years.
7. Operate with an open circuited output.
8. Input Voltage: 480V ac plus or minus 10 percent.
9. Output Voltage: 0 volt to 480 volts, three-phase, 0-Hz to 66-Hz, minimum.
10. Maximum peak voltage of PWM VFD output pulse of 1,000 volts, with pulse rise time of not less than 2 microseconds, and a maximum rate of rise of 500 volts per microsecond. Maximum frequency of PWM VFD 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 the motors suitable for the proposed values.
11. Motor Audible Noise Level: When operating throughout speed range of PWM VFD, 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.
12. Short-Time Overload Capacity: 125 percent of rated load in rms current for 1 minute following full load, full speed operation.
13. Equipment Short-Circuit Rating: As shown on Drawings to match equipment rating.
14. Furnish drives with output current-limiting reactors mounted within equipment enclosure.
15. Diagnostics:
    a. Comprehensive for drive adjustment and troubleshooting:
        1) Memory battery backup; 100-hour minimum during a power loss.
        2) Status messages will not stop drive from running but will prevent it from starting.
        3) Fault Condition Messages and History:
            a) First fault protection function to be activated, ability to store six successive fault occurrences in order. Minimum faults numerically:
                (1) Overcurrent (time and instantaneous).
                (2) Overvoltage.
                (3) Undervoltage (dc and ac).
                (4) Overtemperature (drive, motor windings, motor bearing, pump bearing).
                (5) Serial communication fault.
                (6) Short-circuit/ground fault (motor and drive).

(7) Motor stalled.
(8) Semiconductor fault.
(9) Microprocessor fault.
(10) Single-phase voltage condition.

16. Drive Protection:
    a. Fast-acting semiconductor fuses.
    b. Overcurrent, instantaneous overcurrent trip.
    c. Dc undervoltage protection, 70 percent dropout.
    d. Dc overvoltage protection, 130 percent pickup.
    e. Overtemperature, drive, inverter, converter, and dc link components.
    f. Overtemperature, motor, and pump.
    g. Single-phase protection.
    h. Reset overcurrent protection (manual or automatic reset).
    i. Active current limit/torque limit protection.
    j. Semiconductor fault protection.
    k. Short-circuit/ground fault protection.
    l. Serial communication fault protection.
    m. Microprocessor fault.
    n. Surge protection for transient overvoltage (6,000 volts, 80 joule surge, tested per IEEE C62.41).
    o. Visual display of specific fault conditions.
17. 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 a constant dc voltage to the drive's dc bus for motors smaller than 100 hp. Motors greater than 100 hp shall have 18-pulse rectifier.

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. The output voltage shall vary proportionally with the frequency to maintain a constant ratio of volts to hertz up to 60-Hz. Above 60-Hz, the voltage shall remain constant, with the drive operating in a constant horsepower output mode.

E. Enclosure:

1. NEMA 250, Type 1, gasketed, freestanding, enclosure for mounting against wall, completely front accessible, and hinged doors or as shown on Drawings as mounted within motor control center, see Section 26 24 19, Low-Voltage Motor Control. 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. Furnish drive complete with 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, Low-Voltage Basic Electrical Materials and Methods.
3. Wire drive from below for power and control wiring.
4. Size forced-ventilation for periodic operation to cool each unit with maximum room ambient temperature of 95 degrees F. Furnish redundant fans such that if one fan fails remaining fans furnish adequate ventilation for the drive when operating at maximum capacity. Furnish filters on ventilation intakes.
5. Bundle stranded copper wiring neatly with nylon tie wraps or with continuous plastic spiral binding; label each terminal for permanent identification of leads; identify each wire at each end with imprinted mylar adhesive-back wire markers; incorporate in as-installed wiring diagrams for wire and terminal numbers shown; wiring across door hinges use 19-strand, NEMA WC-57 Class C stranding looped for proper twist rather than bending at hinge; wire connections internal to panels by crimp-on terminal types. For multiple enclosure systems, complete interconnection

wiring with gasketed enclosure openings for wiring; multipoint plug receptacles for any control wiring crossing equipment shipping splits.

6. Selector switches, indicating lights, potentiometers, instruments, protective devices, major system components, etc., identified by means of mechanically attached, engraved, laminated nameplates.

F. Operator Interface:

1. Controls:

a. Mount drive local control on front door of enclosure and include pushbuttons, selector switches, potentiometers, and membrane type keypad for the following operator functions:

1) Start (when in local mode), via Start pushbutton.

2) Stop (when in local mode), via Stop pushbutton.

3) Speed increase (when in local mode), via potentiometer.

4) Speed decrease (when in local mode), via potentiometer.

5) Parameter mode selection (recall programmed parameters).

6) LOCAL/OFF/REMOTE control selection, via LOCAL/OFF/REMOTE selector switch (in remote, furnish for remote RUN command digital input and speed increase/decrease via remote 4 mA to 20 mA analog signal).

7) Fault reset, manual for all faults, via Reset pushbutton (except loss of ac voltage which is automatic upon return).

8) RUN/preset speed.

9) Parameter lock (password or key switch lockout of changes to parameters).

10) Start disable (key switch or programmed code).

2. Control circuit disconnect shall de-energize circuits in units that are not de-energized by main power disconnect device as required by California Administrative Code.

3. 120 volts, single-phase, 60-Hz circuits with 24V dc power supply 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 any single component cannot cause cascading failure(s) of any other component(s).

5. Alphanumeric Display:

a. During normal operation and routine test, the following parameters shall be available:

1) Motor current (percent of drive rated current).

2) Output frequency (Hertz).

3) Output voltage.

4) Running time.
5) Local/remote indicator.
6) Status of digital inputs and outputs.
7) Analog input and output values.
8) Output motor current per leg.
9) All test points.

6. Adjustable Parameters:
   a. Set drive operating parameters and indicate in a numeric form. Potentiometers may not be used for parameter adjustment. Minimum setup parameters available:
      1) Frequency range, minimum, maximum.
      2) Adjustable acceleration/deceleration rate.
      3) Volts per Hertz (field weakening point).
      4) Active current limit/torque limit, 0 percent to 140 percent of drive rating.
      5) Adjustable voltage boost (IR compensation).
      6) Preset speed (adjustable, preset operating point).
      7) Provision for adjustment of minimum and maximum pump speed to be furnished as function of 4 mA to 20 mA remote speed signal.

G. Signal Interface:
   1. Digital Input:
      a. Accept a remote START command contact closure input. Integral seal in.
      b. Accept a remote STOP command contact closure input.
      c. 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 24V dc.
   3. Analog Input: When LOCAL/OFF/REMOTE switch is in REMOTE, control drive speed from a remote 4 mA to 20 mA dc signal. Make provisions for adjustment of minimum and maximum motor speed which shall result from this signal. Factory set this adjustment to comply with operating speed range designated in driven equipment specifications. 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.

5. Serial Communication Interface: RS232/RS 422, compatible with MODBUS as an RTU.
6. Network Communication Interface: MODBUS TCP/IP.
    a. Monitoring over the communication network to include the following:
        1) Phase Currents (Ia, Ib, Ic).
        2) Line-to-Line Voltages (Va-b, Vb-c, Va-c).
        3) Energy & Power (Watt-Hours, Watts, Volts, Volt-Amps, Volt-Amps Reactive).
        4) Frequency.
        5) Power Factor.
        6) Demand (Current, Watts, Volt-Amps Reactive, Volt-Amps).
        7) REMOTE status.
        8) LOCAL status.
        9) FAULT status.
        10) READY status.
        11) ON (running) status.

H. Accessories:
1. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a 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 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 TIA/EIA 359-1, No. 61.
3. Manufacturer's standard.

2.05 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.

B. Record test data for report.

PART 3 EXECUTION

3.01 INSTALLATION

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

3.02 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.

END OF SECTION

SECTION 26 33 23
BATTERY SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. Section includes complete requirements for online battery-backed standby power system for AC and DC loads.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. Institute of Electrical and Electronics Engineers (IEEE):
      a. C62.41, Standards for Surge Withstand Ability.
      b. C62.45, Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000V and Less) AC Power Circuits.
      c. 693, Recommended Practice for Seismic Design of Substations.
      d. 1115, Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications.
   2. National Electrical Contractors Association (NECA).
   3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum)
   4. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
      b. 70E, Electrical Safety Requirements for Employee Workplaces
   5. UL:
      a. 1449, Standard for Safety for Surge Protection Devices
      b. 1778, Standard for Uninterruptible Power Supply

1.03 SUBMITTALS

A. Action Submittals:
   1. Descriptive product information.
   2. Dimensional and assembly drawings.
   3. Itemized bill of material.
   4. Installation instructions.
   5. Connection and interconnection drawings.
   6. Contractor shop drawings of battery room layout with required equipment.

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

B. Informational Submittals:

1. Submit anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Component and attachment seismic qualification certificate of compliance as required by Section 01 45 36, Equipment Seismic Certification.
3. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
4. Certified factory test reports.
5. Electronic AutoCAD drawings of all Shop Drawings. AutoCAD version to match City standards.

1.04 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

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

1.05 ENVIRONMENTAL CONDITIONS

A. As indicated in the Area Classification and Material Selection Table on Drawings.

PART 2 PRODUCTS

2.01 GENERAL

A. Associated Branch Wiring: Type XHHW.

2.02 SWITCHGEAR DC BATTERY SYSTEM

A. Battery

1. Cell Type: Nickel cadmium.
2. Size: 96-cell, 125V dc.
3. Cell Voltage: 1.40 volts to 1.45 volts.
4. 288 discharge ampere per 1 minute, or 25.0 amperes for 8 hours to 1.14 volts per cell.

5. Container: Polypropylene.
6. Bolt Connections: Stainless steel hex headed.
7. Interunit Connections: Lead-plated copper.
8. Ship with electrolyte in fully charged cells.
9. Manufacturer:
    a. Hoppecke.
    b. “Or-equal.”
10. Accessories:
    a. Portable hydrometer.
    b. Vent hole thermometer.
11. Battery Rack:
    a. Type: four-frame steel, arranged to fit 12-foot by 10-foot room without interference with other equipment, see Drawings.
    b. Finish: Two coats of acid-resisting paint before assembly.
    c. Seismically qualified and tested to requirements of IEEE 693, High Seismic Zone.
    d. Provide battery and rack installation instructions to meet IEEE 693, High Seismic Zone.
    e. Station battery system shall be designed so that there will be neither damage nor loss of battery function during and after a seismic event.

B. Battery Charger:
1. Type: Industrial float, constant voltage.
2. Recharge after discharge to 1 volt each cell in 8 hours.
3. Automatically control charging rates.
4. Output: Full rated for both continuous and intermediate dc loads.
5. Voltage regulation and current limiting.
6. Circuitry: Solid state integrated.
7. Supply Voltage: 208 volts, single-phase, 60-Hz.
8. Accessories:
    a. ac ON Indicating Light: Green.
    b. ac Input Breaker: Two-pole, 10,000 AIC, 100-ampere frame.
    c. dc Output Breaker: Two-pole, 10,000 AIC, 100-ampere frame.
    d. Surge Suppressors: MOV type ac and dc.
    e. dc output ammeter and voltmeter.
    f. Zero to 72-hour manual equalize timer.
    g. Float, equalize and current limit adjustable potentiometer.

h. dc output blocking and protective diodes.

9. Alarm Relays:
   a. ac power failure.
   b. dc ground detector.
   c. High-low dc voltage.
   d. Provide “Form C” contacts for each alarm relay for interface with plant SCADA system.
10. dc Ground Detection for Local Indication:
   a. Switch for dc voltmeter indication.
   b. Indicating lights.
   c. Ground test and lamp test switch.
11. Enclosure: As indicated in the Area Classification and Material Table.
12. Manufacturer and Product:
   a. SENS; Energenius iQ.
   b. “Or-equal.”

2.03 UNINTERRUPTIBLE POWER SUPPLY SYSTEM (UPS)

A. General:
   1. Function: Provides isolated, regulated uninterrupted ac output power during a complete or partial interruption of incoming line power.
   2. Type: Continuous-duty, online, double conversion, power isolated.
      a. Major Parts: Rectifier, inverter, battery charger, sealed batteries, automatic bypass, control and monitor electronics.

B. Performance:
   1. Capacity: 8 kVA.
   2. Input Power:
      a. 208/120V ac single-phase, 60-Hz.
      b. Connections: Cord and plug.
   3. Output Power:
      a. 208/120V ac single-phase, 60-Hz.
      b. Connections: Manufacturer’s standard, unless otherwise noted.
   4. Online Efficiency: 85 percent minimum.
   5. Backup Runtime:
      a. Full Load: 30 minutes minimum.
      b. Half Load: 60 minutes minimum.

c. Include provisions for future expansion of battery capacity via manufacturer's standard battery packages.

6. Continuous no-break power with no measurable transfer time.
7. Sine-Wave Output Voltage Total Harmonic Distortion (THD): Plus or minus 6 percent or less.
8. Input Voltage Range: Plus 15 percent, minus 20 percent.
9. Output Voltage Regulation: Plus or minus 3 percent nominal.
10. Operating Temperature: 0 degree C to 40 degrees C (32 degrees to 104 degrees F).
11. Operating Relative Humidity: 5 percent to 95 percent without condensation.
12. Lightning and Surge Protection:
    a. Pass lightning standard IEEE C62.41 Categories A and B tests.
    b. 2,000 to 1 attenuation of input spike.
13. Features:
    a. Bypass Switches: Provide to allow bypass of UPS without interrupting power. Provide integral UPS bypass.
    b. Auxiliary Contacts: Provide a minimum of three Form-C relay outputs for low battery, UPS alarm, and on bypass.
    c. Modbus TCP/IP connection.
14. Enclosures: Tower.
15. Manufacturer and Product:
    a. Cutler Hammer – Eaton; Powerware 9155-8 with PDM outlet.
    b. "Or equal."

2.04 DIRECT CURRENT DISTRIBUTION PANEL

A. Rating: As shown on Drawings.

B. Main and Branch Circuit Breakers:
   1. Two-pole, thermos-magnetic, quick-make, quick-break.
   2. ON, TRIPPED, and OFF indicating handle.
   3. Interrupting rating of 10,000 rms symmetrical amperes.
   4. Amperage: As shown on Drawings.

C. Enclosure: As shown on Area Classification and Material Selection Table.

D. Circuit directory holder inside door surface.

2.05 ALTERNATING CURRENT DISTRIBUTION PANEL

A. Reference Section 26 24 16, Panelboards.

B. Rating as shown on Drawings.

2.06 NAMEPLATES

A. See Section 26 05 02, Basic Electrical Requirements.

B. Color (Laminated Plastic Only): Black, engraved to a white core.

C. Letter Height: 3/8-inch.

D. Attachment Screws: Type 316 stainless steel.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install equipment in accordance with manufacturer's instructions and recommendations.

B. Secure equipment to floor with anchor bolts of sufficient size and number adequate for specified seismic conditions.

C. Install equipment plumb and in longitudinal alignment with wall.

END OF SECTION

SECTION 26 36 23
AUTOMATIC TRANSFER SWITCHES

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): C37.90.1, Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.
   2. National Electrical Manufacturers Association (NEMA):
      a. ICS 1, General Standards for Industrial Control and Systems: General Requirements.
      b. ICS 2, Industrial Control and Systems Controllers, Contactors, and Overload Relays not more than 2000 volts ac or 750 volts ac.
      c. ICS 6, Industrial Control and Systems: Enclosures 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
   4. UL: 1008, Transfer Switch Equipment.

1.02 SUBMITTALS

A. Action Submittals:
   1. Descriptive product information.
   2. Dimensional drawings.
   3. Control diagrams.
   4. Conduit entrance locations.
   5. Equipment ratings.
   6. List of programmable settings and their initial setting.
   7. Submit anchorage and bracing drawings and cut sheets as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:
   1. Submit anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
   2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
   3. Factory test reports.
   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. Component and attachment seismic qualification certificate of compliance as required by Section 01 45 36, Equipment Seismic Certification.

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 UL shall conform to those standards and shall have an applied UL listing mark.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. ASCO.

B. Cummins.

C. Eaton.

D. Russelectric.

2.02 GENERAL

A. Transfer switch to be product of a single manufacturer in order to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's service.

B. In accordance with applicable standards of NFPA 70, NEMA ICS 1, NEMA ICS 2, NEMA ICS 6, IEEE C37.90.1, and UL 1008.

C. Transfer switch consisting of inherently double-throw power switch unit with interconnected control module.

D. Rated 100 percent, in amperes, for total system transfer of motor, electric heating, and discharge lamp loads.

E. Main and arcing contacts visible for inspection with cabinet door and barrier covers removed.

F. Number of Switched Poles: Three pole.

G. Nominal Voltage, Full Load Current, and Short Circuit Withstand Current Rating: As shown on one-line drawing. Provide a three-cycle Withstand Current Rating, unless a longer time period is shown on the one-line drawing.

H. Switch Rating: As shown on one-line drawing.

I. Current carrying capacity of arcing contacts shall not be used to determine the transfer switch rating.

J. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

K. Operating Conditions:
   1. Ambient Temperature: Maximum 50 degrees C.
   2. Equipment to be fully rated without any derating for operating conditions listed above.

2.03 ENCLOSURE

A. Type: NEMA 250, Type 1 with enclosure grounding terminal.

B. Dead front, front accessible cabinet with 14-gauge welded steel construction.

C. Continuously hinged single door, with handle and lock cylinder.

D. Finish: Baked enamel applied over rust-inhibiting, phosphate based coating.
   1. Exterior and Interior Color: Provide gray finish as approved by Jacobs' Engineer.
   2. Unpainted Metal Parts: Plated for corrosion resistance.

2.04 TRANSFER SWITCH

A. Type: Electrically operated, mechanically held, double-throw.

B. Momentarily energized, single-electrically operated mechanism energized from source to which load is to be transferred.

C. Locking mechanism to maintain constant contact pressure.

D. Mechanical interlock switch to ensure only one of two possible switch positions.

E. Silver alloy contacts protected by arcing contacts.

F. Main and arcing contacts visible when door is open and barrier covers removed.

G. Manual operating handle for transfer in either direction under unloaded conditions.

H. Internal control wire connections made with ring or spade type terminals, lock washers, and sleeve type marking labels.

2.05 FACTORY TESTS

A. Test to ensure correct:
   1. Operation of individual components.
   2. Sequence of operation.
   3. Transfer time, voltage, frequency, and time delay settings.

B. Dielectric strength test per NEMA ICS 1.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Secure enclosure to floor using anchor bolts of sufficient size and number adequate for specified seismic conditions.

3.02 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative in accordance with Section 01 43 33, Manufacturers' Field Services, for the following services at Site, for minimum person-days listed below, travel time excluded:
   1. 1/2 person-day for installation assistance, final adjustment, and initial energization of equipment.
   2. 1/2 person-day for functional and performance testing.
   3. 1/2 person-day for adjustment of relay settings.

B. Furnish startup services and training of Owner's personnel at such times as requested by Owner.

END OF SECTION

SECTION 26 42 00
CATHODIC PROTECTION SYSTEM

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. ASTM International (ASTM):
      a. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
      b. A497/A497M, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
      c. A518/A518M, Standard Specification for Corrosion-Resistant High-Silicon Iron Castings.
      d. A615/A615M, Standard Specification for Deformed and Plain Carbon Steel Bars for Concrete Reinforcement.
      e. C94/C94M, Standard Specification for Ready-Mixed Concrete.
      f. C150, Standard Specification for Portland Cement.
      g. C387, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
      h. D1785, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
   3. California DWR Bulletin 74.
   4. Canadian Standards Association (CSA).
   5. Concrete Reinforcing Steel Institute (CRSI).
   6. NACE International (NACE).
   7. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
      b. C80.1, Rigid Steel Conduit, Zinc Coated Specification for.
      c. C80.6, I Intermediate Metal Conduit (IMC)—Zinc Coated.
      d. TC 3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
      e. WC 70, Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
      f. WC 71, Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy.

g. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.

8. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
9. Society for Protective Coatings (SSPC):
   a. SP 1, Solvent Cleaning.
   b. SP 6, Commercial Blast Cleaning.
10. UL:
    a. 6, Standard for Safety Electrical Rigid Metal Conduit Steel.
    b. 360, Standard for Safety Liquid-Tight Flexible Steel Conduit.
    c. 514B, Standard for Safety Conduit, Tubing, and Cable Fittings.
    d. 1242, Standard for Safety Intermediate Metal Conduit.

1.02 DEFINITIONS

A. Active Column: Anode and coke breeze portion of a deep anode groundbed that discharges current.

B. Ferrous Metal Pipe: Pipe made of steel or iron and pipe containing steel or iron as a principle structural material, except reinforced concrete.

C. Inactive Column: Gravel fill and seal portions of a deep anode groundbed that does not discharge current.

D. Lead, Lead Wires, Joint Bonds, Cable: Insulated copper conductor; the same as wire.

E. Pipeline Appurtenances: Fittings, couplings, tees, elbows, valves, and other metallic components in a piping system.

F. Supervision (as relates to Cathodic Protection Specialist and Technician): Cathodic Protection Technician shall be able to immediately contact Cathodic Protection Specialist should need for Cathodic Protection Specialist's input arise.

1.03 SUBMITTALS

A. Action Submittals:
   1. Shop Drawings:
      a. Catalog cuts and other information for products to be used. Clearly mark or highlight products to be used. Indiscriminate product information will not be reviewed and shall be resubmitted.

b. Procedures and equipment for electrical logging of deep anode groundbeds.

c. Proposed electrical logging equipment list for review and approval prior to start of drilling operations for deep anode installation.

d. Overall System Wiring Diagram: Identify location of connections, label markings, wire size, color, and products.

2. Quality Assurance:

a. Qualifications of Cathodic Protection Specialist and Cathodic Protection Technician: Certified by NACE International.

b. Installers and Drillers Experience Statement: Include name of individual(s) who will install the cathodic protection system groundbed and operate the drilling equipment. Provide a copy of the driller's current licensure.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.

2. Operation and Maintenance Data:

a. As specified in Section 01 78 23, Operation and Maintenance Data.

b. Include electrical schematic of rectifier, parts list with part replacement number, and troubleshooting procedures.

3. Field Test and Inspection Reports.

4. Cathodic Protection System Activation Report.

5. Driller's logs for deep anode installations.

6. Certified test report of wire-to-anode connections, including connection resistance values.

1.04 QUALITY ASSURANCE

A. Cathodic Protection Technician:

1. NACE International certified.

2. Perform periodic field observation and testing services during installation of deep anode groundbeds and installation of other cathodic protection system components associated with the Project.

3. Available onsite at beginning of the Work to verify proper installation of cathodic protection system components. Make additional Site visits at intervals required to:

a. Verify proper installation of deep anode groundbeds and associated wiring.

b. Determine compliance with these Specifications.

c. Provide cathodic protection testing as specified herein.

d. Resolve field problems.

B. Cathodic Protection Specialist:

1. NACE International certified.

2. Available for direct communication with the Cathodic Protection Technician in order to:

a. Determine compliance with these Specifications.

b. Verify testing procedures and address issues that arise in the field.

3. Review testing data and provide Cathodic Protection System Activation Report as specified herein.

C. Installer: Minimum 3 years' experience installing type of cathodic protection system specified.

D. Driller: Experience installing a minimum of three deep anode groundbeds within last 5 years. Drillers shall be licensed in accordance with local and state requirements.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Coil anode wires and secure, and package anode as required to prevent damage during shipment. Damaged anode or wire shall be cause for replacement of the complete anode.

1.06 EXTRA MATERIALS

A. Provide for Each Rectifier:

1. Three complete set of spare fuses.

2. Three each ac input lightning arrestors.

3. Three each dc output lightning arrestors.

4. Provide spare parts in sealed, waterproof bag.

PART 2 PRODUCTS

2.01 IMPRESSED CURRENT ANODES

A. High-Silicon Cast Iron-Tubular:

1. Description: Tubular, center-tap connection, modified high-silicon cast iron meeting requirements of ASTM A518/A518M, Grade 3, with dimensions and chemical composition listed below.

2. Dimensions:
    a. Length: 84 inches minimum.
    b. Outside Diameter: 2.7 inches minimum.
    c. Weight: 70 pounds minimum.
3. Composition:
    a. Silicon: 14.20 percent to 14.75 percent.
    b. Manganese: 1.50 maximum.
    c. Carbon: 0.70 percent to 1.10 percent.
    d. Chromium: 3.25 percent to 5.00 percent.
    e. Copper: 0.50 percent maximum.
    f. Molybdenum: 0.50 percent maximum.
    g. Iron: Remainder.
4. Anode-to-Wire Connection:
    a. Manufacturer's standard connection.
    b. Connection Resistance: 0.0015 ohm, maximum.
5. Manufacturer and Product: Anotec Industries Ltd., Langley, B.C., Canada; Z Series Anodes, Type 2684 Z.
6. Number of Anodes Required:
    a. If 96-inch raw sewage pipe is of welded steel construction, provide five anodes.
    b. If 96-inch raw sewage pipe is not of welded steel construction, provide three anodes.

B. Wire-to-Anode Connection:
1. Factory installed using manufacturer's standard and as specified herein.
2. Stronger than the wire.
3. Measure resistance of wire-to-anode connections with a Kelvin bridge circuit or equal.
4. Replace wire connections that have a resistance of 0.004 ohm or greater.
5. Submit test records that include the following information:
    a. Anode number.
    b. Anode wire length.
    c. Resistance value of connection.
    d. Test equipment.
    e. Test method.

C. Wire Labels: Label end of each anode wire with anode number and wire length, stamped onto brass tags. Number anodes sequentially from bottom to top. Label bottom anode No. 1.

2.02 ANODE CENTRALIZERS

A. Metal or plastic assemblies that can be securely attached to anodes to center them in the drilled hole. Centralizers shall not block hole or impair installation of anode, anode wire, or coke breeze.

2.03 ANODE BACKFILL

A. Calcined Petroleum Coke:
   1. Lubricated, low resistance, calcined petroleum coke, suitable for pumping, with the following composition:
      a. Volatile Matter: 0.10 percent maximum.
      b. Ash: 0.6 percent maximum.
      c. Sulfur: 5.8 percent maximum.
      d. Fixed Carbon: 99 percent minimum.
      e. Particle Size: 100 percent passing 16-mesh and 98 percent retained by 200-mesh.
      f. Bulk Density: 65 pounds per cubic foot, minimum.
      g. Minimum Resistivity: 0.10 ohm-cm at 150 psi.
      h. Manufacturers and Products:
         1) Asbury Carbon, Asbury, NJ; Asbury 251-P.
         2) Cathodic Engineering Co., Hattiesburg, MS; Loresco SC-3.
         3) Great Lakes Carbon, New York, NY; Carbo Coke 60.

B. Composition of Metallurgical Coke:
   1. Volatile Matter: 6 percent maximum.
   2. Ash: 18 percent maximum.
   3. Sulfur: 1 percent maximum.
   4. Fixed Carbon: 82 percent minimum.
   5. Particle Size: 1/8 inch to 3/8 inch.
   6. Bulk Density: 45 pounds per cubic foot.

2.04 DEEP ANODE CONSTRUCTION MATERIALS

A. Vent Pipe:
   1. Active Column: 1 inch, ASTM D1785 Schedule 40 PVC pipe, with 1/8-inch holes drilled completely through both sides of pipe at 4-inch centers 0.006-inch longitudinal slots, 3 inches long, cut completely through both sides of pipe at 4-inch centers in active anode column area.
      a. Vertical Length of Active Column: 67 feet.
   2. Inactive Column and Buried: Solid 1-inch, ASTM D1785 Schedule 40 PVC.
      a. Vertical Length of Inactive Column and Buried Section: 183 feet.
   3. Surface Vent Pipe: ASTM A53/A53M standard steel pipe, 1-inch diameter with 180-degree fabricated gooseneck at the top. Sandblast to Commercial Grade (SSPC-SP 6) and coat with paint as specified in Section 09 90 00, Painting and Coating, System No. 5.
      a. Provide Type 316 stainless steel mesh to cover 1-inch diameter opening in Surface Vent Pipe.

B. Casing: Plastic nontoxic and resistant to water and soil; able to withstand installation, grouting, and operating stresses.

C. Groundbed Sealing Material: Cement grout, bentonite-gelatinous mud, puddled clay, or concrete in accordance with applicable state and local regulations.

D. Deep Anode Well Cap:
   1. Two-piece, cast-iron well seal with a rubber packer to form a watertight seal.
   2. Seals shall allow vent pipe penetrations with rubber packing providing a watertight seal of annular space.
   3. Manufacturers:
      a. Campbell Manufacturing, Bechtelsville, PA.
      b. Berkeley Pump Co., Berkeley, CA.

2.05 ANODE HEADER WIRE JUNCTION BOX

A. Junction Box: NEMA 250, Type 4X molded fiberglass, coated 14-gauge steel with minimum inside dimensions of 18 inches by 15 inches by 6 inches deep. Furnish box with a one-piece oil-resistant gasket mounted inside door to form and oiltight and dustfree seal, stainless steel latches, and a hasp for padlocking. Box shall be suitable for mounting with a double hub on two 2-inch or larger PVC coated rigid metal conduits and on one 1-inch or larger PVC coated rigid metal conduit.

B. Coatings for Steel Boxes: Baked enamel or heat-cured 100 percent solid thermosetting epoxy coating.

C. Terminals and Connectors: Furnish separate panelboard, buss bar, and terminal strip or terminal block connectors, and necessary fasteners for connecting anode lead terminals to rectifier positive lead. Fabricate terminal block to allow installation of shorting straps and shunts as shown on Drawings.

D. Shunts: Holloway Type RS, 0.01 ohm.

E. Mounting: Furnish junction box on 3-foot long, 1-5/8-inch Unistrut Series P1000 hot-dipped galvanized steel channel and mounting hardware necessary to provide a rigid support.

F. Terminal Box Manufacturers:
   1. Universal Rectifiers Inc., Rosenberg, TX.
   2. Farwest Corrosion Control Company, Downey, CA.
   3. Stahlin Brothers, Inc., Belding, MI.
   4. Hoffman Engineering Co., Anoka, MN.

2.06 STRUCTURE JUNCTION BOX

A. Structure Junction Box: NEMA 250, Type 4X, 14-gauge Type 304 stainless steel with minimum inside dimensions of 18 inches by 15 inches by 6 inches deep. Furnish box with one piece oil-resistant gasket mounted inside door to form an oil-tight and dust-free seal, stainless steel latches, and a hasp for padlocking. Box shall be suitable for mounting with a double hub on two 2-1/2-inch or larger PVC coated rigid metal conduits and on one 1-inch or larger PVC coated rigid metal conduit.

B. Terminals and Connectors: Furnish separate panelboard, buss bar, and terminal strip or terminal block connectors, and necessary fasteners for connecting structural lead terminals to rectifier positive lead. Fabricate terminal block to allow installation of shorting straps and shunts as shown on Drawings.

C. Pipe ID Tags: Furnish pipe ID tags for each pipe terminal connection containing at a minimum pipe name, pipe type, and pipe diameter.

D. Variable Resistors: Furnish variable resistors as shown on Drawings.

E. Mounting: Furnish junction box on two 2-inch threaded PVC coated rigid metal conduits and one 1-inch threaded PVC coated rigid metal conduit and stainless steel mounting hardware necessary to provide a rigid support.

F. Terminal Box Manufacturer: Farwest Corrosion Control Company, Downey, CA.

2.07 RECTIFIER

A. General: Air-cooled, manually controlled. Design rectifier to operate continuously at an ambient temperature of 45 degrees C and capable of 110 percent of rated input without damage to the rectifier components.

B. Ac Input: 120/240 volts, single-phase, 60-Hz. Furnish suitably sized magnetic type circuit breaker mounted on rectifier panel.

C. Transformer:
   1. Two-winding, insulating type, meeting requirements of NEMA, UL, and CSA.
   2. Furnish with fine and coarse secondary taps with rectifier output controlled by a minimum of 20 evenly divided steps of adjustment. Arrange coarse and fine taps in consecutive order.
   3. Insulation: Rated for a minimum temperature of 130 degrees C with actual hottest spot temperature at rated conditions not to exceed 100 degrees C.

D. Rectifying Elements: Full wave bridge, silicon diode stack with efficiency filter, metal oxide thyristors, and current-limiting devices for overvoltage and overcurrent protection of stack.

E. Output Rating (if 96-inch raw sewage pipe is of welded steel construction): 40 volts, 20 amperes, minimum.

F. Output Rating (if 96-inch raw sewage pipe is of non-ferrous metal construction): 25 volts, 15 amperes, minimum.

G. Lightning Protection: Furnish for ac input and dc output.

H. Meters: Dc voltage and current meters, D'Arsonval jeweled movement type, accurate to within 2 percent of actual voltage and current output.

I. Shunt: Holloway type shunt mounted in series with the ammeter, with voltage and current clearly identified on shunt body.

J. Enclosure:
   1. Enamel-coated steel with legs suitable for pad mounting .
   2. Furnish with hinged doors on front and both sides to allow access, stainless steel latches, and hasp for locking.
   3. Seal enclosure to protect interior components from weather, vandalism, and nest building insects; furnish adequate ventilation.

K. Panelboard:

1. Nonmetallic, suitable for mounting meters, shunt, circuit breaker, fuses, and output terminals.
2. Locate panelboard at front of rectifier to allow access for testing and adjustment.
3. Clearly engrave or identify with a permanent marking system the polarity of output terminals, fine and course transformer tap settings, meters, and fuses.

L. Current Interrupter: Solid state timing device to interrupt secondary current. Interrupter shall be capable of continuous operation, and shall consist of 1-minute adjustable recycling timer or electronic timer, “Test-Normal” toggle switch, and relay or connector to interrupt main circuit.

M. Mounting Hardware: Tap studs, tap bars, nuts, washers, and other mounting hardware shall be suitably sized brass or tin-plated copper.

N. Nameplate: Engraved metal plate mounted on interior side of front door listing manufacturer name, model number, serial number, year manufactured, and ac and dc input and output electrical ratings.

O. Manufacturer: Universal Rectifiers Inc., Rosenberg, TX.

2.08 UNDERGROUND POWER SERVICE

A. Pedestal Rating: 100-ampere, single service pedestal enclosure with a combination meter base and two-pole circuit breaker sized for 110 percent to 135 percent of the ac current flow at maximum rectifier output. Type 3R construction, combination meter/main CB-load center—safety socket with factory installed test/bypass facilities. Provide provisions for padlock on load side hinged door to accommodate a 7/16-inch lock shank.

B. Pedestal Case: 12-gauge steel minimum. Provide provisions for padlock on circuit breaker cover door to accommodate a 7/16-inch lock shank.

C. Special Coating: Furnish pedestal case with a polyamide converted epoxy coating, applied in two coats to a dry film thickness of 8 mils minimum. Pedestals furnished with coating that does not meet or exceed this requirement shall be sanded to bare metal and coated with specified coating.

2.09 CONDUIT, FITTINGS, AND ACCESSORIES

A. Rigid and Flexible Conduit and Fittings: As specified in Section 26 05 33, Raceway and Boxes.

B. Locknuts, Two-Hole Straps, and Miscellaneous Hardware: Aluminum.

C. Conduit Bushings: Threaded plastic or plastic-coated galvanized steel fittings.

2.10 CONCRETE

A. Furnish as specified in Section 03 30 00, Cast-in-Place Concrete.

2.11 CONDUCTORS

A. Conductors, ac: As specified in Section 26 05 05, Conductors.

B. Anode Header Wire: Single-conductor, 4 AWG stranded copper with 600-volt HMWPE insulation.

C. Anode Wire:
   1. Single-conductor, 8 AWG stranded copper.
   2. 600-volt HMWPE insulation.
   3. Furnish sufficient length to extend splice-free from anode connection to anode junction box terminals plus 30 feet.

2.12 ANCILLARY MATERIALS

A. Warning Tape: Heavy-gauge, yellow plastic tape, 3 inches minimum width, labeled with “CAUTION: BURIED CABLES BELOW” in bold black letters for full length of tape. Make warning tape of a nontraceable material resistant to corrosive soil and intended for direct burial service.

B. Wire Connectors: One-piece, tin-plated crimp-on lug connector as manufactured by Burndy Co. or Thomas and Betts.

C. Earthfill: Native soil material free from rocks larger than 2 inches, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious matter.

D. Backfill: Natural material from trench excavation with a maximum particle size of 1/4 inch and free from roots and organic matter and construction debris.

2.13 THERMITE WELD MATERIALS

A. General:
   1. Wire sleeves, welders, and weld cartridges according to weld manufacturer’s recommendations for each wire size and pipe or fitting size and material.
   2. Welding materials and equipment shall be product of a single manufacturer.

3. Interchanging materials of different manufacturers will not be acceptable.

B. Molds: Graphite. Ceramic “One-Shot” molds are not acceptable.

C. Adapter Sleeves:
   1. Furnish for 12 AWG and 2 AWG wires.
   2. Prefabricated factory sleeve joint bonds or bond wires with formed sleeves made in field are acceptable.
   3. Attach field-formed sleeves with appropriate size and type of hammer die furnished by thermite weld manufacturer.
   4. Extend wire conductor 1/4 inch beyond end of sleeve.

D. Cast Iron Thermite Weld Cartridges: Use for cast and ductile iron pipe and fittings; maximum cartridge size 25 grams for steel and 32 grams for cast and ductile iron materials, respectively.

E. Welders and Cartridges:

Pipe Material	Weld Type	Cartridge Size, Max.
4 AWG Wire and Smaller:		
Steel	HA, VS, HC	25 gm
Ductile Iron	HB, VH, HE	32 gm
Cast Iron	HB, VH, HE	32 gm
2 AWG Joint Bonds:		
Steel	FS	25 gm
Ductile or Cast Iron	FC	32 gm
Concrete Cylinder Pipe	HA, GR	32 gm

F. Manufacturers:
   1. Erico Products Inc. (Cadweld), Cleveland, OH.
   2. Continental Industries, Inc. (Thermo-Weld), Tulsa, OK.

G. Thermite Weld Coating:
   1. Thermite Weld Caps: Prefabricated weld cap with coating and suitable primer; Handy Cap with Royston Primer 747, as manufactured by Royston Laboratories, Inc.

2. Use products recommended by pipe or fitting manufacturer to repair spot damage at thermite weld connections not covered by standard pipeline coating repair procedure or thermite weld cap.

PART 3 EXECUTION

3.01 INSTALLATION

A. Construct impressed current cathodic protection system for the following:
   1. Buried steel pipe and appurtenances.
   2. Buried ductile iron and cast iron pipe and appurtenances.

B. Conform to NFPA 70.

C. Provide metering facilities as required by electric utility for utility's installation of metering equipment, service conductors, and mounting of utility company equipment.

3.02 DEEP ANODE GROUND BED INSTALLATION

A. General:
   1. Drilling, electrical logging, lowering of anodes, coke breeze placement, and backfilling shall be done in one continuous operation, and shall be observed by Contractor's Cathodic Protection Specialist.
   2. Perform drilling and waste disposal in accordance with methods and procedures that comply with rules and regulations of state, city, county, or other governing bodies having jurisdiction. Seal hole with groundbed sealing material or as required by local well drilling regulations. The most stringent regulations apply.
   3. Take necessary precautions to avoid entrance of foreign matter into hole, movement of soil strata, or collapsing of hole during progress of the Work. Should movement of soil strata or collapse of drilled hole interfere with proper completion of groundbed, recover wires and anode strings and ream or redrill hole.
   4. Maintain a log describing depth and type of geological formations encountered during drilling.

B. Drilling:
   1. Approximate location of groundbeds is shown on Drawings. Coordinate actual location of groundbed hole in field with Jacobs' Engineer before drilling begins.

2. Drill Depth:
    a. If 96-inch raw sewage pipe is of welded steel construction, total drill depth shall be at least 250 feet, which includes a 67-foot active column.
    b. If 96-inch raw sewage pipe is not of ferrous metal construction, total drill depth shall be at least 160 feet, which includes a 38-foot active column.
3. Construct hole and set casing round, straight, and plumb.
4. Set surface casing prior to completion of the first 50 feet of the hole. Casing, other than surface casing, shall not be installed or left in hole unless in driller's estimation it is necessary for successful completion of the hole. Plastic casing may be installed in the inactive column, at Contractor's option, but shall not extend into the active column.
5. Overdrill the hole to compensate for sloughing or heaving during anode installation.

C. Electrical Logging:
1. Flush the hole and electrically log the hole in the presence of Jacobs' Engineer to determine downhole characteristics for optimum anode elevations.
2. Acceptable Method of Electrical Logging: Make a resistance to earth reading as a short section of pipe is lowered down the hole. Test with suitable meters, a short section of weighted metallic pipe, connection to a low resistance ground, a wire reel with appropriate type, size, and amount of wire to reach bottom of the hole, and a method to measure downhole wire length or footage identification marking on wire to allow determination of test pipe depth.
3. Record resistance reading and depth from surface continuously or at 5-foot increments for entire hole depth.
4. Based on the results of the electrical log data and the driller's log of soil formations, Jacobs' Engineer may modify anode spacing and drilled depth.

D. Lowering of Anodes:
1. Notify Jacobs' Engineer prior to beginning this Work.
2. Lower anodes after drilling is completed.
3. Install anodes and coke breeze on same day as the completion of drilling and electrical logging.

4. Anode Centralizers:
    a. Attach to each anode prior to lowering.
    b. If metal centralizers are used, apply tape to clamps and ends of rods to cover sharp edges to reduce potential for wire insulation damage during anode installation.
    c. If steel casing is used and extends into active column, anode centralizers shall be electrically isolated from casing by a method approved by Engineer.
5. Vent pipe shall be joined by threaded couplings; no glued joints will be allowed.
6. Attach deepest anode to predrilled vent pipe. Lower anode and vent pipe to bottom of hole. Lower remaining anodes individually.
7. Provide sufficient slack in anode wires to prevent damage during anode and coke breeze installation.
8. Damage to anodes or cut, gouged or scraped wire insulation will not be acceptable. No wire splices will be allowed inside deep anode groundbed.
9. If hole is drilled with mud, flush hole with clean water in a continuous process before or after the anodes are lowered, at Contractor's option, until return fluid is sufficiently clear to allow proper installation and settlement of anodes, vent pipe, and coke breeze.

E. Backfilling of Anode Hole:
1. Notify Jacobs' Engineer prior to beginning the Work.
2. Keep hole full of water during installation of the coke breeze.
3. Prepare coke breeze slurry with water in accordance with manufacturer's written recommendations. Pump coke breeze slurry into hole through an additional plastic pipe. Pump coke breeze in an even and continuous manner from bottom of hole to top as plastic pipe is slowly withdrawn. Top-loading the coke breeze, by pouring coke breeze into the hole, will not be permitted.
4. At Contractor's option, coke breeze and anodes may be installed concurrently. Submit proposed alternative methods of anode and coke breeze installation to Jacobs' Engineer for review and approval prior to beginning the Work.
5. Conduct resistance measurements between an appropriate grounded structure or pipeline and each anode lead as coke breeze is installed. Start individual anode resistance measurements at bottom anode. When resistance measurement indicates that coke breeze level has covered bottom anode, connect test leads to next higher anode wire and monitor resistance measurement as coke breeze is installed. Use resistance

measurements to monitor coke breeze level in drilled hole and detect possible coke breeze bridging problems during installation.

6. Install pea gravel to depth shown or as required by local drilling codes.

F. Placement of Seal:

1. Place sealing material in accordance with local and state regulations.
2. Place seal by pumping or forcing material from bottom to within 18 inches of finished grade. Place seal in such a manner that ensures entire filling of the space in one continuous operation.
3. Install sealing material in the annular space between casing and soil.

G. Anode Wire Termination: Cut a smooth hole in side of casing for routing wires to anode junction box. Install rubber grommet or pipe with plastic bushings on both ends in the hole to prevent damage to wire insulation by casing.

H. Groundbed and Vent Pipe Termination: Place vent pipe through well cap, and connect steel portion of vent pipe to plastic vent pipe with appropriate threaded coupling, 6 inches minimum below grade. Place well cap in casing and torque bolts in accordance with manufacturer's recommendations.

3.03 SURFACE GROUND BED INSTALLATION

A. Anode Field Location: Establish and stake the anode location in the field with wood lath for review and approval by Jacobs' Engineer.

B. Anode Spacing/Depth: Install anodes in a vertical position at the spacings and depths shown on Drawings.

C. Vertical Anode: Install individual anodes in a vertical position at the approximate anode depth, hole location, and spacing shown on Drawings. Attach anode centralizer firmly to anode and carefully lower into drilled hole. Carefully pour coke breeze into drilled hole so as to avoid bridging or caving of the hole. Thoroughly compact coke breeze below, above, and around sides of the anode with no voids. Maintain anode in center of coke breeze column, and not in contact with native soil.

D. Drilling: Anode hole shall be nominal depth and diameter shown on Drawings. Overdrill anode hole as required to compensate for sloughing during anode and coke breeze installation. Take precautions to avoid entrance of foreign matter into hole, movement of soil strata, or collapsing of hole during progress of the Work. Should movement of soil strata or collapse of drilled hole interfere with the proper completion of groundbed installation, recover wire and anode, and ream or redrill hole. Drill holes and seal in accordance with rules and regulations of the state, city, county, or other governing bodies having jurisdiction.

E. Earthfill: Carefully place and compact above anode backfill in 6-inch lifts to a point 2 feet above anode backfill. Complete backfilling and compacting to grade. Stop backfill at grade to allow placing of topsoil, pavement, road base, or concrete where required.

F. Anode Lead-to-Anode Header Wire Connections: Connect anode lead wire to anode header wire with specified compression connectors with a suitable sized crimp tool for connector and wire sizes being spliced.

G. Wire Splice Insulation: Install splice kits according to manufacturer's recommendations. Make splices waterproof, suitable for direct burial. Provide 1-hour setting time prior to moving splice or placing splice in trench and backfilling.

H. Anode Header Cable: Install cables in center of trench. Maintain sufficient slack in wire to prevent cable from being unduly stressed or broken during backfill operations.

3.04 TRENCHING

A. Excavation: As specified in Section 31 23 16, Excavation.

B. Fill and Backfill: As specified in Section 31 23 23, Fill and Backfill.

C. Complete excavations and trenching regardless of type, nature, or condition of materials encountered, as required to accomplish specified construction to lines and grades shown.

D. Take care to avoid damage to existing structures and utilities during excavating and trenching process. Cathodic protection excavations and cable trenches shall be in the general location and route as shown. Contractor may modify location as approved by Jacobs' Engineer as required to minimize possible damage to existing structures. Trench shall be of uniform depth and width, level, smooth, and free of sharp objects. Hand trenching may be required in some areas to avoid damage to existing structures.

E. Sheet and brace excavations and trenches as necessary to prevent caving during excavation in unstable material, or to protect adjacent structures, property, workers, and the public.

F. Backfill trench with excavated backfill materials, tamp, and compact so that no subsequent settlement will occur. Do not use backfill material of frozen or consolidated debris. Leave trench with the excess backfill material neatly mounded not more than 4 inches above existing ground level for entire width of trench.

3.05 GUARDRAIL ASSEMBLY

A. Set posts plumb and straight in concrete footing.

3.06 CONDUITS

A. Install conduits in accordance with Section 26 05 33, Raceway and Boxes.

B. Secure conduits entering cabinets, junction boxes, or terminal boxes with double locknuts, one on outside and one on inside.

C. Install insulated bushings and insulated throat connectors on ends of rigid metallic conduit.

D. Use watertight couplings and connections. Install and equip boxes and fittings to prevent water from entering conduit or box. Seal unused openings.

3.07 ANODE TERMINAL BOX INSTALLATION

A. Connect rectifier positive lead and anode wires to junction box terminals with shunts, bus bars, and appropriate fasteners.

B. Label wires in terminal box with permanent brass tags identifying anode number and rectifier lead. Connect numbered anodes in consecutive order to anode terminals starting with number one at the top left-hand side. Maintain sufficient slack to keep wire from being unduly stressed, damaged, or broken during backfill.

3.08 STRUCTURE JUNCTION BOX INSTALLATION

A. Connect rectifier negative lead and structure wires to structure junction box terminals with shunts, bus bars, and appropriate fasteners.

B. Label wires in terminal box with permanent brass tags identifying pipe name, pipe type, and pipe diameter. Maintain sufficient slack to keep wire from being unduly stressed, damaged, or broken during backfill.

3.09 RECTIFIER INSTALLATION

A. Provide conductors and electrical hardware necessary for rectifier installation. From disconnect switch to rectifier use 8 AWG single conductor stranded copper wire with 600-volt THWN insulation.

B. Install rectifier wire from rectifier negative terminal to pipeline. Install rectifier wire from rectifier positive terminal to anode terminal box.

C. Notify Engineer 10 working days prior to completion of rectifier, groundbed, and ac power service installation to allow scheduling of required energizing and testing.

3.10 AC POWER SERVICE

A. Provide alternating current power to rectifier disconnect switch in accordance with Division 26, Electrical. Power service installation shall meet or exceed local and NEC code requirements.

B. Coordinate installation of electrical power service with local power utility.

3.11 CONDUCTOR INSTALLATION

A. Install and pull conductors in accordance with Section 26 05 05, Conductors.

B. Rectifier to Pipeline and Anode Junction Box: Single-conductor, 4 AWG stranded copper with 600-volt High Molecular Weight Polyethylene (HMWPE) insulation 7/64 inch thick.

C. Arrange conductors neatly in rectifier and junction or terminal box. Cut to proper length, remove surplus wire, and attach terminal or connect to appropriate junction box or rectifier terminal.

D. Seal belowground conduit to prevent intrusion of foreign material after wire is in place.

E. Direct buried rectifier or galvanic anode wires shall be 36 inches deep, minimum, below finished grade. Wires shall be free of splices, except those approved by Engineer.

F. Bury warning tape approximately 12 inches above underground rectifier conductors and conduits. Align parallel to and within 2 inches of centerline of conduit or conductor run.

3.12 WIRE CONNECTIONS

A. Provide crimp tool and die recommended by manufacturer for wire and tap connector size.

B. Thermite Weld:

1. Use thermite weld method for electrical connection of copper wire to steel, ductile, and cast iron surfaces. Observe proper safety precautions, welding procedures, thermite weld material selection, and surface preparation recommended by the welder manufacturer. Ensure pipe or fitting wall

thickness is of sufficient thickness that thermite weld process will not damage integrity of pipe or fitting wall or protective lining.

2. After weld connection has cooled, remove slag, visually inspect, and physically test wire connection by tapping with a hammer; remove and replace defective connections.
3. On pipe and fittings with dielectric linings, make weld connection on shop tab provided or on a thick metal section to minimize damage to lining and coating. After weld is made, coat weld with coating repair material.
4. Install a prefabricated thermite weld cap over each completed connection. Repair exposed metal surfaces not covered by thermite weld cap in accordance with coating manufacturer's recommendations. Repair damage to pipe lining in accordance with lining applicator's recommendations.
5. Make wire connections to concrete cylinder pipe by thermite welding to shop welded steel studs or plates provided on pipe for this purpose. Clean steel studs to bright metal before thermite welding. Coat completed wire connection with cement mortar as shown on Drawings.

3.13 FIELD TESTING

A. Provide Cathodic Protection Technician to visit site during installation of impressed current cathodic protection system, insulating flanges, junction boxes, and test stations. Cathodic Protection Technician shall work under the supervision of a Cathodic Protection Specialist and the Cathodic Protection Specialist shall be responsible to ensure compliance with these Specifications, and for observation and testing services.

B. Cathodic Protection System Activation:
   1. The Cathodic Protection Technician, working under the supervision of (as defined herein) the Cathodic Protection Specialist, shall inspect, activate, and evaluate the effectiveness of the cathodic protection system. Cathodic Protection Specialist shall be involved in planning, directing, and troubleshooting test procedures and shall verify the testing procedures and results. Provide a Cathodic Protection System Activation report that has been reviewed and signed by the Cathodic Protection Specialist.
   2. Measure and record a Native Potential Close Interval pipe-to-soil survey prior to activating the cathodic protection system. Measure and record cathodic protection native potentials (i.e., baseline pipe-to-soil potentials) at all cathodic protection test stations prior to activating the cathodic protection system. Measure cathodic protection native potentials on both sides of all buried insulating flanges and at all cathodic protection test station wires. Where two wires are attached to the same pipeline, measure and record the cathodic protection native potentials for both wires.

3. Activate the cathodic protection system by turning on the cathodic protection rectifier.
4. Measure and record “On Potentials” at the same locations where native potentials were previously measured.
5. Measure and record the initial current of all anodes at anode junction box by measuring the voltage drop across the calibrated shunts provided. Calculate the corresponding amount of direct current flow using the shunt rating. Explicitly state the shunt rating on each data sheet.
6. Resurvey the cathodic protection system at least 2 weeks after the initial energization process to allow for the development of the cathodic polarization process. Measure and record On Potentials and Perform “Instant Off” potential testing by using the current interrupter on the rectifier.
7. Furnish all test results including all cathodic protection potential readings, anode current readings, insulating flange test data, dates, and times. Reference all data to pipeline station numbers. Submit all data along with a letter report to the Design-Builder. The letter report shall include a description of the test methods, analysis of the data, and conclusions about the cathodic protection system’s effectiveness. Submit electronic copy of data and letter report.

C. Final Inspection: Notify Jacobs’ Engineer when the cathodic protection system is completely installed. Within 2 weeks the system shall be inspected by the Cathodic Protection Technician in the presence of a Jacobs’ Engineer. Replace or repair any deficiencies in materials and installation that are revealed by these tests.

D. After correction of construction deficiencies, if NACE SP0169 criteria are still not satisfied, conduct testing to determine cause of deficiency for action by Jacobs’ Engineer.

E. Meters: Field test meters for accuracy; replace inaccurate meters.

END OF SECTION

SECTION 26 42 01
PIPE BONDING AND TEST STATIONS

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 Water Works Association (AWWA):
      a. C110, Ductile-Iron and Gray-Iron Fittings for Water.
      b. C205, Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 in. (100 mm) and Larger - Shop Applied.
      c. C207, Steel Pipe Flanges for Waterworks Service - Sizes 4 in. Through 144 in. (100 mm Through 3,600 mm).
      d. C217, Petrolatum and Petroleum Wax Tape Coatings for the Exterior of Connections and Fittings for Steel Water Pipelines.
   3. American Wood Preservers' Association (AWPA):
      a. C2, Lumber, Timber, Bridge Ties, and Mine Ties Preservative Treatment by Pressure Processes.
      b. P9, Standards for Solvents and Formulations for Organic Preservative Systems.
   4. ASTM International (ASTM):
      a. B418, Standard Specification for Cast and Wrought Galvanic Zinc Anodes.
      b. F436, Standard Specification for Hardened Steel Washers.
   5. NACE International (NACE): SP0169, Control of External Corrosion on Underground or Submerged Metallic Piping Systems.
   6. National Electrical Manufacturers Association (NEMA):
      a. C80.1, Electrical Rigid Steel Conduit (ERSC).
      b. TC 2, Electrical Polyvinyl Chloride (PVC) Conduit.
      c. WC 70, Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
   7. NSF International (NSF).
   8. The Society for Protective Coatings (SSPC):
      a. SP 1, Solvent Cleaning.
      b. SP 10, Near-White Blast Cleaning.

1.02 DEFINITIONS

A. Electrical Isolation: Condition of being electrically isolated from other metallic structures (including, but not limited to, piping, reinforcement, casings) and the environment as defined in NACE SP0169.

B. Electrically Continuous Pipeline: Pipeline that has a linear electrical resistance equal to or less than the sum of the resistance of the pipe plus the maximum allowable bond resistance for each joint as specified in this section.

C. Ferrous Metal Pipe: Pipe made of steel or iron, or pipe containing steel or iron as a principal structural material, except reinforced concrete pipe.

D. Foreign-Owned: Buried pipe or cable not specifically owned or operated by Owner.

E. Lead, Lead Wire, Joint Bonds, Pipe Connecting Wires, Cable: Insulated copper conductor; the same as wire.

1.03 SUBMITTALS

A. Action Submittals:
   1. Catalog cuts and information for products proposed for use. Indiscriminate product catalog will not be reviewed and shall be subject to resubmittal.
   2. Qualifications of Cathodic Protection Specialist.

B. Informational Submittals:
   1. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
   2. Factory test reports for isolation fitting.
   3. Field Test Reports, including results of insulator testing.

1.04 QUALITY ASSURANCE

A. Cathodic Protection Specialist Qualifications: NACE International certified.

PART 2 PRODUCTS

2.01 WIRES

A. Conform to applicable requirements of NEMA WC 70.

B. Joint Bond:

1. General: Single-conductor, stranded copper wire with 600-volt HMWPE insulation. Supply joint bonds complete with formed copper sleeve on each end of wire.
2. Push-On, Mechanical, or Flanged Joints: 2 AWG wires, 18 inches long.
3. Flexible Coupling Joints: 2 AWG wires, 24 inches long, with two 12-inch-long HMWPE insulated 12 AWG wire pigtails, as manufactured by Erico Products Inc. (Cadweld), Cleveland, OH.
4. Insulated Flexible Coupling Joints: 8 AWG wire, 18 inches long, with one 12-inch-long HMWPE insulated 12 AWG wire pigtail.

C. Pipe Connecting: Single-conductor, 4 AWG stranded copper wire with 600-volt HMWPE insulation.

D. Test Station: Single-conductor, 12 AWG stranded copper with 600-volt TW, THWN, or THHN insulation and single-conductor, 8 AWG stranded copper with 600-volt HMWPE insulation.

E. Insulation Colors and Wire Identification:

1. Materials shall be suitable for permanent identification.
2. Plastic, paper, or cloth markers will not be permitted.
3. Each pipe test wire shall include pipe diameter and pipe type, reference electrode, as applicable.

2.02 CATHODIC PROTECTION TEST STATIONS

A. Flush Mounted:

1. Test Box: Concrete body cast with cast-iron ring, with a minimum weight of 55 pounds and minimum dimensions of 8-inch inside diameter and 12 inches long. Furnish extensions as required to penetrate concrete surfaces by 4 inches minimum. Furnish with a 12-pound cast-iron lid with letters “TS” or words “Test Station” cast into lid.
2. Terminal Block: Plastic or glass-reinforced, 1/4-inch-thick laminate terminal board with minimum dimensions of 4 inches by 6 inches. Furnish terminal block with five Type 304 stainless steel studs, washers, and lock washers.
3. Manufacturer and Product: Brooks; Models 1RT or 3RT.

B. Post Mounted (Standard):

1. Test Box: Polycarbonate suitable for threaded mounting to a 2-inch or larger polyethylene conduit.

2. Terminal Block: Plastic or glass-reinforced laminate, 1/4 inch thick with seven terminals. Terminals shall have special heads to keep them from turning or shall be easily accessible from both sides of terminal block without requiring its removal. Terminal studs, washers, and nuts shall be Type 304 stainless steel.
3. Mounting Structure: 2-inch or larger polyethylene conduit.
4. Provide integral UV inhibitor for conduit and test box.
5. Manufacturer and Product: Cott; Big Fink.

2.03 PERMANENT REFERENCE ELECTRODES

A. Prepackaged Copper-Copper Sulfate Reference Electrodes:
   1. Material: Permanent type, copper-copper sulfate reference electrode suitable for direct burial with a minimum design life of 30 years.
   2. Wire: 12 AWG stranded copper wire with yellow, 600-volt HMWPE insulation. Wire shall be attached to electrode and insulated with manufacturer's standard connection. Connection shall be stronger than the wire.
   3. Manufacturers and Products:
      a. Borin Manufacturing; Model SRE-007-CUY.
      b. Electrochemical Devices, Inc.; Model UR-CUG-CW.
      c. GMC Electrical, Inc.; Model CU-1-UGPC.

2.04 THERMITE WELD MATERIALS

A. General:
   1. Thermite weld materials consist of wire sleeves, welders, and weld cartridges according to weld manufacturer's recommendations for each wire size and pipe or fitting size and material.
   2. Welding materials and equipment shall be product of a single manufacturer. Interchanging materials of different manufacturers is not acceptable.

B. Weld Kits: Wire-to-pipe connections made by the exothermic welding process. Weld charges and mold size shall be as specified by the manufacturer for various pipe sizes and surface conditions. Weld charges for use on cast and ductile iron are different than those used on steel. Care should be taken during installation to be sure correct charges are used. Welding charges and molds shall be the product of a manufacturer regularly engage in the production of such materials. Weld charges for steel pipelines have green caps.

C. Welding Materials Manufacturers:

1. Erico Products Inc. (Cadweld), Cleveland, OH.
2. Continental Industries, Inc. (Thermo-Weld), Tulsa, OK.

D. Thermite Weld Coating:

1. Weld Cap Primer: An elastomer-resin based corrosion resistant primer for underground service, such as Royston Roybond Primer 747.
2. Weld Caps: Prefabricated plastic cap filled with formable mastic compound on a base of elastomeric tape. Weld caps shall be Royston Handy Cap II.
3. Weld Cap Overcoating: Overcoat with a 74 percent minimum solids by volume, cold-applied, black, thixotropic material containing plasticized coal tar pitch, solvents, and special fillers per MIL-C_18480A such as Protecto Wrap 160/160H, or Carboline 300M. Apply to at least 20-mils dry film thickness.
4. Use products recommended by pipe or fitting coating manufacturer to repair spot damage at thermite weld connections not covered by standard pipeline coating repair procedure or thermite weld cap.

2.05 ANCILLARY MATERIALS

A. Mastic Coating: TC Mastic (Brush Applied) as manufactured by Tapecoat Co., Evanston, IL.

B. Wire Connectors: One-piece, tin-plated crimp-on lug connector as manufactured by Burndy Co. or Thomas and Betts.

C. Shunts: 0.01-ohm Holloway Type RS.

2.06 CONCRETE

A. Furnish as specified in Section 03 30 00, Cast-in-Place Concrete.

2.07 PLASTIC WARNING TAPE

A. Plastic warning tape for horizontal runs of buried leads in cable trenches shall be a minimum of 6-inches wide and minimum of 4-mils thick and made of a non-detectable inert yellow plastic film designed for prolonged use underground and will not degrade when exposed to alkalis, acids, and other destructive elements commonly found in soil. Printed warning, “Caution – Cathodic Protection Cable Buried Below”, or similar, clearly visible in repeating patterns along its entire length.

2.08 WAX TAPE COATING SYSTEM FOR BURIED INSULATING FLANGES

A. General: Apply a wax tape coating system which conforms to AWWA C217 and consists of three parts: surface primer, wax tape, and outer covering.

B. Primer: Blend of petrolatum, plasticizer, and corrosion inhibitors having a paste like consistency. Primer shall have a pour point of 100 degrees F to 11 degrees F and a flash point of 350 degrees F. Use Trenton Wax Tape Primer, “or-equal.”

C. Wax Tape: Synthetic fiber felt, saturated with a blend of high melt microcrystalline wax, solvents, and corrosion inhibitors, forming a tape coating that is easily formable over irregular surfaces and which firms up after application. The tape shall have a saturant pour point between 125 degrees F and 130 degrees F and a dielectric strength equal to a minimum of 100-volts per mil. Tape thickness shall be 50 mils or 90 mils in 6-inch-wide rolls. Use Trenton No. 1 wax tape.

D. The outer covering shall consist of two layers of a plastic wrapper at a total of 3-mils thick. The plastic wrapper material shall consist of clear polyvinylidene chloride, high cling membranes wound together as single sheet. Use Trenton Poly-Ply.

2.09 FUNCTIONAL TEST EQUIPMENT

A. Test Equipment: Before construction begins, obtain test equipment necessary for electrical continuity testing, and the following equipment:

1. Model 601, Aboveground Insulation Checker, as manufactured by Gas Electronics Co., Seymour, MO.
2. One Model 77 Series III, Digital Multimeter, with case and test leads, as manufactured by Fluke Corporation, Everett, WA.
3. Two Model 6B copper-copper sulfate reference electrodes as manufactured by Tinker and Rasor, San Gabriel, CA.
4. One quart of copper sulfate antifreeze solution.
5. One-half pound of copper sulfate crystals.

B. Store test equipment at Site and maintain in accurately calibrated, working condition. Test equipment shall be available to Jacobs’ Engineer for testing purposes. Upon completion of Project, test equipment listed above shall be turned over to Owner in clean, accurate, and fully functional condition, along with operating manuals, test wires, and cases supplied with equipment.

PART 3 EXECUTION

3.01 INSTALLATION

A. Construct system of pipe connecting wires and pipe joint bonds to form an electrically continuous piping network.

B. Connect all pipes to Structure Junction Box as shown on Drawings.

3.02 PIPE JOINT BONDING

A. Electrically bond joints of buried steel and iron pipe, including vault and manhole piping and fittings, and including restrained joints, except joints specified to be threaded, welded, or insulated.

B. Install two joint bond wire assemblies at each joint that requires bonding.

C. Use thermite weld process for electrical connection of wires to pipe and fittings.

1. Make wire connections to the pipeline or other structure with an exothermic weld process per manufacturer's written directions and instructions. Observe proper safety precautions as recommended by the welder manufacturer. Use the proper type and charge size for the weld process, as recommended by the manufacturer. Do not use wet or damp exothermic weld molds.
2. Provide a minimum of one pipe diameter between exothermic welds.
3. Remove a minimum amount of the existing coating required for placement of the weld mold on the steel or ductile iron pipe. Clean the surface to a rust free bright metal and ensure the surface is clean and dry prior to placing thermite weld.
4. Insert disk into the bottom of the cavity inside the mold. Dump the weld metal into the mold being careful not to upset the disk. Tape the bottom of the plastic tube to loosen all the starting powder and spread it evenly over the weld metal. Place a small amount of starting powder on the top edge of the mold under the cover opening for easy ignition. Close the cover.
5. Insert the conductor into the mold noting any special information under "positioning" in the manufacturer's instructions packaged with the welder.
6. After ignition, hold the welder in place for a moment to allow the weld to solidify. After the weld has cooled, remove the slag with a chipping hammer or wire brush and visually inspect. Remove and replace visually defective welds.

7. Physically test the weld integrity by striking it from the side with a 2-pound hammer. If the weld comes off or cracks, move away a minimum of 3 inches and repeat the welding process. Do not re-weld in the same location.

D. Test each bonded joint for continuity.

E. Prepare surface, apply primer and weld cap per manufacturer's instructions.

F. Apply generous coat of bitumen over the weld cap and weld area, overlapping the pipe coating by 3 inches. Allow bitumen to cure per manufacturer's recommendations prior to repair of pipe coating.

3.03 PIPE CONNECTING WIRES

A. Buried Metallic Pipelines: Connect together with insulated wires to provide electrical continuity between pipes.

B. Connect pipes together with 4 AWG insulated copper wire.

3.04 TEST STATION INSTALLATION

A. Determine location of test stations based on actual site conditions and as approved by Jacobs' Engineer.

B. Approximate test station locations are shown on Drawings. Each ferrous metal pipe shall be connected to the cathodic protection system and shall have a test station on each terminating end. Provide post-mounted Type PT-R test stations where test station can be located next to a building or other suitable protective structure. Provide flush mounted Type FT-R test stations where test station cannot be located next to a suitable protective structure.

C. Attach test wires to pipe.

D. Use flush mounted test stations where location or traffic constraints do not allow the use of post mounted test stations. Locate flush mounted test stations directly over pipeline, except in areas of heavy traffic conditions. Where heavy traffic conditions exist, locate test stations to side of street.

E. Where possible, locate post mounted test stations directly over pipe and at protected locations such as next to buildings or fences. Where not possible, locate as close to directly over the pipe as possible, but in a protected location.

F. Bury test and reference electrode wires a minimum of 36 inches below finished grade.

G. Install plastic warning tape above horizontal runs of buried leads in cable trenches.

H. Make wire connections to test station terminals with crimp-on spade lug terminals, except where solid wire is specified or terminal strips with tubular clamps are used.

I. Wire Labels:
   1. Install on conductors in boxes.
   2. Position markers in boxes so they do not interfere with operation and maintenance.
   3. Labels shall indicate pipe size and service.

3.05 CONDUITS

A. Secure conduits entering test station boxes in accordance with manufacturer's installation instructions.

B. Install insulated bushings and insulated throat connectors on ends of rigid metallic conduit.

C. Use watertight couplings and connectors. Install and equip boxes and fitting to prevent water from entering conduit or box. Seal unused openings.

3.06 REFERENCE ELECTRODE INSTALLATION

A. Remove plastic or paper wrapper and place reference electrode within pipeline trench excavation 6 inches from below centerline of pipe in a vertical or horizontal position. Install reference electrode within 18 inches of foreign pipelines between foreign and Owner's pipeline.

B. Pre-soak the reference electrode in a clean bucket of fresh potable water just prior to installation for 30 seconds, per manufacturer's instructions. Place native trench material around the reference electrodes, 6 inches minimum. Pour the remaining water in the bucket over the reference electrode. Terminate wires in test stations.

3.07 DAMAGED WIRE INSULATION

A. Handle wires with care. Splices for damage to wire insulation are not acceptable. Damaged wire insulation shall be cause for rejection and the wire shall be replaced.

3.08 INSULATED JOINTS

A. Install insulated joints to electrically isolate pipeline from other structures as specified in Section 40 27 00, Process Piping—General.

B. Align and install insulating joints as shown on Drawings and according to manufacturer's recommendations.

C. Do not use fastener lubricants that contain graphite or metallic compounds that will interfere with the insulating capability of the completed joint.

D. Test the completed insulating joint as specified herein.

E. Insulating Flange Lining and Coating:

1. After assembly of insulated flanges, repair coatings and linings as shown on Drawings and as specified herein.

    a. Interior Lining: Repair linings in accordance with manufacturer's written directions. For cement mortar linings, prepare cement-mortar surface in accordance with paint manufacturer's instructions and apply a 20-mil minimum thickness of NSF potable water approved, 100 percent solids water or air curing epoxy coating to interior of pipeline. Apply coating for a minimum of two pipe diameter lengths from insulating flange in both directions. Apply and cure coating in accordance with manufacturer's recommendations. Do not apply coating where it will interfere with operation of pipeline valves or other pipeline assemblies.

    b. Exterior Coating: For buried insulating flanges, coat completed joint with petroleum wax tape in accordance with AWWA C217 and manufacturer's recommendations. Extend the wax tape coating system over the adjacent pipe coating by a minimum 18 inches away from the outside flange face, whichever distance is greater.

    c. The surfaces to receive the wax tape coating shall be clean and free of all dirt, grease, and other foreign material. Apply primer as recommended by tape manufacturer or cut strips of wax tape and apply them around all bolts, nuts and other irregular shapes so that there are no voids or spaces under the tape. Apply a sufficient amount of tape to completely encapsulate all exposed metallic surfaces. The minimum wax tape thickness shall be 70 mils over smooth surfaces and 140 mils over sharp and irregular surfaces, or of a thickness required to fill all voids. Apply two layers of polyvinylidene chloride, high cling membrane sheet over the wax tape coating by tightly wrapping it around the pipe such that it adheres and conforms to the wax tape. Secure the plastic wrap to the pipe with adhesive tape.

3.09 FIELD QUALITY CONTROL

A. Electrical Continuity Testing:

1. Furnish necessary equipment and materials, and make electrical connections to pipe as required to test continuity of bonded joints.
2. Conduct continuity test on buried joints that are required to be bonded. Test electrical continuity of joint bonds after bonds are installed but before coating of the joint and backfilling of the pipe.
3. Test electrical continuity of completed joint bonds using either a digital low resistance ohmmeter (DLRO) or by Calculated Resistance Method, at Contractor's option.
    a. Digital Low Resistance Ohmmeter Method:
        1) Provide the following equipment and materials:
            a) One Biddle Model 247001 digital low resistance ohmmeter (Megger International now manufactures Biddle Instruments).
            b) One set of 10-amp duplex test leads heavy duty fixed point current and potential hand spikes, Biddle Model No. 241002, cable length as required.
            c) One calibration shunt rated at 0.001 ohm, 100 amperes, Biddle Model No. 249004; MCM Miller 0.001 ohms, 100 amperes shunt.
        2) Test Procedure:
            a) Measure resistance of joint bonds with low resistance ohmmeter in accordance with manufacturer's written instructions.
            b) At the start and end of each day or shift, check DLRO test lead wire continuity by touching the P1 to P2 and C1 to C2 spikes to each other, which should result in an approximate zero (0) micro-ohm reading. At the same time, conduct field instrument calibration checks to a 100 amp, 0.001-ohm shunt, which should read approximately 1,000 micro-ohms. Conduct additional continuity and calibration checks when requested by Jacobs' Engineer or their representatives and record on test form.
            c) Use heavy duty duplex fixed point hand spikes to contact pipe on each side of joint, without touching thermite weld or bond.
            d) Clean contact area to bright metal by filing or grinding and without surface rusting or oxidation.
            e) Record measured joint bond resistance on test form described herein.

f) Repair damaged pipe coating in accordance with manufacturer's directions.

b. Calculated Resistance Method:

1) Provide the following equipment and materials:
   a) One dc ammeter (meter or clamp-on) with full scale reading of 100 amperes and a minimum resolution of 1 ampere or a 100-ampere shunt with a voltmeter as specified herein.
   b) One high resistance electronic voltmeter with a dc low range of 200 millivolts full scale to a dc high range of 20 volts full scale and capable of a minimum resolution of 1 millivolt (two voltmeters are required if a shunt is used).
   c) One knife switch, safety switch, or time controlled relay suitable for test current.
   d) Two electrical probes for the voltmeter.
   e) Insulated wire suitable for carrying the test current, length as required.
   f) One dc power supply with a steady capacity of 50 amperes minimum; storage batteries are not an acceptable power supply.

2) Test Procedure:
   a) Either tightly clamp or thermite weld current wire connections to the pipe. Determine wire size for the test current, and do not exceed 1,000 feet in length.
   b) Apply a minimum direct current of 50 amperes.
   c) Measure voltage drop across each joint with voltmeter by contacting pipe on each side of joint. Voltmeter connections to bond wire or thermite welds will not be acceptable.
   d) Clean contact area to bright metal by filing or grinding and without surface rust or oxidation.
   e) Measure current applied to test span and voltage drop across joint simultaneously.
   f) Repair damaged pipe coating in accordance with manufacturer's directions.
   g) Record measured voltage drop and current for each joint of test form described herein and calculate bond resistance in accordance with the following formula:

$$R = \frac{E}{I}$$

Where:

R = Resistance of the joint bond.
E = Measured voltage drop across the joint, in volts.
I = Test current applied to the pipe test span, in amperes.

4. Joint Bond Acceptance:

a. Joint Bond Resistance: Less than or equal to the maximum allowable bond resistance values in Table 1.

Table 1

Joint Type	Max. Allowable Resistance	
	1 Bond/Joint	2 Bonds/Joint
Push-On or Mechanical	0.000325 ohm	0.000162 ohm
Flexible Coupling	0.000425 ohm	0.000212 ohm

b. Replace joint bonds that exceed the allowable resistance. Retest replacement joint bonds for compliance with bond resistance.

c. Repair defective joint bonds discovered during energizing and testing.

d. Use a hammer to sharply hit the completed weld to knock off all slag and to physically test the completed exothermic connection. Pull on the bond wire to assure that there is a solid connection.

e. Visually and physically inspect the condition of all joint bond welds for a solid type connection and appearance with the wire being completely encapsulated in a well-formed, solid weld.

f. Where the wire is not fully encapsulated in weld metal, an additional exothermic weld is necessary. Clean the surface of first existing weld and place a second charge directly over the first weld to fully encapsulate the wire.

g. There shall be no evidence of a porous weld with visible honeycombs, pores or hollow tubes. If honeycombed or porous welds are observed, replace bond wire at that location, regardless of whether the bonds meet the specified measured resistance criteria or not.

h. In some instances, extremely hot weather with continued elevated surface temperatures (above 110 degrees F to 120 degrees F) may slightly influence the measured resistance of the joint bond. When testing during extremely hot weather, record the surface temperature with a contact type pyrometer during these times for direct comparison to measured resistance values. Record the measured

temperature and the actual measure resistance value. Contact Jacobs' Engineer for direction.

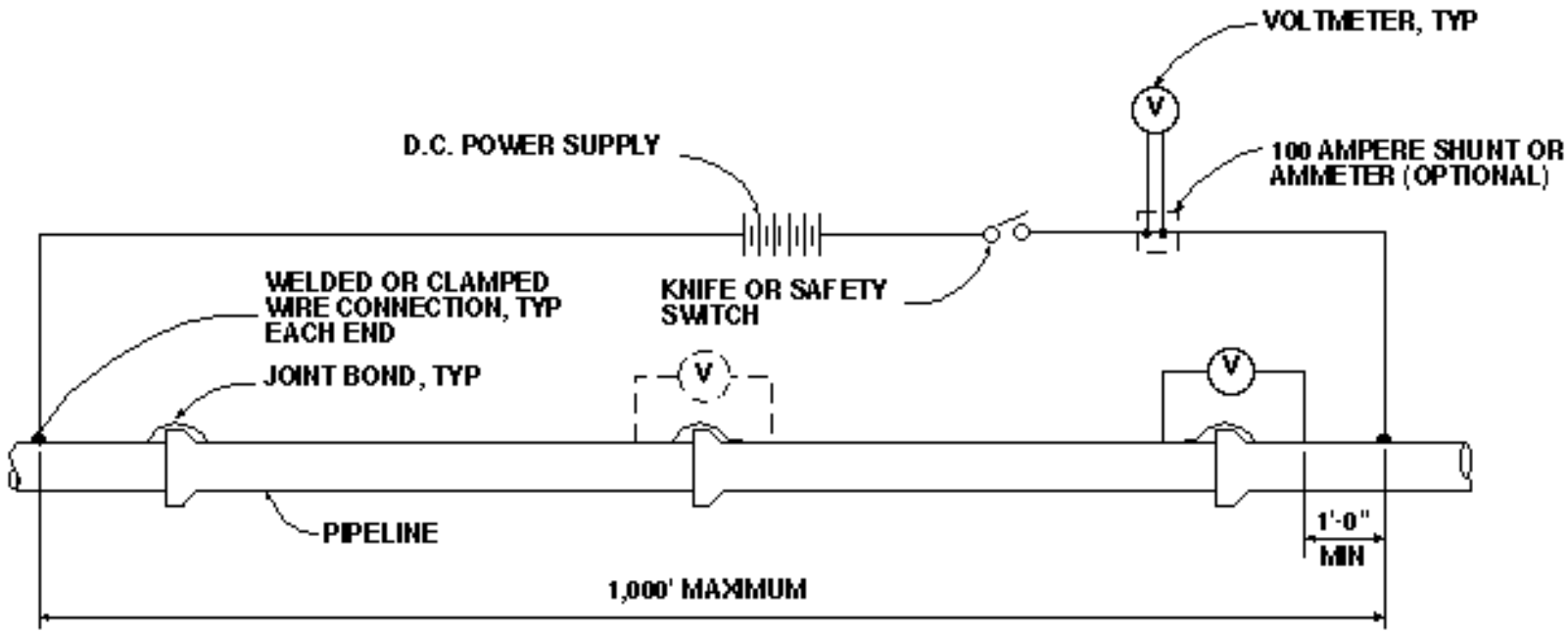
5. Record Tests of Each Bonded Pipeline:
    a. Description and location of pipeline tested.
    b. Starting location and direction of test.
    c. Date of test.
    d. Joint type.
    e. Test current and voltage drop across each joint and calculated bond resistance (Calculated Resistance Method only).
    f. Measured joint bond resistance (Digital Low Resistance Ohmmeter method only).
    g. Record test information on a form that includes information listed above.

B. Insulated Joint Testing:
    1. Provide Jacobs' Engineer with 3 days' advance notice before beginning tests.
    2. Cathodic Protection Specialist shall monitor the tests.
    3. Test each joint after assembly with insulator tester in accordance with manufacturer's written instructions.
    4. For insulating flanges, test and record insulating values of each bolt in addition to the completed flange.
    5. Replace damaged or defective insulation parts.
    6. Correct defects identified during testing.

3.10 SUPPLEMENT

A. The supplement listed below, following "End of Section," are a part of this Specification.
    1. Joint Bond Continuity Test Schematic.

END OF SECTION



JOINT BOND CONTINUITY TEST SCHEMATIC

DTE195.SP 104-17-95/mbb

SECTION 26 43 00
SURGE PROTECTION DEVICES

PART 1 GENERAL

1.01 SUMMARY

A. This section includes surge protection devices (SPD) for low voltage power systems.

1.02 SUBMITTALS

A. Submit product data on each suppressor type, indicating component values, part numbers, and conductor sizes. Include dimensional drawing for each, showing mounting arrangements.

B. Submit manufacturer's UL certified test data and nameplate data for each SPD.

C. Submit electrical single-line diagram showing location of each SPD.

D. Manufacturer's installation instructions.

E. Operating and maintenance data.

1.03 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer of transient voltage surge suppressor systems for minimum 5 years with satisfactory performance record.

B. Regulatory Requirements: UL rating of transient voltage surge suppressor shall meet or exceed UL rating of panelboard, motor control center, or other equipment in which suppressor is installed. UL rating of equipment in which suppressor is installed shall not be affected by suppressor.

C. UL Compliance and Labeling:
   1. For power and signal circuits, SPDs shall comply with UL 1449 and complimentary listed to UL 1283 as an electromagnetic interference filter. Provide units that are listed and labeled by UL.
   2. For telephone circuit protection, SPDs shall comply with UL 497A.

D. ANSI Compliance: Use SPDs in compliance with the recommendations of IEEE C62.41.1, IEEE C62.41.2, and IEEE C62.45.

PART 2 PRODUCTS

2.01 GENERAL

A. All SPDs for power circuits, provided under this section, shall be the product of a single manufacturer.

B. SPDs shall be capable of performance 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. SPDs shall include a fused disconnect to remove the suppressor from the electrical source should the suppressor fail. The fusing shall allow full surge handling capabilities and to afford safety protection from thermal overloads and short circuits.

D. Design SPDs for the specific type and voltage of the electrical service. Single-phase and three-phase wye-configured systems shall have L-N, L-G, and N-G protection. Grounded delta-configured systems shall have L-L and L-G protection.

E. Power Filter: The SPD shall include a high frequency extended range power filter complimentary listed to UL 1283 as an electromagnetic interference filter.

2.02 MANUFACTURER

A. Innovative Technology, VanGuard Series.

B. Advanced Protection Technologies, Inc.

C. General Electric.

D. "Or-equal."

2.03 MAIN 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 shall be not less than the following:
   1. L-N Capacity: 200 kA.
   2. L-G Capacity: 120 kA.
   3. N-G Capacity: 120 kA.

C. Suppressor housing shall be in an enclosure that has the same NEMA rating as the equipment it protects and painted to match.

D. UL 1449 maximum suppression voltage shall not be more than:

System Voltage	Phase	L-L or L-N Suppression Voltage
120	1	400
208Y/120	3	400
240	3	800

System Voltage	Phase	L-L or L-N Suppression Voltage
480Y/277	3	800

2.04 PANELBOARD SPD

A. Provide SPD meeting IEEE C62.41.1 and IEEE C62.41.2 Location Category B.

B. Surge current capacity shall be not less than the following:
   1. L-L Capacity: 80 kA.
   2. L-N Capacity: 80 kA.
   3. L-G Capacity: 80 kA.
   4. N-G Capacity: 80 kA.

C. Suppressor shall be in an enclosure that has the same NEMA rating as the panel it protects or the SPD may be integral to a panelboard.

D. UL 1449 maximum clamp voltage shall not be more than:

System Voltage	Phase	L-L or L-N Clamp Voltage
120	1	400
208Y/120	3	400
240	3	800
480Y/277	3	800

2.05 ANNUNCIATION

A. Provide unit or separately mounted LED-type indication lights to show the normal and failed status of each module. Provide one normally open and one normally closed contacts which operate when the unit fails.

2.06 SURGE COUNTER

A. Provide each SPD rated above 100 kA with a counter displaying the number of voltage transients that have occurred on the unit input. The counter shall be battery backed and retain the count through system power outages.

2.07 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 the 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.

2.08 PAIRED CABLE DATA LINE EXTERIOR SUPPRESSORS

A. Provide units meeting IEEE C62.41, Location Category A.

B. Suppressors shall be a hybrid design with a minimum of three stages, utilizing solid-state components and operating bi-directionally.

C. Suppressors shall 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 the normal applied signal voltage by 200 percent.

PART 3 EXECUTION

3.01 APPLICATION REQUIREMENTS

A. Install SPD when indicated on Drawings and:
   1. Main Distribution SPD in or near each low-voltage switchgear (load center).
   2. Main Distribution SPD in or near each motor control center.
   3. Panelboard SPD In or near each distribution panelboard unless otherwise indicated.

B. 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 all 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. Connecting wires shall be as short as possible with gently twisted conductors, tied together, to prevent separation. Connecting wires shall not exceed 24 inches in length at any point.

D. Field installed conductors shall be the same as specified for building wire, not smaller than 8 AWG and not larger than 4 AWG. Device leads shall not be longer than the length recommended by the manufacturer, unless specifically reviewed and approved by the manufacturer.

E. Provide dedicated disconnecting means for SPDs installed at switchgear and motor control centers. Provide dedicated 30-ampere to 60-ampere circuit breakers (size dependent upon wire size used) with number of poles as required, as disconnecting means for SPDs installed at panelboards. The interrupting capacity of the circuit breakers shall be that specified for the other breakers at that location.

END OF SECTION

SECTION 26 50 00
LIGHTING

PART 1 GENERAL

1.01 SUMMARY

A. This section includes lighting equipment.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. Certified Ballast Manufacturer (CBM).
   2. Federal Communications Commission (FCC).
   3. Illuminating Engineering Society of North America (IESNA).
   4. Institute of Electrical and Electronics Engineers (IEEE): C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
   5. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC) – Softbound Version.
   7. UL:
      a. 844, Electric Lighting Fixtures for Use in Hazardous (Classified) Locations.
      b. 924, Emergency Lighting and Power Equipment.

1.03 SUBMITTALS

A. Action Submittals:
   1. Shop Drawings:
      a. Interior Luminaires:
         1) Catalog data sheets and pictures.
         2) Luminaire finish and metal gauge.
         3) Lens material, pattern, and thickness.
         4) Candle power distribution curves in two or more planes.
         5) Candle power chart 0 degree to 90 degrees.
         6) Lumen output chart.
         7) Average maximum brightness data in foot lamberts.
         8) Coefficients of utilization for zonal cavity calculations.

9) Mounting or suspension details.

b. Exterior Luminaires:
   1) Catalog data sheets and pictures.
   2) Luminaire finish and metal gauge.
   3) Lens material, pattern, and thickness.
   4) IESNA lighting classification and isolux diagram.
   5) Fastening details to wall or pole.
   6) For light poles, submit wind loading, complete dimensions, and finish.

c. Photocells:
   1) Voltage, and power consumption.
   2) Capacity.
   3) Contacts and time delay.
   4) Operating levels.
   5) Enclosure type and dimensions.
   6) Temperature range.

d. Occupancy Sensors:
   1) Type.
   2) Switching capacity.
   3) Coverage.
   4) Time delay AUTO/OFF adjustment.

e. Low Voltage Remote Control Wiring System:
   1) Type.
   2) Switching capacity.
   3) Voltage rating.
   4) Wiring diagrams.

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

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

1.04 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):
   1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.

2. Materials and equipment manufactured within the scope of standards published by UL shall conform to those standards and shall have an applied UL listing mark.
3. Assembled fixture, complete with lamps, shall be in accordance with California Code of Regulations Title 24 requirements.

B. Preinstallation Meeting:
1. Occupancy Sensors: Arrange preinstallation meeting with manufacturer's factory authorized representative at Owner's facility, to verify placement of sensors and installation criteria.

PART 2 PRODUCTS

2.01 LUMINAIRES

A. Specific requirements relative to execution of the Work of this section are located in Luminaire Schedule on Drawings.

B. All exterior luminaires shall be marine grade.

C. Feed-through type, or separate junction box.

D. Wire Leads: Minimum 18 AWG.

E. Component Access: Accessible and replaceable without removing luminaire from ceiling.

F. Soffit Installations:
1. UL Labeled: SUITABLE FOR DAMP LOCATIONS.

G. Exterior Installations:
1. UL Labeled: SUITABLE FOR WET LOCATIONS.
2. When factory-installed photocells are provided, entire assembly shall have UL label.

H. Emergency Lighting:
1. Power Pack: Self-contained, voltage as indicated on Drawings.
2. Lighted, push-to-test indicator.
3. Capable of providing full illumination for 1-1/2 hours in emergency mode.
4. Capable of full recharge in 24 hours, automatically upon resumption of normal line voltage.
5. Capable of protecting against excess charging and discharging.

I. Hazardous Classified Areas:

1. UL Labeled: Class I, Division 1, Groups C and D.
2. Fixture Enclosure and Fittings: Copper-free, cast aluminum in accordance with UL 844.

2.02 LAMPS, LED

A. Construction: Extruded aluminum heat sink, painted gloss white enamel with aluminum accents.

B. Lamps:

1. 6,000 nominal design lumens.
2. Color Temperature: 70 CRI, 4000k CCT.
3. Guaranteed 92 percent lumen maintenance at 60,000 hours.

C. Optics: Wide distribution, highly diffuse acrylic lens.

D. Drivers:

1. Meet requirements for fixture light output, reliable starting, radio interference, total harmonic distortion, electromagnetic interference, and dielectric rating.
2. Certified by electrical testing laboratory to conform to DLC specifications.
3. Thermally protected driver(s) standard with 0V to 10V dimming.
4. LEDs are driven at 350 mA (nominal), Voltage as indicated by Luminaire Schedule.

E. Manufacturers:

1. Lithonia or Holophane by Acuity.
2. Hubbell Lighting.
3. Crouse-Hinds.

F. Manufacturers:

1. CREE
2. Phillips Lighting Company.
3. General Electric Co.
4. Osram Sylvania.
5. “Or-equal.”

2.03 LIGHTING CONTROL

A. Photocell:
   1. Automatic ON/OFF switching photo control.
   2. Housing: Self-contained, die-cast aluminum, unaffected by moisture, vibration, or temperature changes.
   3. Setting: ON at dusk and OFF at dawn.
   4. Time delay feature to prevent false switching.
   5. Field adjustable to control operating levels.
   6. Manufacturers:
      a. Tork.
      b. Paragon Electric Company.
      c. "Or-equal."

B. Dimming System:
   1. Fluorescent dimmer capable of dimming from one to ten 40-watt rapid-start lamps.
   2. Size: Fit in a single gang wall box.
   3. Positive OFF switching and low intensity trim adjustment without removing dimmer from box.
   4. Manufacturers:
      a. Lutron Electronics Co., Inc.
      b. Pass and Seymour/LeGrand.
      c. Lithonia Lighting Co.
      d. "Or-equal."

C. Low Voltage Remote Control Wiring System:
   1. Provide a complete low-voltage, remote control wiring system for control of lighting fixtures as indicated on Drawings and Schedules. System shall be complete with transformers, rectifiers, relays, switches, master switches, electronic controls, enclosures, wall plates, and wiring. System and components shall be of same manufacturer.
   2. Remote control wiring shall be in accordance with Article 725, Class 2 of NFPA 70.
   3. Provide for direct-wired connection of:
      a. Standard of pilot light switches for individual control of relays.
      b. Two independent master override inputs which allow ON/OFF control of all relays while still supporting individual control of each relay.

4. Relay panels shall be configured to allow future addition of up to two master controls of programmable control of all relays.

D. Occupancy Sensors:

1. Passive Infrared:
   a. Wall switch sensors shall be capable of detection of motion at desk top level up to 300 square feet and gross motion up to 1,000 square feet.
   b. Wall switch sensors shall accommodate loads from 0 watts to 800 watts at 120 volts; 0 watts to 1,200 watts at 277 volts and shall have 180-degree coverage capability.
   c. Bi-level wall switch sensors shall accommodate up to two loads from 0 watts to 800 watts at 120 volts; 0 watts to 1,200 watts at 277 volts, for each load.
   d. Passive infrared sensors shall have a multiple segmented lens, in a multiple-tier configuration, with grooves-in to eliminate dust and residue build-up.
   e. Wall switches shall be compatible with electronic ballasts.
2. Dual Technology Units:
   a. Unit to be ceiling mounted for 360-degree coverage.
   b. Unit shall utilize both passive infrared and ultrasonic technologies and be easily programmed to accommodate different environmental and architectural conditions.
   c. Unit must detect up to 2,000 square feet with no blind spots.
   d. No audio dual technology units will be accepted.
3. Circuit Control Hardware—CU Power Packs:
   a. Control Units: Able to mount through a 1/2-inch knock-out in a standard electrical enclosure and be an integrated, self-contained unit consisting internally of an isolated load switching control relay and a transformer to provide low-voltage power. Transformer shall provide power to a minimum of two sensors.
   b. Relay contacts shall have ratings of:
      1) 13A, 120V ac tungsten.
      2) 20A, 120V ac ballast.
4. Wiring: Control wiring between sensors and control units shall be Class II, 14-AWG, stranded, UL Classified, PVC insulated or Teflon jacketed cable approved for use in plenums, where applicable.
5. General:
   a. Sensors shall be capable of operating normally with any electronic ballast and PL lamp systems.

b. Coverage of sensors shall remain constant after sensitivity control has been set. No automatic reduction shall occur in coverage due to cycling of air conditioner or heating fans.

c. Sensors shall have readily accessible, user adjustable controls for time delay and sensitivity.

d. In event of failure, bypass manual OVERRIDE ON key shall be provided on each sensor. When bypass is utilized, lighting shall remain on constantly or control shall divert to a wall switch until sensor is replaced. This control shall be recessed to prevent tampering.

e. Units shall have an extra Form C (1-NO-1-NC) contact for interface with building system. Units shall be designed to be mountable in standard electrical box.

f. Units shall have capability of being ordered with integral power pack.

g. Manufacturers:

1) Unenco, Inc.

2) The Watt Stopper, Inc.

3) "Or-equal."

2.04 POLES

A. Rating (with Luminaire): 100 mph steady winds, without incurred damage.

B. Material: Extruded aluminum.

PART 3 EXECUTION

3.01 LUMINAIRES

A. General:

1. Install in accordance with manufacturer's recommendations.
2. Provide proper hangers, pendants, and canopies as necessary for complete installation and meeting specified seismic requirements.
3. Provide additional ceiling bracing, hanger supports, and other structural reinforcements to building required to safely mount.
4. Install plumb and level.
5. Install each luminaire outlet box with galvanized stud.

B. Mounting:

1. General:

a. Mounting, fastening, and environmental conditions shall be coordinated with Section 26 05 02, Basic Electrical Requirements.

b. Refer to Fastener Schedule in Section 05 50 00, Metal Fabrications.

2. Wall Mounted: Measure mounting heights from center of mounting plate to finished floor or finished grade, whichever is applicable.

3. Pendant Mounted:

a. Provide swivel type hangers and canopies to match luminaires, unless otherwise noted.

b. Space single-stem hangers on continuous-row fluorescent luminaires nominally 48 inches apart.

c. Provide twin-stem hangers on single luminaires.

d. Measure mounting heights from bottom of luminaire to finished floor or finished grade, whichever is applicable.

4. Pole Mounted: Provide cast-in-place concrete base.

C. Swinging Type: Provide, at each support, safety cable capable of supporting four times vertical load from structure to luminaire.

D. Finished Areas:

1. Install symmetrically with tile pattern.

2. Locate with centerlines either on centerline of tile or on joint between adjacent tile runs.

3. Install recessed luminaires tight to finished surface such that no spill light will show between ceilings and sealing rings.

4. Combustible Low Density Cellulose Fiberboard: Provide spacers and mount luminaires 1-1/2 inches from ceiling surface, or use fixtures suitable for mounting on low density ceilings.

5. Junction Boxes:

a. Flush and Recessed Luminaires: Locate minimum 1-foot from luminaire.

b. In concealed locations, install junction boxes to be accessible by removing luminaire.

6. Wiring and Conduit:

a. Provide wiring of temperature rating required by luminaire.

b. Provide flexible steel conduit.

7. Provide plaster frames when required by ceiling construction.

8. Independent Supports:

a. Provide each recessed fluorescent luminaire with two safety chains or two No. 12 soft-annealed galvanized steel wires of length needed to secure luminaire to building structure independent of ceiling structure.

b. Tensile strength of chain or wire, and method of fastening to structure shall be adequate to support weight of luminaire.

c. Fasten chain or wire to each end of luminaire.

E. Unfinished Areas: Locate luminaires to avoid conflict with other building systems or blockage of luminaire light output.

1. Fixture Suspension: Provide 3/8-inch threaded steel hanger rods. Scissor type hangers not permitted.

2. Attachment to Steel Beams: Provide flanged beam clips and straight or angled hangers.

F. Building Exterior: Flush-mounted back box and concealed conduit, unless otherwise indicated.

3.02 LAMPS

A. Provide in each fixture, number and type for which fixture is designed, unless otherwise noted.

3.03 BALLASTS

A. Install in accordance with manufacturer's recommendations.

B. Utilize all ballast mounting holes to fasten securely within luminaire.

C. Replace noisy or defective ballasts.

3.04 LIGHTING CONTROL

A. Outdoor Luminaires:

1. HAND/OFF/PHOTOCELL switch will control the lights:

a. HAND: Lights On.

b. OFF: Lights Off.

c. PHOTOCELL: Lights on at dusk and off at dawn.

B. Dimming Systems:

1. Install in accordance with manufacturer's recommendations.

2. Do not connect ballasts or equipment to dimming system unless acceptable to dimming system manufacturer.

C. Occupancy Sensors: Locate and aim sensors in correct location required for complete and proper volumetric coverage within range of coverage(s) of controlled areas per manufacturer's recommendations. Rooms shall have 90 percent to 100 percent coverage to completely cover controlled area to accommodate all occupancy habits of single or multiple occupants at any location within room(s). Locations and quantities of sensors shown on Drawings are diagrammatic and indicate only rooms which are to be provided with sensors. Provide additional sensors if required to properly and completely cover respective room.

3.05 EMERGENCY BALLAST

A. Install battery, charger, and electronic circuitry metal case inside fixture housing.

B. Install monitoring light and double-pole switch adjacent to light fixture.

C. Wire in accordance with manufacturer's wiring diagrams.

3.06 EMERGENCY LIGHTING UNIT

A. Install in accordance with manufacturer's recommendations.

B. Provide permanent circuit connections with conduit and wire.

C. Connect to branch circuit feeding normal lighting in area ahead of all local switches.

D. Provide separate circuit wiring to luminaire.

3.07 CLEANING

A. Remove labels and markings, except UL listing mark.

B. Wipe luminaires inside and out to remove construction dust.

C. Clean luminaire plastic lenses with antistatic cleaners only.

D. Touch up painted surfaces of luminaires and poles with matching paint ordered from manufacturer.

E. Replace defective lamps at time of Substantial Completion.

END OF SECTION

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. California Building Code (CBC) with local amendments.
   2. California Fire Code (CFC) with local amendments.
   3. California Mechanical Code (CMC) with local amendments.
   4. Institute of Electrical and Electronics Engineers (IEEE): C62.41, Surge Voltages in Low-Voltage AC Power Circuits.
   5. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   6. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
      b. 72, National Fire Alarm 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. 820, Fire Protection in Wastewater Treatment and Collection Facilities.
      f. 1221 Standard for the Installation, Maintenance and Use of Emergency Services Communications Systems.
   7. National Institute for Certification in Engineering Technologies (NICET).
   8. 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.
   9. UL:
      a. 217, Single and Multiple Station Smoke Alarms.
      b. 228, Door Closures-Holders, With or Without Integral Smoke Detectors.
      c. 268, Smoke Detectors for Fire Protective Signaling Systems.
      d. 286A, Smoke Detectors for Duct Application.
      e. 464, Audible Signal Appliances.
      f. 497B, Protectors for Data Communication and Fire Alarm Circuits.

g. 864, Control Units for Fire-Protective Signaling Systems.
h. 1449, Standard for Transient Voltage Surge Suppressors.
i. 1480, Speakers for Fire-Protective Signaling Systems.
j. 1604, Electrical Equipment for Use in Class I and Class II, Division 2, and Class III Hazardous (Classified) Locations.
k. 1638, Visual Signaling Appliances – Private Mode Emergency and General Utility Signaling.
l. 1971, Signaling Devices for the Hearing Impaired.

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. LCD: Liquid Crystal Display.

L. LED: Light-Emitting Diode.

M. MOV: Metal Oxide Varistor.

N. RAM: Random Access Memory.

O. SOM: Sequence of Operations Matrix.

P. 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). Other component locations and quantities shall be determined by fire alarm system installer and shall be included as part of their design. This includes, but is not limited to, smoke detectors, heat detectors, manual pull stations, and notification appliances. Design and installation shall meet requirements of the 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. Coordinate, and include in design, requirements for interfacing with HVAC systems and DCS system.
5. Equipment suitable for addressable fire alarm system.
6. Seismic Design:
    a. Seismic loads as shown on the General Structural Notes in Drawings.
    b. Seismic certification shall be conducted in accordance with 2016 California Building Code, Chapter 17.
    c. Component is required to remain operable following the design earthquake ground motion. Active parts or energized components shall be certified on basis of approved shake table testing or experience only unless demonstrably similar to other equipment so qualified.

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.

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.
3. Sequence of Operations Matrix at the End of Section describes functions of fire alarm system.

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. For each system's control panel, provide written schedule of active and spare addresses provided on each addressable circuit.

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

B. Informational Submittals:

1. Experience and qualifications of firm(s) proposed to design and install system.
2. Certifications documenting service technician's training. Certification shall indicate name of individual, training, dates, systems qualified, and current status.
3. Submit anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
4. Component and attachment testing seismic certificate of compliance in accordance with 2016 California Building Code. Certificate of compliance shall list method and criteria of certification
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. Documentation of system voltage, current, and resistance readings taken during installation, testing, and ATP phases of system installation.
11. System record drawings and wiring details including one set of reproducible masters and drawings on CD-ROM in a DXF format suitable for use in a CAD drafting program.
12. NFPA 72, Record of Completion: Submit to Owner and code-enforcement authorities.
13. NFPA 72, Inspection and Testing Form: Submit to Owner and code enforcement authorities.
14. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.05 QUALITY ASSURANCE

A. Qualifications:
   1. Provide names of projects, locations, and telephone numbers of persons to contact for at least two installations where Contractor or Subcontractor has installed detection and alarm systems that are similar in size and scope as this.
   2. System design, installation and testing shall be performed by licensed firm(s) with established reputation in fire alarm system industry having 5 years' experience in design, installation, and testing of fire alarm systems.
   3. Technician with minimum of NICET Level II Certification for fire alarm systems or professional engineer registered in State of California shall be available onsite.
   4. Service technician shall be formally trained by manufacturer.

B. Regulatory Requirements: Submit Shop Drawings and system design calculations for approval to the following code enforcement authorities.
   1. City of San José Fire Department.

1.06 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.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:
   1. Fike.
   2. Edwards Systems Technology.

2.02 GENERAL

A. Material and equipment shall be standard products of their respective manufacturers, and shall be of a model that has been in production for not less than 3 years. Equipment shall be supported by a service organization that is, in the opinion of Owner, reasonably convenient to Site.

B. Contractor shall become familiar with details of Project, verify dimensions in field, and revise conduit and equipment locations to avoid obstructions and allow installation of new equipment.

C. Contractor shall not begin system installation prior to receiving written approval of Shop Drawings from Design-Builder.

2.03 UL COMPLIANCE

A. Products manufactured within scope of UL shall conform to UL Standards and have an applied UL listing mark.

B. Equipment shall be UL listed in accordance with requirements of NFPA.

2.04 SERVICE CONDITIONS

A. Altitude: Not greater than 3,300 feet above sea level.

B. Ambient Temperature:
   1. Maximum 40 degrees C.
   2. Minimum 0 degree C.

C. Equipment shall be fully rated without derating for these conditions.

2.05 FIRE ALARM CONTROL PANELS

A. General:
   1. Control panel circuit for 24V dc, power limited, initiating circuits per NFPA 70, Article 760.
   2. Assembled panel UL 864 listed Product Category UOJ2, as an integrated control system.
   3. Enclosure:
      a. NEMA 250 Type 1.
      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 Ni-Cd 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 C output circuitry for remote alarm control panel.

9. MOV/gas discharge transient protection for power supply module, plus initiating and indicating alarm devices.

10. 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. System shall be designed and installed so as 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.

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 Signaling Line Circuit Class A and Class A, Style Z 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) Displayable when door is open.
f. Four function keys for control of variable functions related to primary operations keypad, displayable when door is open.

4. TIA 485, NFPA 72, Style 4, Style 6, or Style 7 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, Style B or Style D, initiating device circuits or NFPA 72, Style Y or Style Z, indicating appliance circuits or auxiliary control circuits.

c. Auxiliary control circuit contacts shall be single-pole, double-throw, rated 2 amperes at 24V dc and 0.5 amperes at 120V ac.

9. Auxiliary control circuit contacts shall be 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.

2.06 ADDRESSABLE DETECTOR BASE

A. Solid state circuitry with integral LED visual alarm, dip switch or program selectable addressing, and common base receptacle for ionization, photoelectric, and heat detectors. Device address shall be located in base.

B. Constantly monitors detector status and status changes.

C. Suitable for mounting on standard outlet box.

D. Normally open, double-pole contacts rated 3 amperes, 30V dc.

2.07 INDIVIDUAL ADDRESSABLE MODULE

A. Solid state circuitry with selectable latch/nonlatch operating conditions and mounting plate.

B. Monitors single and multiple devices with dry contacts.

C. Suitable for installing inside 4-inch by 4-inch by 2-1/2-inch electrical box.

2.08 ZONE ADDRESSABLE MODULE

A. Monitor module with solid state circuitry for Class A circuits serving dry contact initiating devices.

B. Signal module with solid state circuitry for supervising and operating Class A circuits serving 24V dc signals, speakers, and telephone devices.

C. Control module with solid state circuitry for supervised control functions.

D. Module complete with mounting plate, suitable for installation in 4-inch by 4-inch by 2-1/2-inch electrical box having 1-1/2-inch deep extension ring.

2.09 INITIATING DEVICE

A. Pull Station, Fire:
   1. Single-action station for general alarm.
   2. Constructed of red molded polycarbonate material, and raised white letters stating “FIRE.”
   3. Surface-mounted with hinged front cover having keyed or Allen-wrench reset lock.
   4. Where required, rated for use in hazardous environments.
   5. Recessed pull handle for single action lift door and pull handle for double action operating station with plastic break rod.
   6. Activated station pull handle, latched in protruding position until reset by key.
   7. Stations keyed alike with fire alarm control panel.
   8. Screw terminal for field connections.
   9. Normally open, double-pole contacts rated 3 amperes, 30V dc for resistive loads.
   10. Manual Pull Station: Microprocessor-based communication circuit address, and compatible with fire alarm control panel.

B. Heat Detector:
   1. Fixed plug-in temperature elements with 460 degrees C trip setting, complete with addressable mounting base.
   2. Nonrestorable fixed temperature elements.
   3. Dangling disk indicator for activated fix temperature element.
   4. Attach detector bases on surface mounted octagon boxes.
   5. Conceal surface mounted boxes with surface trim skirt.
   6. Double-screw terminals for supervised connection.
   7. Normally open, double-pole contacts, rated 3 amperes, 30V dc.

C. Smoke Detector:
   1. Ionization type with plug-in, twist-lock addressable base per UL 217 and UL 268.
   2. Solid state circuitry, unipolar, single source, dual sensing chamber, suitable for device releasing service.
   3. Concealed, field adjustable, sensitivity test switch.
   4. LED; pulsed indication for power availability and steady indication for activated detectors.

5. Self-Compensating Circuitry:
    a. Voltage Range: 15V dc to 30V dc, 24V dc nominal.
    b. Temperature Range: 0 degree C to 38 degrees C.
    c. Operating Temperature Range: Minus 10 degrees C to 50 degrees C.
    d. Humidity Range: 0 percent to 95 percent relative humidity.
6. Normally open, double-pole contacts, rated 3 amperes, 30V dc for resistive loads.
7. Detectors equipped with insect screen.
8. Photoelectric sensors adjusted to within 3 percent of UL 217 window obturation sensitivity value.

D. 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.

2.10 ALARMS

A. Audible Alarm:
1. General:
    a. Polarized, 24V dc device with sound power measured dB in accordance with UL 464.
    b. Separate in/out wire leads for field connections.
    c. Baked red enamel finish.
    d. Audibility: In accordance with NFPA 72 and local requirements.
2. Modular Horn:
    a. Surface basic unit, complete with single projector, designed for mounting on 4-inch square standard electrical box.
    b. Manufacturer supplied box with flush grille plate and basic surface unit for recessed horns.
    c. Explosion-Proof Horns: Vibrating diode type with sealed wires, and tapped for 3/4-inch conduit in accordance with UL 1604.

3. Modular Bell: Vibrating basic unit complete with 6-inch gong designed for mounting on 4-inch standard electrical box.
4. Explosion-Proof Bell: Vibrating diode type with 6-inch gong, sealed wires, and tapped for 3/4-inch conduit in accordance with UL 1604. Rated for environment as shown on Drawings.
5. Chime: Vibrating type with field adjustable volume control, designed for mounting on 4-inch square standard electrical box.
6. Multiple-Tone Horn:
    a. Microprocessor-based, field programmable tone selection and volume control, suitable for installation indoors and outdoors.
    b. Program by setting miniature switches to obtain siren tone.
7. Single protection type bell with weatherproof housing, rated for 120V ac motor, adjustable mounting bracket, and audible output of 115 dB.

B. Visual Alarm, Fire:
1. Polarized, 24V dc, multi-candela indicating output per UL 1638.
2. Solid state circuitry for high intensity control of xenon flashtube.
3. Tamper-proof, translucent molded, polycarbonate, pyramidal shaped lens with “FIRE” in red lettering visible from 180-degree viewing field; red enclosure.
4. Polarized in/out wiring.
5. Designed for mounting on wall, single-gauge electrical box, or as part of audible/visible base housing.

C. Visual Alarm in Outdoor or Hazardous Location:
1. Cast metal fixture with red glass globe and guard.
2. Rating: 100 candela at 120V ac.
3. UL Listed for wet locations when installed outdoors.
4. UL Listed for classification of hazardous location where alarm is to be installed.
5. Designed for wall mounting.

D. Audio 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.

2.11 WIRING

A. AC power wiring shall meet requirements of Section 26 05 05, Conductors.

B. Low voltage wiring shall be solid copper or bunch tinned (bonded) stranded copper, minimum 14 AWG, and shall meet NEC Article 760 for nonpower limited service.

C. Network or addressable loop cables shall be as recommended by manufacturer for installation of their system and UL Listed for Fire Alarm Systems.

2.12 RACEWAYS

A. Conduit used for installation of Fire Alarm or Emergency Alarm system shall follow requirements as identified in Section 26 05 33, Raceway and Boxes.

2.13 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.

2.14 SURGE SUPPRESSORS

A. Surge Protective Devices (SPD): In accordance with Section 26 43 00, Surge Protection Devices.

B. Surge Protection Devices (SPD):
   1. Provide to suppress voltage transients that might damage fire alarm panel/transmitter components. Unit shall wire in series to power supply of protected equipment with screw terminations.
   2. Unit shall be UL 1449 listed with a 330-volt suppression level and have a maximum response time of 5 nanoseconds.
   3. Unit shall meet IEEE C62.41 Category B tests for surge capacity.
   4. Features:
      a. Multi-stage construction that includes inductors and silicon avalanche Zener diodes.
      b. Long life indicator lamp (LED or neon lamp) which extinguishes upon failure of protection components. Fusing shall be externally accessible when this feature is available.
   5. Manufacturer and Product: Edco of Florida, Ocala, FL; Model HSP-121BT2.

2.15 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 13, Wet Pipe Sprinkler Systems, 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.

C. Provide outlet and junction boxes that are compatible with raceway system.

D. Mount detector LEDs so they are readily visible from floor.

E. Program or configure panels and devices, as required to operate as defined by Sequence of Operations Matrix included as Supplement at End of Section.

F. Install conductors in accordance with Section 26 05 05, Conductors, and NFPA 70, Article 760.

G. Install initiating alarm, signal, and communication conductors in separate and independent raceway system.

H. Circuit wiring color-code, as established by installer, to be maintained throughout installation.

I. Size conductors in accordance with device manufacturer's recommendations. Increase AWG size of alarm conductors, if necessary, to maintain terminal voltage drop within acceptable level required by NEC and NFPA.

J. Detectors shall not be installed until after construction cleanup of trades is complete, per requirements of NFPA. Exception, where required by AHJ for protection during construction, detectors installed prior to final clean-up by trades shall be cleaned or replaced.

K. HVAC Equipment: Wire and connect fire alarm system to air handling system, smoke exhaust fan and smoke damper control circuits, and fan status contacts. Coordinate work with Section 23 09 00, Instrumentation and Control Devices for HVAC.

3.03 CONDUIT

A. Requirements apply to fire alarm system conduits, electrical enclosures, terminal cabinets, junction boxes, pullboxes, and device backboxes.

B. Conduit systems shall be dedicated to fire alarm system and shall contain no unrelated conductors.

C. Fire alarm system conduits shall be of sizes and types specified under Section 26 05 33, Raceway and Boxes.

1. Conduit shall be as identified under Section 26 05 33, Raceway and Boxes. Flexible metallic conduit may be used for whips to devices only, maximum length 6 feet, 3/4-inch diameter minimum. Set screw type couplings or connectors are specifically prohibited.
2. Size conduits according to conductors contained therein. Cross sectional area percentage fill for fire alarm system conduits shall not exceed 40 percent.

D. Route and install conduit to minimize potential for physical damage, either mechanical or by fire, and so as not to interfere with existing building systems, facilities or equipment, and to facilitate service and minimize maintenance. Coordinate installation between different trades to avoid conflicts.

1. Conduit, except flexible conduit whips to devices, shall be solidly attached to building structural members or permanent walls. Conduit shall not be attached 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. Conduit shall be routed either parallel or perpendicular to building structural members.

3. Conduit shall be installed at a height so as not to obstruct any portion of a window, doorway cable tray, stairway or a passageway, and shall not interfere with operation of existing mechanical or electrical equipment.
4. Conduit, junction boxes, pull boxes, terminal cabinets, electrical enclosures and device backboxes shall be readily accessible for inspection, testing, service and maintenance.
5. Conduits shall be arranged to minimize the possibility of water in those conduits draining through control panels.
    a. Conduit, except nipples between control panels shall be arranged to enter control cabinets from below.
    b. Conduit shall be provided with three, 1/4-inch drain holes at horizontal low point beneath each control cabinet.
6. Bushings shall be provided at termination of conduit, prior to installation of wire.
7. Install junction boxes as necessary. Conductors shall be pulled through junction boxes, without splices.
8. Pullboxes shall be installed in each conduit at intervals not to exceed 100 feet. Pullboxes shall be 4-inch square, minimum.
9. Device backboxes and junction boxes shall be sized to accommodate number of conductors contained. Extension rings or extension boxes are prohibited.
10. Junction boxes, pull boxes, terminal cabinets, device backboxes, and raceways shall be gasketed and weather-tight per requirements of Section 26 05 33, Raceway and Boxes.

E. Conduit, junction boxes, panels, electrical enclosures, relays and device backboxes shall be exposed in unfinished areas. Conduit and device backboxes shall be concealed in walls, ceiling spaces, electrical shafts or closets, in finished areas, except as noted on Drawings. Exposed conduit penetrations of walls shall be provided with escutcheon plates on either side of the wall.

F. Conduit penetrations of walls, floors and ceilings shall be sealed 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.

G. Pull boxes, junction boxes, conduit bodies, and terminal cabinets shall be painted “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.

H. Conduit shall be grounded by approved ground clamps, and per NEC requirements.

I. Mount end-of-line resistors on terminal blocks.

J. Detection and alarm wire shall be installed in separate conduits. Outgoing and return conductors for each supervised circuit shall be routed in separately as required by NFPA 72. The minimum separation of outgoing and return conduits shall be 1 foot vertically and 4 feet horizontally.

3.04 IDENTIFICATION

A. Junction, terminal, and pulling box covers shall be painted red and identified with engraved labels by loop number zone and circuit that it contains.

B. Detection and terminal devices shall have engraved alphanumeric identification that shall be 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 shall be:
   1. New; wire that has scrapes, nicks, gouges or crushed insulation shall not be used.
   2. Installed in conduit.
   3. Continuous between devices and between devices and intermediary terminal cabinets.
   4. Low voltage conductors shall be minimum size No. 14 AWG.
   5. In accordance with requirements of NEC, Article 760 for nonpower limited service.

C. Splices in conductors are specifically prohibited.

D. Types:
   1. Conductors, except ac power conductors and grounding conductors, shall be 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.
3. Each conductor termination shall be uniquely numbered with durable plastic tags or uniquely identifiable by a combination of numbers and color codes. These conductor numbers shall be shown 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 (i.e., solenoids), such connections shall be soldered and taped.

F. Control Panel Wiring:
1. Fully dressed and bundled with nylon tie wraps at 3-inch intervals.
2. Bundled wiring shall be routed parallel to terminal strips within control panels, with individual conductors turned out at 90 degree angles to their associated terminal connections.
3. AC power conductors shall be bundled and routed separately from low voltage conductors. A minimum 2-inch separation shall be maintained between ac power conductors and low voltage conductors wherever possible.
4. Control cabinets shall be sized to accommodate the requirements of this Section.
5. Control panels shall not be used as raceways. Conductors that do not terminate within a control panel shall not be routed through that control panel.

G. Conductors shall be separated into the following categories:
1. Low voltage circuits that serve devices.
2. ac power circuits.

H. Each category of conductors shall be installed in physically separated, dedicated conduits, and shall not interface with one another, except at common associated control equipment. Conductors shall be further segregated 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 shall be THHN or TFFN stranded. Use of multi-conductor twisted pair or similar wiring is not permitted.

J. Install as nonpower limited circuits in accordance with NFPA 72, and NEC, Article 760.

K. Conductors looped around terminals are prohibited.

L. Wire nut splices are prohibited.

M. T-tapping of circuits is prohibited.

N. Circuits shall be megger tested to voltage rating of their insulation before final terminations are made.

3.06 OVERVOLTAGE AND SURGE PROTECTION

A. Install TVSS for fire alarm control panel per 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 Design-Builder, 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 and Design-Builder.

D. Each smoke detector shall be individually field tested prior to installing device at its designated location to ensure reliability after shipment and storage conditions. A dated log indicating system address, type of device, sensitivity and initials of technician performing test, using test equipment specifically designed for that purpose, shall be prepared and kept for 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. Resistance, current, and voltage readings shall be made as work progresses.
   1. Systematic record shall be maintained of all readings using schedules or charts of tests and measurements. Areas shall be provided on logging form for readings, dates, and witnesses.
   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 (See Supplement at End of Section) referencing each alarm input to every output function affected as a result of an alarm, trouble, or supervisory condition on that. In case of outputs programmed using more complex logic functions involving “any”, “or”, “not”, “count”, “time”, and “timer” statements; complete output equation shall be referenced 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. Incorrect device address.
      f. Loss of data communications between system control panels.
      g. Loss of data communications between system annunciators.
   2. Demonstrate system evacuation alarm indicating appliances as follows:
      a. Alarm notification appliances actuate as programmed.
      b. Audibility and visibility at required levels.
   3. System indications shall be demonstrated as follows:
      a. Correct message display for each alarm input, at control panel, each remote alphanumeric LCD display.
   4. Demonstrate system onsite and offsite reporting functions as follows:
      a. Correct alarm custom message display, address, device type, date and time transmitted, for each alarm input.
      b. Correct trouble custom message display, address, device type, date and time transmitted, for each alarm input.

c. Trouble signals received for disconnect.

5. Secondary power capabilities shall be demonstrated as follows:

a. Disconnect system primary power for a period of time as specified herein; at end of period, alarm condition shall be created and system shall perform as specified for period as specified.

b. Restore system primary power for 48 hours and system-charging current shall be 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. In the event system fails to perform as specified and programmed during acceptance test, test shall be terminated at discretion of acceptance inspector.

1. Retest system, correcting deficiencies and providing test documentation to acceptance inspector.

2. In event that software changes are required during acceptance test, system manufacturer to compare edited program with original and shall furnish utility program. Utility shall yield printed list of changes and system functions, inputs and outputs affected by changes. Items listed by program shall be minimum acceptable to be retested before calling for resumption of acceptance test. Submit printed list and printer log of retesting before scheduling 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 Design-Builder, 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.

3.10 SUPPLEMENT

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

1. Sequence of Operations Matrix.

END OF SECTION

SEQUENCE OF OPERATIONS MATRIX

HEADWORKS 3 ELECTRICAL BUILDING FACP

TAG: 14FACP100

SYSTEM OUTPUTS

SYSTEM INPUTS	FACP ANNUNCIATION											NOTIFICATION											FIRE SAFETY			
	A: ACTUATE ALARM INDICATOR	B: ACTIVATE AUDIBLE ALARM SIGNAL	C: ACTUATE SUPV SIGNAL INDICATOR	D: ACTUATE AUDIBLE SUPERVISORY SIGNAL	E: ACTUATE TROUBLE INDICATOR	F: ACTUATE AUDIBLE TROUBLE SIGNAL	G: TEXT DISPLAY OF DEVICE LOCATION AND DESCRIPTION	H	I	J	K	L: ACTIVATE BUILDING FIRE EVACUATION AUDIO SIGNAL	M: ACTIVATE BUILDING FIRE EVACUATION VISUAL DEVICES	N: TRANSMIT ALARM SIGNAL TO DCS	O: TRANSMIT SYSTEM SUPERVISORY SIGNAL TO DCS	P: TRANSMIT SYSTEM TROUBLE SIGNAL TO DCS	Q: TRANSMIT ALARM SIGNAL TO CENTRAL MONITORING	R: TRANSMIT SYSTEM SUPERVISORY SIGNAL TO CENTRAL MONITORING	S: TRANSMIT SYSTEM TROUBLE SIGNAL TO CENTRAL MONITORING	T	U	V	W: SHUTDOWN ASSOCIATED AIR HANDLING EQUIPMENT.	X	Y	Z
1 FIRE MANUAL PULL STATION	X	X					X					X	X	X			X									
2 AREA SMOKE DETECTION	X	X					X					X	X	X			X						X			
3 BATTERY ROOM VENTILATION FAILURE			X	X			X								X			X								
4 FACP LOW BATTERY					X	X	X									X			X							
5 OPEN CIRCUIT					X	X	X									X			X							
6 GROUND FAULT					X	X	X									X			X							
7 NOTIFICATION CIRCUIT SHORT					X	X	X									X			X							
8 FACP AC POWER FAILURE					X	X	X									X			X							
9																										
10																										
11																										
12																										
13																										
14																										
15																										
16																										
17																										
18																										

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.

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 6 inches below subgrade.

D. Stripping: Removal of topsoil remaining after applicable scalping is completed.

E. Project Limits: Areas, as shown or specified, within which Work is to be performed.

1.02 SUBMITTALS

A. Action Submittals: Drawings clearly showing clearing, grubbing, and stripping limits.

1.03 QUALITY ASSURANCE

A. Obtain Jacobs' Engineer's approval of staked clearing, grubbing, and stripping limits, prior to commencing clearing, grubbing, and stripping.

1.04 SCHEDULING AND SEQUENCING

A. Prepare Site only after adequate erosion and sediment controls are in place. Limit areas exposed uncontrolled to erosion during installation of temporary erosion and sediment controls to maximum of 1 acre.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Clear, grub, and strip areas actually needed for waste disposal, borrow, or Site improvements within limits shown or specified.

B. Do not injure or deface vegetation that is not designated for removal.
   1. Prune damaged areas of plants and trees in accordance with standard horticultural practice to preserve natural character of the plant. Perform in presence of Design-Builder. Remove all dead wood, suckers, and broken or badly bruised branches. Use only clean, sharp tools. Do not cut lead shoot.
   2. Badly damaged trees and plants that do not recover after one year's time shall be replaced to match existing.

3.02 LIMITS

A. As follows, but not to extend beyond Project limits.
   1. Excavation 5 feet beyond top of cut slopes.
   2. Trench Excavation: Minimum 4 feet from trench centerline, regardless of actual trench width.
   3. Fill:
      a. Clearing and Grubbing: 5-feet beyond toe of permanent fill.
      b. Stripping and Scalping: 5-feet beyond toe of permanent fill.
   4. Other Areas: As shown.

B. Remove rubbish, trash, and junk from entire area within Project limits.

3.03 CLEARING

A. Clear areas within limits shown or specified.

B. 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. Strip areas within limits to minimum depths shown or specified. Do not remove subsoil with topsoil.

B. Stockpile strippings, meeting requirements of Section 32 91 13, Soil Preparation, for topsoil, separately from other excavated material.

3.06 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, and that will not be visible from Project.

B. Strippings: Stockpile topsoil in sufficient quantity to meet Project needs. Dispose of excess strippings as specified for clearing and grubbing.

END OF SECTION

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): D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lb/ft^3 (2,700 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. Subgrade: Layer of existing soil after completion of clearing, grubbing, scalping of topsoil prior to placement of fill, roadway structure or base for floor slab.

E. 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 Section 02 41 00, Demolition, Section 31 10 00, Site Clearing, and 31 23 16, Excavation, prior to subgrade preparation.

1.04 QUALITY ASSURANCE

A. Notify Design-Builder when subgrade is ready for compaction or proof-rolling or whenever compaction or proof-rolling is resumed after a period of extended inactivity.

B. Notify Design-Builder when soft or loose subgrade materials are encountered.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Prepare subgrade when unfrozen and free of ice.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 SEQUENCE AND SCHEDULING OF ACTIVITIES.

A. Sequence and scheduling of activities shall consist of excavation, dewatering, compaction and proof-rolling, corrections of poor subgrade (if needed), and in situ testing (if needed).

3.02 GENERAL

A. Keep subgrade free of water, debris, and foreign matters 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.

3.03 COMPACTION

A. Under Earthfill: Minimum four passes using a sheep-foot compactor weighing a minimum of 10 tons.

B. Under Pavements, Structures, and Granular Fill under Structures and Slab-On-Grade: Minimum six passes using a heavy duty sheep-foot compactor weighing a minimum of 10 tons.

3.04 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.

3.05 TESTING

A. Proof-roll subgrade with fully loaded water truck, dump truck, or equipment specified in Article Compaction to detect soft or loose subgrade or unsuitable material, as determined by Jacobs' Engineer.

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, place non-woven geotextile as specified in Section 31 32 19.16, Geotextile, and replace with suitable material, as specified in Section 31 23 23, Fill and Backfill.
   3. The required area and depth of correction/overexcavation to be determined by Jacobs engineer.

B. Unsuitable Material: Over excavate as specified in Section 31 23 16, Excavation, and replace with suitable material, as specified in Section 31 23 23, Fill and Backfill.

END OF SECTION

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.
      d. Numbers, types, and sizes of equipment proposed to perform excavations.
      e. Anticipated difficulties and proposed resolutions.
      f. Reclamation of onsite spoil disposal areas.

1.02 QUALITY ASSURANCE

A. Provide adequate survey control to avoid unauthorized overexcavation.

1.03 WEATHER LIMITATIONS

A. 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.

D. Excavation Support: Install and maintain, as specified in Section 31 41 00, Shoring, as necessary to support sides and bottom of excavations and prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed Work.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Excavate to lines, grades, and dimensions shown and as necessary to accomplish Work. Excavate to within tolerance of plus or minus 0.1 foot, except where dimensions or grades are shown or specified as maximum or minimum. Allow for forms, working space, granular base, topsoil, and similar items, wherever applicable. Trim to neat lines where concrete is to be deposited against earth.

B. Do not overexcavate without written authorization of Jacobs' Engineer.

C. Remove or protect obstructions as shown and as specified in Section 01 50 00, Temporary Facilities and Controls, Article Protection of Work and Property.

3.02 UNCLASSIFIED EXCAVATION

A. Excavation is Unclassified: Complete all excavation regardless of the type, nature, or condition of the materials encountered.

3.03 TRENCH WIDTH

A. Minimum Width of Trenches:
   1. Single Pipes, Conduits, Direct-Buried Cables, and Duct Banks:
      a. Less than 4-inch Outside Diameter or Width: 18 inches.
      b. Greater than 4-inch Outside Diameter or Width: 18 inches greater than outside diameter or width of pipe, conduit, direct-buried cable, or duct bank.
   2. Multiple Pipes, Conduits, Cables, or Duct Banks in Single Trench: 18 inches greater than aggregate width of pipes, conduits, cables, duct banks, plus space between.
   3. Increase trench widths by thicknesses of sheeting if used.

B. Maximum Trench Width: Unlimited, unless otherwise shown or specified, or extend outside right-of-way, or unless excess width will cause damage to existing facilities, adjacent property, or completed Work.

3.04 EMBANKMENT AND CUT SLOPES

A. Shape, trim, and finish cut slopes to conform with lines, grades, and cross-sections shown, with proper allowance for topsoil or slope protection, where shown.

B. Remove 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.

3.05 STOCKPILING EXCAVATED MATERIAL

A. Stockpile excavated material that is suitable for use as fill or backfill until material is needed.

B. Post signs indicating proposed use of material stockpiled. Post signs that are readable from all directions of approach to each stockpile. Signs should be clearly worded and readable by equipment operators from their normal seated position.

C. Confine stockpiles to within easements, rights-of-way, and approved work areas. Do not obstruct roads or streets.

D. Do not stockpile excavated material adjacent to trenches and other excavations, unless excavation side slopes and excavation support systems are designed, constructed, and maintained for stockpile loads.

E. Do not stockpile excavated materials near or over existing facilities, adjacent property, or completed Work, if weight of stockpiled material could induce excessive settlement.

3.06 DISPOSAL OF SPOIL

A. Dispose of and uniformly spread excavated materials, which are unsuitable or exceed quantity needed for fill or backfill, in designated soil disposal areas onsite.

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

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.
   4. Water Level Elevations Observed in Observation Wells: Submit same day measured.
   5. Settlement Benchmark Elevations: Submit weekly record.

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, means of measuring inflow to excavations, 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. Remove and control water during periods when necessary to properly accomplish Work.

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 3 feet below the lowest point of excavation. Continuously maintain excavations free of water, regardless of source, and until backfilled to final grade. Provide means of measuring groundwater elevation; such as piezometers, monitoring/observation wells, and extraction wells.

B. When applicable, dewatering systems may 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 (to maintain bottom stability).

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.

3.04 SETTLEMENT

A. Monitoring Dewatering-Induced Settlement: Establish monuments for monitoring settlement at locations selected by Jacobs' Engineer, including monitoring cracks on wall and structures. Monitor vertical movement of each settlement monument, relative to remote benchmark selected by Design-Builder, at frequency stated in Contractor's Dewatering Plan.

3.05 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.

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. When applicable, remove solids from treatment facilities and perform other maintenance of treatment facilities as necessary to maintain their efficiency.

3.06 PROTECTION OF PROPERTY

A. Make assessment of potential for dewatering induced settlement. Conduct preconstruction surveys to document conditions of existing facilities, completed work, and adjacent properties. Provide and operate devices or systems, including but not limited to, 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, or underpinning.

END OF SECTION

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. D1556, Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
      e. D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
      f. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
      g. D4254, Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
      h. 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 D1557.
   2. Apply corrections for oversize material to either as-compacted field dry density or maximum laboratory dry density, as determined by Jacobs' Engineer.

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. Prepared Ground Surface: Ground surface after completion of required demolition, clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and subgrade preparation.

D. Completed Course: A course or layer that is ready for next layer or next phase of Work.

E. Lift: Loose (uncompacted) layer of material.

F. Geosynthetics: Geotextiles, geogrids, or geomembranes.

G. 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.

H. 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.

I. Selected Backfill Material: Materials available onsite that Jacobs' Engineer determines to be suitable for specific use.

J. Imported Material: Materials obtained from sources offsite, suitable for specified use.

K. Select Fill: Fill materials as required under structures, pavements, and other facilities.

L. Embankment Material: Fill materials required to raise existing grade in areas other than under structures.

1.03 SUBMITTALS

A. Action Submittals:
   1. Certified test results from independent testing agency.
   2. Shop Drawings: Manufacturer's recommendations for backfill around each buried structure, when applicable.
   3. Samples:
      a. Imported material taken at source (minimum 5 gallons sample).
      b. Results of laboratory gradation, corrosion, and Plasticity Index tests.

B. Informational Submittals: Manufacturer's data sheets for compaction equipment.

1.04 QUALITY ASSURANCE

A. Notify Jacobs' Engineer when:
   1. Structure site is ready for backfilling, and whenever backfilling operations are resumed after a period of inactivity.
   2. Soft or loose subgrade materials are encountered wherever embankment or site fill is to be placed.
   3. Fill material appears to be deviating from Specifications.

1.05 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in Section 02 41 00, Demolition; Section 31 10 00, Site Clearing; Section 31 23 16, Excavation; and Section 31 23 13, Subgrade Preparation, prior to placing fill or backfill.

B. Backfill around buried tanks and vaults only after set in position, securely anchored, and ready to be backfilled, and Design-Builder provides authorization to backfill.

C. 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 when applicable:
      a. Earthfill 500 CY.
      b. Granular Fill 500 CY.
      c. Foundation Stabilization Rock 250 CY.
   3. Clearly mark to show source of material and intended use.
   4. Include PI and corrosion tests of Earthfill.

2.02 EARTHFILL

A. When applicable, excavated material from required excavations and designated borrow sites: free from rocks 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 larger than 1.5 inches, or shale particles is unacceptable.

C. Provide imported material of equivalent quality, if required to accomplish Work.

D. Acceptable soil types include CL, ML, SC, SM, SP-SM. and combinations of each.

2.03 GRANULAR FILL

A. 1-inch minus crushed gravel or crushed rock or recycled materials.

B. Rounded rock or partially rounded rock is unacceptable.

C. Free from dirt, clay balls, and organic material.

D. Well-graded from coarse to fine and containing sufficient fines to bind material when compacted, but with maximum 8 percent by weight passing No. 200 sieve.

2.04 BACKFILL AROUND BURIED TANKS

A. As recommended by structure manufacturer.

2.05 WATER FOR MOISTURE CONDITIONING

A. Free of hazardous or toxic contaminates, or contaminants deleterious to proper compaction.

2.06 BASE COURSE ROCK

A. As specified in Section 32 11 23, Aggregate Base Courses.

2.07 FOUNDATION STABILIZATION ROCK

A. Crushed rock, pit run rock, or recycled materials.

B. Uniformly graded from coarse to fine.

C. Free from other organic material.

D. Maximum 2-1/2-inch particle size.

E. Maximum 8 percent fines.

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 density prior to placing succeeding lifts. Slope lifts only where necessary to conform to final grades or as necessary to keep placement surfaces drained of water.

C. During filling and backfilling, keep level of fill and backfill around each structure and buried 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: As shown or specified otherwise.
   2. Grade to establish and maintain slopes and drainage as shown. Reverse slopes are not permitted.

G. Settlement: Correct and repair any subsequent damage to structures, pavements, curbs, slabs, piping, and other facilities, caused by settlement of fill or backfill material.

3.02 BACKFILL UNDER AND AROUND STRUCTURES

A. Under Facilities: Within influence area beneath structures, footings, slabs, pavements, curbs, piping, conduits, duct banks, and other facilities, backfill with a minimum of 12 inches of compacted granular fill, unless otherwise shown. Place granular fill in 8-inch lifts. Compact all lifts to minimum of 95 percent relative compaction, as determined in accordance with ASTM D1557.

B. Other Areas (not Under Facilities): Backfill with earthfill to lines and grades shown, with proper allowance for topsoil thickness where shown. Place in lifts of 6-inch maximum thickness and compact each lift to minimum 90 percent relative compaction as determined in accordance with ASTM D1557.

3.03 SITE TESTING

A. In-Place Density Tests: In accordance with ASTM D6938. During placement of materials, test as follows:
   1. Granular Fill: Three tests every lift per structure.
   2. Backfill around Buried Structure: As determined by Jacobs' Engineer.
   3. Earthfill Three tests every lift for every 3,000 square feet placed.

3.04 REPLACING OVEREXCAVATED MATERIAL

A. Replace excavation carried below grade lines shown or established by Jacobs' Engineer as follows:
   1. Beneath Footings: Granular fill.
   2. Beneath Fill or Backfill: Same material as specified for overlying fill or backfill.
   3. Beneath Slabs-on-Grade: Granular fill.
   4. Trenches:
      a. Unauthorized Overexcavation: Either trench stabilization material or granular pipe base material, as specified in Section 31 23 23.15, Trench Backfill.
      b. Authorized Overexcavation: Trench stabilization material, as specified in Section 31 23 23.15, Trench Backfill.
   5. Permanent Cut Slopes (Where Overlying Area is Not to Receive Fill or Backfill):
      a. Flat to Moderate Steep Slopes (3:1, Horizontal Run: Vertical Rise or Flatter): Select Fill.
      b. Steep Slopes (Steeper than 3:1):
         1) Correct overexcavation by transitioning between overcut areas and designed slope adjoining areas, provided such cutting does not extend offsite or outside easements and rights-of-way, or adversely impacts existing facilities, adjacent property, or completed Work.
         2) Backfilling overexcavated areas is prohibited, unless in Jacobs' Engineer's opinion, backfill will remain stable, and overexcavated material is replaced as compacted Select Fill.

3.05 ACCESS ROAD SURFACING

A. Place and compact as specified in Section 32 11 23, Aggregate Base Courses.

END OF SECTION

SECTION 31 23 23.15
TRENCH BACKFILL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American Public Works Association (APWA): Uniform Color Code.
   2. ASTM International (ASTM):
      a. C33/C33M, Standard Specification for Concrete Aggregates.
      b. C94/C94M, Standard Specification for Ready-Mixed Concrete.
      c. C117, Standard Test Method for Materials Finer than 75 Micrometer (No. 200) Sieve in Mineral Aggregates by Washing.
      d. C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
      e. C150/C150M, Standard Specification for Portland Cement.
      f. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
      g. C1012/C1012M, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
      h. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3)).
      i. D1140, Standard Test Methods for Amount of Material in Soils Finer than No. 200 (75 micrometer) Sieve.
      j. D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
      k. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
      l. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
      m. D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
      n. D4832, Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
   3. National Electrical Manufacturers Association (NEMA): Z535.1, Safety Colors.

1.02 DEFINITIONS

A. Base Rock: Granular Fill as specified in Section 31 23 23, Fill and Backfill.

B. Bedding Material: Granular material upon which pipes, conduits, cables, or duct banks are placed.

C. Imported Material: Material obtained by Contractor from source(s) offsite.

D. Lift: Loose (uncompacted) layer of material.

E. Pipe Zone: Backfill zone that includes full trench width and extends from prepared trench bottom to an upper limit above top outside surface of pipe, conduit, cable or duct bank.

F. Prepared Trench Bottom: Graded trench bottom after excavation and installation of stabilization material, if required, but before installation of bedding material.

G. Relative Compaction: The ratio, in percent, of the as-compacted field dry density to the laboratory maximum dry density as determined by ASTM D698. Corrections for oversize material may be applied to either as-compacted field dry density or laboratory maximum dry density, as determined by Jacobs' Engineer.

H. Trench Stabilization: Adding and compacting stabilization materials in a trench to provide a firm, unyielding support, for the bedding material and pipes.

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.

1.03 SUBMITTALS

A. Action 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. Shop Drawings: Manufacturer's descriptive literature for marking tapes and tracer wire.
   3. Samples: Catalogue and manufacturers' data for geotextile.

B. Informational Submittals:
   1. Catalog and manufacturer's data sheets for compaction equipment.
   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 defined 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.
   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

Color*	Facility
Purple	Reclaimed water, irrigation, and slurry lines
*As specified in NEMA Z535.1, Safety Color Code.	

2.03 TRACER WIRE

A. Material: Minimum 12-gauge solid copper or copper jacket with a steel core, with high-density polyethylene (HDPE) or high-molecular weight polyethylene (HMWPE) insulation suitable for direct bury.

B. Splices: Use wire nut or lug suitable for direct burial as recommended by tracer wire manufacturer.

C. Manufacturers:
   1. Copperhead Industries, LLC.
   2. Performance Wire & Cable Inc.
   3. Pro-line Safety Products Company.

2.04 TRENCH STABILIZATION MATERIAL

A. Foundation Stabilization Rock as specified in Section 31 23 23, Fill and Backfill.

2.05 BEDDING MATERIAL AND PIPE ZONE MATERIAL

A. For 84-inch, 96-inch, 108-inch, and 120-inch RS pipeline, pipe zone material shall consist of CLSM from the bottom of the pipe to one-third up from the bottom of the pipe.

B. For all other pipe zone material and bedding, and above CLSM in RS pipeline, material shall consist of the following:
   1. 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.
   2. Unfrozen, friable, and no clay balls, roots, or other organic material.
   3. Duct Banks: 3/4-inch maximum particle size.
   4. PVC Irrigation System Piping and Ductile Iron Pipe with Polyethylene Wrap: 3/8-inch maximum particle size.
   5. 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.
   6. 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.

7. 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.

2.06 GRANULAR FILL

A. Provide as specified in Section 31 23 23, Fill and Backfill.

2.07 EARTHFILL

A. Provide as specified in Section 31 23 23, Fill and Backfill.

2.08 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 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.

2.09 GRAVEL SURFACING ROCK

A. As specified in Section 32 11 23, Aggregate Base Courses.

2.10 TOPSOIL

A. As specified in Section 32 91 13, Soil Preparation.

2.11 SOURCE QUALITY CONTROL

A. Perform gradation analysis in accordance with ASTM C136 for:
   1. Earthfill.
   2. Trench stabilization material.
   3. Bedding and pipe zone material.

B. Certify Laboratory Performance of Mix Designs: Controlled low strength material.

PART 3 EXECUTION

3.01 TRENCH PREPARATION

A. Water Control:
   1. As specified in Section 31 23 19.01, Dewatering.
   2. Remove water in a manner that minimizes soil erosion and prevent instability 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 soft subgrade is encountered during proof rolling of large diameter pipes or during probing of smaller diameter pipes that may require removal to prevent pipe settlement, notify Design-Builder. Jacobs' Engineer will determine depth of overexcavation, if any required.

3.03 GEOTEXTILE INSTALLATION

A. Install geotextile where shown on Drawings and where at Contractor's option to be installed to improve working platform base.

B. 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.

C. Anchor geotextile to trench walls prior to placing trench stabilization or bedding material.

D. Provide 24-inch minimum overlap at joints.

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 to 95 percent relative compaction prior to placing bedding material.

3.05 BEDDING

A. Furnish imported bedding material where, in the opinion of Jacobs' 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:
   1. As follows:
      a. Pipe 15 Inches and Smaller: 6 inches.
      b. Pipe 18 Inches to 36 Inches: 6 inches.
      c. Pipe 42 Inches and Larger: 8 inches.
      d. Conduit: 3 inches.
      e. Direct-Buried Cable: 3 inches.
      f. 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. Lower 1/3 of RS Pipeline:
   1. Controlled Low Strength Material:
      a. Discharge directly from truck, drum type mixer, or pump truck into trench.
      b. Place in lifts as necessary to prevent uplift (flotation) of new and existing facilities.
      c. Use vibrating "stinger" only as necessary to achieve full contact with pipe.

B. Upper limit of pipe zone shall not be less than following:
   1. Pipe: 12 inches, unless shown otherwise.
   2. Conduit: 3 inches, unless shown otherwise.

3. Direct-Buried Cable: 3 inches, unless shown otherwise.
4. Duct Bank: 3 inches, unless shown otherwise.

C. Restrain pipe, conduit, cables, and duct banks as necessary to prevent their movement during backfill operations.

D. 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.

E. 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.

F. Do not use power-driven impact compactors to compact pipe zone material.

G. 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 to at least 90 percent of maximum dry weight, as determined in accordance with ASTM D1557 test procedure.

H. Take care to avoid damaging pipe and pipe coating.

3.07 MARKING TAPE INSTALLATION

A. Continuously install marking tape along centerline of buried piping, as shown on Drawings. 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 TRACER WIRE INSTALLATION AND TESTING

A. Install tracer wire continuously along centerline of nonmetallic buried piping.

B. Attach wire to top of pipe using tape at maximum of 10-foot intervals. In areas where depth of cover is excessive for allowing detection of tracer wire with electronic pipe locator, install tracer wire within pipe backfill directly above pipe centerline at a minimum depth of 3 feet.

C. Install splices in accordance with manufacturer's instructions for direct bury applications. Tie ends of wire to be joined in a knot as required to reduce tension on splice.

D. Bring tracer wire to surface at each valve box, curb box, vault, air valve, blowoff valve, hydrant, and pipeline marker. Tracer wire shall be brought to surface at least every 1,000 feet. If distance between pipe appurtenances exceeds 1,000 feet, install valve box to allow access to tracer wire. Mark valve box cover with the word "TRACER". Coil enough excess tracer wire at each appurtenance to extend wire 12 inches above ground.

E. Test continuity of tracer wire using electronic pipe locator in presence of Design-Builder, prior to paving.

3.09 BACKFILL ABOVE PIPE ZONE

A. General:

1. If suitable for reuse, process excavated material to meet specified gradation and plasticity requirements for Earthfill.
2. Adjust moisture content as necessary to obtain specified compaction.
3. Do not allow backfill to free fall into trench or allow heavy, sharp pieces of material to be placed as backfill until after at least 2 feet of backfill has been provided over top of pipe.
4. Do not use power driven impact type compactors for compaction until at least 4 feet of backfill is placed over top of pipe.
5. Backfill to grade with proper allowances for topsoil, crushed rock surfacing, and pavement thicknesses, wherever applicable.
6. Backfill around structures with same class backfill as specified for adjacent trench, unless otherwise shown or specified.

B. Earthfill:

1. Place in lifts not exceeding thickness of 8 inches.
2. For areas outside of structure influence zone, pavement, and gravel surfacing, use earthfill and compact each lift to a minimum of 90 percent relative compaction as determined in accordance with ASTM D1557.

C. Granular Fill:

1. Place in lifts not exceeding thickness of 8 inches.
2. For areas under structure influence zone, pavement, and gravel surfacing, use granular fill and compact each lift to a minimum of 95 percent relative compaction as determined in accordance with ASTM D1557.

D. Controlled Low Strength Material as Otherwise Shown or Specified:

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.
4. In other areas fill trench section as shown.

3.10 REPLACEMENT OF TOPSOIL

A. Replace topsoil in top 6 inches where shown nor specified.

B. Maintain finished grade of topsoil even with adjacent area and grade as necessary to restore drainage.

3.11 MAINTENANCE OF TRENCH BACKFILL

A. After each section of trench is backfilled, maintain surface of backfilled trench even with adjacent ground surface until final surface restoration is completed.

B. Gravel Surfacing Rock: Add gravel surfacing rock where applicable and as necessary to keep surface of backfilled trench even with adjacent ground surface, and grade and compact as necessary to keep surface of backfilled trenches smooth, free from ruts and potholes, and suitable for normal traffic flow.

C. Topsoil: Add topsoil where applicable and as necessary to maintain surface of backfilled trench level with adjacent ground surface.

D. Concrete Pavement: Replace settled slabs as specified in Section 32 12 16, Asphalt Paving (as included in Balance of Plant Project).

E. Asphaltic Pavement: Replace settled areas or fill with asphalt as specified in Section 32 12 16, Asphalt Paving (as included in Balance of Plant Project).

F. Other Areas: Add excavated material where applicable and keep surface of backfilled trench level with adjacent ground surface.

3.12 SETTLEMENT OF BACKFILL

A. Settlement of more than 1-inch 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

SECTION 31 32 19.16
GEOTEXTILE

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:
   1. ASTM International (ASTM):
      a. D737, Standard Test Method for Air Permeability of Textile Fabrics.
      b. D4355, Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
      c. D4491, Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
      d. D4533, Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
      e. D4595, Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
      f. D4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
      g. D4716, Test Method for Determining the (In-Plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head.
      h. D4751, Standard Test Method for Determining Apparent Opening Size of a Geotextile.
      i. D4833, Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
      j. D4884, Standard Test Method for Strength of Sewn or Thermally Bonded Seams of Geotextiles.
      k. D4886, Standard Test Method for Abrasion Resistance of Geotextiles (Sand Paper/Sliding Block Method).
      l. D5199, Standard Test Method for Measuring the Nominal Thickness of Geosynthetics.
      m. D5261, Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
      n. D6193, Standard Practice for Stitches and Seams.

1.02 DEFINITIONS

A. Fabric: Geotextile, a permeable geosynthetic comprised solely of textiles.

B. Maximum Average Roll Value (MaxARV): Maximum of series of average roll values representative of geotextile furnished.

C. Minimum Average Roll Value (MinARV): Minimum of series of average roll values representative of geotextile furnished.

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.

1.03 SUBMITTALS

A. Action Submittals:
   1. Shop Drawings:
      a. Manufacturer material specifications and product literature.
      b. Installation drawings showing geotextile sheet layout, location of seams, and direction of overlap.
      c. Description of proposed method of geotextile deployment and provisions for holding geotextile temporarily in place until permanently secured.
      d. Seam welding method and procedure, if required.
      e. Field testing type, location, and frequency.
   2. Samples:
      a. Geotextile: One-piece, minimum 18 inches long, taken across full width of roll of each type and weight of geotextile furnished for Project. Label each with brand name and furnish documentation of lot and roll number from which each Sample was obtained.
      b. Securing Pin and Washer: One each.

B. Informational Submittals:
   1. Certifications from each geotextile manufacturer that furnished products listing specified property values. Certified property values shall be either minimum or maximum average roll values, as appropriate, for geotextiles furnished.
   2. Field seam efficiency test results.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver each roll with sufficient information attached to identify it for inventory and quality control.

B. Handle products in manner that maintains undamaged condition.

C. Do not store products directly on ground. Ship and store geotextile with suitable wrapping for protection against moisture and ultraviolet exposure. Store geotextile in way that protects it from moisture and direct sunlight. If stored outdoors, elevate and protect geotextile with waterproof cover.

1.05 SCHEDULING AND SEQUENCING

A. Where geotextile is to be laid directly upon ground surface, prepare subgrade as specified in Section 31 23 13, Subgrade Preparation, first.

B. Notify Jacobs' Engineer whenever geotextiles are to be placed. Do not place geotextile without Jacobs' Engineer's approval of underlying materials.

C. Notify Jacobs' Engineer after geotextiles are placed. Do not place overlying fills until Jacobs' Engineer's approval of geotextile placement.

PART 2 PRODUCTS

2.01 WOVEN GEOTEXTILE

A. Composed of polymeric yarn interlaced to form planar structure with uniform weave pattern.

B. Calendared or finished so yarns will retain their relative position with respect to each other.

C. Polymeric Yarn: Long-chain synthetic polymers (polyester or polypropylene) with stabilizers or inhibitors added to make filaments resistant to deterioration due to heat and ultraviolet light exposure.

D. Sheet Edges: Selvaged or finished to prevent outer material from separating from sheet.

E. Unseamed Sheet Width: Minimum 5 feet.

F. Nominal Weight per Square Yard: 6 per ASTM D5261.

G. Physical Properties: Conform to requirements in Table No. 1.

Table No. 1
Physical Property Requirements for Woven Geotextile

Property	Requirement	Test Method
Apparent Opening Size (AOS)	30 U.S. Standard Sieve Size	ASTM D4751
Water Permittivity	0.05 $sec.^{-1}$, MinARV	ASTM D4491 (Falling Head)

Table No. 1 Physical Property Requirements for Woven Geotextile		
Property	Requirement	Test Method
Vertical Waterflow Rate	40 gpm/sq ft, MinARV	ASTM D4491 (Falling Head)
Grab Tensile Strength	400 lb, MinARV	ASTM D4632
Grab Elongation	15 percent, MaxARV	ASTM D4632
Wide Width Strip Tensile Strength	225 lb/in.-width, MinARV	ASTM D4595
Ultraviolet Radiation Resistance	70 percent strength retention, MinARV after 500 hours	ASTM D4355

2.02 NONWOVEN GEOTEXTILE

A. Pervious sheet of polyester, polypropylene, or polyethylene fabricated into stable network of fibers that retain their relative position with respect to each other. Nonwoven geotextile shall be composed of continuous or discontinuous (staple) fibers held together through needle-punching, spun-bonding, thermal-bonding, or resin-bonding.

B. Geotextile Edges: Selvaged or otherwise finished to prevent outer material from pulling away from geotextile.

C. Unseamed Sheet Width: Minimum 12 feet.

D. Nominal Weight per Square Yard: 10 per ASTM D5261.

E. Physical Properties: Conform to requirements in Table No. 2.

Table No. 2 Physical Property Requirements for Nonwoven Geotextile		
Property	Requirement	Test Method
Water Permittivity	1.2 $sec.^{-1}$, MinARV	ASTM D4491 (Falling Head)
Grab Tensile Strength, Machine Direction	250 lb/in, MinARV	ASTM D4632
Grab Elongation, Machine Direction	50 percent, MaxARV	ASTM D4632
Puncture Strength	155 lb, MinARV	ASTM D4833
Trapezoid Tear Strength	100 lb, MinARV	ASTM D4533

Table No. 2 Physical Property Requirements for Nonwoven Geotextile		
Property	Requirement	Test Method
Ultraviolet Radiation Resistance	70 percent strength retention, MinARV after 500 hours	ASTM D4355

2.03 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.

PART 3 EXECUTION

3.01 LAYING GEOTEXTILE

A. Lay and maintain geotextile smooth and free of tension, folds, wrinkles, or creases.

3.02 SHEET ORIENTATION ON SLOPES

A. Orient geotextile with long dimension of each sheet parallel to direction of slope.

3.03 JOINTS

A. Unseamed Joints:
   1. Overlapped.
   2. Overlap, 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.

3.04 SECURING GEOTEXTILE

A. Secure geotextile during installation as necessary with sandbags or other means approved by Jacobs' Engineer.

B. Secure Geotextile with Securing Pins:
   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.

3.05 PLACING PRODUCTS OVER GEOTEXTILE

A. Before placing material over geotextile, notify Jacobs' Engineer. Do not cover installed geotextile until after Jacobs' Engineer provides authorization to proceed.

B. If tears, punctures, or other geotextile damage occurs during placement of overlying products, remove overlying products as necessary to expose damaged geotextile. Repair damage as specified in Article Repairing Geotextile.

3.06 INSTALLING GEOTEXTILE IN TRENCHES

A. Place geotextile in a way to completely envelope granular drain material 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 RIPRAP APPLICATIONS

A. Overlap geotextile at each joint with upstream sheet of geotextile overlapping downstream sheet.

3.08 SILT FENCE APPLICATIONS

A. Install geotextile in one piece, or continuously sewn to make one piece, for full length and height of fence, including portion of geotextile buried in toe trench.

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 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.

3.09 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. Secure with heat fusion tacking per manufacturer's recommendations or by other means approved by Jacobs' Engineer.

3.10 REPLACING CONTAMINATED GEOTEXTILE

A. Protect geotextile from contamination that would interfere, in Jacobs' Engineer's opinion, with its intended function. Remove and replace contaminated geotextile with clean geotextile.

END OF SECTION

SECTION 31 41 00
SHORING

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Excavation Support Plan and Trench Support Plan , prepared by a California registered professional engineer, addressing the following topics:
    a. Details of shoring, bracing, sloping, or other provisions for worker protection from hazards of caving ground.
    b. Design assumptions and calculations.
    c. Methods and sequencing of installing and removing excavation support and dewatering systems.
    d. Proposed locations of stockpiled excavated material.
    e. Minimum lateral distance from the crest of slopes or edge of excavation support system for vehicles and stockpiled excavated materials.
2. Monitoring Plan, prepared by a California registered professional engineer, and approved by Jacobs, addressing the following topics:
    a. Survey control.
    b. Location of monitoring points.
    c. Plots of data trends.
    d. Interval between surveys.
    e. Criteria for stopping work.
3. Calculations:
    a. The excavation support plan and the trench excavation plan shall be sealed by a professional engineer licensed in the State of California.
    b. Calculations for the support elements and any bracing, indicating it can withstand all earth and groundwater pressures, equipment, applicable traffic and construction loads, other surcharges, and any other requirements described on Drawings and Specifications.
    c. Calculations for nearby structures and utilities to be protected, indicating it will not adversely impact or damage these structures and utilities.

1.02 QUALITY ASSURANCE

A. Excavation support systems shall be designed by a professional engineer registered in the State of California, with a minimum of 5 years' experience in the design of retaining and shoring structures.

B. Provide surveys to monitor movements of critical facilities, utilities, shoring, completed Work potentially impacted by excavation activities.

C. Maintain a copy of the approved Excavation Support Plan at the Project Site to be available at all times.

D. Coordinate with Section 31 23 19.01, Dewatering.

1.03 DESIGN CRITERIA

A. The type and design of shoring and protection methods that meet the specification requirements herein are the Subcontractor's responsibility and will be of a size large enough to facilitate all the necessary groundwater control, construction operations, pipeline equipment and operations, backfill, and to accommodate indicated connections.

B. Design excavation support systems for all areas to support earth pressure, unrelieved hydrostatic pressures, bottom heave, utility loads, equipment, applicable traffic loads, and other surcharge loads in such manner as it will allow safe excavation and construction and will prevent damage to adjacent structures (including existing pipelines and utilities) and injury to workers and the public. In addition, the installation of excavation support systems shall not cause a disruption to owner convenience or access except where approved road closures are planned.

C. Design the excavation support systems to protect adjacent structures and utilities from damage and to minimize horizontal and vertical movements. The maximum allowable values for deformation shall be determined by Jacobs.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Design, provide, and maintain shoring, sheeting, and bracing as necessary to protect workers and support the sides and bottom of excavations and prevent detrimental settlement and lateral movement of existing nearby facilities, property, utilities, and completed Work; and as necessary to meet all applicable local, state, and federal regulations.

B. Before beginning construction, install and survey monitoring points as per the approved Monitoring Plan and adequately protect existing structures, utilities, and other existing facilities. The repair of or compensation for damage to existing facilities and utilities will be at no additional cost to Jacobs.

1. Perform preconstruction surveys of adjacent structures and utilities to document conditions prior to construction.

C. All welding will conform to the applicable provisions of ANSI/AWS D1.1.

D. Do not discharge water pumped from within the excavation into storm sewers, sanitary sewers, water bodies, ditches, or streets without an approved discharge permit. Discharge must comply with all applicable permit requirements. Water contaminated in any way by polymer or other additives or water that does not meet the requirements must be transported offsite to an acceptable disposal location.

E. Protect shored excavation not in active use for a period of 12 hours or longer with lockable chain link fence to prevent unauthorized entry or access.

3.02 REMOVAL OF EXCAVATION SUPPORT

A. Do not begin to remove excavation support until support can be removed without damage to existing facilities, utilities, completed Work, or adjacent property.

B. Remove excavation support in a manner that will maintain support as excavation is backfilled or buried structure is installed.

C. Remove excavation support in a manner that does not leave voids in the backfill or between buried structure and excavation sides.

D. Any void left by shoring system or voids created by the removal of the shoring system shall be filled with controlled low strength material (CLSM), lean concrete, or cement grout, as approved by the Design-Builder to provide soil support between backfill zone or buried structure and the native soil.

E. Sheet piling removal shall be performed in a manner that will not result in vibration induced settlement of sandy or granular material below the excavation that could cause settlement of the pipeline, utilities, facilities, or other works of construction.

F. The support system removed from the excavation shall remain the property of the Subcontractor and shall be removed from the Site.

3.03 TRENCHES

A. Trench excavations shall meet all applicable requirements of the California Labor Code, including Sections 6505 and 6707; the California Code of Regulations, including Title 8, Subchapter 4, Article 6; local construction safety orders; and federal requirements.

B. At any time, Subcontractor’s personnel are not present within the immediate vicinity of the Work, excavations shall be plated, barricaded, or fenced as necessary to protect the public and worker safety.

END OF SECTION

SECTION 32 11 23
AGGREGATE BASE COURSES

PART 1 GENERAL

1.01 REFERENCES

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

1. American Association of State Highway and Transportation Officials (AASHTO):
    a. T11, Standard Method of Test for Materials Finer Than 75μm (No. 200) Sieve in Mineral Aggregates by Washing.
    b. T27, Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates.
    c. T89, Standard Specification for Determining the Liquid Limit of Soils.
    d. T90, Standard Specification for Determining the Plastic Limit and Plasticity Index of Soils.
    e. T96, Standard Specification for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
    f. T99, Standard Specification for the Moisture-Density Relations of Soils Using a 2.5 kg (5.5 pound) Rammer and a 305 mm (12 in) Drop.
    g. T180, Standard Specification for Moisture-Density Relations of Soils Using a 4.54 kg (10-lb) Rammer and a 457 mm (18-in) Drop.
    h. T190, Standard Specification for Resistance R-Value and Expansion Pressure of Compacted Soils.
    i. T265, Standard Method of Test for Laboratory Determination of Moisture Content of Soils.
    j. T310, Standard Specification for In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
2. ASTM International (ASTM):
    a. C88, Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
    b. D1883, Test Method for CBR (California Bearing Ratio) of Laboratory Compacted Soils.
    c. D2419, Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
    d. D4791, Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.

1.02 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.

C. Base Course: Crushed aggregate or similar as specified placed and compacted on prepared subgrade or subbase course.

D. Gravel Surfacing: Aggregate used for construction of low-volume access and staging area that can be easily graded and compacted.

E. Leveling Course: Crushed aggregate placed and compacted on base course to be used for finish grading.

F. Standard Specifications: When referenced in this section, shall mean the State of California, Department of Transportation (Caltrans) Standard Specifications, 2018.

G. Untreated Aggregate Base Course: Well-graded, clean, hard, tough, durable, and sound mineral aggregates consisting of crushed stone, crushed gravel, or crushed slag, free of organic matter and contamination from chemical or petroleum products.

1.03 SUBMITTALS

A. Informational Submittals:
   1. Certified Test Results on Gradation Analysis and Source Materials: Submit copies from commercial testing laboratory 20 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 BASE COURSE AND SURFACING COURSE

A. As specified for Class 2, aggregate base, 3/4-inch maximum, in Section 26 of the Standard Specifications.

B. Clean, hard durable, pit run gravel or crushed stone graded from coarse to fine containing enough fines to bind material when compacted.

2.02 GRAVEL SURFACING

A. As specified for Class 2, aggregate base, 3/4-inch maximum, in Section 26 of the Standard Specifications.

2.03 SOURCE QUALITY CONTROL

A. Perform tests necessary to locate acceptable source of materials meeting specified requirements.

B. Final approval of aggregate material will be based on test results of installed materials.

C. Should separation of coarse from fine materials occur during processing or stockpiling, immediately change methods of handling materials to correct uniformity in grading.

PART 3 EXECUTION

3.01 SUBGRADE PREPARATION

A. As specified in Section 31 23 13, Subgrade Preparation.

B. Obtain Jacobs' Engineer acceptance of subgrade before placing base course or surfacing material.

C. Do not place base course or surfacing materials in snow or on soft, muddy, or frozen subgrade.

3.02 EQUIPMENT

A. Compaction Equipment: Adequate in design and number to provide compaction and to obtain specified density for each layer.

3.03 HAULING AND SPREADING

A. In accordance with Section 26-1.03 of the Standard Specifications.

B. 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.

C. Spreading Materials:
   1. Distribute material to provide required density, depth, grade, and dimensions with allowance for subsequent lifts.
   2. Produce even distribution of material upon roadway or prepared surface without segregation.
   3. Should segregation of coarse from fine materials occur during placing, immediately change methods of handling materials to correct uniformity in grading.

3.04 CONSTRUCTION OF COURSES

A. Construction of Courses: In accordance with Section 26-1.03 of the Standard Specifications except as modified hereinafter.

B. Untreated Aggregate Base Course:
   1. Maximum Completed Lift Thickness: 6 inches.
   2. Completed Course Total Thickness: As shown on Drawings.
   3. Spread lift on preceding course to required cross-section.
   4. Lightly blade and roll surface until thoroughly compacted.
   5. Blade or broom surface to maintain true line, grade, and cross-section.

C. Gravel Surfacing:
   1. Maximum Completed Lift Thickness: 6 inches.
   2. Completed Course Total Thickness: As shown.
   3. Spread on preceding course in accordance with cross-section shown.
   4. Blade lightly and roll surface until material is thoroughly compacted.

3.05 ROLLING AND COMPACTION

A. In accordance with Section 26-1.03E of the Standard Specifications, except as modified hereinafter.

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. Remove floating or loose stone from surface of preceding course before placing leveling course.

G. Surface Defects: Remedy by loosening and rerolling. Reroll entire area, including surrounding surface, until thoroughly compacted.

H. Finished surface shall be true to grade and crown before proceeding with surfacing.

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 Base Course: Within plus or minus 0.04 foot of grade shown at any individual point.

C. Gravel Surfacing and Leveling Course: Within 0.04 foot from lower edge of 10-foot straightedge placed on finished surface, parallel to centerline.

D. Overall Average: Within plus or minus 0.02 foot from crown and grade specified.

3.07 FIELD QUALITY CONTROL

A. In-Place Density Tests:
   1. Subcontractor is responsible for onsite in-place density tests to be conducted by independent testing agency.
   2. Refer to Table 1 for minimum sampling and testing requirements for aggregate base course and surfacing.

Table 1
Minimum Sampling and Testing Requirements

Property	Test Method	Frequency	Sampling Point
Gradation	AASHTO T11 and AASHTO T27	One sample every 500 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	AASHTO T310 and AASHTO T265 for moisture content	One for each 500 ton but at least every 10,000 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

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): T166, Standard Method of Test for Bulk Specific Gravity (Gmb) of Compacted Hot Mix Asphalt (HMA) Mixtures Using Saturated Surface-Dry Specimens.
   2. ASTM International (ASTM):
      a. D2041, Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures.
      b. D2950, Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods.
      c. E329 REV A, Standard Specification for Agencies Engaged in Construction Inspection Testing, or Special Inspection.

1.02 STANDARD SPECIFICATIONS

A. The following is a list of specifications which may be referenced in this section:
   1. Caltrans: State of California, Department of Transportation Standard Specifications, 2018.
   2. City of San José: Department of Public Works, Standard Specifications, July 1992.

1.03 DEFINITIONS

A. Combined Aggregate: All mineral constituents of asphalt concrete mix, including mineral filler and separately sized aggregates.

1.04 DESIGN REQUIREMENTS

A. Prepare asphalt concrete mix design, meeting the following design criteria, tolerances, and other requirements specified in Section 39-2.01A(3)(b) and Section 39-2.02A(3)(b), “Job Mix Formula,” of the Caltrans Standard Specifications.

1.05 SUBMITTALS

A. Informational Submittals:
   1. Asphalt Concrete Mix Formula:
      a. Submit minimum of 15 days prior to start of production.

b. Submittal to include the following information:
   1) Gradation and portion for each aggregate constituent used in mixture to produce a single gradation of aggregate within specified limits.
   2) Bulk specific gravity for each aggregate constituent.
   3) Measured maximum specific gravity of mix at optimum asphalt content determined in accordance with ASTM D2041.
   4) Properties as stated in Section 39-2.02B of the Caltrans Standard Specifications, for at least four different asphalt contents other than optimum, two below optimum, and two above optimum.
   5) Percent of asphalt lost due to absorption by aggregate.
   6) Index of Retained Strength (TSR) at optimum asphalt content as determined by AASHTO T283 as the ratio of wet and dry moisture susceptibility as specified in Section 39-2.02B(2) of the Caltrans Specification.
   7) Percentage of asphalt cement, to nearest 0.1 percent, to be added to mixture.
   8) Optimum mixing temperature.
   9) Optimum compaction temperature.
   10) Temperature-viscosity curve of asphalt cement to be used.
   11) Brand name of any additive to be used and percentage added to mixture.

2. Test Report for Asphalt Cement:
   a. Submit minimum 10 days prior to start of production.
   b. Show appropriate test method(s) for each material and the test results.
3. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services, and with Section 6-1.07 of the City of San José Standard Specifications for the following materials:
   a. Aggregate: Gradation, source test results as defined in Section 39-2.02B(4), "Aggregates," of the Caltrans Standard Specifications.
   b. Asphalt for Binder: Type, grade, and viscosity-temperature curve.
   c. Tack Coat: Type and grade of asphalt.
   d. Additives.
   e. Mix: Conforms to job-mix formula.
4. Statement of qualification for independent testing laboratory.
5. Test Results:
   a. Mix design.
   b. Asphalt concrete core.
   c. Gradation and asphalt content of uncompacted mix.

1.06 QUALITY ASSURANCE

A. Qualifications:
   1. Independent Testing Laboratory: In accordance with ASTM E329.
   2. Asphalt concrete mix formula shall be prepared by approved certified independent laboratory under the supervision of a certified asphalt technician.

1.07 ENVIRONMENTAL REQUIREMENTS

A. In accordance with Section 39-6.01 of the City of San José Standard Specifications.

PART 2 PRODUCTS

2.01 MATERIALS

A. Tack Coat: Emulsified asphalt, Grade CSS-1, CSS-1h conforming to Section 94, “Asphaltic Emulsions” of the Caltrans Standard Specifications.

B. Sand (Blotter Material): Clean, dry, with 100 percent passing No. 4 sieve, and a maximum of 10 percent passing No. 200 sieve.

2.02 ASPHALT CONCRETE MIX

A. General:
   1. Mix formula shall not be modified except with written approval of Design-Builder.
   2. Source Changes:
      a. Should material source(s) change, establish new asphalt concrete mix formula before new material(s) is used and submit for approval.
      b. Perform check tests of properties of plant-mix bituminous materials on first day of production and as requested by Design-Builder to confirm that properties are in compliance with design criteria.
      c. Make adjustments in gradation or asphalt content as necessary to meet design criteria.

B. Asphalt Concrete: Type A Hot Mix Asphalt (HMA) as specified in Section 39-2.02B of the Caltrans Standard Specifications.
   1. Asphalt Concrete Base Lift: Type A HMA 3/4-inch.
   2. Asphalt Concrete Surface Lift: Type A HMA 1/2-inch.

C. Asphalt Cement: Paving Grade PG 64-10 as specified in Section 92 of the Caltrans Standard Specifications.

PART 3 EXECUTION

3.01 GENERAL

A. Traffic Control: Minimize inconvenience to traffic but keep vehicles off freshly treated or paved surfaces to avoid pickup and tracking of asphalt.

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 Sections 39-2.04, 39-5.01, and 39-5.03 of the City of San José Standard Specifications.

3.04 PREPARATION

A. Prepare subgrade as specified in Section 31 23 13, Subgrade Preparation.

B. 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 Sections 39-6.02 and 39-6.03 of the City of San José Standard Specifications.

B. Tack Coat:
   1. Prepare materials a specified in Section 39-2.01C(3)(f), “Tack Coat” of the Caltrans Standards Specifications prior to application.
   2. Apply uniformly to clean, dry surfaces avoiding overlapping of applications.
   3. Do not apply more tack coat than necessary for the day’s paving operation.
   4. Touch up missed or lightly coated surfaces and remove excess material.
   5. Application Rate: As specified in Section 39-2.01C(3)(f), “Tack Coat” of the Caltrans Standard Specifications.

C. Pavement Mix:

1. Place asphalt concrete pavement mix in accordance with Section 39-6.02, "Spreading," and Section 39-6.03, "Compaction," of the City of San José Standard Specifications.
2. Compacted Lift Thickness:
    a. Minimum: Twice maximum aggregate size, but in no case less than 25 millimeters (1 inch).
    b. Maximum: 100 millimeters (4 inches).
3. Total Compacted Thickness: As shown.
4. Apply such that meet lines are straight and edges are vertical.
5. Collect and dispose of segregated aggregate from raking process. Do not scatter material over finished surface.
6. Joints:
    a. Offset edge of each layer a minimum of 150 millimeters (6 inches) so joints are not directly over those in underlying layer.
    b. Offset longitudinal joints in roadway pavements so longitudinal joints in wearing layer coincide with pavement centerlines and lane divider lines.
    c. Form transverse joints by cutting back on previous day's run to expose full vertical depth of layer.
7. Succeeding Lifts: Apply tack coat to pavement surface between each lift.
8. After placement of pavement, seal meet line by painting a minimum of 150 millimeters (6 inches) on each side of joint with cut back or emulsified asphalt. Cover immediately with sand.

D. Compaction:

1. Uniformly compact each course until there is no further evidence of consolidation and roller marks are eliminated. When placement rate exceeds 90 mg (100 tons) per hour, operate minimum of two rollers for compaction.
2. Roll until roller marks are eliminated and minimum density of 98 percent of the laboratory density as specified in Section 39-6.03 "Compacting" of the City of San José Standard Specifications is obtained.
3. Joint Compaction:
    a. Place top or wearing layer as continuously as possible.
    b. Pass roller over unprotected end of freshly laid mixture only when placing of mix is discontinued long enough to permit mixture to become chilled.
    c. Cut back previously compacted mixture when Work is resumed to produce slightly beveled edge for full thickness of layer.
    d. Cut away waste material and lay new mix against fresh cut.

E. Tolerances:
   1. General: Conduct measurements for conformity with crown and grade immediately after initial compression. Correct variations immediately by removal or addition of materials and by continuous rolling.
   2. Completed Surface or Wearing Layer Smoothness:
      a. Uniform texture, smooth, and uniform to crown and grade.
      b. Maximum Deviation: 3 millimeters (1/8 inch) from lower edge of a 3.6 meter (12 foot) straightedge, measured continuously parallel and at right angle to centerline.
      c. If surface of completed pavement deviates by more than twice specified tolerances, remove and replace wearing surface.
   3. Transverse Slope Maximum Deviation: 6 millimeters (1/4 inch) in 3.6 meters (12 feet) from rate of slope shown.
   4. Finished Grade:
      a. Perform field differential level survey on maximum 15 meter (50 foot) grid and along grade breaks.
      b. Maximum Deviation: 6 millimeters (0.02 foot) from grade shown.

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 12 millimeters (1/2 inch) below surface.

B. Application:
   1. Tack Coat: As specified in this section.
   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 50 millimeters (2 inches).
   5. Actual compacted thickness of intermittent areas of 100 square meters (120 square yards) or less may exceed 50 millimeters (2 inches), but not 100 millimeters (4 inches).
   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.

B. Application:
   1. Patch Thickness: 75 millimeters (3 inches) 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 350 to 525 Newtons per linear centimeter (200 to 300 pounds per linear inch). Use hand tampers where rolling is impractical.
   2. Begin rolling top course at edges of patches, lapping adjacent asphalt surface at least 1/2 the roller width. Progress toward center of patch overlapping each preceding track by at least 1/2 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 6 millimeters (1/4 inch) or minus 0 millimeter 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.
   1. Jacobs is responsible for coordination of onsite in-place density tests from an independent testing agency.

B. Field Density Tests:
   1. Perform tests from cores or sawed samples in accordance with AASHTO T230 and AASHTO T166.
   2. Measure with properly operating and calibrated nuclear density gauge in accordance with ASTM D2950.

3. Maximum Density: In accordance with ASTM D2041, using sample of mix taken prior to compaction from same location as density test sample.

C. Testing Frequency:
   1. Quality Control Tests:
      a. Asphalt Content, Aggregate Gradation: Once per every 500 tons 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 or once every 8 hours, whichever is greater.
   2. Density Tests: Once every 500 tons of mix or once every 4 hours, whichever is greater.

END OF SECTION

SECTION 32 16 00
CURBS AND GUTTERS 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): T99, Standard Specification for the Moisture-Density Relations of Soils Using a 2.5 kg (5.5 pound) Rammer and a 305 mm (12 in.) Drop.
   2. American Concrete Institute (ACI): 304R, Guide for Measuring, Mixing, Transporting, and Placing Concrete.
   3. ASTM International (ASTM):
      a. C94, Standard Specification for Ready-Mixed Concrete.
      b. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
      c. D994, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
   4. City of San José Construction Standards.
   5. Standard Specification: City of San José, Department of Public Works, Standard Specifications, 1992.

1.02 SUBMITTALS

A. Action Submittals:
   1. Form Material: Information on metal forms, if used, including type, condition, surface finish, and intended function.
   2. Complete data on concrete mix, including aggregate gradations and admixtures in accordance with requirements of ASTM C94.

B. Informational Submittals:
   1. Curing Compound: Manufacturer's Certificate of Compliance and application instructions.
   2. Ready-mix delivery ticket for each truck in accordance with ASTM C94.

1.03 QUALITY ASSURANCE

A. Regulatory Requirements: Conform to the City of San José Standard Specifications.

PART 2 PRODUCTS

2.01 EXPANSION JOINT FILLER

A. Preformed asphalt-impregnated, expansion joint material meeting ASTM D994, 1/2-inch thick.

2.02 CONCRETE

A. As specified in Section 03 30 00, Cast-in-Place Concrete.

2.03 CURING COMPOUND

A. Liquid membrane forming, clear or translucent, suitable for spray application and meeting ASTM C309, Type 1.

PART 3 EXECUTION

3.01 FORMWORK

A. Lumber Materials:
   1. 2-inch dressed dimension lumber, or metal of equal strength, straight, free from defects that would impair appearance or structural quality of completed curb and sidewalk.
   2. 1-inch dressed lumber or plywood may be used where short-radius forms are required.

B. Metals: Steel in new undamaged condition.

C. Setting Forms:
   1. Construct forms to shape, lines, grades, and dimensions.
   2. Stake securely in place.

D. Bracing:
   1. Brace forms to prevent change of shape or movement resulting from placement.
   2. Construct short-radius curved forms to exact radius.

E. Tolerances:
   1. Do not vary tops of forms from gradeline more than 1/8 inch when checked with 10-foot straightedge.
   2. Do not vary alignment of straight sections more than 1/8 inch in 10 feet.

3.02 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. Construct ramps where shown on Drawings.

B. Expansion Joints: Place at maximum 45-foot intervals and at the beginning and end of curved portions of curb and at connections to existing curbs. Install expansion joint filler at each joint.

C. Curb Facing: Do not allow horizontal joints within 7 inches from top of curb.

D. Contraction Joints:
   1. Maximum 15-foot intervals in curb.
   2. Provide open joint type by inserting thin, oiled steel sheet vertically in fresh concrete to force coarse aggregate away from joint.
   3. Insert steel sheet to full depth of curb.
   4. Remove steel sheet with sawing motion after initial set has occurred in concrete and prior to removing front curb form.
   5. Finish top of curb with steel trowel and finish edges with steel edging tool.

E. Front Face:
   1. Remove front form and finish exposed surfaces when concrete has set sufficiently to support its own weight.
   2. Finish formed face by rubbing with burlap sack or similar device to produce uniformly textured surface, free of form marks, honeycomb, and other defects.
   3. Remove and replace defective concrete.
   4. Apply curing compound to exposed surfaces of curb upon completion of finishing.
   5. Continue curing for minimum of 5 days.

F. Backfill curb with earth upon completion of curing period, but not before 7 days has elapsed since placing concrete.
   1. Backfill shall be free from rocks 2 inches and larger and other foreign material.
   2. Compact backfill firmly.

3.04 SIDEWALK CONSTRUCTION

A. Thickness:
   1. 4 inches in walk areas.
   2. 6 inches in driveway areas.

B. Connection to Existing Sidewalk:
   1. Remove old concrete back to an existing contraction joint.
   2. Clean the surface.
   3. Apply a neat cement paste immediately prior to placing new sidewalk.

C. Expansion Joints: Place in adjacent curb, where sidewalk ends at curb, and around posts, poles, or other objects penetrating sidewalk. Install expansion joint filler at each joint.

D. Contraction Joints:
   1. Provide transversely to walks at locations opposite contraction joints in curb.
   2. Dimensions: 3/16-inch by 1-inch weakened plane joints.
   3. Construct straight and at right angles to surface of walk.

E. Finish:
   1. Broom surface with fine-hair broom at right angles to length of walk and tool at edges, joints, and markings.
   2. Mark walks transversely at 5-foot intervals except where shown differently on Drawings, with jointing tool; finish edges with rounded steel edging tool.
   3. Apply curing compound to exposed surfaces upon completion of finishing.
   4. Protect sidewalk from damage and allow to cure for at least 7 days.

END OF SECTION

SECTION 32 17 23
PAVEMENT MARKINGS AND SIGNAGE

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American Association of State Highway and Transportation Officials (AASHTO):
      a. M237, Standard Specification for Epoxy Resin Adhesives for Bonding Traffic Markers to Hardened Portland Cement and Asphalt Concrete.
      b. M247, Standard Specification for Glass Beads Used in Traffic Paint.
      c. M248, Standard Specification for Ready-Mixed White and Yellow Traffic Paints.
      d. M249, Standard Specification for White and Yellow Reflective Thermoplastic Striping Material (Solid Form).
   2. ASTM International (ASTM): D4280, Standard Specification Extended Life Type, Nonplowable, Prismatic, Raised, Retroreflective Pavement Markers.
   3. City of San José, Department of Public Works Standard Specifications dated July 1992.
   4. Federal Specifications (FS):
      a. A-A-2886A, Paint, Traffic, Solvent Based.
      b. TT-B-1325C, Beads (Glass Spheres); Retroreflective.
   5. Manual Uniform of Traffic Control Devices (MUTCD), latest edition.

B. Standard Specification: State of California, Department of Transportation (Caltrans), Standard Specifications, 2018.

1.02 SUBMITTALS

A. Action Submittals:
   1. Shop Drawings:
      a. Product Data:
         1) Paint.
         2) Epoxies, resins, and primers to be used.
      b. Glass Beads: Proposed gradation.

B. Informational Submittals:

1. Description of proposed methods for removal of drips, overspray, improper markings, paint and thermoplastic material tracked by traffic, and existing markings.
2. Manufacturer's Certificate of Compliance for products specified in this section.

PART 2 PRODUCTS

2.01 GENERAL

A. All products shall be in accordance with Pavement Markings of Section 84 of the Standard Specifications.

2.02 PAINT

A. Color: White or yellow as shown.

1. Blue and white for ADA parking.

B. Traffic paint in accordance with Section 84-2.02C of the Standard Specifications.

C. Homogeneous, easily stirred to smooth consistency, with no hard settlement or other objectionable characteristics during storage period of 6 months.

2.03 SIGNAGE

A. In accordance with the MUTCD, latest edition.

2.04 GLASS BEADS

A. In accordance with Section 84-2.02D of the Standard Specifications.

PART 3 EXECUTION

3.01 GENERAL

A. Surface Preparation Application, and Protection: In accordance with Section 84-2.03 of the Standard Specifications.

3.02 SURFACE PREPARATION

A. Cleaning:

1. Thoroughly clean surfaces to be marked before application of pavement marking material.

2. Remove dust, dirt, and other granular surface deposits by sweeping, blowing with compressed air, rinsing with water or a combination of these methods.
3. Completely remove rubber deposits, surface laitance, existing paint markings, and other coatings adhering to pavement with scrapers, wire brushes, sandblasting, approved chemicals, or mechanical abrasion.
4. Scrub areas of old pavement affected with oil or grease with several applications of trisodium phosphate solution or other approved detergent or degreaser, and rinse thoroughly after each application.
5. Surfaces shall be completely free of dirt and ice, and dry of water at the time of application of materials specified herein.
6. Oil-Soaked Areas: After cleaning, seal with cut shellac to prevent bleeding through the new paint.
7. Reclean surfaces when the Work has been stopped due to rain.
8. Existing Pavement Markings:
    a. Remove existing pavement markings that may interfere or conflict with newly applied marking patterns, or that may result in a misleading or confusing traffic pattern.
    b. Do not apply thermoplastic markings over existing preformed or thermoplastic markings.
    c. Perform grinding, scraping, sandblasting or other operations so finished pavement surface is not damaged.

B. New Asphalt Pavement: Allow a minimum pavement cure time of 30 days before applying paint.

3.03 PAINT APPLICATION

A. General:
1. Thoroughly mix pigment and vehicle together prior to application and keep thoroughly agitated during application.
2. Do not add thinner.
3. Apply only when air and pavement temperatures are above 50 degrees F and less than 95 degrees F. Maintain paint temperature within these same limits.
4. Apply only when surface is dry.
5. Do not apply when conditions are windy to the point of causing overspray or fuzzy line edges.
6. Provide guidelines and templates to control paint application.
7. Take special precautions in marking numbers, letters, and symbols.
8. Sharply outline edges of markings and apply without running or spattering.

B. Rate of Application:
   1. Reflective Markings: Apply evenly, 105 plus or minus 5 square feet per gallon.
   2. Glass Bead Application:
      a. Apply immediately following application of paint.
      b. Use evenly distributed drop-on application method.
      c. Rate: 5 pounds per gallon of paint.
   3. On new pavement or new asphalt surface treatments, apply two coats of paint at a uniform rate of 210 square feet per gallon.

C. Drying:
   1. Provide maximum drying time to prevent undue softening of bitumen and pickup, displacement, or discoloration by traffic.
   2. If drying is abnormally slow, discontinue painting operations until cause is determined and corrected.

D. Protection:
   1. Protect markings from traffic until paint is thoroughly dry.
   2. Protect surfaces from disfiguration by paint spatters, splashes, spills, or drips.

E. Cleanup: Remove paint spatters, splashes, spills, or drips from the Work and staging areas including areas outside the immediate Work area where spills occur.

END OF SECTION

SECTION 32 84 23
LANDSCAPE IRRIGATION SYSTEMS

PART 1 GENERAL

1.01 SUMMARY

A. The subcontractor shall prepare an irrigation layout plan showing locations of sprinklers, valves, and irrigation piping as well as related appurtenances including vacuum breakers and electrical conduit.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. American Petroleum Institute (API): 603, Corrosion-resistant, Bolted Bonnet Gate Valves—Flanged and Butt-welding Ends.
   2. American Society of Mechanical Engineers (ASME): B16.5, Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24.
   3. ASTM International (ASTM):
      a. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
      b. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
      c. B32, Standard Specification for Solder Metal.
      d. B88, Standard Specification for Seamless Copper Water Tube.
      e. B584, Standard Specification for Copper Alloy Sand Castings for General Applications.
      f. D1784, Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
      g. D1785, Standard Specifications for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
      h. D2241, Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
      i. D2466, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
      j. D2467, Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
   4. National Fire Protection Association (NFPA): NFPA No. 70, National Electrical Code (NEC).

5. Standard Specification: City of San José, Department of Public Works, Standard Specifications, 1992.

1.03 SUBMITTALS

A. Action Submittals:
   1. Shop Drawings:
      a. Product Data:
         1) Valves and valve access boxes.
         2) Vacuum breakers.
         3) Pipe and fittings.
         4) Sprinkler heads.
      b. Layout Drawings: Detailed system layout including site plan with locations of all irrigation features planned for installation.

B. Informational Submittals:
   1. Qualifications:
      a. System manufacturer.
      b. System installer.
   2. Record Drawings: Completed irrigation system.

1.04 QUALIFICATIONS

A. System Supplier: Regularly engaged in the production of irrigation systems.

B. System Installer: Minimum of 5 years' previous experience installing systems of complexity and size for similar type projects. Resident representative thoroughly familiar with materials specified for installation and methods of installation to be present onsite and with authority to direct Work under this section throughout its installation.

PART 2 PRODUCTS

2.01 PIPE BASE MATERIAL

A. 1/4-inch minus clean sand.

2.02 GRAVEL

A. 3/4-inch minus, 1/2-inch plus, clean, washed, round gravel.

2.03 PIPE AND FITTINGS

A. Plastic:
   1. Pipe: Rigid PVC, Type I, Grade 1, ASTM D1784, ASTM D1785, and ASTM D2241.
      a. Class 200, SDR 21 when installed with solvent weld fittings.
      b. Schedule 80, when threaded fittings are used.
   2. Fittings:
      a. Threaded: Type I, Schedule 80, ASTM D2467; Uscolite (U.S. Rubber Co.), Koroseal (B.F. Goodrich), or Kraloy/Chemtrol.
      b. Solvent Weld: Type I, Schedule 40, ASTM D2466.
   3. Joint Material:
      a. Threaded: Teflon tape or Teflon spray.
      b. Solvent Weld: Pipe manufacturer's recommendations.

B. Risers to Sprinkler Heads: Schedule 80 PVC.

C. Pipe Under Improved Areas (Curbs, Walks, Pavements): Schedule 80 PVC.

2.04 SLEEVES

A. Schedule 80 PVC, twice the interior diameter of the pipe inserted into the sleeve.

2.05 VALVES

A. Gate Valves:
   1. Zone Shutoff Valves 1-1/2 Inches and Smaller: Bronze, double disc wedge type with integral taper seats.
   2. 2 Inches and Larger: Iron body, brass trimmed, double disc wedge type with integral taper seats.
   3. Service rated (nonshock cold water) at not less than 200 psi. Cast or stamp manufacturer's identification on valve body.
   4. Manufacturer: Velan.

B. Pressure Regulating Valves (PRV):
   1. Brass body and trim with cast iron spring and case, Buna-N diaphragm, and threaded connections.
   2. Inlet pressure of 100 psi; outlet pressure as shown.
   3. Manufacturers and Products:
      a. Fisher; Type 75A.
      b. Mueller; Type H-9310.

C. Electric Remote Control Zone Valves:
   1. Normally closed type with automatic shutoff in event of power failure.
   2. Close or not open in less than 4 seconds.
   3. Capable of manual control during power failure.
   4. Flow Control Device: To eliminate effects of flow on opening or closing of valve.
   5. Corrosion-resistant metal such as brass, or stainless steel.
   6. Waterproofed for burial.
   7. Union for supply line connection.
   8. Operation not dependent on pressure loss through valves.
   9. Motor assembly removable without disturbing valve body.
   10. Power operated by 24V ac to 26-1/2V ac controller.
   11. Include flow control mechanism.
   12. UL listed.

D. Quick-Coupling Valves:
   1. Allow for attachment of hose swivels and for air blowout of system.
   2. Body:
      a. One- or two-piece type with locking cap.
      b. Heavy-duty brass in accordance with ASTM B584, 81-3-7-9 type.
      c. Cap: Purple thermoplastic cover.
   3. Watertight before and after coupler is inserted.
   4. Mechanism designed so valve seat is closed before coupler is removed.
   5. Manufacturer's casting or stamp on valve body.
   6. Valve design compatible with valve couplers, keys, and hose swivels.
   7. Provide two keys for locking caps.
   8. Hose Swivels: 3/4 inch with 90-degree swivel ell, and free turning through a 360-degree swing.
      a. Swivel Spindle: Watertight in service. Furnish two hose swivels.

E. Drain Valves:
   1. Automatic: Spring-loaded type; valve box and cover at each drain valve.
   2. Manual: Bronze, brass, or stainless steel, manual angle valve designed so the valve seat rises completely out of the water flow line. Include a heavy-duty standard star handle or notched round handle for easy operation of valve by hand or with long handle valve key.

2.06 MANUAL VALVE OPERATING KEY

A. Two for manual control valves and manual drain valves, 30 inches long, steel rod with all-welded construction and with protective coating.

2.07 VALVE MARKERS

A. Locking type to be installed in top of 2-inch PVC pipe. Furnish two operating keys for valve markers.

2.08 VALVE ACCESS BOXES AND COVERS

A. Box: Thermoplastic to house remote control, manual control, zone shutoff, gate, automatic drain valves and globe valves that will not be installed with valve markers.

B. Covers: Thermoplastic; locking or hinged covers are not required unless otherwise specified or shown.

C. Manufacturers and Products:
   1. Remote Control Valves 3 Inches and Smaller: Ametek; “Standard” Model.
   2. Adjustable Valve Box for Large Zone Shutoff Valves and Larger Remote Control Valves: Ametek; “Jumbo” Model.

2.09 PRESSURE GAUGE

A. 2 inch, heavy-duty with metal case, equipped with setscrews. Zero to 150 psi range, minimum. Fitted with 1/4-inch iron pipe screwed (IPS) male connection.

2.10 ELECTRICAL CONDUCTORS AND CONDUIT

A. Conductors:
   1. Power Source to Controller or Timer: Conduit encased copper, minimum size No. 10, Type TW, consisting of two conductors and bare copper ground wire.
   2. Controllers or Timers to Valves: Standard copper Type UF irrigation control wire.
   3. Wire Sizes: As recommended by automatic control valve manufacturer.
   4. Meet requirements of Section 26 05 05, Conductors.

B. Conduit:
   1. Aboveground: Galvanized, rigid steel, electrical type.
   2. Underground: Schedule 40 PVC electrical type.

3. Meet requirements of Section 26 05 04, Low-Voltage Basic Electrical Materials and Methods.

2.11 ELECTRICAL CONNECTORS

A. Manufacturers and Products:
   1. 3M; DBY-Direct Bury Splice Kit.
   2. Rain Bird; Pen-Tite wire connectors, No. PT 101 through 104.

2.12 SPRINKLERS

A. Pop-Up Rotary: Gear drive, full circle and part circle type, heavy-duty unit; removable from aboveground; adjustable, as indicated; orifices or nozzles interchangeable.

2.13 VACUUM BREAKERS

A. Pressure or Atmospheric Type: Bronze body, with machined valve seat; working pressure rating to 150 psi.

B. Pressure Type Assembly:
   1. Vacuum breaker.
   2. Two gate valves of same size as vacuum breaker.
   3. One check valve for 2 inches and smaller or two check valves for 2-1/2 inches and larger; of same size as vacuum breaker.
   4. Union and nipples.

2.14 ACCESSORIES

A. Metal Stakes: Intermediate Grade, new billet steel, deformed, ASTM A615/A615M, Grade 40; or Sta-Stake, manufactured by King Bros. Industries, Sepulveda, CA.

B. Worm-Gear Clamps: Stainless steel with 3/8-inch wide stainless-steel hex head screw.

PART 3 EXECUTION

3.01 TRENCH EXCAVATION, PREPARATION AND BACKFILL

A. Areas Receiving Topsoil: Commence irrigation system construction only after topsoil has been spread, compacted, and rough graded.

B. Excavation:

1. Section 31 23 16, Excavation, unless otherwise specified below:
    a. Excavation: Unclassified.
    b. Depth: From top of waterline pipe to finished ground surface not less than 20 inches.
    c. Width: Excavate to narrowest practicable.
    d. Bottom: Reasonably true to grade and free of protruding stones, roots, and other undesirable material. Uniformly slope to low points.

C. Backfill:

1. Section 31 23 23.15, Trench Backfill, unless otherwise specified below:
    a. Pipe Base Material: Place and firmly tamp sand to 2-inch depth to provide continuous solid foundation for pipe.
    b. To a point 4 inches above pipe, place and compact excavated material.
    c. Place backfill in layers not exceeding 6 inches, thoroughly compact each layer, up to finished grade, except in planting areas.
    d. Planting Areas: In accordance with Section 32 91 13, Soil Preparation.
    e. Smooth up and make clean and free of excess materials and debris those areas disturbed by operations performed under this Specification.

3.02 INSTALLATION OF PIPE AND FITTINGS

A. Plastic Pipe:

1. Use only strap wrenches on threaded joints.
2. Follow manufacturer's recommendations in use of solvent cement.
3. Do not subject unthreaded pipe joints to hydrostatic pressure for 48 hours after making joints.
4. Lay pipe on the prepared pipe base, snaking pipe from one side of trench to the other to provide for subsequent contraction.
5. Start backfill activities only after successful completion of hydrostatic pressure testing.

B. Pipe under Improved Areas (Curbs, Walks, Pavements): Install inside sleeves.

3.03 SLEEVES

A. Provide a minimum cover of 18 inches where installed under improved areas.

3.04 INSTALLATION OF VALVES AND VALVE ACCESS BOXES

A. Valves: Install with a union.
   1. With Handles: Set at a depth to provide clearance between top of handle and box cover, or sleeve in which placed, when the valve is in open position and the cover is closed.
   2. Quick-Coupling: 4 inches above finished grade for flower beds and 12 inches from the edge of lawns, curbs, pavement, or graveled surfaces.

B. Valve Access Boxes and Sleeves: Install on a gravel base to provide foundation, ease of leveling, and proper drainage.
   1. Lawn Areas: Set to bring cover flush with finished ground surface.
   2. Shrub Areas: Set 2 inches above finished ground.

C. Group manual zone control valves together.

3.05 VACUUM BREAKER ASSEMBLIES

A. Install each assembly as one unit, complete with gate and check valves, so each assembly extends 6 inches higher than the highest sprinkler head it serves.
   1. Atmospheric Type: Install on discharge side of section control valves.
   2. Pressure Type: Install in supply side ahead of section control valves and after meter or pump.

3.06 IRRIGATION LINE CLEARANCES

A. Same Trench: Minimum 6-inch horizontal clearance.

B. Crossing Lines: Minimum 2-inch vertical clearance.

C. Other Utilities: Minimum 12-inch clearance in any direction.

3.07 SYSTEM DRAINAGE

A. Drain Valves: Locate at low points of pipelines so entire system is drained.

B. Slope line(s) to ensure entire system effectively drained to drain valves.

3.08 ELECTRICAL CONDUCTORS AND CONDUIT

A. Meet requirements of Section 26 05 05, Conductors.

B. Conduit: Meet requirements of Section 26 05 33, Raceway and Boxes.

3.09 ELECTRICAL CONNECTORS

A. Meet requirements of Section 26 05 04, Low-Voltage Basic Electrical Materials and Methods.

3.10 SPRINKLERS

A. Set perpendicular to finished grade at manufacturer's recommended height.

B. Variations in arrangement of heads to avoid trees, shrubs, and other obstacles subject to Design-Builder's prior approval.

C. Locate minimum 4 inches from walkways, drives, paths, curbs or other paved areas or concrete structures.

D. Install heads with swing joint assemblies.

E. Adjusting and Tightening:
   1. Adjust sprinklers having adjustable pin nozzles so the pin is directed into the stream for proper water distribution.
   2. Tighten nozzles on stationary pop-up sprinklers or stationary heads after installation.
   3. Adjust sprinklers having adjusting screw, adjusting stem, or adjusting friction collar on a lateral line or circuit, as necessary for proper coverage and discharge rate.
   4. Adjust sprinklers to ensure that no spray is discharged onto buildings.

3.11 FLUSHING

A. Flush supply lines and laterals as follows:
   1. Before installation of valves and fittings.
   2. Reflush after installation of valves and fittings.

3.12 TESTING AND INSPECTION

A. Do not perform hydrostatic pressure test on solvent welded pipeline and pipe joints for at least 48 hours after installation of zone to be tested.

B. Test each zone to 125 psi and as follows:
   1. Center load sections of pipe as necessary to prevent arching or whipping during testing.
   2. Test lateral lines from the section control valves to the sprinkler heads for 1 hour, minimum.

3. Test main lines to section control valves until leak-free for a period of 48 hours.

C. Remove and replace defective piping, and perform testing until test zone is completely watertight at which time test may be considered successfully completed.

3.13 SYSTEM BALANCING

A. Adjust and balance the completed system at normal water pressure with fully open valves.

END OF SECTION

SECTION 32 91 13
SOIL PREPARATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:
   1. ASTM International (ASTM):
      a. C33, Standard Specification for Concrete Aggregates.
      b. C602, Standard Specification for Agricultural Liming Materials.
   2. U.S. Bureau of Reclamation (USBR):
      a. 514.4.4, Reclamation Instructions, Series 510—Land Classification Techniques and Standards, Part 514—Laboratory Procedures, Chapter 4—Particle-Size Analyses.
      b. 514.8.7, Reclamation Instructions, Series 510—Land Classification Techniques and Standards, Part 514—Laboratory Procedures, Chapter 8—Soil Chemical Tests.

1.02 SUBMITTALS

A. Action Submittals:
   1. Shop Drawings: Product labels/data sheets.

B. Informational Submittals:
   1. Certified Topsoil Analysis Reports:
      a. Indicate quantities of materials necessary to bring topsoil into compliance with textural/gradation requirements.
      b. Indicate quantity of lime, quantity and analysis of fertilizer, and quantity and type of soil additive.

1.03 SEQUENCING AND SCHEDULING

A. 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.

B. Organic Matter: Minimum 1.5 percent by dry weight as determined in accordance with USBR 514.8.7.

C. pH: Range 6.0 to 7.2.

D. Textural Amendments: Amend as necessary to conform to required composition by incorporating sand, peat, manure, or sawdust.

E. Source: Stockpile material onsite, in accordance with Section 31 10 00, Site Clearing.

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 SAWDUST OR GROUND BARK

A. Nontoxic, of uniform texture, and subject to slow decomposition when mixed with soil.

B. 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.

2.04 FERTILIZER

A. Manure:
   1. Well-rotted, stable or cattle manure, free from weed seed and refuse.
   2. Maximum 50 percent sawdust or shavings by volume.
   3. Age: Minimum 4 months; maximum 2 years.

B. Commercial: Per soil analysis recommendations. Commercial, uniform in composition, free-flowing, suitable for application with equipment designed for that purpose.

2.05 SAND

A. Fine Aggregates as specified in Section 03 30 00, Cast-in-Place Concrete.

2.06 SOURCE QUALITY CONTROL

A. Topsoil Analysis/Testing: Performed by county or state soil testing service or approved certified independent testing laboratory. Soil analysis to be performed after rough grading.

PART 3 EXECUTION

3.01 SUBGRADE PREPARATION

A. Scarify subgrade to minimum depth of 6 inches where topsoil is to be placed.

B. Remove stones over 2-1/2 inches in any dimension, sticks, roots, rubbish, and other extraneous material.

C. Limit preparation to areas which will receive topsoil within 2 days after preparation.

3.02 TOPSOIL PLACEMENT

A. Place 6 inches of topsoil in all areas to be seeded with grass and other plants.

B. Do not place topsoil when subsoil or topsoil is frozen, excessively wet, or otherwise detrimental to the Work.

C. Mix soil amendments, lime, and fertilizer 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.

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 inches, 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

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 90 days after all planting under this section is completed.

B. Satisfactory Stand:
   1. Hydroseeded section of lawn that has:
      a. No bare spots larger than 3 square feet.
      b. Not more than 10 percent of total area with bare spots larger than 1 square foot.
      c. Not more than 15 percent of total area with bare spots larger than 6 square inches.

1.02 SUBMITTALS

A. Action Submittals: Product labels/data sheets.

B. Informational Submittals:
   1. Seed:
      a. Certification of seed analysis, germination rate, and inoculation:
         1) Certify that each lot of seed has been tested by a testing laboratory certified in seed testing, within 6 months of date of delivery. Include with certification:
            a) Name and address of laboratory.
            b) Date of test.
            c) Lot number for each seed specified.
            d) Test Results: (i) name, (ii) percentages of purity and of germination, and (iii) weed content for each kind of seed furnished.
         2) Mixtures: Proportions of each kind of seed.
   2. Seed Inoculant Certification: Bacteria prepared specifically for legume species to be inoculated.
   3. Description of required maintenance activities and activity frequency.

1.03 DELIVERY, STORAGE, AND PROTECTION

A. Seed:
   1. Furnish in standard containers with seed name, lot number, net weight, percentages of purity, germination, and hard seed and maximum weed seed content, clearly marked for each container of seed.
   2. Keep dry during storage.

B. Hydroseeding Mulch: Mark package of wood fiber mulch to show air dry weight.

1.04 WEATHER RESTRICTIONS

A. Perform Work under favorable weather and soil moisture conditions as determined by accepted local practice.

1.05 SEQUENCING AND SCHEDULING

A. Prepare topsoil as specified in Section 32 91 13, Soil Preparation, before starting Work of this section.

B. Complete Work under this section within 3 days following completion of soil preparation.

C. Notify Design-Builder at least 3 days in advance of:
   1. Each material delivery.
   2. Start of planting activity.

D. Planting Season: Between September 15 and December 15.

1.06 MAINTENANCE SERVICE

A. Subcontractor:
   1. Perform maintenance operations during maintenance period to include:
      a. Watering: Keep surface moist.
      b. Washouts: Repair by filling with topsoil, liming, fertilizing, seeding, and mulching.
      c. Mulch: Replace wherever and whenever washed or blown away.
      d. Mowing: Mow to 2 inches after grass height reaches 3 inches, and mow to maintain grass height from exceeding 3-1/2 inches.
      e. Reseed unsatisfactory areas or portions thereof immediately at the end of the maintenance period if a satisfactory stand has not been produced.
      f. Reseed/replant during next planting season if scheduled end of maintenance period falls after December 15.

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. Top Dress Type: As recommended by local authority.

2.02 SEED

A. Fresh, clean new-crop seed that complies with the tolerance for purity and germination established by Official Seed Analysts of North America.

B. Seeds of Legumes: Inoculated with pure culture of nitrogen-fixing bacteria prepared specifically for legume species in accordance with inoculant manufacturer's instructions.

C. Seed Mix: TWCA Aqua Wise Fescue, supplied by Pacific Coast Seed.

Species	Proportion By Weight
Nanook Hard Fescue	40%
Bighorn GT Blue Fescue	17%
SR3210 Blue Fescue	8%
Quatro Sheeps Fescue	20%
Heathland Chewings Fescue	15%

2.03 TACKIFIER

A. Derived from natural organic plant sources containing no growth or germination-inhibiting materials.
   1. Capable of hydrating in water, and to readily blend with other slurry materials.
   2. Manufacturers and Products:
      a. S&S Seeds; M-Binder.
      b. Chevron Asphalt Co.; CSS 1.
      c. Terra; Tack AR.
      d. J Tack; Reclamare.

2.04 HYDROSEEDING MULCH

A. As specified in Section 01 57 13, Temporary Erosion and Sediment Control.

2.05 EDGING

A. Plastic: Polyethylene edging 1/8 inch by 4 inches wide, black, with integral design to provide a firm hold without staking.

PART 3 EXECUTION

3.01 PREPARATION

A. Grade areas to smooth, even surface with loose, uniformly fine texture.
   1. Roll and rake, remove ridges, fill depressions to meet finish grades.
   2. Limit such Work to areas to be planted within immediate future.
   3. Remove debris, and stones larger than 1-1/2-inch diameter, and other objects that may interfere with planting and maintenance operations.

B. Moisten prepared areas before planting if soil is dry. Water thoroughly and allow surface to dry off before seeding. Do not create muddy soil.

C. Restore prepared areas to specified condition if eroded or otherwise disturbed after preparation and before planting.

3.02 FERTILIZER

A. Apply evenly over area in accordance with manufacturer's instructions. Mix into top 2 inches of topsoil, when applied by broad cast method.

B. Application Rate: Determined by soil test results in accordance with Section 32 91 13, Soil Preparation.

3.03 SEEDING

A. Start within 2 days of preparation completion.

B. Hydroseeding:
   1. Application Rate:
      a. 3,000 pounds per acre including the following minimum amounts:
         1) 220 pounds per acre of seed.
         2) 2,000 pounds per acre of wood fiber.
         3) 150 pounds per acre of tackifier.

4) Minimum rate of fertilizer and other soil amendments shall comply with the Topsoil Analysis Report.

2. Apply on moist soil, only after free surface water has drained away.
3. Prevent drift and displacement of mixture into other areas.
4. Upon application, allow absorption and percolation of moisture into ground.
5. Mixtures: Seed and fertilizer may be mixed together, apply within 30 minutes of mixing to prevent fertilizer from burning seed.

C. Water: Apply with fine spray after mulching to saturate top 4 inches of soil.

3.04 FIELD QUALITY CONTROL

A. 8 weeks after seeding is complete and on written notice from Subcontractor, Design-Builder will, within 15 days of receipt, determine if a satisfactory stand has been established.

B. If a satisfactory stand has not been established, Design-Builder will make another determination after written notice from Subcontractor following the next growing season.

END OF SECTION