

- B. Junction Boxes and Pull Boxes:
1. Boxes shall be installed where required and where indicated on the Drawings.
  2. Boxes shall be accessible.
  3. Boxes shall not be installed in finished areas.
  4. Pull boxes shall be provided at least every 150 feet on long straight conduit runs. Spacing shall be reduced by 50 feet for each 90 degree bend. See Section 16110 for maximum bends in conduit systems.
  5. Box dimensions shall be in accordance with size and quantity of conductors and conduits entering and leaving box per NEC Article 314 requirements.

END OF SECTION

## SECTION 16140 WIRING DEVICES

### PART 1 - GENERAL

#### 1.01 SECTION INCLUDES

- A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.
- B. Work Included:
  1. Installation, connection and furnishing all single, duplex, GFI, and special purpose receptacles complete with wall plates and/or covers as shown on the Drawings.
  2. Installation, connection and furnishing of all single pole, three-way, pilot light, and momentary position toggle switches complete with wall plates and or handle operators as shown on the Drawings.

#### 1.02 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

#### A. American National Standards Institute (ANSI):

1. C73 Plugs and Receptacles
2. C73a Plugs and Receptacles

#### B. Federal Specifications (FS):

1. W-C-596 D & E General Specifications for Cable Outlet Electrical Connector
2. W-S-896 D & E General Specifications for Flush Mounted Toggle and Lock Switches

Boxes

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- C. National Electrical Manufacturers Association (NEMA):
1. WD 1 General Requirements for Wiring Devices
  2. WD 6 Wiring Devices - Dimensional Requirements

- D. Underwriters Laboratories, Inc. (UL):
1. 20 General-Use Snap Switches
  2. 498 Electrical Attachment Plugs and Receptacles
  3. 514 Electrical Outlet Boxes
  4. 943 Class A Ground Fault Receptacle Interrupting Requirements

1.03 SUBMITTALS

- A. The following information shall be submitted in accordance with Section 01300:
1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
  2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

- B. Submit material or equipment data in accordance with the requirements of Section 16010.

1.04 LOCATIONS

- A. Refer to Section 16010, General Electrical Requirements, for definitions of types of locations.

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PART 2 - PRODUCTS  
2.01 RECEPTACLES

- A. General: Receptacles shall be heavy duty, high abuse, grounding type conforming to NEMA configurations, NEMA WD1 and UL 514 Standards.
- B. Single and Duplex Receptacles:
1. Receptacles shall be of back and side wire design utilizing screw type terminals suitable for stranded wires. Receptacles shall be rated 20 ampere, two-pole, 3-wire, 120 Vac, NEMA 5-20 configuration, self-grounding. Color shall be brown in industrial areas and ivory or white in office and laboratory areas. Power contacts shall be a T-type design and shall be brass. Ground contacts shall be brass.
  2. Devices shall have a nylon composition face with a nylon or melamine body. Units shall comply with Federal Specification W-C-596E and meet UL 498 test requirements. Receptacles shall be Hubbell 5362; Daniel Woodhead 5262DW; or approved equal.
- C. Special Purpose Receptacles: Receptacles shall be of the ampereage, voltage and NEMA configuration indicated on the Drawings. Compliance to standards and tests shall be as listed in Item B above.
- D. GFI Receptacles:
1. Device shall be rated 20 ampere, 2-pole, 3-wire, 120 Vac, conforming to NEMA WD1.10 configuration. Face shall be nylon composition meeting UL 498 test standards. Unit shall have test and reset push buttons. Reset push button shall have a visible indicator band to indicate the tripped condition.
  2. GFCI component shall meet UL 498 Class A standards with a tripping time of 1/40 second at 5 milliamperes current unbalance. Terminations shall be suitable for stranded wires. Operating range shall extend from 31°F to 158°F. Unit shall be ceramic encapsulated for protection against moisture.
  3. Provide Hubbell 5362; Daniel Woodhead; or approved equal.
- E. Corrosion Resistant Receptacles: Units shall comply with standards listed in Item B above, but shall also have tin-nickel plated brass connecting equipment and stainless steel hardware. Receptacle face color shall be yellow to identify the device as having these special qualities. Provide Hubbell Catalog No. 52CM62 and 53CM62; Daniel Woodhead; or approved equal.
- F. Surface Multiple Outlet Assemblies: Units shall have outlets on center-to-center spacing as indicated on the Drawings. Assembly shall conform to Article 353 of the NEC and receptacles shall conform to the standards listed in Item A above.

2.02 SWITCHES

- A. Line Voltage Types: Switches shall be rated 20 amperes at 120 or 277 Vac only. Units shall be flush mounted, self-grounding, quiet operating toggle devices. Handle color shall be brown in industrial areas and white or ivory in office and laboratory

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areas. Units shall conform to Federal Specifications W-S-896 D and E, UL 20, and NEMA WD1 standards. Sierra Electric, Monumental Grade, Catalog No. 5721; Daniel Woodhead 1900 Series; or approved equal.

## 2.03 PLATES

- A. General: Plates shall be of the style and color to match the wiring devices, and of the required number of gangs. Plates shall conform to NEMA WD1, UL 514, and ANSI C73. Plates on finished walls shall be non-metallic or stainless steel. Plates on unfinished walls and on fittings shall be of zinc plated steel or cast metal having rounded corners and beveled edges.
- B. Non-Metallic: Plates shall be smooth finish with contoured edges and shall be nylon or fiberglass.
- C. Stainless Steel: Plates shall be 0.035 inch thick with beveled edges and shall be manufactured from No. 302 alloy having a brushed or satin finish.
- D. Galvanized: Plates shall be galvanized sheet steel raised ½ inch, with rounded corners.
- E. Cast Metal: Plates shall be cast or malleable iron covers with gaskets so as to be moisture resistant or weatherproof.
- F. Blank Plates: Cover plates for future telephone or television outlets shall match adjacent device wall plates in appearance.
- G. Damp or Wet and Corrosive Locations: Plates shall have weather protective double doors. Material of manufacture shall be die-cast aluminum for metallic plates or nylon for non-metallic plates.

## 2.04 TEL/DATA OUTLETS

- A. Provide tel/data outlets as shown on the Drawings. Each outlet shall provide for one Ethernet data connection and one telephone connection, and be complete with one RJ45 jack and one RJ11 jack. Jacks and wall plates shall be Leviton or approved equal.

## PART 3 - EXECUTION

### 3.01 INSTALLATION OF WIRING DEVICES

- A. Dry Locations: The device shall be installed in flush mounted boxes with washers as required to bring the device mounting strap level with the surface of the finished wall.
- B. Damp or Wet Exterior Locations: Install only wiring devices approved for outdoor service in these locations.

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- C. Mounting Heights: Locations of wall outlets shall be measured from the finished floor to the center of the outlet box. Boxes shall be adjusted so that the front edge of the box shall not be further back from the finished wall plane than ¼ inch. Boxes shall be adjusted so that they do not project beyond the finished wall. Height above finished floor shall be as follows:

Receptacles Toggle Switches	Inches From Floor 18, except where shown otherwise 44
--------------------------------	---

- D. Damp or Wet Interior Locations: Install only wiring devices approved for outdoor service. Adjust boxes so that front edge will be ¼ inch beyond the rear edge of the finished wall. Use metal tubing sleeves to bring device mounting straps flush with the front edge of the finished wall.
- E. Receptacles:
  1. Receptacles shall be grounded by a grounding conductor, not by a yoke or screw contact.
  2. Receptacles shall be oriented so that the grounding slot is located at the bottom of the outlet.
  3. Receptacles shall be installed with connections pigtailed (spliced) to the branch circuit wiring so that removal of the receptacle will not lose neutral continuity and branch circuit power will not be lost to other receptacles on the same circuit.

### 3.02 INSTALLATION OF WALL PLATES

- A. General: Plates shall match the style of the device and shall be plumb within 1/16 inch of the vertical or horizontal.
- B. Interior Dry Locations: Install plates so that all four edges are in continuous contact with the finished wall surfaces. Plaster filling will not be permitted. Do not use oversize plates or sectional plates.
- C. Exterior and/or Wet Locations: Install plates with gaskets on wiring devices in such a manner as to provide a rain-tight weatherproof installation. Cover type shall match box type.
- D. Future Locations: Install blank cover plates on all unused outlets.

### 3.03 TESTS

- A. Receptacles:
  1. Receptacles shall be tested for blade and ground plug tension prior to installation. Do not install any receptacle having less than 16 ounce individual blade retention.
  2. After installation of receptacles, circuits shall be energized and each receptacle tested for proper ground continuity, reversed polarity, and/or open neutral condition.

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3. GFI receptacles shall be tested with the circuits energized. Devices shall be tested with a portable GFI receptacle tester capable of circulating 7.5 milliamperes of current, when plugged in, between the "hot" line and "ground" to produce tripping of the receptacle. Resetting and tripping shall be checked at least twice at each GFI receptacle.

#### END OF SECTION

#### SECTION 16160 PANELBOARDS

##### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.

##### 1.02 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

- A. American National Standards Institute (ANSI):
  1. Z55.1 Gray Finishes for Industrial Apparatus and Equipment
- B. National Electrical Manufacturers Association (NEMA):
  1. PB 1 Panelboards
  2. 250 Enclosures for Electrical Equipment (1,000 Volt Maximum)
- C. Federal Specifications (FS):
  1. W-P-115 Panel, Power Distribution
  2. W-C-375 Circuit Breakers, Molded Case, Branch Circuit and Series Service, Series Trip
- D. Underwriters Laboratories, Inc. (UL):
  1. 50 Electrical Cabinets and Boxes
  2. 869 Electrical Service Equipment
  3. 869A Reference Standard for Device Equipment

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### 1.03 SUBMITTALS

- A. The following information shall be submitted in accordance with Section 01300:
1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
  2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
- B. Submit material or equipment data in accordance with the requirements of Section 16010.
- C. Shop Drawings: For each panelboard, submit manufacturer's name and data as required:
1. Panelboard type.
  2. Main bus and terminal connection sizes.
  3. Location of line connections.
  4. Cabinet dimensions.
  5. Gutter space.
  6. Gauge of boxes and fronts.
  7. Finish data.
  8. Voltage rating.
  9. Breaker types, trip ratings, and interrupting ratings.
  10. Connections, support, and anchorage per Sections 01190 and 16010.
- 1.04 LOCATIONS
- A. Refer to Section 16010 for definitions of types of locations.

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### PART 2 - PRODUCTS

#### 2.01 PANELBOARDS

- A. General: All panelboards shall be the automatic circuit breaker type. The number and arrangement of circuits, trip ratings, spares, and blank spaces for future circuit breakers shall be as shown on the Drawings. All circuit breakers shall be quick-make, quick-break, thermal magnetic, bolt-on type, and 1, 2, or 3 pole as shown, each with a single operating handle.
1. Each panelboard shall have a field-mounted identifying plastic nameplate giving the panel identification as shown on the Drawings. In addition, each panelboard shall have a manufacturer's nameplate showing the voltage, bus rating, phase, frequency and number of wires.
  2. For panelboards used in dry locations, finish of doors and trim shall be ANSI 61 or 49, in accordance with ANSI Z55.1. Boxes of all such panelboards shall be galvanized, field finished to match the fronts.
  3. Where specified, panelboards shall have NEMA 3R/12 and/or NEMA 4X enclosures.
  4. Panelboards and enclosures shall conform to NEMA PB1 and 250, UL 50, and requirements of all relevant codes. Panelboards used as service equipment shall conform to UL 869.
- B. Lighting Panelboards:
1. General: Lighting panelboards shall be rated as shown on the Drawings. Panelboards shall meet the requirements of Federal Specification W-P-115 for Type I, Class 1 panelboards with circuit breakers.
  2. Lighting panelboards shall have front doors with key latch, common keying, and a typed directory card and holder. Panelboard circuits shall be arranged with odd numbers on the left and even numbers on the right.
  3. Circuit Breakers: Circuit breakers shall be the molded case type with ratings as shown on the Drawings. Circuit breakers shall have interrupting ratings of 10,000 RMS symmetrical amperes at 120/240 Vac.
  4. Manufacturer: Panelboards shall be Cutler Hammer Pow-R-Line C; Square D NQOD; or equal.
- PART 3 - EXECUTION
- 3.01 INSTALLATION
- A. Panelboards shall be installed as indicated on the Drawings and in accordance with the manufacturer's instructions.
- B. Provide a panelboard directory indicating up-to-date circuits during construction. Directory shall be typed and shall indicate panelboard power source. No handwritten directory is acceptable.

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3.02 MOUNTING HEIGHTS

- A. Lighting and distribution panelboards not installed in a Motor Control Center shall be mounted with the top of the box 6-feet-6-inches above the floor. Panelboards shall be plumb within 1/8 inch. The highest breaker operating handle shall not be higher than 72 inches above the floor.

3.03 PERFORMANCE TESTS

- A. Insulation Resistance Tests: Perform insulation resistance tests on circuits to be energized with a line-to-neutral voltage of 120 Vac or more. Test the insulation with a 500 Vdc insulation resistance tester with a scale reading 100 megohms. The insulation resistance shall be 20 megohms or more. Submit results for review.
- B. Grounding: Panelboard grounding shall conform to Section 16450.
- C. Continuity: Panelboard circuits shall be tested for continuity prior to energizing. Continuity tests shall be conducted using a DC device with a bell or buzzer.

END OF SECTION

SECTION 16180

PROTECTIVE DEVICES AND SWITCHES

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.
- B. Work Included: Provide all necessary labor, tools and material to install circuit protective devices as shown on the Drawings and as described in these Specifications.

1.02 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

- A. American National Standards Institute (ANSI):
1. Z55.1 Gray Finishes for Industrial Apparatus and Equipment
- B. National Electrical Manufacturers Association (NEMA):
1. ICS 3 Industrial Systems
  2. ICS 6 Enclosures
  3. 250 Type 1 Enclosures for Electrical Equipment (1,000 Volts Maximum)
- C. Federal Specifications (FS):
1. W-C-375 Circuit Breakers, Molded Case, Branch Circuit and Series Service, Series Trip
  2. W-F-1726 Class H Cartridge Fuses

Panelboards

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Protective Devices and Switches



- D. Underwriters Laboratories, Inc. (UL):
1. 50 Electrical Cabinets and Boxes
  2. 198C Fuses, High-Interrupting-Capacity-Current Limiting Types
  3. 489 Molded Case Circuit Breakers and Enclosures
  4. 698 Industrial Control Equipment for Use in Hazardous (Classified) Locations
- E. National Fire Protection Association (NFPA):
1. 70 National Electric Code
- 1.03 SUBMITTALS
- A. The following information shall be submitted in accordance with Section 01300:
1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
  2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
- B. Submit material or equipment data in accordance with the requirements of Section 16010.
- C. For the Generator Connection Panel, submit manufacturer's drawings and data. Drawings and data shall include, as a minimum, dimensioned general arrangement drawings, UL listing information including UL control or file number, component data, mounting provisions, conduit entry locations and installation instructions.
- 1.04 LOCATIONS
- A. Refer to Section 16010 for definitions of types of locations.

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## PART 2 - PRODUCTS

### 2.01 ENCLOSED CIRCUIT BREAKERS

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## 2.03 GENERATOR CONNECTION PANEL

- A. General: Provide a Generator Connection Panel as shown on the Drawings. Panel shall be rated at 480 Vac, 3-phase, 4-wire, with ground. Panel shall be rated for 1000 Amps.
- B. Generator connection panel shall be UL listed and labeled under the UL 1008 standard with a minimum 22KA withstand rating.
- C. Generator connection panel manufacturer shall provide a complete factory assembled and tested panel.
- D. Generator connection panel shall consist of cam-style male connectors and grounding terminals, all housed within a padlockable enclosure.
- E. Generator connection panel shall be Type 3R, constructed of continuous seam-welded, powder coated galvanized steel. The main access shall be through a hinged door that extends the full height of the enclosure. Access for portable generator cables with female cam-style plugs shall be via cable entry openings in the bottom of the enclosure. A hinged flap door shall be provided to cover the cable openings when cables are not connected; the hinged flap door shall allow cable entry only after the main access door has been opened. Enclosure shall be powder coated after fabrication; color shall be light gray.
- F. Cam-style male connectors (inlets) shall be UL Listed single-pole separable type, each rated 400 amps at 600 Vac. Cam-style male connectors shall be color coded. Multiple cam-style male connectors shall be provided for each phase, neutral and ground. The ground cam-style male connectors shall be bonded to the enclosure, and a ground lug shall be provided for connection of the facility ground conductor. None of the cam-style male connectors shall be accessible unless the main access door is open.
- G. Manufacturer: TempTap by ESL Power Systems; POSI-LOK by Cooper; or equal.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Install units plumb within 1/8 inch of vertical, and in accordance with manufacturer's instructions. Make sure that fuse ratings are as shown on the Drawings, and that breaker trip settings are per the Owner's instructions.

### 3.02 MOUNTING HEIGHTS

- A. Disconnect switches and enclosed circuit breakers shall be centered 5'-0" above the floor.
- B. Generator connection panel shall be mounted such that the bottom of the panel is 3'-0" above finished grade.

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### 3.03 PERFORMANCE TESTS

- A. Insulation Resistance Tests: Perform insulation resistance tests on circuits to be energized with a line-to-neutral voltage of 120 Vac or more. Test the insulation with a 500 Vdc insulation resistance tester with a scale reading 100 megohms. The insulation resistance shall be 20 megohms or more. Submit results for review.
- B. Continuity Tests: Perform circuit continuity tests from a low powered DC test source to operate a buzzer or bell. Tests shall be made prior to energizing the protected circuit.
- C. Operating Tests: Demonstrate that the protected circuit can be manually controlled by the installed equipment.

END OF SECTION

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# SECTION 16205

## STANDBY DIESEL ENGINE-GENERATOR SET

### PART 1 - GENERAL

#### 1.01 DESCRIPTION

- A. Provisions: Applicable provisions of Sections 11001 and 16010 become a part of this Section as if repeated herein.
- B. Work Included: Furnish all labor, materials, equipment, services and incidentals required to provide a complete and operable standby diesel engine-generator system. Materials and equipment shall be new and of best quality, as specified and shown on the Drawings. The work shall include, but not be limited to:
  1. Standby diesel engine-generator set (hereinafter called engine-generator) complete with all appurtenances. Unit shall be complete with all standard accessories for the manufacturers and models listed in paragraph 2.01.E in addition to those additional and special features described.
  2. Sub-base fuel tank, including, fuel piping from day tank to engine, and engine-mounted fuel pump.
  3. Automatic starting and shutdown controls, starting batteries, battery rack, charger, and generator controls.
  4. Exhaust system complete with flexible connectors, silencer, exhaust piping, and supports for silencer and exhaust pipe.
  5. Weatherproof, sound attenuating enclosure.
  6. Portable load bank including related cables and equipment.
  7. Cables with female cam-loc connectors.
- C. Related Work Specified in Other Sections:
  1. Division 2: Excavation and Backfill
  2. Section 09000: Painting
  3. Division 3: Concrete Work
  4. Section 16120: Low Voltage Wire and Cable
  5. Section 16180: Protective Devices and Switches
  6. Section 16250: Automatic Transfer Switch
  7. Section 16924: Adjustable Frequency Drives (AFDs)

#### 1.02 QUALITY CONTROL

- A. Comply with all rules and regulations of authorities having jurisdiction over work specified herein.
- B. Permits and inspection shall be in accordance with Division 1 of this Specification.
- C. The Drawings are diagrammatic. Size of equipment and pipes and general method of routing are shown, but it is not intended to show every offset and fitting nor every structural difficulty that may be encountered.

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Standby Diesel  
Engine-Generator Set

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## 1.03 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

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- A. ASTM International (ASTM) Publication:
  1. A123 Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
- B. Federal Specification (FS):
  1. FF-H-106C Hardware, Builders Locks and Door Trim
- C. National Electrical Manufacturers Association (NEMA) Publications:
  1. ICS-1 General Standards for Industrial Controls and Systems
  2. ICS-2 Standards for Industrial Control Devices, Controllers and Assemblies
  3. 250 Enclosures for Electrical Equipment (1,000 Volts Maximum)
  4. MG 1 Motors and Generators
- D. National Fire Protection Association (NFPA) Publications:
  1. 30 Flammable and Combustible Liquid Code
  2. 37 Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
  3. 70 National Electrical Code
  4. 110 Standard for Emergency and Standby Power Systems
- E. Underwriters Laboratory (UL) Standard:
  1. 508 Electric Industrial Control Equipment
- F. All state and local building codes, including building, mechanical, fire and electrical.

## 1.04 SUBMITTALS

- A. The following information shall be submitted in accordance with Section 01300:
  1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed

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written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

- B. Submit material or equipment data in accordance with the submittal requirements of Section 16010.

- C. Shop Drawings: Submit shop drawings and include the following information. Check the shop drawings submittal to verify that all details and data required below are included. If the submittal is not complete, it cannot be favorably reviewed and will be returned for completion.

1. Plan layout drawings for the engine-generator with location dimensions for all connections including: electrical, fuel, and exhaust with base dimensions and weights, including sound attenuating enclosure.
2. Composite assembly drawing of engine-generator showing location of all auxiliary equipment, dimensions and weight.
3. Front, rear, and both side elevations of the complete engine-generator unit assembly, including fuel tank, radiator exhaust air duct or sound attenuating enclosure.
4. Specification sheets with performance data and engineering details adequate to determine compliance with specifications of:
  - a. Engine (including engine cranking amperes at 20°F)
  - b. Radiator and water pump
  - c. Alternator and voltage regulator
  - d. Base assembly, housing, and vibration isolation mounts
  - e. Control panel with all components
  - f. Jacket water heater
  - g. Engine-mounted fuel pump
  - h. Governor
  - i. Battery system
  - j. Exhaust silencer, piping and accessories
  - k. Battery charger
  - l. Alarms
  - m. Weatherproof, sound attenuating enclosure
  - n. Sub-base fuel tank and accessories
  - o. Load bank and accessories
5. Electrical interconnection diagram including: alternator, voltage regulator, control panel, circuit breaker, batteries, jacket heater, switches, and accessories.

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6. Complete identification of all components and materials by manufacturer, model number, rating and material.
7. Complete engine and alternator voltage dip and load data. Provide calculations to show compliance with specified performance requirements specifically prepared for this project. Generalized catalogs are not sufficient to meet this requirement. The voltage dip characteristics shall also be confirmed in the field. Failure of this field test shall constitute evidence that the equipment has not met the voltage dip criterion. The equipment shall be replaced or modified until the installed equipment operates successfully as specified herein. (See Paragraph 3.03 Testing and Run-In.) Under no circumstances will equipment with a voltage dip greater than specified be acceptable.
8. Wiring diagrams for alternator excitation and regulation circuits, alarm circuits, and instrument circuits.
9. Elementary control diagram and separate wiring diagram for automatic engine starting and protective shutdown controls. These diagrams shall show a wire number for every control circuit wire. Include a comprehensive description of operation.
10. Complete surface preparation and finish data for the engine, alternator, cabinet, panels, frame, housing, and other surfaces.
11. Detailed description of factory testing program, testing equipment, reporting procedure, and criteria for test passing or failing.
12. Detailed description of field testing program including: description of tests, testing equipment, reporting procedure, and criteria for test passing or failing. (This may be a separate submittal made at a later time, but not later than 30 days before the actual tests.)
13. Seismic Anchorage Design, including layout and calculations, signed and sealed by a Professional Engineer, registered in the State of California.
14. Submit Level 2 certification from the manufacturer that the equipment is capable of resisting seismic loads. Loading shall be as described in Section 01190.
- D. Factory Test Report: After fabrication and testing but before shipping from the factory, submit results of the factory test for review. Do not ship any generator units until the factory test results have received favorable review.
- E. Field Test Report: Submit field test report for review within 15 days of the time of completion of the field test.
- F. Manual: Provide in conformance with Sections 01300 and 16010.

## PART 2 - PRODUCTS

### 2.01 ENGINE-GENERATOR SET

- A. General:
  1. The engine-generator shall be factory-fabricated and assembled package of new and current equipment, and shall consist of engine, alternator, controls, and other accessories as specified and as may be required for a complete and operable assembly, capable of automatic startup and shutdown. Provide engine type as required to meet EPA and local emission requirements.

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- Elevation of installation is at sea level with ambient temperatures between 20 and 90°F.
2. The engine-generator shall be supplied with earthquake-restrained vibration isolation and permanently mounted to welded steel base for connection to a sub-base fuel tank. The engine-generator and sub-base fuel tank shall be shipped as a single assembly.
  3. The engine-generator shall have only one source of supply and responsibility. The assembly and complete installation shall comply with the National Electrical Code and the State of California Code, including UL Listing.

#### B. Engine:

1. Type: The engine shall be for operation on No. 2 diesel fuel, shall be air-cooled, and shall include a jacket water circuit, mounted radiator with duct flange, and pusher-type fan. The engine brake horsepower rating shall be adequately sized for motors shown in paragraph 2.01.E, including starting loads, as well as lighting and control loads.
2. Control Panel: Provide an engine-generator controller meeting NFPA 110, Level 1 requirements. The control panel shall be wired, tested, and shock-mounted on the engine-generator by the manufacturer. The control panel shall incorporate the following features:
  - a. Engine Start System: Provide a complete automatic engine start-stop control which shall start engine on closing remote contact and initiate engine cool down and shutdown on opening contact. The engine controls shall also include a three-position selector switch with the following positions: RUN/STOP/AUTOMATIC; the STOP position shall shut the engine down immediately, bypassing the cool down cycle.
  - b. Safety Shutdowns: Provide a cranking limiter to open the starting circuit in approximately 45 to 60 seconds if the engine fails to start in that time. Provide sensing elements to shut the engine down immediately when conditions reach a level deemed harmful to the unit. Provide an individual signal light and alarm terminals for each condition. Provide one set of Form C output contacts for connection to the telemetry system as a composite "Generator Shutdown" alarm. Safety shutdowns shall include:
    - 1) Low lubricating oil pressure
    - 2) High water temperature
    - 3) Overspeed
    - 4) Overcrank
    - 5) Low coolant level
    - 6) Low fuel level
    - 7) Any additional conditions standard with the manufacturer.
  - c. Alarm Outputs: Provide one set of Form C output contacts for connections to the telemetry system as a "Composite Generator Warning" Alarm. The contacts shall be actuated for any one or more of the shutdown conditions or for overcurrent trip of the generator main breaker; provide alarm signal light for such overcurrent trip. The contacts shall remain activated during the entire period of the abnormal condition, and reset shall be automatic.
  - d. Provide one set of Form C output contacts to indicate that the engine is running.

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- e. Fuel System Control: Provide auxiliary contacts for monitoring the fuel level and leak detection instruments of the sub-base fuel tank assembly. Provide engine shutdown in the event of no fuel in the fuel tank.
- f. The contacts shall be wired to a terminal strip inside a closed, gasketed box.
3. Batteries: Provide starting batteries mounted in attached battery racks with non-conducting floor. Guarantee the batteries for one year or more and provide a new battery for any battery found defective within the guarantee period. Mount batteries above the concrete floor level. Batteries shall be the lead acid type. Engine shall be at the temperature maintained by the jacket heater for a 20°F ambient.
4. Battery Charger: Provide a charger of the two-rate type, with current and voltage ratings to suit the batteries. Include a dc ammeter, fused ac input and dc output, and charge rate selector switch. The charger shall operate on 120 Vac. Charger output shall be current limited to 140% of rated current.
5. Jacket Water Heater: Provide single-phase jacket water heater(s) with one thermostat. Size heater to maintain 100°F in 20°F ambient. Heaters having a total wattage of 1,200 or less shall be 120 volts; larger shall be 208 volts.
6. Initial Fills:
- Provide crankcase oil.
  - Provide initial fill of engine coolant as recommended by the manufacturer to protect engine cooling system to a minimum temperature of 20°F, and as required to inhibit corrosion in the cooling system.
  - Fuel Oil: Supply sufficient fuel oil for testing of operation.
  - Fuel Oil: Fill the fuel tank after completion of testing
- C. Alternator:
- The alternator shall be four-pole and of revolving field design with temperature-compensated solid state voltage regulator and high speed brushless rotating rectifier exciter system with permanent magnet. The stator shall be directly connected to the engine flywheel housing and rotor shall be driven through semi-flexible driving flanges to ensure permanent alignments. The insulation system shall be Class F with Class B temperature rise. The three-phase, broad range generator shall be 12-lead, reconnectable, and shall meet the requirements of NEMA Standard MG-1.
  - Alternator Performance:
    - Frequency regulation shall be isochronous  $\pm 1.0\%$  from no-load to rated load.
    - Steady-state voltage regulation shall be within  $\pm 2\%$  of rated voltage, from no-load to full rated load. Rheostats shall provide a minimum of  $\pm 5\%$  voltage adjustment from rated value. Voltage regulator shall be of the silicon controlled rectifier type.
    - The instantaneous voltage dip at any point in the loading sequence shall not exceed 18% of rated voltage.
  - Control Panel: The alternator control panel shall be wired, tested, and shock mounted on the generating set by the manufacturer, as shown on the Drawings. It shall contain panel lighting, manual reset circuit breaker,

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- frequency meter, running time meter, voltage adjusting rheostat, ac voltmeter, ac ammeter (which indicates current each phase), and voltmeter-ammeter phase selector switch with OFF position. Frequency meter, ammeter and voltmeter shall be 250 degree circular switchboard type, 2% accuracy class.
4. Alternator Main Power Circuit Breaker: Provide a main power circuit breaker as shown on the Drawings. The circuit breaker shall be molded case, 3-pole, 480 Vac, 100% rated, capable of interrupting the maximum fault current the alternator is capable of producing. The breaker shall be housed within the engine-generator enclosure. Breaker shall be quick-make, quick-break type, with wiping contacts and arc chutes for each pole. Breaker shall be trip free and have trip indication independent of on-off positions. Main conductors: Provide necessary sets of line lugs capable of accepting 400 kcmil conductors as shown on the Drawings.
5. Load Bank Power Circuit Breaker: Provide a load bank main power circuit breaker as shown on the Drawings. The circuit breaker shall be molded case, 3-pole, 480 Vac, 100% rated, capable of interrupting the maximum fault current the alternator is capable of producing. The breaker shall be housed within the engine-generator enclosure. Breaker shall be quick-make, quick-break type, with wiping contacts and arc chutes for each pole. Breaker shall be trip free and have trip indication independent of on-off positions. Main conductors: Provide necessary sets of line lugs capable of accepting cables as specified in paragraph 2.02.B.
- D. Vibration Isolation System for Engine-Generator Unit:
- Isolation system shall consist of earthquake-restrained spring vibration isolators attaching the engine-generator to the welded steel base system.
  - Vibration isolation shall be greater than 95%.
  - Vibration isolation system shall be Korfund Dynamics Corporation Series L Isolators supporting a Type RCPF base frame, Mason Industries Type KSL Base supported on SSLFH Mounts with adjustable vertical limit stops, or equal.
- E. Engine-Generator and Accessories Manufacturers, and Sizing Data:
- Engine Manufacturer: Onan/Cummins; Caterpillar; or equal
  - Minimum standby rating: 500 KW (at 0.8 power factor)
  - Step Load characteristics:

Step No.	Load No.	Load Size	Starting Method
1	Lighting Panelboards	90 KW	
2	Grit Washer	0.5	Across the Line
	Sluice Gate	0.5	Across the Line
	Secondary Clarifier	0.5	Across the Line
	Exhaust Fan	0.5	Across the Line
	Aeration Valves (22)	0.5	Across the Line
3	Aeration Blower 1	100	AFD
4	Aeration Blower 2	100	AFD
5	Hiller Road Pump 1	20	Across the Line
	Hiller Road Pump 2	20	Across the Line
	Grit Pump	20	Across the Line

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Step No.	Load No.	Load Size	Starting Method
6	Secondary Effluent Pump 1	15	AFD
	Secondary Effluent Pump 2	15	AFD
	RAS Pump 1	7.5	AFD
	RAS Pump 2	7.5	AFD
	RAS Pump 3	7.5	AFD
7	UW Pump 1	7.5	AFD
	Pond 4 Pump 1	5	AFD
	Pond 4 Pump 2	5	AFD
	TD/SN Pump	5	Across the Line
	Chlorine Injection Mixer	2	Across the Line
	Pond 4 Rectirc Prevention Valve	1	Across the Line
	Ejector Pump	1	Across the Line
	Mechanical Screen	1	Across the Line
	Grit Chamber Equipment	0.75	Across the Line

- Voltage: 480Y/277
  - Phase: 3
  - Wires: 4
- Maximum engine speed: 1,800

## 2.02 PORTABLE LOAD BANK

- Provide a portable load bank with manual generator load controller. The load bank shall provide an incremental mimic load which will be manually added/subtracted from the generator. Provide a load bank control panel integral to the load bank.
- Power connection to the load bank shall be 3-phase, 3-wire. Provide external cables for connection of the load bank to the generator load bank breaker specified in paragraph 2.01.C.5. Provide two conductors per phase. Conductors shall be heavy duty portable power cables suitable for outdoor use, and shall be 50 feet long.
- Load Indication: Load indication shall consist of three current transformers, which are to sense total current output of the alternator, an ammeter switch and ammeter in the load bank control panel, and interconnecting wiring.
- Manual Load Bank Ratings at 3,000 Feet Elevation and 100°F:
  - Capacity: 300 kW, 1.0 p.f.
  - Voltage: 480 Vac, 3-phase
  - Load Steps: 2- 50 kW and 2- 100 kW; each step shall have a fuse or circuit breaker protection for resistor elements
  - Frequency: 60 Hz
  - Time Rating: Continuous
  - Maximum Air Temperature Rise: 25°F
- The system shall have a load bank control panel which as a minimum includes the following:
  - Fuse or circuit breaker protected
  - Voltmeter (one-phase)
  - Ammeter and ammeter switch (three-phase and off)

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- Kilowatt Meter: 2% accuracy, total generator output sensing
  - Manual load step switching for 4-step control.
  - NEMA 3R enclosure
- The load bank shall be Avtron Model LPH400, or equal.

## 2.03 ENGINE EXHAUST SYSTEM

- Exhaust Silencer:
  - Provide an exhaust silencer of the critical silencing type capable of not less than 25 dBA attenuation, sized by the engine manufacturer to provide silencing without harmful backpressure, and mounted at the factory prior to shipment. Furnish with minimum 18-inch-long steel flexible exhaust connection sections and rain cap. Install silencer inside enclosure in accordance with the manufacturer's recommendations.
- Exhaust Piping: Provide Schedule 40, Standard ASTM A53, Grade B steel pipe with condensate drains at low points.

## 2.04 SUB-BASE FUEL TANK

- Sub-base Fuel Tank Assembly: The fuel system will consist of sub-base mounted fuel tank, double-wall (rupture basin) and shall include the following:
  - Provide UL 142 listed, double-walled steel, sub-base fuel tank mounted underneath the enclosure, sized for 48 hours of operation at full load.
  - Fuel level sight gauge.
  - Flexible fuel lines for feed and return. Fuel returns from engine by gravity. Provide check valves in return and intake lines if recommended by engine supplier.
  - The fill line shall be extended through the enclosure and provided with an anti-theft and lockable cap. Include overflow prevention valve, overflow alarm and spill containment pan on the fill system.
    - Containment pan shall have a minimum 5-gallon capacity, and shall have a drain tube that drains any spillage back into the tank. Cover shall have a lockable hasp.
    - Overflow prevention valve shall automatically stop fuel flow and 90% capacity and drain fuel from the highest point to allow fill nozzle to be removed without spilling.
    - Fuel tank overflow protection alarm: Provide a sensor with an audible/visible alarm that indicates when fuel level is at approximately 90% capacity.
  - Leak and level detection instruments to monitor any leak from the tank and low and high fuel levels. Instrument signals and power supply wiring shall be routed from Control Panel.
  - 2-inch normal vent, 4-inch primary and 4-inch emergency vent, all with piping extended to 12 feet above-grade in accordance with the Fire Code.
  - Drain pet cock valve.
  - Fuel strainer.

## 2.05 ENGINE-GENERATOR ENCLOSURE

- Provide a sound attenuating, weatherproof, skin-tight dropover enclosure for the engine-generator. The enclosure shall be fabricated from 12-gauge steel, with

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stainless steel hinges. The maximum outside dimensions for the enclosure shall be as shown on the Drawings. Configure louvers, access doors, noise traps, etc. to accommodate the layout shown on the Drawings. The enclosure shall include the following accessories and meet the following requirements:

1. The enclosure shall be insulated with sound-absorbing material to reduce the overall general noise level to less than 72 dBA at 23 feet. Sound absorbing material shall be mechanically secured to the inside of the enclosure at a sufficient number of locations to prevent sagging or failure of the material due to age, water damage, or normal use.
2. Air intake and exhaust louver(s) sized to exceed the minimum cooling air intake and exhaust requirements of the engine-generator ratings through operation of the engine-generator set radiator cooling fan.
3. A minimum of one access door shall be provided on each side of the enclosure, for access to the control panel and other maintenance points on the unit. The doors shall have stainless steel lockable latches and door stops. Doors shall be removable.
4. Exhaust muffler shall be installed within enclosure. Coordinate sound attenuation design with equipment manufacturer's muffler selection. Provide rain cap for exhaust outlet.
5. Access for filling of the engine radiator and sub-base fuel tank shall be provided through the enclosure.
6. The mounting holes for the enclosure shall be inset 12 inches from the edge of the enclosure base and the edge of the inertia pad shall align vertically with the side of the enclosure.
7. Coating system shall be as follows:
  - a. Primer: Shop prime with zinc-rich, rust-inhibiting primer at 3.5 DFT mils; SSPC-SP6 surface preparation.
  - b. Second coat: Epoxy coat, 3.0 DFT mils exterior, 6.0 DFT mils interior
  - c. Finish coat: Polyurethane, 3.0 DFT mils exterior only.
  - d. Total DFT mils: Exterior 9.5 mils, Interior 9.5 mils
  - e. Color to be selected by Engineer.

## 2.06 ENGINE-GENERATOR CABLES

- A. Provide cables to connect the generator Main Power Circuit Breaker to the Generator Connection Panel, as shown on the Drawings. Size the cables as shown on the Conduit and Wire Schedules. Cable shall be as specified in Section 16120. Cables shall be fitted with female cam-loc connectors compatible with the Generator Connection Panel.

## PART 3 - EXECUTION

### 3.01 ENGINE-GENERATED INSTALLATION

- A. General: Mount and anchor the engine-generator assembly, including the sub-base fuel tank, to a concrete base pad. Mount the engine-generator set on concrete inertia base. Design the engine-generator set assembly anchorage and support systems to resist seismic earthquake forces in accordance with Section 01190. In the shop drawing submittals, include calculations to demonstrate the adequacy of the anchorage and support systems.

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- B. Foundations, Installation and Grouting: Furnish the necessary materials and construct suitable concrete foundations.

- C. Skilled mechanics shall install all such equipment in accordance with the instructions of the manufacturer.

- D. In setting equipment, make an allowance of at least 1 inch for grout under the equipment bases. Shims used to level and adjust the bases shall be steel. Shims may be left embedded in the grout, in which case they shall be installed neatly and so as to be as inconspicuous as possible in the completed work. Unless otherwise approved, all grout shall be an approved non-shrink, non-metallic grout.

- E. Fuel and Lubricants: During testing and prior to acceptance, furnish all fuel and lubricants necessary for the proper operation of this equipment.

- F. Tools: For each type of equipment to be furnished by the Contractor, provide a complete set of all special tools (including grease guns or other lubricating devices) which may be necessary for the routine adjustment, operation and maintenance of such equipment.

- G. Exhaust pipe shall have approved metal shield and thimble to provide clearance between exhaust and combustible roof materials in accordance with the Mechanical Code. Install condensation drains at low point in exhaust piping and rain cap at the outlet of the exhaust pipe.

### 3.02 WIRING

- A. Wiring, including ground, control circuits, and accessories, between alternator and alternator control panel, starter, and automatic transfer switch shall be in accordance with manufacturer's recommendations and NEC, unless shown otherwise. Battery cables shall be adequate to supply full voltage to the starter. Battery charger and jacket water heater shall be wired on separate circuit breakers and circuits.

- B. Route conduits to reach their destination in a neat and orderly manner.

- C. All engine-generator wiring embedded in concrete, below grade, or floor level, shall be in rigid conduits.

- D. Conduits terminating on the engine-generator shall be protected from vibration by a section of flexible conduit.

- E. Grounding: Generator shall be grounded directly to the service entrance ground, in accordance with NEC.

- F. In the vicinity of terminations, lace all power conductors to resist short circuit forces.

### 3.03 TESTING AND RUN-IN

- A. General: Tests are to determine proper operation and capacity of the equipment and to demonstrate compliance with the Drawings and Specifications. All equipment that fails any test will be rejected, and complete re-testing will be required after the Contractor makes corrections or modifications to equipment which has previously failed any test. All field tests shall be witnessed by the Engineer.

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- B. Factory Tests: Factory test the engine-generator to assure compliance with the Drawings, Specifications, NEMA MG-1, and the manufacturer's quality control provisions. Provide three copies of all factory test reports.
- C. Field Tests:
1. General: Fully field test the engine-generator and load bank to demonstrate that all components are in compliance with the Specifications and are ready for service.
  2. Installation of the engine-generator shall be complete and the unit shall be serviced, tested, adjusted, and ready for use before the field tests are scheduled.
  3. Provide written notice to the Engineer of the scheduled dates for the field test at least 10 working days prior to the field test date. The notice shall include a written test schedule listing the tests, the test procedure, the criteria for a satisfactory test, ratings of load bank to be used, and description of special measurement equipment to be employed.
  4. Provide load bank to simulate the initial load, 100% load and motor starting loads specified in paragraph 2.01.E or coordinate testing using actual plant loads for part of the 100% load.
  5. Make repairs and adjustments as required to achieve satisfactory performance of the engine-generator unit. If repairs or adjustments are made during the tests, additional testing shall be performed as required by the Engineer, at no additional cost.
  6. Make written records of the tests, and within 10 days after completion of the field test, submit three copies of the test records to the Engineer. The test record shall indicate the test criteria and arrangement, the time of the test, the results, and pertinent data such as voltage, frequency, kilowatts, power factor, load current, oil pressure, water temperature, and ambient temperature. Pertinent data shall be recorded for each test, and at least every 30 minutes when the test requires more than 30 minutes.
- D. Alarm, Control, and Equipment Tests:
1. Demonstrate each alarm and safety shutdown provision as being caused by the abnormal condition unless an alternative test condition has been favorably reviewed by the Engineer prior to the scheduling of the tests.
  2. Operate each control circuit and device to demonstrate its proper operation.
  3. Demonstrate the battery charger and jacket water heater operation successfully.
- E. Operational Tests:
1. Simulate a power failure in order to demonstrate the proper operation of the transfer switch and engine-generator.
  2. Demonstrate motor starting capability by applying the specified initial load and then the equivalent of starting and running the specified motor loads. Voltage dip shall be measured and recorded to demonstrate conformity to the Specifications.
  3. Show that phase rotation of the engine-generator and the utility power are compatible at the site.

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F. Endurance Tests:

1. Operate the engine-generator for 30 minutes at one-half its kW rating.
  2. Operate the engine-generator for 6 hours continuously at 100% of its kW and kVA ratings.
- G. Provide load banks, fuel, test equipment, labor, materials, and all other equipment and services required for all tests.

3.04 OWNER ORIENTATION

- A. Provide instruction of Owner's representatives as specified in Section 11001.

END OF SECTION

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SECTION 16250

AUTOMATIC TRANSFER SWITCH

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.
- B. Work Included. Provide transfer switch complete with controls and accessories, as shown on the Drawings at each location shown on the Drawings.
- C. Related Work Specified in Other Sections:
  - 1. Section 16205: Standby Diesel Engine-Generator Set
  - 2. Section 16405: Switchboard

1.02 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

- A. American National Standards Institute (ANSI) Publication:
  - 1. Z55.1 Gray Finishes for Industrial Apparatus and Equipment
- B. National Electrical Manufacturers Association (NEMA) Publications:
  - 1. ICS1 Industrial Control and Systems: General Requirements
  - 2. ICS6 Enclosures
- C. Underwriters Laboratories (UL) Publication:
  - 1. 1008 Automatic Transfer Switches (revised 2012).

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#### D. International Electrical Testing Association (NETA):

1. TS Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems

#### 1.03 SUBMITTALS

- A. The following information shall be submitted in accordance with Section 01300:
  1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
  2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
- B. Submit material or equipment data in accordance with the Product Review category of Section 01300 and the submittal requirements of Section 16010.
- C. Submit shop drawings that include:
  1. Dimensioned drawings.
  2. Elementary diagrams.
  3. Wiring diagrams.
  4. Nameplate list.
  5. Evidence that the equipment will be provided with all specified accessories, options, features, and characteristics.
  6. Certifications that the equipment is designed and manufactured in conformance with applicable codes and standards.
  7. Seismic Anchorage Design, including layout and calculations, signed and sealed by a Professional Engineer, registered in the State of California. Refer to Section 01190 for requirements.
- D. Manual. Provide manufacturer's installation and maintenance instruction manuals in conformance with Section 16010.

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#### PART 2 - PRODUCTS

##### 2.01 AUTOMATIC TRANSFER SWITCH

- A. General. The automatic transfer switch shall transfer from the normal service to a standby engine generator in the event of power failure. The switch shall transfer the system back to normal power after normal power has been restored. The switch shall include all controls and accessories. The switch shall be UL labeled, shall meet the requirements of UL Standard 1008 and shall be suitable for total system transfer including motor and lighting loads.
- B. Construction:
  1. The automatic transfer switch shall be of the mechanically held double throw type, actuated by two electrical operators momentarily energized and connected to the transfer mechanism by a simple over-center linkage. All main power contacts and auxiliary contacts shall be mechanically attached to a common shaft, shall be double-break silver alloy with wiping action, and shall be protected by arcing contacts. Arcing contacts shall close before and open after the main contacts and shall be readily replaceable. Contact design and arrangement shall permit repeated making and breaking of full-load current, in a combination of motor and other loads, without damage to the main contacts. Provide a main transfer mechanism utilizing rugged metal parts throughout. Molded circuit breaker type designs are not acceptable.
  2. The switch transfer shall be produced in such a way that a time delay of at least 0.4 seconds exists between the opening of the closed contacts and the closing of the open contacts. The transfer switch shall be capable of transferring in either direction with 70% of rated voltage applied at the switch terminals.
  3. All switch and relay contacts, coils, springs, and control elements shall be serviceable or removable from the front of the mounted switch and accessory assembly without the removal of either assembly from its compartment and without disconnection of drive linkages, power conductors, or control conductors.
  4. Automatic transfer switch shall be integrated within the switchboard. The enclosure shall be NEMA 1 construction with hinged doors on the front for access to the interior controls. Secure doors by a locking type latch. Provide two keys for the lock.
  5. Cable connections shall be accessible from the front without removing internal components.
  6. Safety Requirements.
    - a. Arrange the electrical supply to each control panel to be disconnected by a single switch or circuit breaker, except for necessary foreign circuits. Cover any live parts within the control panel fed from foreign control or signal circuits or arrange for them to be disconnected by one of the following methods:
      - 1) Enclosed relays which are automatically de-energized when the main disconnecting switch is opened; or
      - 2) Door-operated enclosed disconnect switches; or
      - 3) Clearly identified enclosed manually operated disconnect switches, which may be located inside the control panel door, provided the operating handles are isolated or barred from all open live parts.

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- b. Arrange the controls so that manipulation of control switches, adjustments to timing relays, or replacement of fuses can be done without exposure to live parts.
7. The transfer switch shall have the following features:
  - a. Continuous rating of 1600 A, 480 volts, 3-phase, with 3-poles and full neutral bus.
  - b. Adequate line and load lugs for terminating the power conductors shown on the Drawings.
  - c. A terminal strip with terminals for terminating all external control circuits. Number all terminals using the wire number for the wire terminated.
  - d. Cable wiring with cable ties, secured in place and guarded where subject to mechanical injury.
  - e. Permanent identification of each wire at each point of connection using numbered wiring sleeves. Provide electrically common wires with the same number. Uniquely number electrically different wires.

C. Controls. Include the following controls and accessories:

1. Three-Phase Relay Protection. Three adjustable close differential relays, connected phase-to-phase, all set to drop out at 80% and to pick up at 90% of nominal voltage.
2. Test Switch. A test control switch which shall cause the automatic transfer switch to start the engine, transfer, retransfer, and the like, simulating a power outage. Mount this switch on the door of the transfer switch compartment.
3. Indicating Lights. One each to indicate "ATS in Normal" or "ATS in Standby" position. One each indicating "Normal Source Available" and "Standby Source Available". Provide LED indicators as required, in oil-tight units with clear lenses. Label each light with plastic nameplates engraved per descriptions, respectively. Mount lights on the door of the transfer switch compartment.
4. Engine Starting Delay. A timer which, following loss or deterioration of "normal" power, will delay closure of engine starting contact for an adjustable period up to 2 minutes, to eliminate starts during brief or momentary outages of "normal" power. Set delay at 5 seconds.
5. Transfer Relay. A relay to prevent the transfer to standby until the standby power voltage and frequency are 90% of rated values.
6. Retransfer Delay. A timer to provide an adjustable delay from 2 up to 25 minutes (minimum range) before retransfer to "normal" power. If "standby" power fails before preset delay period elapses, and if "normal" power is within set limits of voltage, override the delay and retransfer immediately.
7. Nameplates. An engraved plastic nameplate for every lamp, switch, and other control device or indicator. Identify all switch and control positions. Nameplate wording shall be subject to review by the Owner.
8. Unloaded Generator Operation. A timer which, following retransfer to "normal" power, will maintain engine in unloaded operation for a fixed period of 5 minutes before signaling it to shut down.
9. Auxiliary Contacts. Two sets of Form C contacts, which change state after the engine starting delay. One of these sets is for starting the engine; the other is spare. One Form A contact each to indicate "ATS in Normal" or "ATS in Standby" position. One each indicating "Normal Source Available" and "Standby Source Available".

10. Transfer Delay. A timer to provide an adjustable delay of 1 to 5 seconds in the closing of the open contacts after the closed contacts have opened. Provide this delay for both transfer and retransfer switch operations.
11. Retransfer to normal power shall include "In-phase" transfer.

D. UL Label. The transfer switch shall have a UL label on the unit when it arrives at the site. Absence of the UL label shall be sufficient cause for the unit to be rejected. Provide all of the specified features, options, and accessories. If the manufacturer's standard UL unit does not have the specified features, options, or accessories, then provide alternative features, options, or accessories to accomplish the same purpose in a manner similar to that specified, while still providing a unit with a UL label.

E. Current Ratings. The transfer switch shall have continuous ampere rating as shown on the Drawings and minimum short-circuit withstand rating for 3 cycles at 480 volts as follows:

Continuous Ampere Rating	Withstand RMS Amperes, Symmetrical
1600 A	50,000

F. Factory Tests. Assemble, wire and test the automatic transfer switch at the factory. Conduct tests to assure that every component functions properly. Submit prototype test reports on bus bracing for the Engineer's review.

G. Manufacturer: ASCO Series 7000; Zenith (GE); or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

A. The transfer switch shall be part of switchboard assembly as specified in Section 16405.

B. Lace all power conductors to resist short circuit forces.

3.02 TESTING

A. Field Tests. Perform the tests for automatic transfer switches as outlined in NETA. Submit reports for review by the Owner.

END OF SECTION

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SECTION 16280  
SURGE PROTECTIVE DEVICES

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. This Section describes the materials and installation requirements for surge protective devices (SPD). These devices are used to protect AC electrical circuits from the effect of lightning induced currents, substation switching transients and internally generated transients resulting from inductive and or capacitive load switching.

1.02 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

- A. UL 1449 Second Edition 2007 - Transient Voltage Surge Suppressors  
B. UL 1283 - Electromagnetic Interference Filters  
C. ANSI/IEEE C62.41.1-2002 - IEEE Guide on the Surge Environment in Low Voltage (1000 V and Less) AC Power Circuits; C62.41.2-2002 - IEEE Recommended Practice on Characterization of Surge Voltages in Low Voltage AC Power Circuits; and C62.45-2002 - IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage AC Power Circuits.  
D. NEC 2008, Article 285.

1.03 SUBMITTALS

- A. The following information shall be submitted in accordance with Section 01300:  
1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole.

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Surge Protective Devices

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- If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

## PART 2 - PRODUCTS

### 2.01 GENERAL

- A. SPD shall be listed in accordance with UL 1449 Second Edition 2007 and UL 1283, Electromagnetic Interference Filters.
- B. SPD shall be Component Recognized in accordance with UL 1449 Second Edition, at the standard's highest short circuit current rating (SCCR) of 200 kA.
- C. SPD shall be tested with the ANSI/IEEE Category C High exposure waveform (20kV-1.2/50µs, 10kA-8/20µs).
- D. SPD shall provide suppression for all modes of protection: L-N, L-G, and N-G in WYE systems.
- E. The manufacturer of the SPD shall be the same as the manufacturer of the service entrance and distribution equipment in which the devices are installed and shipped. Also, this distribution equipment shall be fully tested and certified to the following UL standards:
1. UL 67 = Panelboards
  2. UL 845 = Motor Control Centers
  3. UL 857 = Busway
  4. UL 891 = Switchboards
  5. UL 1558 = Low Voltage Switchgear.

### 2.02 SPD RATINGS

- A. Minimum surge current rating shall be 160 kA per phase (80 kA per mode) for service entrance and 80 kA per phase (40 kA per mode) for distribution applications.

- B. UL 1449 clamping voltage must not exceed the following:

VOLTAGE	L-N	L-G	N-G
240/120	800/400V	800/400V	400V
208Y/120	400V	400V	400V
480Y/277	800V	800V	800V

- C. Pulse life test: Capable of protecting against and surviving 5000 ANSI/IEEE Category C High transients without failure or degradation of clamping voltage by more than 10%.
- D. SPD shall be designed to withstand a maximum continuous operating voltage (MCOV) of not less than 115% of nominal RMS voltage.
- E. SPD shall be constructed of one self-contained suppression module per phase.
- F. Visible indication of proper SPD connection and operation shall be provided. The indicator lights shall indicate which phase as well as which module is fully operable. The status of each SPD module shall be monitored on the front cover of the enclosure as well as on the module. A push-to-test button shall be provided to test each phase indicator. Push-to-test button shall activate a state change of dry contacts for testing purposes.
- G. SPD shall be equipped with an audible alarm which shall activate when any one of the surge current modules has reached an end-of-life condition. An alarm on/off switch shall be provided to silence the alarm. The switches and alarm shall be located on the front cover of the enclosure.
- H. SPD shall be equipped with dry contacts (normally open or normally closed) to allow connection to a remote monitor or other system. The output of the dry contacts shall indicate an end-of-life condition for the complete SPD or module.
- I. SPD shall be equipped with dry contacts (normally open or normally closed) to allow connection to a remote monitor or other system. The output of the dry contacts shall indicate that the SPD has operated to protect the equipment from a surge.
- J. Terminals shall be provided for necessary power and ground connections.

### 2.03 MANUFACTURERS

- A. Square D; SurgeLogic IMA Series; or equal.

### PART 3 - EXECUTION - NOT USED

### END OF SECTION

Surge Protective Devices

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SECTION 16402  
UNDERGROUND ELECTRICAL WORK

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.
- B. Work Specified in Other Divisions:
  - 1. Section 02085: Precast Concrete Utility Vaults

1.02 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

- A. The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only.
  - 1. Federal Specifications:
    - a. RR-F-621C Frames, Covers, Gratings, Steps, Sump and Catch Basin, Manhole
    - b. RR-G-661D Grating, Metal, Bar Type (Floor, except for Naval Vessels)
  - 2. American Concrete Institute (ACI):
    - a. 318 Building Code Requirements for Reinforced Concrete
  - 3. ASTM International (ASTM):
    - a. A36 Structural Steel
    - b. A153 Specifications for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
    - c. A615 Deformed and Plain Billet - Steel Bars for Concrete Reinforcement
    - d. C33 Concrete Aggregates

- e. C139 Concrete Masonry Units for Construction of Catch Basins and Manholes, Specification for
- f. C150 Portland Cement
- g. C478 Precast Reinforced Concrete Manhole Sections, Specification for Recommended Practice for Minimum Structural Design Loading for
- h. C857 Underground Precast Concrete Utility Structures
- i. C858 Standard Specification for Underground Precast Concrete Utility Structures
- 4. American Association of State Highway and Transportation Officials (AASHTO):
  - a. HB-13 Standard Specifications for Highway Bridges
- 5. American National Standard Institute (ANSI):
  - a. C2 National Electrical Safety Code
- 6. National Fire Protection Association (NFPA):
  - a. 70 National Electrical Code (NEC)
- 7. Pacific Gas and Electric Company (PG&E) Standard:
  - a. Drawing Primary Electric Underground Equipment 062000 enclosures.
- 8. State of California Public Utilities Commission (Cal. PUC) Publication:
  - a. G.O.128 Construction of Underground Electric Supply and Communication System, Rule for

#### 1.03 SUBMITTALS

- A. The following information shall be submitted in accordance with Section 01300:
  - 1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
  - 2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

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- B. Submit material or equipment data in accordance with the requirements of Section 16010 and Section 02085.
- C. Manufacturer's Data and Shop Drawings:
  - 1. Manholes and handholes - Include a table of dimensions which shows proposed size of each handhole.
  - 2. Manholes and handhole frame and cover
  - 3. Sealing material for precast manhole joints
  - 4. Steps, ladder rungs and other hardware
  - 5. Location and type of joints
- D. Certificates
  - 1. Test Reports: Submit for approval 30 days before the materials are used, copies of laboratory test reports for the following:
    - a. Arc-proofing test for cable fireproofing materials.

#### PART 2 - PRODUCTS

##### 2.01 GENERAL

- A. Materials and equipment shall conform to the respective specifications and standards and to the Specifications herein. Electrical ratings shall be as indicated.
- B. Conduit: Provide per Section 16110.
- C. Wire and Cable: Provide per Section 16120 and Section 16124.

##### 2.02 HANDHOLES

- A. Provide handholes of reinforced precast concrete, or injection molded composite plastic material. Handholes shall include a base, a body, extensions, and a cover. Handholes with a perimeter of 10 feet or more (e.g., 3 feet by 2 feet) shall have both pulling irons and cable racks. All hardware shall be stainless steel, or hot-dip galvanized after fabrication; cable racking hardware, however, shall be non-metallic and corrosion resistant. If no handhole size is shown on the Drawings, size units per NEC or provide 12 inches by 24 inches by 18 inches deep, whichever is larger. Structure shall be fabricated in accordance with ACI 318.
- B. Aggregate used in pre-cast handholes shall conform to the specifications given in ASTM C33.
- C. Cement used shall be Type 11, low alkali Portland cement and shall meet ASTM C150, Type 11.
- D. Reinforcing bars shall be intermediate grade billet steel conforming to ASTM A615.
- E. Design wheel loads for handhole covers shall be HS 20-44 as given in AASHTO HB-13.

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## 2.03 PRECAST MANHOLES

- A. Provide in accordance with the requirements of Section 02085
- B. Duct entrances and windows shall be located near the corners of structures to facilitate cable racking.
- C. Provide all necessary lugs, rabbets, and brackets. Set pulling-in iron shall be installed in the wall opposite each duct line entrance. The words "ELECTRICAL" shall be cast in the top face of all manhole covers. Cable racks, including rack arms and insulators, shall be adequate to accommodate the cable. Cable racking hardware shall be non-metallic and corrosion resistant as manufactured by Pacific Utilities Supply or equal.
- D. Metal Frames, Covers: Provide steel or malleable iron frames, and covers conforming to Federal Specification RR-G-861, Type I.
- E. Complete manholes shall be rated for HS 20-44 wheel loading as given in AASHTO HB-13.

## PART 3 - EXECUTION

### 3.01 TRENCHING, BACKFILL, AND COMPACTION

- A. See Division 2.

### 3.02 WIRE AND CABLE INSTALLATION

- A. See Section 16120 and Section 16124.

### 3.03 UNDERGROUND RACEWAYS WITH CONCRETE ENCASEMENT

- A. Provide raceways with concrete encasement only if specifically shown on the Drawings, otherwise provide without concrete encasement as specified in paragraph 3.04.
  1. Concrete encasement shall be a minimum of 3 inches around outer walls of raceways and a minimum of 2 inches between raceways. Conduits shall be PVC-40.
  2. Concrete shall be Portland cement type with 4 sacks cement per cubic yard of concrete, maximum coarse aggregate size of 3/8 inches and shall have a minimum strength of 2,000 psi after 28 days. Amount of water shall not exceed slump required for placement.
  3. Underground raceways shall slope toward manholes, pull boxes, etc., at a minimum rate of 3 inches per 100 feet unless indicated otherwise on Drawings. Raceway entrances in manholes, handholes, etc., shall be by means of bell ends and shall be sealed against entry of silt, debris, rodents, etc., into raceways.

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4. Top of concrete encasement shall be a minimum of 24 inches below grade.
5. Minimum radius of all horizontal bends in underground duct banks shall be twelve (12) times nominal conduit size. Bends shall be formed of factory made sweeps or continuous assembly of bend segments or curved segments, except that PVC-40 conduits may be field formed. Minimum radius of all vertical bends in underground raceways shall be twelve (12) times nominal size of conduit.
6. Underground raceways within roadways shall be run parallel or perpendicular to road centerline.
7. Pull wires left in underground raceways shall be 1/8-inch nylon rope or 3/16-inch polypropylene.
8. Terminate conduits in end-bells where duct lines enter manholes and handholes. Provide structural support for concrete encased duct banks at the point where they terminate. Separators shall be of precast concrete, high impact polystyrene, steel, or any combination of these. Stagger the joints of the conduits by rows and layers so as to provide a duct line having the maximum strength. During construction, protect partially completed duct lines from the entrance of debris such as mud, sand and dirt by means of suitable conduit plugs. As each section of a duct line is completed, draw a brush through having the diameter of the duct, and having stiff bristles until the conduit is clear of all particles of earth, sand, and gravel; then immediately install conduit plugs.
9. Construct underground raceway systems (whether single raceways, or multiple raceway banks) utilizing snap together plastic "chairs" spaced and staked to the trench floor, no more than 6 feet apart along the entire length of the trench to maintain the specified minimum encasement between raceways, and between the duct bank and trench walls and floor. Provide Carlon Snap-N-Stac or equal.

- B. Connections to Existing Ducts: Where connections to existing duct lines are indicated, excavate the lines to the maximum depth necessary. Cut off the lines and remove loose concrete from the conduits before new concrete encased ducts are installed. Provide a reinforced concrete collar, poured monolithically with the new duct line, to take the shear at the joint of the duct lines. Remove existing cables that constitute interference with the work. Abandon in place those used ducts and cables that do not interfere with the work.

- C. Removal of Ducts: Where duct lines are removed from existing manholes, close the openings to waterproof the manhole. Chip out the wall opening to provide a key for the new section of wall.

- D. See Section 16110 for additional requirements.

### 3.04 UNDERGROUND RACEWAYS WITHOUT CONCRETE ENCASEMENT

- A. Provide raceways without concrete encasement unless specifically shown otherwise on the Drawings.
- B. Provide sand backfill three inches all around the raceway.

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- C. Construct raceways per the applicable provisions above for underground raceways with concrete encasement.
- D. See Section 16110 for additional requirements.

### 3.05 MANHOLES AND HANDHOLES

- A. Install and test in accordance with the requirements of Section 02085.
- B. Provide manholes and handholes complete with all accessories, as indicated. Identify each casting by having the manufacturer's name and address cast into an interior face or permanently attached thereto.
- C. Manhole, Handhole or Concrete Pull Box Grounding: Ground rods installed in electrical distribution system handholes or concrete pull boxes shall be properly connected to the cable shielding, metallic sheath, and armor at each cable joint or splice by means of No. 4 AWG or equivalent braided tinned copper wire. Connections to metallic cable sheaths shall be by means of tinned terminals soldered to ground wires and to cable sheaths. Care shall be taken in soldering not to damage metallic cable sheaths or shields. Ground rods shall be protected with a double wrapping of pressure-sensitive plastic tape for a distance of 2 inches above and 6 inches below concrete penetrations. Ground wires shall be protected with a double wrapping of pressure-sensitive plastic tape for a distance of 2 inches above and 6 inches below concrete penetrations. Ground wires shall be neatly and firmly attached to handhole walls and the amount of exposed bare wire shall be held to a minimum.
- D. Installation of Cable in Manholes and Handholes: Do not install cables utilizing the shortest route, but route along those walls providing the longest route and the maximum spare cable lengths. Form all cables to closely parallel walls, not to interfere with duct entrances, and support on brackets and cable insulators at a maximum of 18 inches. In existing handholes and vaults where new ducts are to be terminated or where new cables are to be installed, provide cable supports and grounding as required for a neat and workmanlike installation with all cables properly arranged and supported. Support cable splices in underground structures by racks, leaving top space open for future cables, except as otherwise indicated for existing installations. Provide one spare three-insulator rack arm for each cable rack in each underground structure. Provide additional cable racks in each existing underground structure through which new cable is run.

END OF SECTION

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### SECTION 16405 SWITCHBOARD

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.
- B. Related Work Described Elsewhere:
1. Section 16250: Automatic Transfer Switch
  2. Section 16110: Conduit, Raceways, and Fittings
  3. Section 16120: Low Voltage Wire and Cable

##### 1.02 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

- A. American National Standard Institute (ANSI) Publications:
1. C57.13 Requirements for Instrument Transformers
- B. International Electrical Testing Association (NETA) Publications:
1. ATS Acceptance Testing Specifications for Electric Power Distribution Equipment and Systems
- C. National Electrical Manufacturers Association (NEMA) Publication:
1. PB 2.1 General Instructions for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards
- D. National Fire Protection Association (NFPA) Publication:
1. 70 National Electrical Code (NEC)

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- E. Underwriters Laboratories (UL) Publication:  
1. 891 Deadfront Switchboards

#### 1.03 SUBMITTALS

- A. The following information shall be submitted in accordance with Section 01300:  
1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
- B. Submit material or equipment data in accordance with the Product Review category of the General Conditions and the submittal requirements of Section 16010.
- C. Shop Drawings: Submit shop drawings which shall include: complete layout of equipment and devices; front and end elevations and floor plan to scale with major dimensions; structural details and overall weights; complete nameplate data and ratings of all devices; material, sizes, locations, and short circuit bracing rating of all buses; nameplate schedules; and circuit breaker time-current curves.
- D. Regarding the seismic anchorage requirements, submit a sketch or description of the anchorage system.
- E. Factory Test Report: Include the results of the applicable production tests as required in NEMA PB2.
- F. Manuals: Provide in conformance with Section 16010.

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#### PART 2 - PRODUCTS

##### 2.01 SWITCHBOARD

- A. Standards: Design, build and test the switchboard in accordance with applicable portions of NEMA PB 2.1 and UL 891, and comply with the NFPA 70.
- B. Switchboard shall be rated as shown on the Drawings.
- C. Structure: The switchboard shall be a NEMA 1 completely self-supporting structure of the required number of vertical sections bolted together to form one metal-enclosed switchboard approximately 90 inches high. Sides, top and rear covers shall be code gauge steel, bolted to the switchboard structure. The frame structure members shall be die-formed 12-gauge steel bolted together and reinforced at external corners with rugged gussets both internal and external to the structure members. The switchboard frame shall be suitable for use as floor sills. Structure shall be for indoor use. Switchboard shall be constructed so that when installed on the concrete pad (see Part 3) the unit complies with the NFPA 70 6-6" rule. Access shall be from the front.
- D. Devices: The switchboard shall include all the devices shown on the Drawings. Devices with operating handles or control knobs or switches shall have the handles, knobs or switches externally accessible without opening any inner doors or covers.
- E. Buses:  
1. Main buses shall be copper, supported with high impact non-tracking insulation material, and braced to withstand mechanical forces exerted during short circuit conditions of 50,000 RMS symmetrical amperes. The continuous current density of the buses shall not exceed 1,000 amperes per square inch of cross section for copper or 750 amperes per square inch for aluminum. Continuous current ratings shall be as shown on the Drawings. Bus arrangement shall be A-B-C (left-to-right, top-to-bottom, front-to-rear) throughout.  
2. Ground bus shall be copper, not less than 1/4-square-inch in cross section.  
3. Secure to the vertical section.  
Neutral bus shall be copper and not less than 50% of the rating of the main bus. Bus shall be insulated from the structure. Provide removable link between neutral and ground bus.
- F. Wiring: Factory install all wiring within the switchboard and neatly cable and secure to supporting surfaces. Provide terminal lugs for all external wiring. Small wire shall be Type SIS.
- G. Provision for Future: Arrange horizontal main buses for convenient future extension as shown on the Drawings. Provide vertical buses to the spaces shown on the Drawings for future devices, arranged to accept future mounting bolts and bus connecting straps.
- H. Ambient Temperature: Base device ratings on operation in an ambient temperature not exceeding 40°C.

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- I. Connections: Cable connectors and device lugs shall be compression type and suitable for use with copper or aluminum cables.
- J. Hardware: All hardware used on conductors shall have high tensile strength and suitable protective finish.
- K. Handling Means: Provide the switchboard with adequate lifting means and make switchboard capable of being rolled or moved into position and bolted directly to the floor without the use of floor lifts.
- L. Finish: Chemically clean and treat all steel surfaces, providing a bond between paint and metal surfaces to help prevent the entrance of moisture and the formation of rust under the paint film. Finish the switchboard exterior with ANSI 61 light gray paint, not less than 2 mils thick.
- M. Provide individually mounted main breaker and group mounted feeder circuit breakers.
- N. Main Circuit Breaker:
1. Insulated or molded case type, 3-pole, manually operated, 600 Vac, 100% rated, 50,000 RMS symmetrical amperes interrupting capacity at 480 volts. Frame and trip ratings shall be as shown on the Drawings. It shall have an integral current sensor in each pole and an integral solid state self-powering programmable trip unit with three fault indicators. The trip unit shall provide the following tripping characteristics, all adjustable:
    - a. Sensor Rating
    - b. Sensor Setting Range
    - c. Long Time Delay
    - d. Short Time Delay
    - e. Ground Fault Setting
    - f. Ground Fault Delay
    - g. Auxiliary contacts for "Closed", "Open" and "Tripped"
  2. Manufacturer: Cutler-Hammer with Digitrip Electronic unit; Square D PE with Micrologic Trip; General Electric; or equal.
- O. Feeder Circuit Breakers:
1. Molded case type, 3-pole, manually operated, 600 Vac, 100% rated, 35,000 RMS symmetrical amperes interrupting capacity at 480 volts. Each breaker shall have an integral current sensor in each pole and an integral solid state self-powering programmable trip unit with three fault indicators. For breakers larger than 225A provide a trip unit with the following tripping characteristics, all adjustable:
    - a. Sensor Rating
    - b. Sensor Setting Range
    - c. Long Time Delay
    - d. Short Time Delay
    - e. Instantaneous
    - f. Ground Fault Setting
    - g. Auxiliary contacts for "Closed", "Open" and "Tripped"

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2. Manufacturer: Cutler-Hammer with Digitrip Electronic unit; Square D PE with Micrologic Trip; General Electric; or equal.
- P. Utility Metering Section: Provide pull section for service entrance with sealable cover, barrier, and cable terminating facilities, bus or cables from pull section landing lugs to service section, provisions for mounting utility current transformers, and sockets for utility meters, all as shown on the Drawings and as required by Pacific Gas and Electric Company.
- Q. Current Transformers: Provide three current transformers in accordance with ANSI C57.11, 600 volt, 10 kV BIL, with ANSI metering accuracy class of 0.3 at burden B-0.1 and continuous thermal rating factor of 2.0.
- R. Power Monitor: Provide a microprocessor-based power monitor to measure electrical parameters such as current, voltage, kW, power factor, frequency, and KWH. Power monitor shall include a keypad and a data port for Ethernet communications connected to the programmable logic controller as specified in Section 17330. Data shall be made available for display on the SCADA system. Provide Allen Bradley Power Monitor 3000, Power Monitor II, or equal.
- S. Surge Protection: Provide 3-phase, 600 volt, surge protective device, connected to the main bus assembly. Refer to Section 16280.
- T. Switchboard shall be listed and labeled as service entrance equipment if the switchboard is used as service entrance.
- U. Ground Connections: Provide binding post type lugs for attachment of ground cables to sheet steel enclosures. Lugs shall be of the binding post type, shall accommodate a range of stranded copper cable from #2 AWG to #2/0 AWG, shall have a 1/2 to 13 NC stud size and shall be attached to enclosures using a threaded or tapped boss welded to the sheet steel. These lugs shall be Burndy Type KC; Anderson Type KS; or equal. Provide bolted pressure connectors for all other ground connections. Provide one lug for each outgoing circuit.
- V. Nameplates: Nameplates shall be provided for each control component. The nameplate shall be phenolic, black background with white lettering. All nameplates shall be fastened by stainless steel screws.
- W. Switchboard shall be Cutler-Hammer Pow-R-Line Series; Square D I-Line Series; General Electric; or equal.

### PART 3 - EXECUTION

#### 3.01 CONDUIT AND WIRE INSTALLATION

- A. Install conduit and wire in conformance with Section 16110 and 16120.

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3.02 SWITCHBOARD INSTALLATION

- A. Mount the switchboard and anchor to a 3-inch concrete pad. Install level and plumb. Doors shall open and close freely and all manually operated device handles and controls shall operate properly. Repair any damage to the enclosure, components, or finish. Clean switchboard inside and out and all nameplates.

- B. Lace conductors to resist short circuit forces. Follow manufacturer's recommendations.

3.03 GROUNDING INSTALLATION

- A. Ground in accordance with Section 16450.

3.04 FIELD TESTING

- A. Test switchboard and circuit breakers in accordance with NETA.

END OF SECTION

SECTION 16450

ELECTRICAL GROUNDING

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.
- B. Work Included: Furnish all labor, material, equipment, tools, and services necessary for the installation, connection, and testing of all grounding as specified herein and as shown on the Drawings.

1.02 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

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A. ASTM International (ASTM):

1. B228 Copper Clad Steel Conductors Specification
2. D178 Specifications for Rubber Insulating Matting

B. National Fire Protection Association (NFPA):

1. 70 National Electric Code (NEC)

C. International Electrical Testing Association (NETA):

1. ATS Acceptance Testing Specifications for Electrical Equipment for Power Systems

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Electrical Grounding

### 1.03 SUBMITTALS

- A. The following information shall be submitted in accordance with Section 01300:
1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
  2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
- B. Submit material or equipment data in accordance with the requirements of Section 16010.

### PART 2 - PRODUCTS

#### 2.01 GENERAL

- A. The grounding systems shall consist of the ground rods, grounding conductors, ground bus, ground fittings and clamps, and bonding conductors to water piping and structural steel as shown on the Drawings.

#### 2.02 SYSTEM COMPONENTS

- A. Ground Rods: Ground rods shall be cone pointed copper clad Grade 40 HS steel rods conforming to ASTM B228. The welded copper encased steel rod shall have a conductivity of not less than 27 percent of pure copper. Rods shall be not less than ¾ inch in diameter and 8 feet long, unless otherwise indicated. Rods longer than 8 feet shall be made up of 8-foot units joined together with threaded couplings. The manufacturer's trademark shall be stamped near the top.

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- B. Ground Conductors: Buried conductors shall be medium-hard drawn bare copper; other conductors shall be soft drawn copper. Sizes over No. 6 AWG shall be stranded. Coat all ground connections except the exothermic welds with electrical joint compound, non-petroleum type, UL listed for copper and aluminum applications.
- C. Ground Connections: Connection to ground rods and buried connections shall be by exothermic weld. Lugs for attachment of cables to steel enclosures shall be of the binding post type with a 1/2-13NC stud. Each post shall accommodate cables from #4 AWG to #2/0 AWG.
- D. Ground Rod Boxes: Boxes shall be a 9-inch-diameter precast concrete unit with hot-dip galvanized traffic covers. Units shall be 12 inches deep. Covers shall be embossed with the wording "Ground Rod".
- E. Ground Bus: Ground bus shall be a high conductivity copper alloy strap measuring 2 inch by ¼ inch by 12 inch as shown on the Drawings. Bus shall be predrilled and tapped to accept 8-32 brass machine screws on 12-inch centers.

#### 2.03 RUBBER MATS

- A. Provide corrugated rubber mats that conform to ASTM D178 Type II, oil resistant. Mats for low voltage switchboards and motor control centers shall be rated for protection for 1,000 volts minimum to ground.
- B. Mat shall be a minimum of ¼ inch thick and black in color with beveled edges. Mats shall extend the full width of the equipment with a minimum width of 30 inches. Mats shall be 4 feet deep in front of low voltage equipment.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Ground all equipment for which a ground connection is required per NEC whether or not the ground connection is specifically shown on the Drawings.
- B. Provide a ground rod box for each ground rod so as to permit ready access for the connection and/or removal of any pressure connectors to facilitate testing.
- C. Where ground rods must be driven to depths over 8 feet, increase rod diameter used sufficiently to prevent the rod from bending or being damaged.
- D. Bond metallic water piping at its entrance into each building. Ground separately derived electrical system neutrals to the metallic water piping in addition to the system driven ground, per NEC requirements.
- E. Provide a ground wire in every conduit carrying a circuit of over 150 volts to ground.

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F. Effectively bond structural steel for buildings to the grounding system using exothermic welds.

G. Install rubber mats in front of low voltage switchboards and motor control centers.

### 3.02 PERFORMANCE TESTING

A. Conduct ground resistance tests using a ground megohmmeter with a scale reading of 25 ohms maximum.

B. Test methods shall conform to NETA Standard ATS using the three-electrode method. Conduct tests only after a period of not less than 48 hours of dry weather.

C. Furnish to the Engineer a test report with recorded data of each ground rod location.

D. Furnish a separate report on the rubber mats. Make measurements in conformance with manufacturer's instructions.

### END OF SECTION

## SECTION 16460

### DRY TYPE TRANSFORMERS

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.

##### 1.02 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

A. American National Standards Institute (ANSI):

1. 70 National Electrical Code
2. C2 National Electrical Safety Code

B. National Electrical Manufacturers Association (NEMA):

1. ST 20 Dry-Type Transformers for General Applications

##### 1.03 SUBMITTALS

A. The following information shall be submitted in accordance with Section 01300:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer

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shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

B. Submit material or equipment data in accordance with the requirements of Section 16010.

C. Shop Drawings: Submit manufacturer's name and data as required:

1. Nameplate Data:

- a. KVA rating.
  - b. Nominal primary voltage.
  - c. Tap voltages.
  - d. Nominal secondary voltage.
  - e. Percent impedance.
  - f. Weight.
  - g. Physical dimensions and mounting requirements, including seismic certification, design calculations and drawings as required by Sections 01190 and 16010.
  - h. Submit Level 2 certification from the manufacturer that the equipment is capable of resisting seismic loads. Loading shall be as described in Section 01190.
2. Single Submittal: A single complete submittal is required for all products covered by this Section.

#### 1.04 FACTORY TESTING

A. Tests on transformers shall include the manufacturer's standard tests, including winding resistance, ratio, polarity, phase relation, no-load loss, impedance, full load losses, and dielectric tests. Certified copies shall show compliance with all referenced standards.

#### 1.05 LOCATIONS

A. Refer to Section 16010 for definitions of types of locations.

## PART 2 - PRODUCTS

### 2.01 DRY TYPE TRANSFORMERS

- A. General Purpose: Transformers for supplying lighting and small power loads shall be dry type, energy efficient, two winding, 60 Hz, copper windings, temperature rise not exceeding 80°C under full load in an ambient of 40°C with Class H, 220°C insulation. Capacity ratings and voltages shall be as shown on the Drawings. Transformers shall comply with all applicable provisions of NEMA Standard ST20 and shall have NEMA Standard taps. Transformers shall be indoor type with sound levels 5 dB below NEMA Standard or outdoor type with NEMA Standard sound levels. Terminal compartment shall have a temperature rise not to exceed 35°C. Outdoor units shall be equipped with weather shields. Transformers 30 kVA and larger, 3 phase, shall be energy efficient type.

## PART 3 - EXECUTION

### 3.01 TRANSFORMER INSTALLATION

- A. Transformers shall be installed as indicated on the Drawings.
- B. Transformers shall be connected with flexible, liquidtight metallic conduit to prevent the transmission of sound through the conduit system. Potted non-ventilated types below 30 kVA shall be installed on resilient vibration-isolating mountings.
- C. Transformer grounding shall be sized in accordance with NEC requirements for separately derived systems and shall be connected to the nearest cold water pipe or, if available, structural steel member. Ground rod and connections shall be as detailed in Section 16450. Provide conduit and wire for both the ground rod and cold water pipe or structural steel member connections.
- D. Lace secondary conductors to resist short circuit forces. Follow manufacturer's recommendations.

### 3.02 PERFORMANCE TESTS

- A. Test per NETA. Submit results for review.

END OF SECTION

Dry Type Transformers

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SECTION 16500

LIGHTING

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.
- B. Work Included: Provide a lighting system complete, including fixtures, lamps, standards, bases, hangers, reflectors, glassware, lenses, auxiliary equipment, ballasts, sockets, and photoelectric cells.

1.02 REFERENCE STANDARDS

This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

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A. Federal Regulations

- 1. Title 21 Performance Standards for Light Emitting Products CFR 1040

B. Underwriters Laboratories (UL) Standards

- 1. 57 Electric Lighting Fixtures
- 2. 844 Electric Lighting Fixtures for Use in Hazardous (Classified) Locations

1.03 SUBMITTALS

A. The following information shall be submitted in accordance with Section 01300:

- 1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements.

Check marks (✓) shall denote full compliance with a paragraph as a whole.

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If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
- B. Submit material or equipment data in accordance with the Product Review category of the General Conditions and the submittal requirements of Section 16010.
- C. Submit photometric curves for each fixture configuration proposed. Substitutions will not be considered unless the photometric distribution curve indicates the proposed fixture is equal to or exceeds the specified luminaire.
- D. Submit shop drawings showing proposed methods for mounting interior lighting fixtures which are not attached directly to the ceiling or wall.
- E. Regarding the seismic anchorage requirements, refer to Section 01190 for equipment certification and anchorage design.

#### 1.04 GUARANTEE

- A. Lamps which fail within 90 days after acceptance by the Owner shall be replaced at no cost to the Owner.

### PART 2 - PRODUCTS

#### 2.01 FIXTURES

- A. Fixtures shall be of the types, wattages and voltages as shown on the Drawings, comply with UL 57, and be UL classified and labeled for intended use. Fixtures for use in hazardous locations shall be UL listed per UL Standard 844.
- B. Luminaire wire, and the current carrying capacity thereof, shall be in accordance with the NEC.

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- C. Luminaires and lighting equipment shall be delivered to the project site complete, with suspension accessories, aircraft cable, stems, canopies, hickies, castings, sockets, holders, ballasts, diffusers, louvers, frames, recessing boxes and related items, including supports and braces.

- D. Flexible fixture hangers shall be manufactured by Crouse-Hinds Type ARB; Appleton Type GS; or equal.

#### 2.02 BALLASTS

- A. Ballasts: Provide energy efficient solid state electronic ballasts. Input watts shall not exceed 72 with "E" rated 3,700 lumen lamps operated at 25,000 hertz. Sound rating shall be "A". Crest Factor shall be 1.6. Unit shall be FCC Certified and UL listed. Minimum lamp starting temperature shall be 50°F. Solid state ballast shall be suitable for dimming of T-8 and T-5 lamps. An internal MOV shall provide transient protection and a 3-year extended warranty shall be provided. Ballast shall be General Electric; Phillips; or equal.
- B. High pressure sodium lamp ballasts shall be the auto-regulator type providing 3% voltage variation to the lamp with 10% line voltage variation. Ballast power factor shall be at least 90%. Ballasts shall bear the UL label.
- C. Ballasts in luminaires for exterior use shall provide reliable starting of lamps at 0°F at 90% of the nominal line voltage. All locations, other than totally enclosed rooms, shall be considered exterior.
- D. Ballasts producing excessive noise (above 36 dB) or vibration will be rejected and shall be replaced at no expense to the Owner.
- E. LED driver shall be solid state unit mounted within fixture and shall be adequately ventilated and match the LED fixture rating in watts and voltage. Driver shall have a power factor of at least 85% and shall be suitable for dimming from 25% to full rated watts.

#### 2.03 LAMPS

- A. All luminaires shall be LED type as shown on the Drawings.
- B. LED units shall have the minimum rating of watts and output lumens as indicated on the Drawings and shall be provided by the same manufacturer as the LED driver.

#### 2.04 PHOTOELECTRIC CELL

- A. Photoelectric cell shall have adjustable turn on range from 2- to 50-foot candles. Cell shall operate from 120 Vac, 60 hertz. Switched contacts shall be single pole, single throw and tungsten rated 1,800 watts minimum at 120 Vac. Housing shall be weatherproof with threaded conduit fitting suitable for mounting to a junction box. Cell shall be Tork; Intermatic; or equal.

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## 2.05 TIME SWITCH

- A. Time switch shall be electronic type, programmable, equipped with astronomical (24-hour, seasonally adjusting) dials and reserve power springs for a 10-hour minimum carry-over in the event of a power outage. Units shall be complete with a manual bypass switch.

## 2.06 LAMP POSTS AND STANDARDS

- A. Lamp posts and standards shall be of the type, configuration, and dimensions shown on the Drawings, and shall be suitable for the indicated lamp mounting height.
- B. Furnish complete with anchor bolts, bolt circle template, handholes, and cover plate.

## 2.07 LIGHT CONTROL RELAYS

- A. Units shall be mechanically held with contacts rated 30 amperes to 600 volts. Number of poles and operating coil voltage shall be as shown on the Drawings.

## 2.08 EXIT AND EMERGENCY FIXTURES

- A. General: Fixture enclosures shall consist of an injection molded, high impact, NEMA 4X gasketed corrosion resistant reinforced polyester fiberglass housing. All hardware shall be stainless steel.
- B. Emergency power shall be automatically supplied to light sources from sealed spiral wound pure lead batteries with a life expectancy rating of 15 years. Units shall comply with all requirements of UL 924.
- C. Electronic solid-state logic shall provide 20 millisecond switching, automatic power cutoff at 87-1/2% cell voltage, recharging of batteries within 12 hours, and pilot light indication of battery and charger conditions. A manual test switch shall be provided to allow checking equipment function.
- D. Emergency light fixtures shall be dual or single head as shown on the Drawings.
- E. Exit lights shall have 5-3/4-inch red lettering silk screened on a high impact clear acrylic face.
- F. For self-illuminating non powered exit signs, refer to the Drawings

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. General:
1. All fixtures and luminaires shall be clean and lamps shall be operable at the time of acceptance.

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2. Install luminaires in accordance with manufacturer's instructions, complete with lamps, ready for operation as indicated.
3. Align, mount, and level the luminaires uniformly.
4. Avoid interference with and provide clearance for equipment. Where an indicated position conflicts with equipment locations, change the location of the luminaire by the minimum distance necessary.

### B. Mounting and Supports:

1. Mounting heights shall be as shown on the Drawings. Unless otherwise shown, mounting height shall be measured to the centerline of the outlet box for a wall mounted fixture and to the bottom of the fixture for all other types.
2. For suspended luminaires, the mounting heights shall provide clearances between the bottoms of the luminaires and the finished floors as indicated.
3. Luminaire supports shall be anchored to the structural slab or structural members as indicated. Supports shall maintain the luminaire positions after relamping and cleaning.
4. Surface mounted fixtures shall be rigidly bracketed from mounting surfaces. Luminaires installed in rows shall have a non-cumulative dimensional alignment tolerance of 1/16 inch. Nipples carrying wiring between luminaires shall be watertight.
5. Pendant luminaires shall be provided with 7/32-inch aircraft cable to assure a plumb installation and shall have a minimum 25 degree clear swing from horizontal in all directions.
- C. Mount fixtures level and securely support from the ceiling. Provide earthquake clips for fixtures mounted in suspended ceilings.
- D. Pendant Fixture Mounting:
1. In office areas with level ceilings, provide stems and canopies to match fixtures.
2. In office areas with sloping ceilings, provide flexible fixture mounting canopies and stems to match fixtures.
- E. Mount lamp posts and lighting standards plumb and make free of dents or other damage.
- F. Concrete Bases:
1. Templates and anchor bolts shall be obtained before starting any work.
2. Concrete bases shall be constructed in accordance with Section 03300.
- G. Battery Operated Emergency Lighting Fixtures:
1. Wall mounted at designated height per manufacturer's instructions.
2. Battery disconnect switch to be left in the "off" position until building power is fully operational.

END OF SECTION

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SECTION 16722

FIRE ALARM DEVICES

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
1. Applicable provisions of Section 16010 become a part of this Section as if repeated herein.
  2. Furnish smoke detectors and wiring.
- B. Related Sections:
1. Section 16110: Conduit, Raceways, and Fittings
  2. Section 16120: Low Voltage Wire and Cable

1.02 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

- A. American National Standards Institute (ANSI) Publication: C2, National Electrical Safety Code.
- B. National Fire Protection Association (NFPA) Publications:
1. 70 National Electrical Code
  2. 72 National Fire Alarm Code
- C. Underwriters Laboratories Inc. (UL).

1.03 SUBMITTALS

- A. The following information shall be submitted in accordance with Section 01300:

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1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
- B. Submit material or equipment data in accordance with the Product Review category of the General Conditions and the submittal requirements of Section 16010.
- C. Shop Drawings: Shop drawings shall include interconnection diagrams, elementary diagrams, riser diagrams, and complete descriptions of components and zones. Interconnection diagram shall be of sufficient detail to verify suitability of the fire alarm control system ducts shown on the Drawings. It shall also allow coordination for fire alarm control system conduit and wiring inside structures that is not shown on the Drawings. Submit diagrams and verify duct sizes prior to the installation of duct banks and building conduits. Notify the Engineer immediately of any cases where additional ducts are required or where duct sizes are inadequate.
- D. As-Built Diagrams and Manuals: Upon completion of work and prior to final testing and inspection, furnish as-built drawings showing the exact sequence of all initiating devices as they were installed in the circuits.
- E. Operational and Maintenance Manuals: Furnish operation and maintenance manuals as required under Section 16010. Provide:
  1. Statement of Guarantee including date of termination and name and phone number of service personnel to be called in the event of equipment failure.
  2. Individual factory issued manuals containing all technical information on each piece of equipment installed. In the event such manuals are not obtainable from the factory, it shall be the responsibility of the Contractor to provide them. Advertising brochures in lieu of manuals are not acceptable.

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## PART 2 - PRODUCTS

### 2.01 GENERAL

- A. All equipment shall be UL listed, FM listed, and tested by a nationally recognized fire test laboratory.
- B. Provide all equipment and accessories for a complete, electrically supervised, non-code, fire detection system as described herein and as shown on the Drawings.

### 2.02 COMPONENTS

- A. Smoke Detector Bases: All smoke detector heads shall be suitable for insertion into twist lock bases. The base shall contain electronics that communicate the detector status to the Main Control Panel via an electric circuit.
- B. Device Supervision: Should a device fail, it shall not hinder the operation of other system devices.
- C. Conduit and Wire: Conduit and wiring are shown on the Drawings. All fire alarm interconnecting conduit and wire shall be coordinated and provided under this Section. Should the fire alarm system require additional conduits not shown on Drawings, Contractor shall provide them as part of the system at no additional cost to the Owner. Provide all conductors as required for a fully operational system. Power conductors shall be #12 AWG minimum. Control conductors shall be 16 AWG minimum. Signal conductors shall be 18 AWG minimum signal cable with shield. All conductors shall be suitable for installation underground in ducts. Provide grounding and ground wires as necessary; conduit shall not be used for ground return. All conductors shall conform to Sections 16120 and 16124. All conductors shall be labeled to represent the function in the circuit. Each fire alarm circuit wire termination shall be made with a solderless tool crimped ring terminal. All interior conduit runs shall be run in the slab or concealed in walls and shall conform to Section 16110.
- D. Connect the smoke alarm devices to the Main PLC as shown on the Drawings.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Earthquake resistant installation/fastening of equipment shall be required.
- B. All wiring shall be in conduit. Terminations in control panels shall be made on terminal strips with a separate point for each conductor.
- C. Mount all end-of-line resistor boxes, if required, where they will be readily accessible at all times and at 54 inches above the finished floor.

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- D. Install no automatic detection equipment on its ceiling mounting plate until the associated room has been painted and cleaned. A minimum of 2 percent or two (whichever is larger) automatic detection elements shall be given to the Owner as spares.
- E. After completion of the installation and after all environmental systems are in normal operation, the Contractor shall test and calibrate the system.
- F. After completion of check-out, a certified letter shall be provided to the Engineer indicating that fire alarm system is complete and operable.
- G. During test, in conjunction with other sections under this Division, ascertain that all other equipment operated by or in conjunction with automatic fire detection system operates in proper fashion.
- 3.02 TESTING
- A. Any equipment proving defective shall be immediately replaced with new equipment at no additional cost to the Owner.
- B. All wiring shall be checked and tested to ensure that there are no grounds, opens or shorts. The minimum allowable resistance between any two conductors or between conductors and ground is 10 megohms as checked by a Megger after all conduit, conductors, detector bases, etc., have been installed but before the detector devices are plugged into the bases or end-of-line devices installed.
- C. Perform all electrical and mechanical tests required by the equipment manufacturer's form. In addition, measure and adjust each of the ionization and photoelectric detectors to the maximum stable sensitivity setting. This must be performed at the operational location of the unit and under normal operational environmental conditions in the area. Bench settings are not acceptable. A checkout report shall be prepared by the technician and submitted in triplicate, one copy of which will be registered with the equipment manufacturer. The report shall include, but not be limited to:
1. A complete list of equipment installed and wired.
  2. Indication that all equipment is properly installed and functions and conforms to these Specifications.
  3. Serial numbers and model number for each installed detector.
  4. Voltage (sensitivity) settings for each ionization and photoelectric detector as measured in place with air conditioning system operating.
  5. Technicians name, certificate number, and date.
  6. After completion of all the tests and adjustments listed above, the Contractor shall submit the following information to the Engineer:
    - a. Conduit layout diagrams, including wire color code and/or tag number.
    - b. Complete as-built wiring diagrams, including room and equipment designation.
    - c. Detailed catalog data on all installed system components.

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- D. The completed smoke detection system shall be tested to insure that it is operating properly. This test shall consist of exposing the installed units to a standard test. Acceptance of the system shall also require a demonstration of the stability of the system. This shall be adequately demonstrated if the system operates for a 90-day period without any unwarranted alarms. Should an unwarranted alarm(s) occur, the Contractor shall readjust or replace the detector(s) and begin another 90-day test period. The Contractor shall recheck the detectors using the fire test after each readjustment or replacement of detectors. This test shall not start until the Owner has obtained beneficial use of the building under test. If the requirements provided in the paragraph above are not completed within 1 year after beginning the tests described therein, the Contractor shall replace the system with another acceptable manufacturer and the process repeated until acceptance of the equipment by the Owner.

END OF SECTION

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SECTION 16920

MOTOR CONTROL CENTER

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.
- B. Work Included: Provide Arc-resistant motor control centers, complete, at the locations shown on the Drawings.
- C. Related Work Described Elsewhere:
  - 1. Section 16924: Adjustable Frequency Drives (AFDs)

1.02 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

- A. National Electrical Manufacturers Association (NEMA) Publications:
  - 1. ICS1 Industrial Control and Systems: General Requirements
  - 2. ICS2 Controllers, Contactors and Overload Relays rated 600 V
  - 3. ICS 4 Terminal Blocks for Industrial Control Equipment and Systems
  - 4. ICS 6 Enclosures
- B. International Electrical Testing Association (NETA) Publication:
  - 1. ATS Acceptance Testing Specifications for Electrical Power and Distribution Equipment and Systems

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- C. Underwriters Laboratories (UL) Publication:
1. UL 845 Motor Control Centers
  2. UL 489 Molded Case Circuit Breakers
  3. UL 1063 Safety Machine-Tools Wires and Cables
- D. Arc-resistant or Arc-containing low voltage MCCs shall be tested, rated, and labeled in accordance with the requirements of IEEE C37.20.7-2007 'IEEE Guide for Testing Metal-enclosed Switchgear Rated up to 38 kV for Internal Arcing Faults'.
- 1.03 SUBMITTALS
- A. The following information shall be submitted in accordance with Section 01300:
1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
  2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
- B. Submit material or equipment data in accordance with the Product Review category of the General Conditions and the submittal requirements of Section 16010.
- C. Shop Drawings: Submit shop drawings as specified under "Submittals" in Section 16010 and include the following: a wiring diagram and an elementary control diagram for each unit; an overall connection diagram for the motor control center; a dimensioned outline drawing to scale showing space for conduits, etc.; complete identification of all electrical components in the control center and their interconnections within the motor control center; all connections to external equipment and controls; bus material and ratings; wire marking scheme; and method of installation to resist seismic forces. Where unit arrangement or wiring deviates in any way from that shown on the Drawings, provide a complete record and explanation of such deviations.
- D. Seismic Anchorage Design, including layout and calculations, signed and sealed by a Professional Engineer, registered in the State of California. Submit Level 2 certification from the manufacturer that the equipment is capable of resisting seismic loads. Loading shall be as described in Section 01190.
- E. Arrange submittals in a logical manner and use the device abbreviation identifications and equipment names as shown on the Drawings, in order to expedite and facilitate review by the Engineer.
- F. Spare Parts List: Submit a spare parts list showing recommended parts and quantities as well as complete ordering information for replacement components. Provide instruction books for special control devices and special equipment installed in the control center. Submit these to the Owner prior to installation of the equipment.
- G. Manuals: Provide manuals as specified in Section 16010.
- 1.04 QUALIFICATIONS
- A. The manufacturer of the assembly shall be the manufacturer of the major components within the assembly.
- B. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of 5 years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.
- PART 2 - PRODUCTS
- 2.01 MOTOR CONTROL CENTER
- A. General: The motor control center shall be a free-standing, completely metal enclosed, dead front, dead rear, grouped motor control center arranged as shown on the Drawings. The motor control center shall be suitable for use on a 480Y/277-volt, 3-phase, 4-wire radial system grounded at the supply, with a short circuit capacity of up to 42,000 amperes without a neutral conductor in the motor control center. The motor control center shall conform to all applicable requirements of current NEMA Standards ICS 1 and ICS 2 and be UL listed. Each MCC section shall bear the UL label. Equipment shall be assembled into standardized drawout units. The motor control center shall be NEMA Class II, Type B construction.
- B. The MCC shall provide Type 2 Accessibility as defined by IEEE C37.20.9-2007 'IEEE Guide for Testing Metal-enclosed Switchgear Rated up to 38 kV for Internal Arcing Faults'.

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C. Structure and Arrangement:

1. The motor control center shall consist of NEMA 1A vertical freestanding sections, each at least 20 inches wide, 20 inches deep and 90 inches high, and containing not more than six space units. A space unit shall be the space required for a Size 1 combination starter together with associated control transformer. The motor control center shall be suitable for floor mounting against a wall. Provide a horizontal wireway 6 inches high at the bottom of the motor control center, and a vertical wireway 4 inches wide in each 20-inch-wide structure. Coordinate horizontal wireway dimensions with that of the housekeeping concrete pad (see Part 3) to ensure conformance with the NEC 6-7" rule (NEC 404-8).
2. Each cubicle shall have an individual door with concealed hinges. Doors shall be part of the structure, shall be readily interchangeable, and shall be interlocked so that the unit power is off before the door can be opened; provide door hinges on the side of the cubicle which ensures compliance with the 30-inch rule in NEC paragraph 110-26. In addition, each unit shall be padlockable in the off position and in the tilted-out disconnected position.
3. All components shall be within individual control cubicles, except as noted. Control components shall be as specified in Section 16955.
4. "Future" spaces shall be cubicles arranged for future addition of the door and unit of the size indicated on the Drawings. The vertical bus shall extend to but not be exposed within "future" spaces.
5. Arrangement and grouping of cubicles shall be substantially as shown on the Drawings. Avoid deviations from the arrangement shown, if possible; otherwise, submit changes to the Owner for review. The number of vertical freestanding sections shown on the Drawings is the minimum required. If additional sections are needed to house all equipment, including relays and timers, indicated to be located within the motor control center:
  - a. Provide such sections at no additional cost to the Owner, and
  - b. Provide a sufficient number of additional sections such that the total number of future spaces is at least the number shown on the Drawings or 15% of the total motor control center size, whichever is smaller.
6. Insulating sheets shall be provided on the inside of end closing plates for horizontal bus openings to help prevent burn-through of the end closing plate in the event that an internal arcing fault occurs in the horizontal bus compartment. Vertical wireway doors shall be provided with arc-resistant latches to help keep the door latched in the event that an internal arcing fault occurs

D. Buses:

1. Each motor control section shall have a main 3-phase, 3-wire, horizontal insulated bus rated 1600 or 600 amperes as shown on the Drawings. Each vertical section shall have a rigid vertical insulated bus rated not less than 300 amperes and extending to all space units; the bus in vertical sections containing either main lugs or main breakers shall have the same ratings as the horizontal bus. Brace buses for 42,000 amperes symmetrical.
2. Provide each motor control center with a ground bus not smaller than 1/4-square inch in cross sectional area, copper equivalent, extending to all sections. Provide a solderless connector for copper cable at each end of each ground bus, sized for the grounding conductor shown on the Drawings. All solderless connectors shall be NEMA Standard.

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3. All phase and ground buses shall be of copper with silver-plated or tin-plated joints and connections, or shall be of aluminum completely tin-plated. If aluminum buses are used, take special precautions at all joints to offset the effects of creep of the aluminum and to minimize effects of contact between dissimilar metals. All terminal lugs shall be suitable for copper conductors.

E. Wiring:

1. All wiring entirely within each motor control center shall be completely factory installed and shall be thermoplastic machine tool wiring rated 600 volts.
2. Provide a control terminal block with identified terminals in each cubicle for external control wiring associated with that cubicle. Terminal blocks, in cubicles and on doors, shall be as specified elsewhere herein under Motor Control Units.
3. Connections of wiring from devices on fixed surfaces to door-mounted devices shall have hinge loops of extra flexible wires securely fastened at each end to permit opening and closing the door without "working" the terminations.
4. Each control or feeder unit in the motor control sections shall be connected to the vertical bus by means of self-aligning, free-floating, copper alloy, plug-in pressure stab units. All components shall be mounted on a removable pan secured by quick opening fasteners and aligned by means of guide rails. Units shall be interchangeable.

F. Motor Control Units:

1. General: Each unit shall consist of a motor circuit protector and a magnetic starter. The combination shall have an interrupting rating of not less than 42,000 amperes symmetrical at 480 volts. Each unit shall have a control terminal board and other components as shown on the Drawings.
2. Motor circuit protector shall be molded case quick-make, quick-break with magnetic trip only. The motor circuit protector shall be rated 600 volts with adjustable trip settings and interrupting rating of not less than 30,000 RMS symmetrical amperes. The motor circuit protector shall have the rating and trip setting as shown on the Drawings and shall be UL listed. Motor circuit protector shall be Cutler-Hammer HMCP; Square D MagGuard; or equal.
3. Control power transformers shall be dry type machine tool transformers. These shall be Hevi-Duty SBE Series; Square D Class 9070; or equal. Sizes shall be as required for the inrush and continuous current requirements of the circuits. Primary windings shall be fused in both phases. Secondaries shall be fused and grounded.
4. Pushbuttons, selector switches, indicating lights, control relays, elapsed time meters, and timing relays shall be as specified in Section 16955.
5. Terminal blocks shall be rated 600 volts and at least 30 amps. These shall be either the box lug type or isolating switch type, as required. Any circuit within the unit that can be energized when the unit power is off shall have isolating switch type terminals. Provide terminals for all external connections as shown on the Drawings, and, in addition, at least 15% spare terminals. Permanently identify each terminal with the same number as the wire being terminated. Terminal blocks shall conform to NEMA ICS4 and shall be Buchanan NQO; Phoenix Contact; Square D Class 9080; or equal.

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- G. Feeder circuit breakers shall be thermal magnetic and of the size shown on the Drawings. Interrupting rating shall be at least 30,000 amperes symmetrical at 480 volts.
- H. For Adjustable Frequency Drives refer to Section 16924.
- I. Nameplates and Identification:
1. Provide the motor control center with manufacturer's nameplate that indicates voltage, phases, number of wires, frequency, and bus ratings.
  2. Provide the motor control center with an identifying nameplate inscribed as shown on the Drawings.
  3. On each cubicle door in the control center, provide an identifying nameplate inscribed as shown on the Drawings.
  4. In those cases where integral legend plates cannot be used, install additional special nameplates on doors to identify selector switches, pushbuttons or other devices, as required by the Drawings or as specified herein. All integral legend plates shall be large size and shall be uniform for all control centers.
  5. Identify all internal wiring using a system consistent with the terminal identification system. Each wire at each terminal shall have attached to it permanent means of identification made of moisture resistant non-fading material.
- J. Finish: Paint finish shall be ANSI 61 and the dry film thickness shall be not less than 3 mils.
- K. Manufacturer:
1. The motor control center shall be standard catalog equipment modified as shown on the Drawings or specified herein as normally manufactured by the specified manufacturer.
  2. The motor control center shall be as manufactured by Allen Bradley; Eaton; Square D; General Electric; Siemens; or equal. All shall be factory assembled, except for shipping splits.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Install the motor control center level and plumb, and secure to a 3-inch-high housekeeping concrete pad in conformance with the favorably reviewed seismic mounting method. Doors shall swing freely and close tightly.
- B. Carefully repair any damage to the structure, components or finish to the satisfaction of the Construction Manager. Clean all nameplates.
- C. Exercise care at all times after installation of motor control center to keep foreign matter, dust, dirt, debris, and moisture out of the control center.
- D. Lace incoming and outgoing power conductors to resist short circuit forces. Follow manufacturer's instructions.

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### 3.02 FIELD TEST

- A. Test the motor control center per NETA.

### 3.03 TRAINING

- A. Provide a training session for up to five Owner's representatives for normal workdays at the job site or other office location chosen by the Owner.
- B. A manufacturer's qualified representative shall conduct the training session.
- C. At a minimum, the training program shall consist of the following:
  1. Review of the MCC one-line drawings and schedules.
  2. Review of the factory record shop drawings and placement of the various cubicles.
  3. Review of each type of starter cell, components within, control, and power wiring.
  4. Discuss the maintenance timetable and procedures to be followed in an ongoing maintenance program.

END OF SECTION

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SECTION 16924  
ADJUSTABLE FREQUENCY DRIVES (AFDs)

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Applicable provisions of Section 16010 become a part of this Section as if repeated herein.
- B. Work Included: Provide a controller for each of those motors so shown on the Drawings.
- C. Related Work Specified Elsewhere:
  - 1. Section 11002: Electric Motor Drives
  - 2. Section 16920: Motor Control Center
  - 3. Section 16955: Control Devices

1.02 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

- A. National Electrical Manufacturers Association (NEMA) Publications:
  - 1. ICS1 Industrial Control and Systems: General Requirements
  - 2. ICS2 Controllers, Contactors and Overload Relays rated 600 V
  - 3. ICS 3 Industrial Systems
  - 4. ICS 3.1 Safety Standards for Construction and Guide for Selection, Installation and Operation of Adjustable-speed Drive Systems
  - 5. ICS 4 Terminal Blocks for Industrial Control Equipment and Systems
  - 6. ICS 6 Enclosures
  - 7. ICS 7 Industrial Control and Systems: Adjustable – Speed Drives

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- B. American National Standards Institute (ANSI) Publication:  
1. C37.90 Relays and Relay Systems Associated with Electric Power Apparatus
- C. Institute of Electrical and Electronic Engineers (IEEE) Publication:  
1 519 Harmonic Control and Reactive Compensation of Static Power Converters

### 1.03 SUBMITTALS

- A. The following information shall be submitted in accordance with Sections 01300 and 16010:
1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
  2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
- B. Submit shop drawings, including: complete elementary (ladder) diagrams; comprehensive interconnection diagrams for AFD, motor, external control devices and controllers, and other related devices; drawings showing physical arrangement of components; front elevation to scale with overall dimensions, conduit entrance spaces and weights; and Bill of Materials.
- C. Submit written descriptions explaining ladder diagram operation, system operation and analog signal processing.
- D. Within 45 days following Notice to Proceed:
1. Submit a report documenting the results of computer or factory based voltage distortion and commutation notch area simulations. Obtain all data needed for the report. Obtain other data from the field as necessary. The simulations shall

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- model the effects of full load AFD operation on the line side of the AFD. Simulations shall demonstrate compliance with IEEE 519 for general systems. If simulations show that compliance with IEEE 519 cannot be achieved with the equipment shown on the Drawings, include in the report the manufacturer's recommended design modifications needed to ensure compliance with IEEE 519. Include additional simulation data for the recommended system demonstrating compliance. Simulation shall include specific filtering or impedance modifications necessary. Perform and submit a report on the results of a power factor analysis and document any special switching requirements necessary to eliminate filter induced leading power factors.
3. Submit sketches of the revised single line diagram and a revised scale drawing of the equipment room layout. Room layout shall show location and mounting requirements for filters, reactors, or other devices required. All additional equipment shall meet the seismic anchorage requirements as described in this Section.
  4. Simulation report, analysis, and design shall be included in the Contractor's bid price.
  5. Additional filters, reactors, enclosures, conduit, wire, and all other components necessary for a fully functioning system complying with IEEE 519 for general systems shall be included in the Contractor's bid price.

E. Regarding the seismic anchorage requirements, refer to Section 01190 for equipment certification and anchorage design.

F. Submit certified factory test report before equipment is shipped.

G. Manuals: Provide in conformance with Section 16010.

H. Submit certification that AFD, motor, and driven load are compatible throughout the specified speed range. Certification shall include a certification from the pump manufacturers specified in other Sections that AFD is compatible with supplied pumps.

I. Submit list of manufacturer's recommended spare parts.

J. Submit certified statement from the manufacturer accepting responsibility for providing a fully functioning installation as specified herein.

K. Submit certified test reports of the AFD field tests.

### 1.04 COORDINATION

A. Motor: Obtain and review the appropriate data for the driven motor and load over the required speed range, for a complete system analysis. Verify that equipment is mutually compatible and free of resonance over the complete operating range. Coordinate the assignment of any critical frequencies with the motor supplier per Section 11002. Prepare the certificate required under Submittals paragraph in this Section, the certificate shall specifically state whether the AFD equipment is rated for variable torque or constant torque applications and compatible with the requirements of the driven equipment.

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B. Standby Generator: Submit information on waveform distortion and inrush currents, including power factor, to the standby generator manufacturer for calculation of voltage and frequency changes caused by motor starting and stopping. Review standby generator manufacturer's calculations and verify that AFD and generator are compatible. Prepare the certificate required under the Submittals paragraph in this Section.

C. Instrumentation and Controls: Review and coordinate requirements with the instrumentation and controls work of Division 17. Provide all necessary interfacing to produce a complete, fully operational system.

## PART 2 - PRODUCTS

### 2.01 SYSTEM

A. General: Provide integrated, all solid state adjustable frequency drives (AFDs). Provide all AFDs complete with minimum 3% incoming line reactors. Provide all additional components necessary to meet IEEE 519 as described below. System shall comply with NEMA ICS 1, 3, 4, 3.1, 4, and 6.

B. Manufacturers: Products of the following manufacturers are acceptable, subject to conformance with these Specifications: Allen-Bradley - PowerFlex; Eaton CVX;

C. Operation: Accomplish speed control by adjusting the output frequency according to the desired reference speed. Adjust ac voltage and frequency simultaneously to provide the constant volts/Hertz necessary to operate the motor at the desired speed. The AFD must use pulse width modulation (PWM) technology.

D. Rating:

1. Line Voltage: 460 volts, -5% continuous, -10% momentary, +10%, 3 phase.
2. Line Frequency: 60 Hz, 2 Hz
3. Ambient Temperature: 5°C to 40°C
4. Altitude: Up to 3,300 feet above sea level.
5. Service Factor: 1.15. Service factor is defined as the AFD continuous current rating shall be 115% of actual motor full load current nameplate rating.
6. Power Factor: Above 0.98 at full speed and rated load.
7. Suitable for use with constant torque loads and having a 150% overload capacity for 1 minute in addition to Service Factor.

E. Performance:

1. Efficiency: Above 95% at 100% full speed, above 93% at 70% full speed, both for centrifugal pump loads.
2. AFD Inrush Current: As required to start motor under normal load.
3. Duty Cycle: 6 starts per hour.
4. Speed Range: 34% to 100% full speed, with adjustable minimum and maximum speeds.

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## F. Features:

1. Provisions to accept the following control signals for automatic and manual operation:

- a. Run signal from a single remote contact closure; and
- b. A 4-20 mA dc signal for speed control. The AFD shall provide linear speed control of the motor from minimum speed to maximum speed as the adjustable speed input signal varies from its minimum to maximum. Input impedance shall be 250 ohms resistive.

2. Selector switch for automatic, manual or off.

3. Potentiometer for manual speed control.

4. Motor speed indicator calibrated in percent of full speed.

5. Incoming line circuit breaker.

6. Incoming line reactor for 6-pulse drives.

7. All components necessary to ensure compliance with IEEE 519 for general systems: 5% voltage distortion factor and 22,800 voltmicroseconds commutation notch area. It is the intent of this Specification to achieve a system that operates within the guidelines of IEEE 519 for general systems.

8. 24 Vdc or 120 Vac control circuitry.

9. Adjustable time delay for delaying motor drive restart after power failure; timer range shall be 0 to 120 seconds, with initial settings differing by 10 seconds for each drive; provide module which causes multiple attempts to restart.

10. Provision for automatic emergency shutdown in any mode, actuated by the following:

- a. Motor thermal protection (see Section 11002).
- b. Any additional abnormal conditions as shown on the Drawings. Provide for manual restart.

11. Auxiliary contacts for remote indication of "Run", "Motor Overtemperature" and "AFD Fail."

12. Auxiliary contact for "In Manual" or "In Auto."

13. Output speed signal consisting of 4-20 mA.

14. AFD able to withstand harmonic distortion and notching as defined in IEEE-519 for dedicated system (10% voltage distortion factor and 36,500-volt microseconds commutation watch area).

15. Linearity and repeatability accuracy of 3-phase output of 1% of analog input control signal regardless of input power voltage fluctuations between 437 and 505 volts.

16. Independent acceleration and deceleration controls, adjustable from 2 to 30 Hz per second.

17. Displays indicated above integrated in an operator interface keypad.

G. Protection: Protect AFD against the following conditions:

1. Reverse phase sequence and single phasing of input power.
2. Input power failure.
3. Input transient voltages, including peak suppression and snubbers, in accordance with ANSI C37.90.
4. Radio and television interference.
5. Output overcurrent.
6. Input overcurrent.
7. Motor overtemperature.

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- H. Construction:
1. AFDs shall be housed within a motor control center specified in Section 16920.
    - a. Door-mount the following devices:
      - 1) Power On indicating light.
      - 2) Manual-Off-Auto selector switch.
      - 3) On-Off switch.
      - 4) Manual Speed potentiometer.
      - 5) Speed indicator calibrated in percent of full speed.
      - 6) Motor Run indicating light.
      - 7) Motor Overtemperature indicating light.
      - 8) Controller Failure indicating light.
      - 9) External operating handle for the incoming line circuit breaker.
      - 10) Cabinet overheat indicating light.
      - 11) Elapsed time meter.
    - b. Some of the above indications can be integrated within the standard manufacturer keypad.

I. Factory Test:

1. Subject AFD and motor control to a complete simulated operational test. Drive a calibrated load at various speeds over the specified speed range to determine AFD efficiency.
  2. Submit certified test report to the Owner before equipment is shipped.
- J. Spare Parts: Furnish two sets of spare power fuses for each size and type of fuse used; furnish a minimum of five fuses of each size and type of control circuit fuse.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installation shall be in conformance with Section 16010.
- B. Provide the services of a factory trained service technician to inspect and check out each system before energizing.
- C. Lace power conductors to resist short circuit forces. Follow manufacturer's instructions.

3.02 FIELD TESTING

- A. Provide the services of a factory trained service technician to make final adjustments to equipment and carry out a full operational test in the presence of the Construction Manager.

- B. Replace any failed or damaged parts at no cost to Owner.
- C. Following installation and manufacturer's field test, perform a field test under utility and standby operating conditions. Operate the drive from no load to full load and perform a spectrum analysis to verify that the waveform on motor control bus is in compliance with IEEE 519 for general systems. Submit a complete certified test report for review by the Owner. If compliance has not been attained, provide additional equipment as specified herein and perform the test again.

3.03 TRAINING

- A. Service technician shall instruct operating personnel in the operation, maintenance, programming and adjustment of the AFDs.

END OF SECTION



SECTION 16955

CONTROL DEVICES

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Provisions: Applicable provisions of Section 16010 become a part of this Section as if repeated herein.
- B. Work Included: Furnish and install all control devices complete, including, as applicable, enclosures, engraved escutcheons or nameplates, gaskets, lenses, lamps and mounting provisions.
- C. Related Work Specified Elsewhere:
  - 1. Section 16920: Motor Control Center
  - 2. Section 17510: Panels

1.02 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

- A. National Electrical Manufacturers Association (NEMA) Publications:
  - 1. ICS1 Industrial Control and Systems: General Requirements
  - 2. ICS2 Controllers, Contactors and Overload Relays rated 600 V
  - 3. ICS6 Enclosures

1.03 SUBMITTALS

- A. The following information shall be submitted in accordance with Section 01300:
  - 1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in

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the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

B. Submit material or equipment data in accordance with the requirements of Section 16010.

## PART 2 - PRODUCTS

### 2.01 GENERAL

A. All control devices shall conform to applicable provisions of NEMA Standards ICS1 and ICS2.

### 2.02 CONTROL AND TIMER RELAYS

A. General Requirements:

1. Provide relays rated for 1 million operations at 10 amp, 120 Vac, at power factor of 0.2.
2. Where timing relays are interfaced to motor starters or adjustable speed motor controllers, provide auxiliary machine-tool relays or Size 0 magnetic contactors.
3. Where timing relays or control relays require additional contacts, provide auxiliary control relays, properly sized for the application.

B. Relays shall be provided as necessary to perform switching functions required of control panels and other control circuits. Relays shall be of the following types (abbreviations in parentheses correspond to labels on the Drawings):

1. Size 0 Magnetic Contactors (MS): Provide Size 0 magnetic contactors for driving Size 4 and Size 5 ac operated motor starters. Provide Size 0 contactors of the same type and manufacture as the motor starter contactors.
2. Relays (CR):
  - a. Provide machine tool relays for the following applications:
    - 1) All relays driving 120-Vac motor starters up to and including Size 3.
    - 2) All relays driving non-motor loads up to 6 amps (or 720 VA).
  - b. Provide machine tool type relays with convertible contacts rated 10 amperes continuous with NEMA Rating Designation A600 for ac applications and N600 for dc applications. Coils shall be designed for continuous duty and shall have the voltage rating indicated on the Drawings.

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- c. Relays shall be the magnetically held type unless designated otherwise on the Drawings. For each relay, provide one spare Form C contact over and above the number indicated on the Drawings. In addition, for latching relays, provide coil clearing contacts as necessary.
- d. Manufacturer: Square D, Class 8501 Type X; General Electric CR120B; or equal.

3. General Purpose Control (CR) Relays (plug-in):

- a. Provide plug-in style 2-, 3-, or 4-pole enclosed relays with integral neon or LED indicators for the following applications:

- 1) Relay logic (relays driving other relays, including machine tool relays) operating at voltages up to 120 Vac.

- 2) Control power switching.

- 3) All relays driving non-motor loads up to 2 amps (240 VA) at 120 Vac.
- b. Provide relay sockets rated for 10 amp, 240 Vac with screw-type barriered terminals.

- c. Manufacturer: IDEC RH Series; Square D, Class 8501 R; or equal.

4. Analog or Digital Signal Switching (SR) Relays:

- a. Provide plug-in style indicating type relays with gold plated silver contacts for switching low level currents (less than 100 mA).

- b. Provide relay sockets with screw-type barriered terminals.

- c. Manufacturer: IDEC RY/RM series or equal.

5. Latching Relays (LR):

- a. Heavy duty latching relays shall be 600-volt machine tool industrial relays, magnetically held, two-coil type. Relay shall have convertible contacts rated 10 amperes with NEMA rating design A600. Latching relay shall be Square D Class 8501 Type X; General Electric CR170BL; or equal.

- b. General purpose latching relays shall be general purpose plug-in relay, two-coil magnetically held with an integral neon or LED indicators. Relay contacts shall be rated for 10 amp, 240 volts with coil voltage as shown on the Drawings. Relay shall be complete with socket and shall be Square D, Class 8501 Type K; IDEC RR2KP Series; or equal.

6. Timing Relays (TR) and (TD):

- a. General: Relays designated TR shall be machine tool industrial relays, while those designated as TD shall be general purpose plug-in time delay relays.

- b. Timing Relay (TR): Timing relay shall be machine tool industrial relay with solid-state timer and external adjustment dial. Range shall be 0 to 120 seconds unless indicated otherwise on the Drawings. Relay shall include an LED indicator and instantaneous and time-delay contacts rated at 10 amps, meeting NEMA A600 designation. Timing relay shall be "on delay" or "off delay" as indicated on the Drawings and shall be Allen Bradley 700-PS; Square D Class 8501 Type X; or equal.

- c. Time Delay Relays (TD): Relay shall be solid-state with multi-range programmable settings. The relays shall include a calibrated front dial and LED indicator and shall be complete with socket. Relays shall be "on delay" or "off delay" type as indicated on the Drawings. Provide an additional Form C contact over and above the number indicated on the Drawings. Relay contacts shall be rated 10 amp, 120 Vac. Relays shall be IDEC Type RTE; ATC Type 339B; or equal.

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## 2.03 INTRINSICALLY SAFE RELAYS (ISR)

- A. Unit shall be fixed sensitivity type and either UL or FM approved for use with a remote pilot device (dry contact) located in Class 1, Division 1, Groups C and D atmospheres. Supply power shall be 120 Vac, 60 Hz. Provide load contacts as shown on the Drawings, except provide a minimum of one single-pole double-throw set. Contact ratings shall be 5 amperes or better at 120 Vac. Unit shall be GEMS SAFE-PAK; Warrick Series 17; or equal.

## 2.04 ELAPSED TIME METERS (ETM)

- A. Elapsed time meters shall be of the synchronous motor-driven type having a minimum of 6 decimal digits where the least significant digit shall represent tenths (1/10ths) of hours. Unless specified otherwise, they shall not be equipped with a reset button. They shall be for panel mounting with a square bezel approximately 2 1/2 inches on a side. Meter voltage shall be not more than 120 Vac for meters mounted in instrumentation panels. Elapsed time meters shall be ATC 5702; Yokogawa/General Electric Series 200, Type 240; or equal.

## 2.05 CONTROL PANEL ACCESSORIES

- A. Relays, timers, and other internally mounted equipment shall be of the types specified in other Sections of these Specifications.
- B. Panel face mounted equipment shall be of the types specified in other Sections of these Specifications.

- C. Standards: All control devices shall conform to applicable provisions of NEMA Standards ICS 1 and ICS 2.

- D. Pushbuttons, Selector Switches, and Pilot Lights: Shall be heavy-duty oillight units; each unit shall have an engraved escutcheon plate unless nameplates are indicated on the Drawings or are necessary because of length of identification. Pushbuttons and selector switches shall have contacts rated 10 Amps continuous at 300 Vac, Rating Designation A600 in conformance with NEMA ICS 2. Selector switches shall have multiple contact blocks ganged together and shall be expandable for additional contact blocks.

- E. Multiposition control switches shall have rotary action, round knurled handle and the number of positions and stages shown on the Drawings. They shall be suitable for panel mounting. Each position shall have a positive detent. Contacts shall have a continuous current rating of 10 Amps at 300 Vac. Switches shall have integral indicator.

- F. Colors and Descriptions:

1. Indicating Lamps: Unless otherwise noted on the Drawings, the following color code and inscriptions shall be followed for the lenses of all indicating lights.

Indicating Lamp Inscription	Color
ON/START	Green
OFF/STOP	Red
CLOSED	Red

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Indicating Lamp Inscription	Color
LOW	Amber
FAIL	Amber
HIGH	Amber
OPEN	Green
POWER ON	White

2. Lettering shall be black on white and amber lenses. Lettering shall be white on red and green lenses.
3. Pushbuttons: Follow color-coding for indicating lamp above.
4. All unused or non-inscribed buttons shall be black. Lettering shall be black on white and yellow buttons. Lettering shall be white on black, red, and green buttons.

- G. Panel Lights and Receptacles: Panels shall be internally lighted by fluorescent lamps, provided with guards and a toggle switch located convenient to each access door. One duplex GFI type receptacle shall be provided in each panel section. The lights and receptacles shall be wired to outgoing terminal blocks for 120 Vac, 60 Hz, single-phase supply.

- H. Nameplates: Unless specified otherwise in the Drawings, nameplates shall be black lamacoid with minimum 3/16-inch-high white letters for major area titles, 5/32-inch for component titles, and 1/8-inch for subtitles, and shall be fastened with a permanent but dissolvable adhesive or by screws.

## 2.06 CONTROL STATIONS

- A. Provide control stations complying with NEMA ICS 6 for manual control functions as follows and as shown on the Drawings: start-stop pushbutton, Local-Off-Remote, forward-reverse-jog-stop, etc. Control stations shall include selector switches, pushbuttons, and indicators as specified in this Section.

- B. Enclosures shall be as follows:

1. Dry Locations: NEMA Type 12
2. Corrosive Locations: NEMA Type 4X
3. Wet Locations: NEMA Type 4 or 4X
4. Damp Locations: NEMA Type 4 or 4X.

- C. Nameplates: Provide an engraved plastic nameplate for each control station and escutcheons or nameplates for devices mounted thereon.

- D. Provide pushbuttons, selector switches, indicators, etc., as shown on the Drawings and as required. Provide control devices with NEMA ratings matching that of the control station.

- E. Manufacturer: Provide Allen-Bradley; Eaton; or equal.

## 2.07 DOOR INTRUSION SWITCHES

- A. Magnetic switches shall be of the type customarily used for security work. The magnetic switches shall be UL listed and suitable for use on steel doors. Use one switch for single doors and two switches for double doors.

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B. Manufacturer: GE Sensors 2507A or equal.

C. Connect the door switches to the Main PLC as shown on the Drawings.

### PART 3 - EXECUTION

#### 3.01 GENERAL

A. Identify all control devices with engraved plastic nameplates or escutcheons, as applicable. Install control devices as recommended by the manufacturer.

END OF SECTION

### SECTION 17010

#### INSTRUMENTATION AND CONTROLS, GENERAL REQUIREMENTS

### PART 1 - GENERAL

#### 1.01 SECTION INCLUDES

##### A. Work Included:

1. Provide all tools, equipment, materials, and supplies and be responsible for all labor required to complete the installation, startup and operational testing of a complete and operable Instrumentation and Control (I&C) System as indicated on the Drawings and as specified herein.
2. Provide all the necessary equipment components and interconnections along with the services of manufacturers' engineering representatives necessary to ensure that the Owner receives a completely integrated and operational I&C system as herein specified.
3. Provide all terminations for wiring at field-mounted instruments, equipment enclosures, alarm, and status contacts.
4. Provide all Instrumentation and Control wire required for a fully functioning Instrumentation and Controls System as shown on the Drawings except for wire specifically specified in Division 16. See Section 16010.
5. Coordinate all work with I&C Subcontractor who is responsible for PLC and HMI SCADA programming.

##### B. Work Specified in Other Divisions:

1. Process piping, installation of inline instrumentation, gas monitors, chlorinators and sulfonators, air compressors, main air supply headers, and other mechanical work and equipment as specified in Divisions 11, 13, 14, or 15.
2. Instruments and controls which are not directly used for process control, i.e., those provided as part of a package system, such as a boiler, air compressor, etc. as specified in Divisions 11, 13, 14, 15, or 16.
3. Division 16 work, including all instrumentation and controls conduit, and only that wire specified in Division 16. Refer to Division 16 Specifications for specific requirements for wire, conduit, grounding, and other electrical equipment.
4. Final control elements as specified in Section 15050.
5. General mechanical requirements as specified in Section 11001.

#### 1.02 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

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Instrumentation and Controls,  
General Requirements



Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

A. American National Standard Institute (ANSI) Publications:

1. Y14.15a Drafting Practice
2. C62.1 Surge Arrestors

B. Instrumentation Society of America (ISA) Publications:

1. S5.4 Instrument Loop Diagrams
2. S20 Specification Forms for Process Measurement and Control Instruments, Primary Elements and Control Valves

1.03 I&C SUBCONTRACTOR

- A. An I&C Subcontractor shall be an electrical contractor who has demonstrated experience in purchasing, calibrating, fabricating, installing, and testing the Instrumentation and Control (I&C) products listed in this Specification Section. Normally, the I&C Subcontractor is a systems house regularly engaged in the business of panel fabrication, control component procurement, programmable logic controller and personal computer (PC) application in the process control industry.
- B. The I&C Subcontractor must have at least 5 years of experience in performing all aspects of the type of work specified in this Section and shown on the Drawings.
- C. The Owner shall sub-contract with SCADA Support Group, California, for the programming of the two PLCs shown on the Drawings. SCADA Support Group shall design and install the PLC programs in accordance with these Specifications and the Owner's requirements for a complete PLC system, local operator interface and network communications.
- D. Instrumentation and control work and services beyond those provided by SCADA Support Group will be required by the Contractor as specified in the contract documents. The Contractor may sub-contract with SCADA Support Group for this additional work and services.

1.04 I&C SUBCONTRACTOR SYSTEM RESPONSIBILITIES

- A. General: The I&C equipment as specified in this Division shall be considered an integrated system. Entire system installation including calibration, verification, startup, operation testing, and training shall be performed by qualified personnel, possessing all the necessary skills and equipment, and who have had experience performing similar installations. Instrumentation and control systems drawings are

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diagrammatic only; it is the responsibility of the Contractor to obtain technical data, determine performance requirements, develop instrumentation detail installation designs, and coordinate the selection of specified equipment with Contractor supplied equipment to meet the design conditions stated.

B. System Responsibilities:

1. Instrumentation and control system drawings are diagrammatic only. Ensure that all components of the instrumentation system, including primary measuring, indicating, transmitting, receiving, recording, totalizing, controlling, and alarming devices and all appurtenances are completely compatible and shall function as outlined and shall furnish and install such additional equipment, accessories, etc., as are necessary to meet these objectives at no cost to the Owner.
2. Compatibility: See that all components of the instrumentation system, including equipment specified under other Divisions, are completely compatible and function properly as a system. Provide such additional equipment, accessories, etc., as are necessary to meet these objectives at no cost to the Owner.
3. Coordination: For control components, devices, and systems specified in Divisions 11, 12, 13, 14, 15, 16, and 17 or shown on the Drawings.
  - a. Provide technical advice to mechanical and electrical subcontractors as necessary regarding their installation of instruments.
  - b. Verify the correctness of installation of all instruments.
  - c. Verify that the proper type, size, and number of control wires with their conduits are provided.
  - d. Verify that the proper type, size, and number of pneumatic tubes with their conduits are provided.
  - e. Verify that proper electric power circuits provided for all components and systems.
  - f. Resolve all manufacturers' installation discrepancies between requirements and the detail requirements of the Drawings and Specifications.
  - g. Supervise final signal connections, both electric and pneumatic, to all process instrumentation and control equipment.
  - h. Adjust, startup, and test all process instrumentation and control equipment.
  - i. Provide specified documentation and training.
4. Performance: While the Drawings provide sufficient information to establish the form and function of the systems and their relationships, the responsibility for system integration and performance rests solely with the Contractor. The Construction Manager provides technical instruction and guidance where needed.
5. Site and Instrument Inspection: Inspect site for conformance to Drawings, paying special attention to space allocation and dimensions shown or required on Drawings. Inspect completed work and verify that it is ready for installation of instruments and equipment. Inspect each instrument and piece of equipment for damage, defects, completeness, and correct operation before installing.

- C. PLC and SCADA System Coordination: Coordinate work including testing plans with Owner's Representative. Coordination shall include startups of all phases in proper sequence.

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## 1.05 SUBMITTALS

- A. The following information shall be submitted in accordance with Section 01300:
1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
  2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
- B. Shop Drawings: Submit shop drawings (diagrams) for review in complete bound sets indexed by Specification number, with exterior tabs marked by subject. Submit manufacturer's catalog cuts for each item for which shop drawings are not required. Manufacturer's catalog cuts, specifications or data sheets shall be clearly marked to delineate the options or styles to be furnished. Show dimensions, physical configurations, methods of connecting instruments together, mounting details, and wiring schematics. Drawings shall be complete with device tag numbers, wire numbers and terminal board numbers. Submit fabrication details, nameplate legends, and control panel internal wiring and piping schematic drawings. Submit panel graphic drawings where applicable. Include material lists and/or bills of material.
1. Interconnection Diagrams: Submit point-to-point type interconnection diagrams conforming to ANSI Y14.15a. Include each conduit run, with wirefill noted for each run. Include electric panel and circuit numbers for all sources of 120 Vac power. Show conduit and wiring interconnections between each control panel, instrument, multiplexer or telemetry unit, motor control center, motor combination starter, motor, valve actuator, and other field-mounted device. Include all equipment and appurtenances provided in this contract regardless of the Division in which it is specified.
  2. Elementary Diagrams: Submit an elementary diagram (also known as a schematic diagram) for control, protection, and monitoring circuits. Elementary diagrams are not required for lighting, communications and those systems

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clearly defined on the single line diagram. Show all interconnections between power sources, apparatus, and device elements of a particular system or equipment, and all interlocks with other systems in a manner, which fully indicates circuit function and operation. Refer to the Drawings for functional and operational requirements.

### C. Specification Forms:

1. Submit completed Specification Forms per ISA S20, including those instrumentation and control components directly related to process control, but specified in other Divisions of these Specifications.
2. Include on each form the assigned tag numbers, manufacturer's part numbers, and device data. More than one tag numbered item may be included on a sheet.

D. As-Built Drawings: Submit a revised set of full size shop drawings that incorporates all change orders and modifications made during performance of the work. In addition to updated loop diagrams, interconnect diagrams and elementary diagrams, submit equipment and device wiring diagrams and other drawings as necessary to depict the "as-built" condition of equipment. Include all installed field and panel conduit and piping/tubing runs and routing, tray systems, supports, mounting details, interconnection diagrams with cable, wire, tube and termination numbers. Coordinate all drawings with the conductor identification requirements in Section 16120 and Section 16124. Submit a copy of CAD produced drawings on magnetic media in AutoCAD DWG format.

E. Operation and Maintenance Manuals: Furnish Operation and Maintenance Manuals, including Instruction Manuals and Part Lists, for equipment provided under Division 17 as required by Division 1. Obtain data from manufacturers, and format and bind as specified. Obtain distribution method instructions from the Owner or his representative.

1. Schedule: Deliver at least two (2) copies of manuals in 3-ring binders (8½-by-11-inch format) not later than the equipment shipment date.
2. Contents: Include in manuals not less than the following information, as applicable, for each instrument, equipment, subsystem and/or control loop:
  - a. General, introduction and overall description, purpose, functions, simplified theory of operations, etc.
  - b. Specifications (including equipment specification data sheet as described above under Shop Drawings), sufficiently detailed for reordering exact duplicates of the original items.
  - c. Installation instructions, procedures, sequences, tolerances, and precautions.
  - d. Operational procedures.
  - e. Shutdown procedures.
  - f. Maintenance, calibration, and repair instructions.
  - g. Parts list and spare parts recommendations.
  - h. Calibration curves, rating tables, and any other data showing the relationship of the variable inputs and the calibrated output of all measuring devices and controlled equipment.
  - i. Software programs (PLC Ladder Logic) RSLogix5000 files and hard copies.

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3. Format:
- Use drawings and pictorials to illustrate the text to the extent necessary to insure a clear, concise presentation. If manuals have been written to cover a family of similar instruments or equipment, strike out inapplicable information in a neat fashion or emphasize applicable portion by heavily weighted arrows, circles or boxes; whichever provides the clearest and neatest presentation.
  - Group manuals by system control panels, including field instrumentation connected or associated with the panel. Where identical instruments are used in more than one control loop or subsystem, include only one instruction manual, per panel grouping; however, an index by tag number for all instruments shall identify its location in that manual.
  - Provide control loop and/or subsystem operational descriptions to identify the function of each instrument and its relation to the other instruments in the loop.
  - Binding: Bind each manual in a cover which indicates the panel or process area to which it applies, manufacturer's name, local address and telephone number, and year of purchase. Punch and bind manuals in standard three ring binders and include system name and subcontractor's name on binding.
- F. Accessory and Maintenance Materials: Submit data for the following items:
- Special Tools and Accessories: Special tools, instruments, and accessories for maintaining instruments and equipment requiring periodic repair and adjustment as specified elsewhere herein. Also, furnish special lifting and handling devices for equipment requiring such devices.
  - Maintenance Materials and Spare Parts: Submit a list of manufacturer recommended spare parts for each item specified. Refer to other sections of these Specifications.
- G. Test Reports: Submit the following test reports as described herein:
- Instrument Calibration Data Sheets (paragraph 2.11)
  - Factory Testing of Control Panels (paragraph 2.12)
  - Instrument Verification Report (paragraph 3.07.C)
  - Final Operational Testing (paragraph 3.07.D)
- H. Submit a construction and Test Plan for implementing the construction sequence described in Section 01010-1.07 of the Specification.
- I. Demonstration and Final Operation Test Plan and Results: Submit a document that outlines all procedures to be used in final operational testing of instrument and control systems. Include a description of each system, the scope of testing, test methods and materials, testing instruments and recorders, a list of functional parameters to be recorded on each item, and Shop Drawings showing temporary bypasses, jumpers, and devices. The Test Plan shall be jointly produced by the Contractor and the I&C subcontractor.

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## 1.06 QUALITY CONTROL

- Standard of Quality: The Contractor shall provide equipment of the types and sizes specified which has been demonstrated to operate successfully. Provide equipment which is new and of recent proven design.

## 1.07 INSPECTIONS

- The Owner's Representative may inspect the fabricated equipment at the factory before shipment to job site. Provide the Construction Manager with sufficient prior notice so that an inspection can be arranged at the factory.
- Inspection of the equipment at the factory by the Owner's Representative will be made after the manufacturer has performed satisfactory checks, adjustments, tests and operations.
- Favorable review of the equipment at the factory only allows the manufacturer to ship the equipment to the project site. The Contractor shall be responsible for the proper installation and satisfactory startup operation of the equipment to the satisfaction of the manufacturer and the Owner's Representative.

## 1.08 DRAWINGS

- Drawings: The Instrumentation Drawings are diagrammatic; exact locations of instrumentation products shall be determined in the field by the Construction Manager. Except where special details are used to illustrate the method of installation of a particular piece or type of equipment or material, the requirements or descriptions in this Specification shall take precedence in the event of conflict.
  - Locations of equipment, inserts, anchors, motors, panels, pull boxes, manholes, conduits, stub-ups, fittings, power and convenience outlets, and ground wells are approximate unless dimensioned; verify locations with the Construction Manager prior to installation. Field verify scaled dimensions on Drawings.
  - Review the Drawings and Specification Divisions of other trades and perform the instrumentation work that will be required for the installations.
  - Should there be a need to deviate from the Instrumentation Drawings and Specifications, submit written details and reasons for all changes to the Construction Manager for favorable review.
  - Resolution of varying interpretations of the Contract Documents shall conform to Division 0, General and Supplementary Conditions.
  - The Drawings provide details of installation and supersede the manufacturer's recommendation where a conflict exists.

## 1.09 PRODUCT DELIVERY, STORAGE, AND HANDLING

- Box, crate, or otherwise enclose and protect instruments and equipment during shipment, handling, and storage. Keep all equipment dry and covered from exposure to weather, moisture, corrosive liquids and gases or any element, which

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could degrade the equipment. Protect painted surfaces against impact, abrasion, discoloration, and other damage. Notify the Owner's Representative in writing in the event that any equipment or material is damaged. Obtain prior favorable review by the Owner's Representative before making repairs to damaged products.

#### 1.10 INSTRUMENT SCHEDULE

- A. See Appendix A for Instrument Schedule.

#### PART 2 - PRODUCTS

##### 2.01 MATERIALS AND STANDARD SPECIFICATIONS

- A. Provide instruments, equipment and materials suitable for service conditions and meeting standard specifications such as ANSI, ASTM, ISA, and SAMA. The intent of this Specification is to secure instruments and equipment of a uniform quality and manufacture throughout the plant. All instruments in the plant of the same type shall be made by the same manufacturer.

##### 2.02 NAMEPLATES

- A. For each piece of equipment, provide a manufacturer's nameplate showing his name, location, the pertinent ratings and the model designation.
- B. Identify each piece of equipment and related controls with a rigid laminated engraved phenolic nameplate. Engrave nameplates with the inscriptions indicated on the Drawings and, if not so indicated, with the equipment name. Securely fasten nameplates in place using two stainless steel screws or, where favorably reviewed by the Construction Manager, with epoxy cement. Where no inscription is indicated on the Drawings, furnish nameplates with an appropriate inscription furnished by the Construction Manager upon prior request by the Contractor.
- C. Each control device, including pushbuttons, control switches, and indicating lights, shall have an integral legend plate or nameplate indicating the device function. These shall be inscribed as indicated on the Drawings or as favorably reviewed by the Construction Manager.

- D. Provide CAUTION or SAFETY nameplates to alert operators of special conditions that may result in faulty equipment operations. Devices containing batteries that must be replaced periodically must be clearly identified. Nameplates are not required if the device senses and displays a low battery warning.

##### 2.03 NAME TAGS

- A. All instrumentation and equipment items or systems shall be identified by name tags. Field equipment shall be tagged with the assigned instrumentation tag number listed in the Instrument Schedule.

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- B. Name tags shall be stainless steel with engraved or stamped black characters of 3/16-inch minimum height. Tags shall be attached to equipment with a tag holder and stainless steel band with a worm screw clamping device. Use 20-gauge stainless steel wire where banding is impractical. For field panels or large equipment cases use stainless steel screws; however, such permanent attachment shall not be on an ordinarily replaceable part.

##### 2.04 FIELD-MOUNTED EQUIPMENT

- A. All instrument and control equipment mounted outside of protective structures shall be equipped with suitable surge arresting devices to protect the equipment from damage due to electrical transients induced in the interconnecting lines from lightning discharges or nearby electrical devices. Protective devices used on 120 Vac inputs to field mounted equipment shall be secondary valve surge protectors conforming to the requirements of ANSI C62.1.

##### 2.05 EQUIPMENT OPERATING CONDITIONS

- A. All equipment shall be rated for normal operating performance with varying operating conditions over the following minimum ranges:
1. Electrical Power: 120 Vac  $\pm$  10%, 60 Hz, unregulated, except where specifically stated otherwise on the Drawings or in the Specifications, or when two-wire, loop-powered devices are specified.
  2. Air: 85 psig,  $\pm$  5 psig
  3. Field Instruments:
    - a. Outdoor Areas:
      - Ambient Temperature: +15°F to +120°F
      - Ambient Relative Humidity: 5% to 100%
      - Weather: Rain, sleet, snow and ice
    - b. Indoor Unheated Areas:
      - Ambient Temperature: +40°F to +120°F
      - Ambient Relative Humidity: 5% to 95%, non-condensing
    - c. Indoor Environmentally Controlled Areas:
      - Ambient Temperature: +60°F to +104°F
      - Ambient Relative Humidity: 10% to 90%, non-condensing

##### 2.06 EQUIPMENT LOCATIONS

- A. Provide equipment and materials suitable for the types of locations in which they are located as defined under Division 16. All equipment specified for field mounting shall be weatherproof and splash proof as a minimum. If electrical or electronic components are contained within the equipment, they shall be housed in NEMA 3R gasketed cases outside, NEMA 4X in wet, damp or corrosive locations, and NEMA 7 in hazardous locations unless noted otherwise on the Drawings.

##### 2.07 ANALOG SIGNAL INDICATED UNITS

- A. For all instruments with local or remote indicators, provide indicators scaled in actual engineering units, i.e., gallons per minute, feet, psi, etc., rather than 0 to 100%, unless noted otherwise on the Drawings or Instrument Schedule.

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## 2.08 SIGNAL TRANSMISSION

### A. Analog:

1. Signal transmission between electric or electronic instruments shall be 4-20 mA and shall operate at 24 Vdc. Signal output from all transmitters and controllers shall be current regulated and shall not be affected by changes in load resistance within the unit's rating. Where practical, milliampere signals from the field shall be converted to a voltage signal at the external terminals of each panel, and all instruments within a panel shall be parallel wired.
  2. Nonstandard transmission systems such as impulse duration, pulse rate, and voltage regulated will not be permitted except where specifically noted in the Instrument Schedule or shown on the Drawings. When transmitters with nonstandard outputs do occur, their output shall be converted to 4-20 mA prior to transmission.
- B. Discrete: All alarm and status signals shall be 120 Vac unless specified otherwise on the Instrument Schedule.
- C. Proprietary data highway or serial bit transmissions such as RS232C, etc. shall be allowed to the extent shown on the Drawings.

## 2.09 PAINTING

- A. Factory paint all instruments and equipment except where installed in pipelines. Where instrument panels are installed adjacent to electrical control panels provided under Division 16, provide instrument panels of identical color to that of electrical control panels. Paint as required in Division 9 for structural supports, brackets, etc. Repair damaged factory paint to satisfaction of the Construction Manager. Feathering, priming and painting shall produce a reasonable match to the surrounding paint work.

## 2.10 FASTENERS

- A. Fasteners for securing equipment to walls, floors and the like shall be either hot-dip galvanized after fabrication or stainless steel. Provide stainless steel fasteners in corrosive locations. When fastening to existing walls, floors, and the like, provide capsule anchors, not expansion shields. Size capsule anchors to meet load requirements. Minimum size capsule anchor bolt is 3/8 inch.

## 2.11 INSTRUMENT CALIBRATION

- A. Each field instrument shall be calibrated at 0%, 25%, 50%, 75% and 100% of span using test instruments to simulate inputs and read outputs that are rated to an accuracy of at least 5 times greater than the specified accuracy of the instrument being calibrated. Such test instruments have accuracies traceable to the National Institute of Standards and Technology (NIST).

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- B. Submit a written report to the Owner's Representative on each instrument. This report shall include a laboratory calibration sheet or the manufacturer's standards calibration sheet on each instrument and calibration reading as finally adjusted within tolerances.

- C. The Contractor may, at his option, choose to perform calibration on an instrument by acquiring the services of an independent test lab, or by obtaining the required test instruments and performing the calibration.

## 2.12 FACTORY TESTING OF CONTROL PANELS

- A. All fabricated equipment shall be tested before it leaves the factory. At the factory verify wiring continuity and equipment operation by simulating input and output.
- B. Factory testing of control panels/devices/equipment shall be accomplished. Refer to individual Specification sections for tests requiring favorable review.
- C. Upon completion of factory testing, submit a report certifying the control panels/devices/equipment are operable and meet the Specifications.

## PART 3 - EXECUTION

### 3.01 EQUIPMENT MOUNTINGS

- A. Mount and install equipment as indicated. Mount field instruments on pipe mounts or other similar means in accordance with suppliers' recommendation. Where mounted in control panels, mount according to requirements of that Section.
- B. Equipment specified for field mounting shall be suitable for direct pipe mounting or surface mounting, surface-mounted indicators and equipment with calibration adjustments or requiring periodic inspection shall be mounted not lower than 3 feet 6 inches nor higher than 6 feet above walkways, platforms, catwalks, and the like.
- C. Note that applicable specifications require detail drawings showing seismic sway bracing design and anchorage requirements for their equipment. Seismic zone requirements are specified in Division 1.
- D. All devices shall be accessible to operators for servicing, operating, reading, etc. Provide permanent platforms to assure devices are continuously accessible.

### 3.02 PROCESS CONNECTIONS

- A. Provide instrument impulse tubing to meet the intended process service and ambient environmental condition for corrosion resistance, etc. Install impulse tubing with a continuous slope according to service to promote self-draining or venting back to the process. Terminate connection to process lines or vessels in a service rated root valve, provided under other Divisions, that will permit closing off the impulse line or removal of the element without requiring shut down of the process. Include blowdown of drip legs and valves for terminations of impulse lines at the instruments.

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- B. Process vessels, line penetrations, and root valves shall be furnished and installed under other Divisions of these Specifications. Instrument tubing, valve manifolds, and test taps are installed as part of this Specification.

### 3.03 FIELD WIRING

- A. Ring out signal wiring prior to termination and perform surge withstand tests where required (see Section 16010, Part 3 for methods). Verify wire number and terminations are satisfactory as designated on the Loop and Interconnect Diagrams. Verify all terminations are tight and shields are uniformly grounded at one location.

### 3.04 ELECTROMAGNETIC INTERFERENCE (EMI)

- A. Construction shall proceed in a manner which minimizes the introduction of noise (RF/EMI) into the I&C System.
- B. Cross signal wires and wires carrying ac power or control signals at right angles.
- C. Separate signal wires from wires carrying ac power or switched ac/dc control signals within control panels, terminal cabinets, telemetry equipment, multiplexer cabinets, and data loggers as much as possible. Provide the following minimum separations within such equipment unless indicated otherwise on the Drawings:

Power Wiring Capacity	Separation (inches)
120 volts ac or 10 amps	12
240 volts ac or 50 amps	18
480 volts ac or 200 amps	24
4,160 volts ac or 800 amps	48

### 3.05 SIGNAL GROUNDING

- A. Proper grounding of equipment and systems in this Division is critical. The Drawings and Division 16, Section 16450, specify safety grounding for all equipment in this Division.
- B. A single-point grounding system for instrument signals is required for all instrument panels. This instrument single point grounding system does not use building steel or conduit systems for its ground path.
- Ground all signal shields, signal grounds, and power supplies at an isolated signal bus within each instrument panel, rack, or enclosure. See Section 17510 for isolated bus requirements. The shields at the far ends of these signal cables must be disconnected (floated) from any ground to prevent ground loops.
  - Do not connect the rack or enclosure frames to the signal grounding buses.
  - Connect each isolated signal ground bus within each panel using a stranded, insulated copper wire of size 6 AWG or larger directly to a system ground rod installed per the Drawings.

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- C. If more than one instrument panel or rack is installed side-by-side, locate an isolated system grounding plate in one of the panels (see Section 17510 for requirements).
- Connect all the isolated signal buses in such instrument panel or rack radially to the system ground plate using a stranded, insulated copper wire of size 8 AWG or larger.
  - Do not use conduit, cable raceways or building steel to distribute the grounding connections; use dedicated wires as specified above. Install a single conduit containing a #2 AWG insulated ground wire from the insulated grounding plate directly to a system ground rod installed per the Drawings. See Division 16 for conduit requirements.

### 3.06 PREPARATION

- A. Ensure that installation areas are clean and that concrete or masonry operations are completed prior to installing instruments and equipment. Maintain the areas in a broom-clean condition during installation operations.
- B. Panels shall be protected during construction to prevent damage to front panel devices and prevent dust accumulation in the intervals. Other protective measures (lamp, strip heaters, etc.) shall be included as weather conditions dictate.

### 3.07 FIELD TESTING

- A. General: The purpose of the field testing is to verify instruments are calibrated and operationally performing their intended function. Provide the services of factory trained and experienced engineers to perform verification and operational testing as prescribed below. Since the initial calibration of instruments may not satisfy the final operation of system, perform recalibration or adjust setpoints as required to satisfy the performance requirements of the system. Notify the Construction Manager in writing a minimum of 48 hours prior to the proposed date for commencing final operational testing and acceptance.
- B. Coordinate with Owner Programmer for testing of all PLC and SCADA functions. Testing and scheduling shall be coordinated with Owner Programmer and Construction Manager.
- C. System Verification Testing: Verify that each instrument shown on the Instrument Schedule is operating and calibrated as specified in the Instrument Schedule by simulating inputs at the primary element in each system loop and verify performance at loop output devices (i.e. recorder, indicator, alarm, etc., except controllers). Simulate inputs at 0%, 25%, 50%, 75%, and 100% of span or with on-off inputs, as applicable. During system verification:
- Make initial or provisional settings on levels, alarms, etc. listed in the Instrument Schedule.
  - Verify controllers by observing that the final control element moves in the proper direction to correct the process variable as compared to the set point.
  - Cause malfunctions to sound alarms or switch to standby to check system operation.

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4. Check all loop instruments thoroughly for correct operation.
5. Immediately correct all defects and malfunctions disclosed by tests.
6. Submit a report certifying completion of verification of each instrument system. This report shall include a data sheet on each instrument tested that indicates instrument tolerances, instrument calibration verification, data and initial settings made to devices.

D. Final Operational Testing: Upon completion of instrument verification, test all systems under process conditions in the presence of the Construction Manager and Telstar. System testing shall be accomplished in accordance with the approved Test Plan (Paragraph 1.05H). The test for each portion thereof shall be witnessed, documented and signed off upon completion by the Owner's Representative. The intent of this test is to demonstrate and certify the operational interrelationship of plant instrumentation and control systems. This testing shall include, but not be limited to:

1. Making final adjustments to levels, alarms, etc.
2. Checking all alarms, failure interlocks, and operational interlocks.
3. Immediately correcting all defects and malfunctions and retesting.
4. Submit the witnessed test results and a transmittal letter indicating that all required systems have been tested satisfactorily and the systems meet all the functional requirements of their applicable specifications.

### 3.08 INSTRUCTION OF OWNER'S PERSONNEL

A. Provide the services of a factory trained and field experienced instrumentation engineer to conduct group training of up to ten of the Owner's designated personnel in the operation of each instrument system. This training shall be for the time period of 5 working days and shall be performed during the operational testing period. Include instruction covering basic system theory, operating principles and adjustments, routine maintenance and repair, and "hands on" operation. The text for this training shall be the Operation and Maintenance Manuals furnished under these Specifications.

END OF SECTION

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### SECTION 17010A

#### INSTRUMENT SCHEDULE

[This Instrument Schedule is not intended to represent a bill of material or a complete list of all required instruments]

Loop Number	Description	Cal Range	Setpoint	PAID	Spec Section	Spec Para.
FE/FIT 2201	Influent Flow Transmitter	0 - 4,000 MGD	1221	17120	NA	2.01
LSH 2202	RS Channel Level Switch	FT	3.0 FT	17140	1221	2.02
AIT 4201A	Aeration Basin 1 DO Transmitter	0 - 100 MG/L	NA	17110	1421	2.01
AIT 4201B	Aeration Basin 1 pH Transmitter	0 - 14	NA	17110	1421	2.02
AIT 4202A	Aeration Basin 2 DO Transmitter	0 - 100 MG/L	NA	17110	1421	2.01
AIT 4202B	Aeration Basin 2 pH Transmitter	0 - 14	NA	17110	1421	2.02
FE/FIT 4311	Aeration Blower 1 Discharge Flow Transmitter	0 - 3,000 SCFM	NA	17120	1431	2.03
FE/FIT 4312	Aeration Blower 2 Discharge Flow Transmitter	0 - 3,000 SCFM	NA	17120	1431	2.03
FE/FIT 4313	Aeration Blower 3 Discharge Flow Transmitter	0 - 3,000 SCFM	NA	17120	1431	2.03
LSL 4414	Clarifiers Scum Pit Level Switch	FT	2.0 FT	17140	1441	2.02
LSH 4414	Clarifiers Scum Pit Level Switch	FT	5.0 FT	17140	1441	2.02
LSH 4414	Clarifiers Scum Pit Level Switch	FT	6.0 FT	17140	1441	2.02
LSSL 4453	Secondary Effluent Pump Station Level Switch	FT	5.0 FT	17140	1442	2.02
LSH 4453	Secondary Effluent Pump Station Level Switch	FT	12.3 FT	17140	1442	2.01
LE/LIT 4454	Secondary Effluent Pump Station Level Transmitter	0 - 16.75 FT	NA	17140	1442	2.01
FE/FIT 4454	Secondary Effluent to Polishing Ponds Flow Transmitter	0 - 4,000 GPM	NA	17120	1442	2.01
FE/FIT 4456	Secondary Effluent Contact Basin Flow Transmitter	0 - 4,000 GPM	NA	17120	1442	2.01
FE/FIT 4515	RAS Pumps 1 and 2 Flow Transmitter	0 - 1,500 GPM	NA	17120	1451	2.01
FE/FIT 4516	RAS Pumps 3 and 4 Flow Transmitter	0 - 1,500 GPM	NA	17120	1451	2.01
FE/FIT 4612	WAS Pump Flow Transmitter	0 - 125 GPM	NA	17120	1451	2.01
PSH 4611	WAS Pump Discharge Pressure Switch	PSIG	50 PSIG	17150	1451	2.03

Instrument Schedule

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SECTION 17010A

INSTRUMENT SCHEDULE

(This Instrument Schedule is not intended to represent a bill of material or a complete list of all required instruments)

Type	Loop Number	Description	Cal Range	Setpoint	P&ID	Spec Section	Spec Para.
LSSL	8301	TD/Supernatant Pump Station Level Switch	FT	3.0 FT	1831	17140	2.02
LSL	8301	TD/Supernatant Pump Station Level Switch	FT	9.0 FT	1831	17140	2.02
LSH	8301	TD/Supernatant Pump Station Level Switch	FT	14.75 FT	1831	17140	2.02
LSH	8301	TD/Supernatant Pump Station Level Switch	FT	19.25 FT	1831	17140	2.02
LSL	8321	South Chlorine Contact Basin Level Switch	FT	5.50 FT	1832	17140	2.02
LSL	8322	North Chlorine Contact Basin Level Switch	FT	5.50 FT	1832	17140	2.02
FE/FT	8323	Utility Water Flow Transmitter			NA	1832	2.01
PT	8324	Utility Water Pressure Transmitter			NA	1832	2.02

Notes:

1. Settings indicated are considered initial settings. Final settings shall be accomplished in the field to suit actual operating conditions.

END OF SECTION

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Instrument Schedule

SECTION 17110  
ANALYTICAL INSTRUMENTS

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Provisions: Requirements of Division 1 and Section 17010 form a part of this Section.
- B. Work Included: This Section specifies analytical instruments for process instrumentation, auxiliary equipment and supplies directly related to the installation and operation of these analytical instruments, to perform the required functions in conjunction with information and equipment specified in other sections of Division 17. See Section 17010; this is the Schedule referred to herein. This Schedule shall not be construed as Bills of Material or as a complete listing of all required devices.

1.02 SUBMITTALS

- A. The following information shall be submitted in accordance with Section 01300:
  1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
  2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

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Analytical Instruments



B. Shop drawings to be submitted in this Section shall be made in one package under the Product Review category of Shop Drawings.

C. Shop Drawings: In addition to the requirements of Section 17010, shop drawings shall include for each type of instrument: supply voltage and frequency, electrical load, accuracy, description of operation, operating instructions, and calibration procedure.

D. Installation Method: Provide proposed method of mounting sensors or probes and instruments with submittal.

E. Parts List: Submit a Parts List with current net prices and a list of recommended spares.

F. Manuals: Furnish manufacturer's installation, lubrication, operation and maintenance manuals, bulletins and spare parts lists.

#### 1.03 QUALITY CONTROL

A. Manufacturer: In addition to the requirements of Section 17010, analytical instruments furnished shall be manufactured by firms regularly and currently engaged in the design and manufacture of similar equipment. All equipment furnished shall be new and of current design.

B. Maintainability: All equipment shall be designed for ease of maintenance and repair, and access to critical parts shall not require a major disassembly. Internal field adjustments where permitted or required herein shall be easily accessible upon removal of a panel or cover.

C. Materials and Installation: Materials and installation shall comply with the requirements of the current editions of referenced electrical codes and standards, and the codes and standards referred to shall be used for establishing the minimum quality of the materials and equipment supplied and installed. All equipment of the same type shall be products of the same manufacturer. Capacities of all equipment shall not be less than that indicated on the Drawings or specified.

#### PART 2 - PRODUCTS

##### 2.01 DISSOLVED OXYGEN PROBES AND ANALYZERS

A. General:

1. Dissolved oxygen element shall be of the galvanic cell type, provided with probe, transmitter, and probe mounting hardware.
2. Probe shall be of the galvanic cell type with a platinum cathode and lead anode. A replaceable 1 mil Teflon membrane shall separate the electrode assembly from the sampled liquid. Elements shall be provided with automatic temperature compensation in the range of 0 to 50°C and shall consistently have zero output at zero dissolved oxygen concentration. Accurate

measurement of dissolved oxygen shall be unaffected by the presence of hydrogen sulfide, ammonia, sulfur dioxide, and carbon dioxide.

3. Transmitter shall be 4-microprocessor-based which will receive the microampere signal from the element, amplify it, provide local indication with a selectable scale range of 0 to 100 mg/l and transmit a 4-20 mAdc signal linearly proportioned to the dissolved oxygen concentration into the loads with impedances in the range of 0 to 750 ohms without load adjustments. Unit shall be temperature compensated over the range of 0 to 50°C. Accuracy shall be  $\pm 0.1$  mg/l. Transmitter shall be suitable for mounting to an outdoor panel unless otherwise noted and shall operate on 120 Vac power. Transmitter shall include 2.5" x 4.5" LCD display and keypad.
4. Transmitters shall be of NEMA 4X construction.
5. Each unit shall have a face-mounted receptacle to receive the dissolved oxygen element extension cable plug, a calibration knob, meter function selector switch, and a two-position selector switch to switch from field receptacle to local receptacle during calibration. Units shall transmit a 4-20 mAdc signal in linear proportion to measured dissolved oxygen.
6. Probe operating range 0-10 mg/l.

B. Manufacturer: Hach LDO probe; Royce Model 9200 with 95A probe; or equal.

##### 2.02 PH PROBES AND ANALYZERS

A. pH measuring systems shall consist of the following:

1. pH element and extension cable with watertight plug.
2. Analyzer/transmitter, junction box with watertight receptacle.
3. Receptacle and switch for local calibration.
4. pH element shall be housed in a Ryton, Teflon, or Derakone enclosure suitable for mounting as noted or shown. Each element shall be provided with a nonelectrolyte consuming reference electrode or standard, a glass pH measuring electrode, a thermocompensator, and an integrally mounted preamplifier/signal conditioner. pH measuring electrodes shall be suitable for the scale ranges noted. Unit shall provide automatic temperature compensation for stream temperature variations of 0 to 50°C. Preamplifier/signal conditioner shall be encapsulated and suitable for operation in 100% relative humidity. Overall system accuracy shall be greater than  $\pm 0.1$  pH unit.
5. pH elements shall be either in-stream or flow-through configurations as noted. Flow-through elements shall be suitable for mounting in-line as shown, with 1-inch NPT connections, and be capable of withstanding 50 psig pressure. Flow-through elements shall be provided with a 5-foot cable with watertight plug.
6. In-stream elements shall be provided with stainless steel support pipes as shown unless otherwise noted, complete with watertight cable connection and a 10-foot cable with watertight plug. The in-stream element configuration shall provide adequate stream contact and protection for the electrodes. Unit shall be suitable for complete submersion in the stream.
7. Each pH element shall be provided with a NEMA 4 junction box with watertight receptacle to mate with the sensor cable plug. Provide each pH element installation with sufficient cable for connection between the NEMA 4 junction box and the associated panel-mounted pH analyzer/transmitter.

Analytical Instruments

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Analytical Instruments

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8. pH analyzer/transmitters shall be field mounted in NEMA 4X enclosure unless otherwise noted. Cases shall be thermoplastic (polycarbonate or polypropylene). On the face of each unit shall be a 4-inch (minimum) indicating scale with range as noted, and a standardization adjustment. Where alarms are noted, face of each unit shall contain high and low adjustment knobs and alarm lights. Alarms shall have adjustable deadband. In addition to energizing the two alarm lights, alarm-equipped units shall make contact closures, rated for 5 amps at 120 Vac. In addition to receiving inputs from the field-mounted elements and locally indicating the measured pH value, the unit shall generate an electrically isolated 4-20 mA dc signal in linear proportion to pH into loads in the range of 0 to 450 ohms without load adjustment. The unit shall operate on 120 volt, 60 Hz power.
  9. Each unit shall be provided with a receptacle suitable for panel-face mounting as shown, to receive the watertight plug of a pH element extension cable. A two-position selector switch shall be provided with each analyzer/transmitter to switch from the field receptacle to the local receptacle for element standardization. When in LOCAL, alarm functions shall be disabled.
  10. The analyzer shall have a selectable span initially set for a range of from 2 to 14 pH, but shall be continuously adjustable; it shall have full range suppression.
- B. Manufacturer:
1. pH elements shall be Endress Hauser, Hach, or equal
  2. pH analyzer/transmitters shall be Endress Hauser, Hach or equal.
  3. Both pH elements and analyzer/transmitters shall be the products of the same manufacturer.

### PART 3 - EXECUTION

#### 3.01 INSTALLATION

- A. Installation, testing, calibration, validation, startup and instruction shall be in accordance with Section 17010.
- B. Provide sufficient extension cable to allow installation along the support cables in the Aeration Basins as shown on the Drawings.
- C. Provide two spare DO probe membranes.

END OF SECTION

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### SECTION 17120 FLOW MEASUREMENT

#### PART 1 - GENERAL

##### 1.01 SECTION INCLUDES

- A. Provisions: Requirements of Division 1 and Sections 17010 and 11001 form a part of this Section.
- B. Work Included: This Section specifies flow measurement devices for process instrumentation, auxiliary equipment and supplies directly related to the installation of and operation of these flow measurement devices, to perform the required functions in conjunction with information and equipment specified in other sections of Division 17.
- C. Related Work Specified Elsewhere:
  1. Section 15050: Piping, Valves, and Accessories

##### 1.02 QUALITY CONTROL

- A. Manufacturer: In addition to the requirements of Section 17010, flow measurement devices furnished shall be manufactured by firms regularly and currently engaged in the design and manufacture of similar equipment. All equipment furnished shall be new and of current design.
- B. Maintainability: All equipment shall be designed for ease of maintenance and repair, and access to critical parts shall not require a major disassembly. Internal field adjustments where permitted or required herein shall be easily accessible upon removal of a panel or cover.
- C. Materials and Installation: Materials and installation shall comply with the requirements of the current editions of referenced electrical codes and standards, and the codes and standards referred to shall be used for establishing the minimum quality of the materials and equipment supplied and installed. All equipment of the same type shall be products of the same manufacturer. Capacities of all equipment shall not be less than that indicated on the Drawings or as specified.

##### 1.03 SUBMITTALS

- A. The following information shall be submitted in accordance with Section 01300:
  1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in

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the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

B. Shop drawings to be submitted in this section shall be made under the Product Review Category of Shop Drawings.

C. Shop Drawings:

1. In addition to the requirements of Section 17010, shop drawings shall include for each type of instrument: supply voltage and frequency, electrical load, accuracy, description of operation, operating instructions, and calibration procedure.
2. Furnish Shop Drawings for each item of mechanical equipment presenting sufficient data to determine compliance to these Specifications. Submit completed ISA S20 forms for each device and physical dimensions. Also submit manufacturer's recommended upstream and downstream straight piping lengths, recommended location of any pressure taps, and estimates of pressure losses through the device.

D. Installation Method: The proposed method of mounting sensors and instruments shall accompany all shop drawings.

E. Parts List: Submit a Parts List with current net prices and a list of recommended spares.

F. Factory Testing and Calibration: All meters shall be factory tested. Perform a factory test and/or provide certification of calibration from an independent test laboratory. Calibration curves based on factory and/or laboratory testing (see option below) shall be provided for the Construction Manager's favorable review. Furnish calibration curves in units of output (inches or rpm/gpm) versus measured flow. Upon receipt of the Construction Manager's favorable review, the Contractor may have the meters shipped to the job site:

1. As an option to laboratory testing each meter, the calibration curves of six (6) "like devices" may be substituted provided the calibration data is available from at least one identical device (pipe size, flow range, and type plus accessories such as extension registers).

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2. The flow tube supplier shall provide laboratory calibration data to the transmitter supplier or, where practical, test the flow tube and transmitter as an integral assembly. The integral test shall be accomplished at no extra cost to the customer.

G. Manuals: Furnish manufacturer's installation, lubrication, operation and maintenance manuals, bulletins, and spare parts lists.

H. Affidavits: Furnish affidavits from the manufacturers stating that the meters have been properly installed and tested and each is ready for full time operation.

#### 1.04 SEISMIC PROTECTION

- A. Seismic restraint for metering devices that are integral with piping shall be as specified for the piping system in which they are installed. Seismic design certification and anchorage descriptions are required by Section 01300.

#### 1.05 INDICATING UNITS

- A. Provide flow indication in GPM, CFS, MGD, etc. Do not use indicators that read 0 to 100%, 4-20 mA, etc.

### PART 2 - PRODUCTS

#### 2.01 MAGNETIC FLOWMETER - INDUCTION TYPE

- A. General: Magnetic meters shall utilize the principle of electromagnetic induction to produce an output proportional to the rate of fluid flow. A set of pulsed dc, electrically powered coils shall generate a magnetic field, which in turn induces a voltage in the flowing fluid, which is sensed by a pair of electrodes in contact with the fluid.

1. Protect coils from contact with the fluid. The electrodes shall be made of Type 316 stainless steel. The meters shall be housed in a NEMA 4 enclosure. The metering tube shall be lined with hard rubber. Meters shall be resistant to electrode coating. The electrode shall be designed to be inserted in water pipes and shall not be affected by solids, air bubbles, oil or coating. The electrode wetted parts shall be of Type 316 stainless steel.
2. The meters shall be designed to operate from a 120-volt ac, 60 cycle, single-phase power supply. A 10% variation in power line voltage or frequency shall not affect the meter output accuracy in excess of 1% of full scale.
3. Provide magnetic flowmeters suitable for fluids with conductivities as low as 5.0 micromho/cm.
4. Each magnetic flow meter system shall have an accuracy within 1% of actual for flow velocities between 10% and 100% of full scale. Meters shall have a repeatability within 0.25% of full scale.
5. Each magnetic flow meter shall be equipped with a signal converter (transmitter) to transmit an analog 4-20 mA dc signal proportional to flowrate. The signal converter shall be microprocessor-based unit with keypad for calibration. Output span and zero shall be manually adjustable. Provide span

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## 2.03 MASS FLOWMETER – GAS

- A. General: Mass flowmeters are used to measure air. These meters provide a direct measurement of gas flow that is independent of pressure, temperature and specific gravity, thus eliminating the need to make many independent measurements and calculations. The mass flowmeter shall be designed for insertion mounting and utilize hot-wire method.
- B. Provide a sensor designed for insertion into a pipe or provided with a flange spool. Mating flanges shall be 150 pound ANSI raised face flange. All materials shall be designed for use in the intended service. Turndown ratio shall be at least 5:1. Accuracy shall be 1% of actual flow rate or less.
- C. A remote electronic indicating transmitter and integral totalizer shall produce a 4-20 mAdc signal that is proportional to linearized flow. The indicator shall be calibrated in SCFM. The transmitter/sensor distance shall be of NEMA 4X or 4 construction and shall be capable of mounting up to 500 feet or may be co-located provided hazardous service requirements are observed. The transmitter shall be supplied by 120 Vac.
- D. Manufacturer: Unit shall be from FCI, Inc., Model GF 90; Sierra Instruments; or equal.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Provide installation, testing, calibration, verification, and startup instructions in accordance with Sections 15050 and 17010.

### 3.02 FIELD TESTING

- A. All flow devices are to be field-tested against a secondary standard at the normal (or expected) process flow rates.
- B. The Contractor may select at his option to either install a second flow device of known calibration in the line to verify flow device calibration or perform fluid capacity tests such as volumetric measurement per unit time.
- C. Totalizer tests are not to be performed in the field.

END OF SECTION

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adjustment capable of producing 100% strength analog at flow rates that are 30% of maximum. Signal shall be linear with flow within the accuracy specified above. The converter shall be a wall-mounted unit.

- 6. The signal converter shall have the capability of positive zero return for shutdown conditions.
- B. The magnetic flow meters shall have flanged end connections. Field coils shall be either completely encapsulated in the meter lining material or a protective shield shall be provided suitable for withstanding the scouring velocities of the process fluid at the maximum flow rates.
- C. Grounding: Provide a grounding circuit for each magnetic meter. Furnish and install grounding rings or protective shield when meter is installed in nonconductive line.
- D. Special Tools: Furnish special tools, which are necessary for the replacement of parts and the adjustment of the equipment.
- E. Manufacturer: Meters and signal converters shall be Endress Hauser, Foxboro; or equal.

## 2.02 ROTAMETERS

- A. General:
  - 1. This type rotameter shall include a Type 316 stainless steel housing or frame and a calibrated borosilicate glass metering tube with float. The float shall be of a material and shape suitable for the process fluid. The tube shall be readily field removable for cleaning. All other wetted parts shall be Type 316 stainless steel, except O-rings shall be Teflon unless otherwise recommended by the manufacturer for the process fluid specified. End fittings shall be chosen to suit the installation requirements in the field. The metering scale shall be a nominal 250 mm in length with graduations in units specified in the Instrument Index. Meters shall have a minimum rangeability of 10:1. Accuracy shall be  $\pm 2\%$  of full scale (maximum) for all ranges.
  - 2. Purge type rotameters shall be supplied with an inlet needle valve; all other types shall be supplied with a globe valve on the discharge for throttling.
- B. Freeze Protection: Rotameters used in areas subject to freezing temperatures shall use either frost-free construction or shall be provided with space heaters. Heaters shall be powered from 120 Vac service.
- C. Transmitters: Transmitters, when shown on the Drawing, shall be mounted on the rotameter and shall be of the two-wire type powered by the receiver. They shall transmit a 4-20 mAdc signal linear and proportional to the flow within  $\pm 4\%$  of full scale. Housing shall meet NEMA 4 requirements.
- D. Manufacturer: Rotameters shall be manufactured by Brooks; Krohne; or equal.



SECTION 17140  
LEVEL MEASUREMENT

PART 1 – GENERAL

1.01 SECTION INCLUDES

- A. Provisions: Requirements of Division 1 and Section 17010 form a part of this Section.
- B. Work Included: Level measurement devices for process instrumentation, auxiliary equipment and supplies directly related to the installation of and operation of these level measurement devices, to perform the required functions in conjunction with information and equipment specified in other sections of Division 17. Refer to the Instrument Schedule in Section 17010 for a listing of required devices.

1.02 SUBMITTALS

- A. The following information shall be submitted in accordance with Section 01300:
  - 1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
  - 2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
- B. Shop drawings to be submitted in this section shall be made in one package under the Product Review Category of Shop Drawings.

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Level Measurement

- C. Shop Drawings: In addition to the requirements of Section 17010, shop drawings shall include for each type of instrument: supply voltage and frequency, electrical load, accuracy, description of operation, operating instructions, and calibration procedure.
- D. Installation Method: The proposed method of mounting sensors and instruments shall accompany all shop drawings.
- E. Parts List: Submit a Parts List with current net prices and a list of recommended spares.

### 1.03 QUALITY CONTROL

- A. Manufacturer: In addition to the requirements of Section 17010, level measurement devices furnished shall be manufactured by firms regularly and currently engaged in the design and manufacture of similar equipment. All equipment furnished shall be new and of current design.
- B. Maintainability: All equipment shall be designed for ease of maintenance and repair, and access to critical parts shall not require a major disassembly. Internal field adjustments where permitted or required herein shall be easily accessible upon removal of a panel or cover.
- C. Materials and Installation: Materials and installation shall comply with the requirements of the current editions of referenced electrical codes and standards, and the codes and standards referred to shall be used for establishing the minimum quality of the materials and equipment supplied and installed. All equipment of the same type shall be products of the same manufacturer. Capacities of all equipment shall not be less than that indicated on the Drawings or specified.

## PART 2 – PRODUCTS

### 2.01 LEVEL TRANSMITTER/ULTRASONIC TYPE SENSOR

- A. General: This type of level sensor shall use the following principle. An intense burst of sonic energy is directed toward a target surface of interface. The interface may be air-liquid, air-solid, liquid-solid, and also liquid-liquid if the densities of the two liquids are sufficiently different and provide a clearly definable interface. The return time of the reflected echo is measured and converted into an electrical signal proportional to the distance from the sensor to the interface, or alternatively the distance from another reference level, such as the tank bottom, when the sensor is top mounted. Automatic temperature compensators correct for the change in sound velocity in the transmitting fluid. Temperature sensing may be in the ultrasonic transmitting-receiving probe, or in a separate probe when this would provide a more representative temperature for the transmitting medium.

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### B. Specific Requirements:

- Specific applications indicators, switches, and other requirements shall be as shown on the Drawings. Level ranges, output signals and setpoints are specified in the Instrument Schedule.
  - Sensor and transceiver shall be temperature compensated over a range from +10°F to +120°F. Sensor heaters, if required, shall be powered from the transceiver power circuit.
- C. Construction: The level sensing system shall consist of a sensing probe and a separately mounted solid state electronic controller-converter housed in a NEMA 4X case. A level indicator shall be provided and shall be of the type and in the units specified in the Instrument Schedule. All instruments and sensors to be installed in hazardous locations shall be rated for the class, division, and group indicated on the Drawings.
- D. Mounting: The probe shall be flange-mounted, unless otherwise shown on the Drawings. The transceiver shall be surface-mounted as shown on the Drawings.
- E. Power: The system shall operate from 120 VAC power, and variations of ±10% in voltage shall not affect the accuracy in excess of 0.5%.
- F. Manufacturer: Millitronics Hydromanager 200 (Siemens); Endress and Hauser; or equal

### 2.02 LEVEL SWITCH – FLOAT TYPE, SUMP DUTY

- A. General: Level switch shall use the movement of a float, the weight of whose moving parts is less than that of the displaced process liquid, to actuate switches as the level changes. The switch(es) shall be integrally mounted within the float and connected to a terminal box by a waterproof electric cable. A movable weight shall be mounted on the cable to keep the cable immersed in the liquid.
- B. The switch operating levels shall be adjusted by moving the weight along the cable or altering the height of the cable fixing point.
- The switch covering shall be made of indestructible polypropylene material. The cable shall be PVC coated.
  - The switches shall be reversible such that the switching action operates on rising or falling level.
  - The switch actuating points shall be as listed in the Instrument Schedule.
  - The float shall be rated for 150-psi (10.5 kg/cm<sup>2</sup>) pressure and 140°F (60°C) temperature. The float shall not be greater than 7 inches (178 mm) in diameter.
  - The switches shall be rated for 250 volts ac or dc and 5 amperes minimum, and shall be terminated with 14 AWG wires in a NEMA 4X terminal box.
  - Provide intrinsically-safe relays (IR) for switches used in hazardous locations where shown on the Drawings.
- C. Manufacturer: Float type sump level switches shall be as manufactured by Kari; Flygt; or equal

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PART 3 – EXECUTION

3.01 INSTALLATION

- A. Installation, testing, calibration, validation, startup and instruction shall be in accordance with Section 17010.

END OF SECTION

SECTION 17150  
PRESSURE MEASUREMENT

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Requirements of Division 1 and Section 17010 form a part of this Section. This section specifies pressure measurement devices for process instrumentation, auxiliary equipment and supplies directly related to the installation of and operation of these pressure measurement devices, to perform the required functions in conjunction with information and equipment specified in other sections of Division 17. Refer to the Instrument Schedule in Section 17010 for a listing of required devices.

1.02 SUBMITTALS

- A. The following information shall be submitted in accordance with Section 01300:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

- B. Shop drawings to be submitted in this section shall be made in one package under the Product Review Category of Shop Drawings.

Level Measurement

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Pressure Measurement

C. Shop Drawings: In addition to the requirements of Section 17010, shop drawings shall include for each type of instrument: supply voltage and frequency, electrical load, accuracy, description of operation, operating instructions, and calibration procedure.

D. Parts List: Submit a Parts List with current net prices and a list of recommended spares.

### 1.03 QUALITY CONTROL

A. Manufacturer: In addition to the requirements Section 17010, pressure measurement devices furnished shall be manufactured by firms regularly and currently engaged in the design and manufacture of similar equipment. All equipment furnished shall be new and of current design.

B. Maintainability: All equipment shall be designed for ease of maintenance and repair, and access to critical parts shall not require a major disassembly. Internal field adjustments where permitted or required herein shall be easily accessible upon removal of a panel or cover.

C. Materials and Installation: Materials and installation shall comply with the requirements of the current editions of referenced electrical codes and standards, and the codes and standards referred to shall be used for establishing the minimum quality of the materials and equipment supplied and installed. All equipment of the same type shall be products of the same manufacturer. Capacities of all equipment shall not be less than that indicated in the Instrument Schedule.

## PART 2 - PRODUCTS

### 2.01 DIFFERENTIAL PRESSURE TRANSMITTERS - ELECTRONIC

A. General:

1. Electric indicating-type differential pressure transmitters shall convert a differential or gauge pressure measurement to a 4-20 mA dc linear electric output signal capable of transmission into at least a 600 ohm maximum load at 24 Vdc or less. Signal and power transmission shall be provided by a single pair of wires unless 4-wire transmitters are shown on the Drawings. Operating ambient temperature shall be at least -15° to +82°C.
2. Range shall be as indicated on the Instrument Schedule and calibrated span shall be field adjustable over at least a 4 to 1 range. Elevation and suppression shall be provided. Overrange protection shall be at least 1-1/2 times span without degradation of accuracy. Reference accuracy shall be  $\pm 0.2\%$  of calibrated span or better. Integral adjustable hydraulic or electronic damping shall be provided. The indicator shall be provided with scale markings calibrated in the units' gpm, psig, feet, etc., specified in the Instrument Schedule.

Pressure Measurement

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B. Construction:

1. The transmitter enclosure shall be NEMA 4X rated except where explosion-proof is required. The process connection shall be 1/4 inch and stamped with high (H) and low (L) pressure ports. Wetted diaphragm materials shall be suitable for the process fluid may be provided. Vent and drain plugs shall be provided on meter body.
2. Transmitters shall be liquid-filled employing remote seals where shown on the Drawings. Standard seal flange shall be a 3-inch 150-pound USAIS lap joint flange. A mating transmitter ANSI flange shall be provided with each transmitter per Section 15050.

C. Manufacturer: Transmitters shall be as manufactured by Rosemount; Endress and Hauser; Foxboro; or equal.

### 2.02 PRESSURE TRANSMITTERS - ELECTRONIC

A. General:

1. Electronic indicating-type pressure transmitters shall convert a gauge or absolute pressure measurement to a 4-20 mA dc linear electrical output signal capable of transmission into at least a 600-ohm maximum load at 24 Vdc or less. Signal and power transmission shall be provided on a single pair of wires. Operating ambient temperature limits shall be at least -40° to +82°C.
2. Range shall be as indicated in the Instrument Schedule. Overage protection shall be at least 1-1/2 times span without degradation of accuracy. Reference accuracy shall be  $\pm 1/2$  percent or better.

B. Construction: The transmitter enclosure shall be NEMA 4X rated. The process connection for clean liquid service shall be 1/4-inch NPT. Enclosure and wetted surface material shall be corrosion resistant and suitable for the process fluid.

C. Manufacturers: Rosemount, Endress and Hauser, Foxboro; or equal.

### 2.03 PRESSURE SWITCHES

A. Pressure switches shall incorporate bourdon tubes, diaphragms, or bellows as the sensing and actuating element. The actuating element shall be Type 316 stainless steel or phosphorous bronze, depending on compatibility with the process fluid. The actuating point shall be readily field-adjustable in the range specified with adjustable dead band. Switches shall be SPDT, rated at 5 ampere minimum at 120 Vac. Enclosures shall be NEMA 4X unless specified explosion-proof as shown on the Drawings. Process connection shall be 1/4-inch NPT.

B. There shall be calibrated external adjustments for set point and differential. Element shall be rated for at least 50% over range pressure. Switches used for alarm shall have manual reset. Provide diaphragm seals on corrosive fluid and gas lines and those lines having large amounts of suspended solids.

C. Pressure switches shall be as manufactured by IMO Delaval (Barksdale); Merco; or equal. Adjustable differential switches shall be as manufactured by ASCO; Merco; or equal.

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Pressure Measurement

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## 2.04 DIAPHRAGM PRESSURE SEALS

### A. General:

1. Units shall consist of corrosion-resistant lower housing and diaphragm, and instrument mounting upper housing. Lower housing shall have a 1-inch NPT female process and a 3/8-inch flushing connection terminated with a 3/8-inch hose bibb and shall be Type 316 stainless steel. Diaphragm shall be Type 316 stainless steel, unless otherwise noted. Upper housing shall have bleed screw, NPT female instrument connection, and shall be steel, unless otherwise noted. Filling fluid shall be suitable for a temperature range of -17° to +260°F.
2. Where noted on the Drawings, capillary assembly shall be furnished to connect diaphragm seal to instrument.

- B. Manufacturer: Units shall be Mansfield & Green, Type SG; Ashcroft, Type 101; or equal.

## 2.05 INSTRUMENT MANIFOLDS

- A. Provide test valve manifolds for pressure and differential pressure transmitters and pressure switches and pressure/vacuum gauges installed in clean liquid (no entrained solids) service or filtered water. Provide corrosion resistant test manifolds with integral 2-valve assemblies (or block and bleed assembly) for pressure transmitters and switches and gauges and 3-valve assemblies (block and bypass with manometer ports) for differential pressure transmitter installation.

- B. Provide manifold(s) with the following hardware, performance features and ratings:

1. Traditional mount manifold type. Two-valve or three-valve.
2. Direct mount manifold type. Two-valve.
3. Coplaner manifold type. Three-valve integral.
4. Process connection. 1/2-14 MNPT.
5. Material: Body, Bonnet, Stem, Drain/Vent Plug, 316 SST.
6. Packing material: Grafoil.
7. Calibration tap or adapter.

- C. Manufacturer: Provide Rosemount Model 305AT traditional mount, 306AT direct mount, or 305AC coplaner flange; or equal.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. On systems requiring diaphragm seals, the Contractor shall order (or assemble) a completely filled system. The filling fluid shall be silicone oil. Interconnecting piping shall be kept short. The filled system shall retain the same calibration requirements of the individual components.

- B. Installation, testing, calibration, validation, startup and instruction shall be in accordance with Section 17010.

### END OF SECTION

## Pressure Measurement

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## SECTION 17330

## PROGRAMMABLE LOGIC CONTROLLER

### PART 1 - GENERAL

#### 1.01 SECTION INCLUDES

- A. Provisions: Requirements of Division 1 and Section 17010 form a part of this Section.

#### B. Related Sections Include:

1. Section 16955: Control Devices - control relays
2. Section 17010: Instrumentation and Controls, General Requirements
3. Section 17510: Panels

#### 1.02 SUBMITTALS

- A. The following information shall be submitted in accordance with Section 01300:

1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.

2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.

3. Catalog cuts for PLC panel components. These shall include, but not be limited to the central processing unit, input modules, output modules, programmer, magnetic program storage device, interfacing equipment, power line voltage regulation transformer, power line surge protection device, Ethernet to fiber optic media converters and fiber optic patch panels.

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4. An Input/Output (I/O) record containing a textual description for each item of input and output, connection diagram addressing (rack, module, channel and address numbers), and data table bit and data table word assignments.
5. A typewritten document containing startup, operation, and maintenance procedures.
6. The Factory and Field Witnessed Test procedure.
7. The Factory and Field Witnessed Test results.
8. Spare Parts Items: As specified herein.

#### 1.03 QUALITY CONTROL

- A. Provide programmable logic controllers (PLCs), which comply with NEMA Standard ICS 3-304. This standard applies to the construction, programming, performance, test, installation, protection, and safety of PLCs.

#### 1.04 UL LABEL

- A. Programmable controller enclosures shall bear the UL label. See Section 17510.

#### 1.05 APPENDICES

- A. Appendix A: Control Strategies. These strategies are to be used to program the PLCs. PLC programming shall be by the Owner.
- B. Appendix B: PLC Input/Output Schedule. This schedule is a schedule of PLC I/O. Additional I/O may be configured as required to implement control strategies by first assigning an instrument tag number, description, function and I/O type.

### PART 2 - PRODUCTS

#### 2.01 PROGRAMMABLE LOGIC CONTROLLERS

- A. General: The I&C subcontractor shall provide programmable logic controller hardware and software as described herein and as shown on the Drawings. Refer to the SCADA Block Diagram shown in the Drawings for locations of PLCs and other requirements. Provide one PLC with local I/O in the new Electrical and Maintenance Building, and remote I/O in the existing Control Building.
- B. Programmable Logic Controller: Provide each PLC with the following hardware.
  1. Power Supply: Provide power supply module to power the processor and local I/O modules. I/O back plane loading shall not exceed 75% of power supply rating amps on any chassis.
  2. Memory Enhancement: The processor shall have basic 1.5 MB word memory as listed below. Provide memory enhancement if the program exceeds 75% of capacity.
  3. Cables: Provide a full complement of cables for connecting to programming terminal and interface devices.

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4. Central Processing Unit: The Central Processing Unit (CPU) shall be powered by 24 VDC, and shall have the following:
  - a. PLC "ladder logic" software with extend math functions and on line/off line programming functions.
  - b. Local I/O Scanner.
  - c. Ethernet port.
  - d. PID loop control.
  - e. Battery-backed (10-year lithium) CMOS RAM.
  - f. CPU shall be CompactLogix Model L1769-L35E; no equal.
  - g. CompactFlash removable media, Model 1784-CF128; no equal.
5. Input and Output Modules:
  - a. Analog inputs (AI) shall meet the following requirements:
    - 1) 4 to 20 mAdc inputs, 250-ohm impedance maximum, 16 single ended configuration.
    - 2) Accuracy of  $\pm 0.15\%$  of span.
    - 3) Resolution: 16 bits
    - 4) Common Mode Rejection of 100 dB at 60 Hz, minimum.
    - 5) Normal Mode Rejection of 80 dB at 60 Hz, minimum.
    - 6) Isolation shall meet or exceed surge-withstand test, IEEE-472.
    - 7) Drift shall not exceed 1.5% within a one-year period @ 25°C.
    - 8) Modules shall be Allen-Bradley 1769 series for CompactLogix; no equal.
  - b. Discrete inputs (DI) shall meet the following requirements:
    - 1) Unpowered contact inputs or power inputs at 24 Vdc.
    - 2) Input isolation shall meet or exceed IEEE-472. Relay isolation is unacceptable.
    - 3) Provide filtering on a per unit point basis to provide contact bounce protection.
    - 4) Discrete inputs shall be powered by the PLC by a 24 Vdc power supply; shall be current limited to conform with NEC Class 2 remote control and signal wiring circuits.
    - 5) Modules with 16 inputs with common ground terminals. Voltage input modules shall have their channels fully isolated.
    - 6) Modules shall be Allen-Bradley 1769 series for CompactLogix; no equal.
  - c. Analog outputs (AO) shall meet the following requirements.
    - 1) Output: 4-20 mAdc into a 0 to 500 ohm load; 6 individually isolated output configurations with separate grounds.
    - 2) Isolation: From the multiplexer ground.
    - 3) Resolution: 13 bits.
    - 4) Accuracy:  $\pm 0.1\%$  of 4 to 21 mA
    - 5) Drift: Shall not exceed 1% in a one-year period.
    - 6) Output short circuit protection shall be electronically limited to 21 mA or less with 24 V AC/DC maximum overvoltage protection
    - 7) Modules shall be Allen-Bradley 1769 series for CompactLogix; no equal.

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d. Discrete outputs (DO) shall meet the following requirements:

- 1) Electrically-latched outputs shall require one program command for set and reset. Loss of power shall return the output to a preselected state. Both fail open and fail close contact states shall be provided.
- 2) Contact configuration shall be N.O.; triac outputs - supply with suppression circuit for inductive load.
- 3) Provide the following ratings: 2A steady state, 15A make at 30 Vdc inductive load for external relays.
- 4) Provide arc-suppression for each contact.
- 5) Provide 16 isolated output configuration.
- 6) Modules shall be Allen-Bradley 1769 series for CompactLogix; no equal.
- e. Provide spare inputs and outputs so that a minimum of 15% of each type is spare, functional, and installed in the mounting racks. Permanently label each input and output on each module by the tag number and description given in the Instrument Schedule.
7. Network Communications: Provide a 1769-AENT module in the remote I/O rack for network communications to the PLC in the Electrical Building.

C. Programmable Logic Controller Enclosure:

1. The PLC hardware shall be furnished completely assembled and wired in a control panel (see Section 17510). Provide for serviceable layout of parts. Provide enclosure finish and color to match the motor control center.
2. Note that certain selector switches, pushbuttons, relays and instruments shall be furnished and installed in addition to the programmable logic controller hardware proper.

D. Uninterruptible Power Supply (UPS): Provide a UPS unit rated for 200% of PLC load with batteries sized to provide at least 1-hour service at full load. Provide Tripp Lite; Powerware; or equal.

E. Managed Ethernet Switches: Provide 10/100/1000 Mbps combined copper cable and fiber optic cable managed switches in PLC panels and where shown on the Drawings. Switches shall meet the following specifications:

1. Full duplex capability.
2. IGMP snooping.
3. Port mirroring.
4. VLAN.
5. Auto-negotiation and manually configurable speed/duplex.
6. Wire speed switching fabric.
7. SNMP for switch management.
8. IEEE 802.1 Spanning Tree Protocol.
9. Port trunking.
10. Latest version of the manufacturer's software for configuring and monitoring Ethernet switches shall be provided. If more than one software package is available, provide the package with the greatest capability. If specialty cable is needed to connect between PC and switches, provide cable.
11. Each field Ethernet switch shall have at least one spare (unused) RJ45 port.
12. All Ethernet switches shall be compatible models from a single manufacturer. The switches shall be Stratix by Rockwell Automation; or approved equal.

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F. Fiber Optic Patch Panel: Provide space for a fiber optic patch panel. Refer to Section 16124 for details.

G. Interconnecting Cable: Provide all interconnecting cables as required to connect the panel components.

H. Spare Parts: Provide the following spare parts.

1. One input/output module for each type provided.
2. One PLC processor module including memory for each type provided.
3. One communications module for each type provided.
4. One power supply for each type provided.

## PART 3 - EXECUTION

### 3.01 WITNESSED TEST

A. General: The PLC shall be tested at the factory together with the computer system and Human Machine Interface (HMI) software:

1. The programs shall be loaded to each PLC by the Owner during the Witnessed Test and the entire system shall be tested jointly by the Contractor and the Owner.
2. The Contractor shall coordinate with the Owner and the Engineer to provide any technical information regarding PLC hardware.
3. The Owner will inspect control panels prior to shipment.

B. Prior to shipment of the PLC to the jobsite, perform a Witnessed Test. This test shall demonstrate full compliance of the PLC with contract requirements. The test shall be performed by the Contractor and the Owner.

C. Prepare a detailed written witnessed test procedure to be submitted at least 2 weeks prior to start of the test. The test procedure shall describe testing methods and provide detailed specification of the input data and data sequences to be used in the test. If, in the opinion of the Engineer, a resubmission of the proposed test procedure is required, the date for the performance of this test shall be set at least 6 weeks following delivery of the resubmitted test procedure.

D. Perform the witnessed test in accordance with the test procedure and coordinate with the Engineer and the Owner. Any deviation in performance from that specified in these Specifications shall be corrected prior to shipment. If the deviation in performance is deemed by the Engineer to be substantial and if it is not corrected within the period allowed for the test, a second test shall be performed. No extension of Contract time will be allowed in the event that this second test is necessary.

E. Submit the results of the test in a formal document within 2 weeks following satisfactory performance of the test. The test results shall document all problems encountered in running the test, corrective action taken, and the detailed results of each phase of the test.

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### 3.02 FIELD TEST

- A. After the PLC has been installed at the jobsite, a demonstration of compliance with all functional objectives shall be made under actual or simulated operating conditions, subject to favorable review by the Engineer.
- B. Prepare a detailed written witnessed test procedure to be submitted at least 2 weeks prior to start of the test. The test procedure shall describe testing methods and provide detailed specification of the input data and data sequences to be used in the test. If, in the opinion of the Engineer, a resubmission of the proposed test procedure is required, the date for the performance of this test shall be set at least 6 weeks following delivery of the resubmitted test procedure.
- C. Perform the witnessed test in accordance with the test procedure. Any deviation in performance from that specified in these Specifications shall be corrected prior to shipment. If the deviation in performance is deemed by the Engineer to be substantial and if it is not corrected within the period allowed for the test, then a second test shall be performed. No extension of Contract time will be allowed in the event that this second test is necessary.
- D. Submit the results of the test in a formal document within 2 weeks following satisfactory performance of the test. The test results shall document all problems encountered in running the test, corrective action taken, and the detailed results of each phase of the test.

### 3.03 TRAINING

- A. General: To familiarize the Owner's personnel with PLC operation, training shall be provided as detailed hereunder. The training course shall be conducted under the direction of a training director who shall design a detailed training plan that complements the experience and skill levels of the Owner's personnel. The training course shall be conducted at the treatment plant. The text for both training courses below shall be the O&M Manual and selected handouts. The Owner may videotape the training at the Owner's expense.
- B. PLC Operations Training: A minimum one-day course shall be provided for up to six persons. The level of training shall be sufficient to familiarize the personnel with the operation of the PLC and programming and program storage device. All essential system operating procedures shall be described as required to enable Owner's personnel to observe the controller operation via the programming device displays.
- C. PLC Corrective Maintenance Training: A one-day course shall be conducted for up to six persons on maintenance of modifications to the PLC. Instruction shall be given in the use of hardware diagnostic routines, test equipment and test procedures as required to enable the Owner's personnel to detect and isolate system faults to the circuit board or module level and to implement repairs by replacing failed circuit boards or modules. Step-by-step written procedures shall be provided for identifying hardware faults to the circuit board or module level for all items of digital equipment. All equipment corrective maintenance training activities

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shall be limited to the use of diagnostic routines with the aid of the programming device. If it is necessary to use special purpose test equipment, which is only available from the equipment manufacturer, then such test equipment shall be provided as a part of the system and shall become the property of the Owner.

- D. Additional PLC Training: If requested by Owner, a portion of the field instrument training required in Section 17010 may be allocated toward a continuation of either training course above or covering a specific topic. The Owner and Contractor must agree to the training content prior to commencing any training.

END OF SECTION

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SECTION 17330A

CONTROL STRATEGIES

The Control Strategies are numbered to match the Instrumentation drawing number to which they refer. The Control Strategies are attached in the following order:

- Common Control Strategies
- 221 – Influent Screening and Sampling
  - 411 – Calcium Hydroxide Storage and Metering
  - 421 – Aeration Basins
  - 431 – Aeration Air Blowers
  - 441 – Secondary Clarifiers and Scum Pumping
  - 442 – Secondary Effluent Pumping
  - 451 – RAS and WAS Pumping
  - 831 – Tank Drain/Supernatant Pumping
  - 832 – Utility Water Pumping
  - 833 – Ejector Pumping

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Control Strategies

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## COMMON CONTROL STRATEGIES

## EQUIPMENT HAND-OFF-AUTO OR START-STOP CONTROL

- A. Operations puts the Hand-Off-Auto (HOA) or Start-Stop (O/I) switches for equipment in the desired positions. There may be more than one level of switches for each piece of equipment. The combined positions of the switches determine how the equipment operates and whether control is by the operator or PLC logic.
- B. There will be a local physical switch for each piece of equipment. This switch will either be within sight of the equipment or in an MCC that controls the equipment.
- C. The local physical switch determines whether control is direct from that switch or passed to the HMI/SCADA and PLC (automated) system.
1. Local O/I switches control the equipment directly and manually. When the switch is in the 0 (Stop) position, the equipment is called to stop; when in the 1 (Start) position, it is called to start. There is no control from the automated system.
  2. In addition to local HOA switches, equipment which may be controlled by a PLC shall have at least one level of software switch in PLC logic. Equipment with local HOA switches shall have the switch "A" status as well as equipment Running/Stopped status connected to PLC inputs. The "A" status will be shown as AUTO to indicate the equipment is "ready" for PLC control.
- a. When a local HOA switch is in the "H" position, the switch contacts shall energize the motor control coil that starts the equipment; when it is in the "O" position, the coil is de-energized. Likewise, a valve, which is controlled by SCADA and RTU OCA switches, must be in REMOTE at the valve for SCADA operation.
  - b. When a local HOA switch is in "A", the control will be passed to the PLC and the SCADA/HMI. The HMI/SCADA switch(es) determine whether the equipment is called manually to stop or start by the operator or automatically through PLC logic. HMI/SCADA switches start equipment via PLC outputs.
  - c. Where the local physical switch status is "H" or "O", a PLC logic based alarm shall be programmed. When the switch position and the equipment status do not agree, a non-retentive PLC timer shall run. When the timer times out, an equipment fail alarm shall be triggered and displayed on the HMI and SCADA displays. Each timer shall have an operator adjustable preset of from 1 to 30 seconds. This alarm and timer shall also signal equipment fail when the local HOA switch is in the "A" position and the PLC output status for automated start of the equipment does not agree with equipment running status.
  - d. A table of local switch statuses and alarms monitored by the SCADA system follows.



# Status for Local Manual Equipment Control

LOCAL SWITCH	POSITION	DISPLAY STATUS	SCADA STATUS	ALARM DELAY	FAIL ALARM
HOA	HAND	LOCAL HAND	Running	1-30 s	OFF
HOA	HAND	LOCAL HAND	Off	1-30 s	ON
HOA	OFF	LOCAL OFF	Off	1-30 s	OFF
HOA	OFF	LOCAL OFF	Running	1-30 s	ON

D. HMI and SCADA software switches determine control of the equipment when the local physical HOA switch in the "A" position.

- There may be more than one level of HMI/SCADA software switches. For example, there may be a local control panel in the equipment vicinity with HMI, and a more distant control room SCADA computer station. There could also be a higher level, remote SCADA terminal somewhere on the SCADA network. Each level that is able to control the equipment shall have a separate software switch. The switch hierarchy shall be:
  - Physical switch
  - Local HMI switch
  - Closest level of SCADA interface
  - Next closest level of SCADA, etc.
- A switch shall be enabled when the physical switch and all of the software switches above it in the hierarchy are in the "A" position. If a switch is enabled, the operator can select "H", "O", or "A" positions. The "H" position for an enabled switch shall turn on the PLC output for automated start of the equipment; the "O" position shall turn off the output to stop the equipment; and the "A" position shall pass control to the next level switch. When the local physical switch and all of the software switches are in the "A" position, PLC logic routines calculate control the equipment and operate PLC outputs.

- Indicators on the HMI/SCADA displays shall show when the equipment is in fully automatic control.
- When the equipment is not in fully automatic control the displays shall show which switch controls and the status of that switch.

- When the physical local switch is in the "A" position and the equipment PLC input Running/Stopped status does not agree with the automated PLC output, Run/Stop status generates a fail alarm.
- Motorized valves in REMOTE will create a fail alarm if the OPEN or CLOSE command does not agree with the feedback OPENED or CLOSED status within an operator adjustable preset of from 10 to 120 seconds.
- The following tables summarize control of equipment through HMI / SCADA when the local HOA switch is in AUTO.

# Status for HMI/SCADA/PLC Equipment Control

HMI HOA SWITCH*	TIER 1 SCADA HOA SWITCH	TIER 2 SCADA HOA SWITCH	PLC ACTION	STATUS DISPLAY
HAND	Disabled	Disabled	Start ON	SCADA HAND
OFF	Disabled	Disabled	Start OFF	SCADA OFF
AUTO	HAND	Disabled	Start ON	SCADA HAND
AUTO	OFF	Disabled	Start OFF	SCADA OFF
AUTO	AUTO	HAND	Start ON	SCADA HAND
AUTO	AUTO	OFF	Start OFF	SCADA OFF
AUTO	AUTO	AUTO	By Logic	AUTO

\* HMI control level may or may not be present.

## Fail Alarm Status

PLC OUTPUT	STATUS FEEDBACK	ALARM DELAY	FAIL ALARM
START ON	OFF	1-30 s	ON
START ON	ON	1-30 s	OFF
START OFF	OFF	1-30 s	OFF
START OFF	ON	1-30 s	ON
OPEN ON	CLOSED	10-120 s	ON
OPEN ON	OPENED	10-120 s	OFF
CLOSED ON	CLOSED	10-120 s	OFF
CLOSED ON	OPENED	10-120 s	ON

E. Where an AFD controls the speed of Equipment, the following additional control requirements must be met.

- When the local physical switch is not in the "A" position, speed adjustments shall be made manually through the AFD physical interface.
- If the physical switch is set to the "A" position, a PLC output or network bus sends the desired speed to the equipment AFD.
  - When the equipment is in full automatic (all switches set to "A"), PLC logic routines calculate the PLC speed output.
  - If the controlling HMI/SCADA software switch is in the "H" position, the local display for that switch shall display an operator adjustable slider and digital input register to set the PLC output to the AFD. The status of the output shall display on all other automated control level displays.
  - When the controlling software switch is set to the "O" position, there shall be no operator adjustable control, and the PLC output signal to the AFD shall be zero.
- If a feedback speed signal is sent to the PLC, it shall be monitored and displayed on the equipment's automation displays at each level of HMI/SCADA.

## COMMON CONTROL STRATEGIES

### EQUIPMENT LEAD/LAG/STANDBY CONTROL

- F. Equipment shall have runtime registers that accumulate the time that the equipment runs or is in service.
1. Equipment shall have an ongoing accumulated run time register that contains the hours the equipment has run. A security protected, software reset shall be available to reset the accumulation to zero when executed. The value accumulated just before reset will be held in a "value at last reset" register.
  2. Equipment shall have a daily runtime register that accumulates runtime for the current day in tenths of hours. The register shall reset at a preset time each day. The accumulated daily time just before reset will be transferred to a register for yesterday's accumulated runtime, in tenths of hours.
- G. Equipment shall have start count registers that accumulate the number of starts for the equipment.
1. Equipment shall have an ongoing accumulated start count register that contains the number of starts the equipment has experienced. A security protected, software reset shall be available to reset the accumulation to zero when executed. The value accumulated just before reset will be held in a "value at last reset" register.
  2. Equipment shall have a daily start count register that accumulates start counts for the current day. The register shall reset at a preset time each day. The accumulated daily start count just before reset will be transferred to a register for yesterday's accumulated starts.

- A. This Section describes the monitoring and control of equipment that is installed in sets, where each item in the set has a common purpose. The purpose might be to provide an air flow or to pump a common fluid. For example, an influent pump station may have a set of two or more pumps.
- B. When two or more units of mechanical equipment are declared to operate in LEAD/LAG, LEAD/LAG /STANDBY, or LEAD /STANDBY modes, they will be controlled sequentially. The LEAD, LAG, and STANDBY status of each member of the set will be determined by selected control parameters.
- C. Three or more (n) equipment items are designated to run LEAD /STANDBY.
- D. Two equipment items are designated to run LEAD /STANDBY.
- E. The operator shall have software switches, as specified by the design, to select how LEAD equipment is determined.
  1. When a specific equipment item is selected as LEAD by a switch, it will act as LEAD until another item is selected as LEAD, or until ALTERNATE is selected.
  2. If ALTERNATE is selected, the LEAD selection will alternate to the next equipment item in the set when the alternate criteria are met. If the last item in the set is LEAD when the alternate criteria are met, the 1<sup>st</sup> item in the set becomes LEAD. Switch(es) shall be available to select each alternate criteria. Control description for an equipment set will specify which criteria must be available. Criteria may include the following:
    - a. Alternate when all units in a set stop.
    - b. Alternate when the accumulated run time in a LEAD runtime register reaches an operator adjustable preset time. The register for the preset time should be adjustable between 1 and 48 hours. The accumulated LEAD run time will reset when the LEAD alternates.
    - c. Alternate when a specific condition is met (such as pressure drop or value of an on-line analysis). Control description for the set will describe the condition based alternation.
  3. Equipment must be in automatic mode (all physical and software switches in the "A" position) and not failed to be available for alternation. If a unit is not available for alternation, the PLC logic will exclude it from the set when determining LEAD /LAG/STANDBY status. The next available unit in the set shall be promoted to the LEAD /LAG status that the unavailable unit(s) would have had. A set with a STANDBY unit will not have a standby status if any unit is unavailable.
  4. If a unit is selected by switch to be LEAD and it is unavailable, the next unit in the set will act as LEAD. The HMI/SCADA displays will show the "SELECTED AS LEAD" and "ACTING AS LEAD" statuses.



5. If a unit is running in "HAND" mode, it will be designated as acting lead by the control logic. Lag selections will be determined by logic from equipment available to operate automatically.
- F. Sequentially start and stop LEAD/LAG units.
1. When a unit in a set starts or stops, delay the start or stop of any unit in the set by a preset time. This will limit electrical and hydraulic surges.
  2. If a safety issue requires immediate start or stop of any unit, override the sequenced start or stop.

## COMMON CONTROL STRATEGIES

### ALARMS

- A. This Section describes features common to all alarms and to specific types of alarms.
- B. A specific alarm input to a PLC from equipment will indicate an alarm condition.
- C. Operating conditions that indicate a hazardous or abnormal operation will cause a derived alarm condition. Control descriptions for equipment and systems will describe these alarms.
- D. Alarm contacts on equipment wired to PLC inputs will indicate an alarm condition.
- E. Derived alarms will be determined by PLC logic from analog signals and discrete signals and will be calculated as described in equipment or system control strategies. Signals may be PLC I/O wired to devices or from control network communications from equipment.
- F. Alarms from alarm inputs for an equipment unit or package shall be delayed by an operator adjustable time. The time will be a preset for a non-retentive timer. Unless specified otherwise in the equipment control description, the time shall be adjustable from 1 to 30 seconds. The alarm signal must remain on for the full delay period before the alarm output is generated and displayed.
- G. Alarms derived from analog signals shall have operator adjustable setpoints. The setpoints shall be scaled in the same units as the displayed analog value. These alarms shall be delayed by an operator adjustable time. The time will be a preset for a non-retentive timer. Unless specified otherwise in the equipment control description, the time shall be adjustable from 1 to 30 seconds. The alarm signal must remain on for the full delay period before the alarm output is generated and displayed.
- H. Alarms may be latched or non-latched. Equipment and system control descriptions will specify the alarm type.
  1. Latched alarms will remain on once generated, until the alarm condition ends and a reset signal is generated by the operator. The reset signal will be specified as a global reset from a common operator input, or a specific reset input or action.
    - a. Latched alarms for pumps, blowers, and compressors shall be reset by a dedicated momentary switch or by cycling one of the enabled physical or software switches from "O" to "H" or "A", or from "0" to "1".
    - b. Latched alarms may have interlocks as describe in the equipment control description.
  2. Non-Latched alarms will cancel when the alarm condition stops. These alarms may also be interlocked with equipment operation.
- I. Once an alarm is generated by the PLC, the HMI/SCADA displays will activate the alarm in the displays and log the alarm to an alarm history database.

# CONTROL STRATEGY 221

TITLE: 221 – Influent Screening and Sampling

AREA: Screening

PROCESS AND INSTRUMENTATION DIAGRAM: I221

## RELATED EQUIPMENT:

Headworks Influent Flow Element: FE-2201  
 Headworks Influent High Level Switch: LSH-2202  
 Mechanical Screen: SCN-2210  
 Mechanical Screen Upstream Level Transmitter: LE/LIT-2210A  
 Mechanical Screen Downstream Level Transmitter: LE/LIT-2210B  
 Mechanical Screen Spray Wash Solenoid Valve: FSV-2210  
 Mechanical Screen Control Panel: PNL-2210  
 Influent Sampler: SMP-2205

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## A. General:

Raw sewage is pumped from the Fisher Road and Hiller Road Lift Stations to the headworks influent channel. It then flows through the mechanical screen which removes debris (screenings) from the raw sewage. The screen washes, dewater, and conveys the screenings to a container located at grade. The screen is provided with a manufacturer furnished control panel, emergency stop, and water level control.

Mechanical screening is normally done 24 hours per day, 7 days per week. Isolation gates and a bypass channel with manual bar screen allow the mechanical screen to be removed from service for maintenance. Should the mechanical screen fail and become blinded, water within the influent channel will rise and automatically overflow to the manual bar screen. Should both the mechanical screen and manual screen fail, an emergency overflow weir is provided that will cause influent flow to bypass the headworks and flow directly to the secondary process.

The influent sampler is used to capture and accumulate small amounts of the influent to the plant and preserve them for lab analysis. The influent sampler is programmable to collect samples that can be time-based and/or flow-based.

## B. Operator Controls:

Location	Item	Type
Screen control panel	Screen - Hand-Off-Auto Spray zone – Hand-Off-Auto Forward-Reverse Emergency stop System reset	Selector switch Selector switch Selector Switch Push button Push button

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Influent Screening and Sampling  
 (Control Strategy 221)

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C. Control Modes:

1. Manual Control:

- Conveyor: The screen conveyor operates continuously when the Hand-Off-Auto selector switch located on the mechanical screen control panel is placed in the Hand position.
- Wash system: The screen's spray wash system operates continuously when the wash system's Hand-Off-Auto selector switch located on the mechanical screen control panel is placed in the Hand position.
- Emergency stop: An emergency stop push button can be used to stop the screen. To restart the screen, all emergency stops must be enabled and the system reset button must be pressed.

- Automatic Control: The screen operates automatically (cleaning cycle is initiated automatically) when the Hand-Off-Auto selector switch located on the screen control panel is placed in the Auto position. During normal operation, the cleaning cycle starts automatically based on water level upstream and downstream of the mechanical screen as sensed by LE-2210A and LE-2210B. Cleaning is also initiated based on preset time intervals. Refer to Section 11120 for additional detail. A separate water level switch (LSH-2210) measures the water level upstream of the screen and initiates a high water alarm registered on the plant SCADA system.

The mechanical screen automatically restarts following a power failure.

D. Interlocks with Other Equipment:

- The influent sampler is flow paced to provide a proportional collection of sample volume using a flow signal from the influent flow meter.

E. Status Indications: Operational statuses are displayed as follows:

Location	Status	Visual Indication
Screen control panel	Control power Running Total run time	White light Green light Digital readout
Sampler control panel	Running	As provided by sampler manufacturer
SCADA/PLC	Auto Running Total run time	Screen display Screen display Digital readout

F. Alarm Indications: Alarm conditions are displayed as follows:

Location	Status	Visual Indication
Screen control panel	Mechanical screen fault	Amber light
Sampler control panel	Sampler fault	As provided by sampler manufacturer
SCADA/PLC	Mechanical screen fault Influent channel level high Sampler fault	Screen display Screen display Screen display

Screen faults include high current and motor thermal overload. The screen will stop immediately should these faults occur. The system reset button must be pressed before restarting the screen.

END OF CONTROL STRATEGY 221

## CONTROL STRATEGY 411

TITLE: 411 – Calcium Hydroxide Storage and Metering

AREA: Chemical Addition

PROCESS AND INSTRUMENTATION DIAGRAM: I411

### RELATED EQUIPMENT:

Calcium Hydroxide Storage Tank Mixer: MIX-4111

Calcium Hydroxide Metering Pump 1: P-4121

Calcium Hydroxide Metering Pump 1 Leak Detector: MS-4121

Calcium Hydroxide Metering Pump 2: P-4122

Calcium Hydroxide Metering Pump 2 Leak Detector: MS-4122

Calcium Hydroxide Spill Sensor: LSH-4123

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### A. General:

Calcium hydroxide is used to add alkalinity to the incoming raw sewage by injecting it upstream of the raw sewage flow splitting flumes at the headworks. During normal operation, calcium hydroxide is applied continuously and is automatically controlled based on plant influent flow rate (flow paced). The flow rate signal is continuous and immediate (i.e. response time is insignificant).

The feed pumps are variable speed, positive displacement, flexible tube type (peristaltic) with on-board controls. Only one pump is needed to run in order to meet the maximum projected demand for calcium hydroxide. The pumps will be controlled in a lead/lag fashion. Should plant flow exceed the operator adjustable setpoint for more than a preset time period with the lead pump operating at full speed (200 rpm), the lag pump will start. The lag pump will then pace its speed based on the difference in the actual plant flow and the preset value at which the lag pump is set to turn on. During this period of time the lead pump will continue to operate at full speed (200 rpm). Should the treatment plant flow drop below the operator adjustable setpoint for more than a preset period of time, the lag pump will turn off.

The lag pump starts automatically should the lead pump fail.

The pumps are provided with integral leak detection units that shut off the pump should their flexible tubing fail. A calcium hydroxide spill detector is also located in the discharge piping from the pressure relief valves that leads to a waste container. This detector will alarm upon detecting discharge from the pressure relief valves and will shut the pumps off.

The calcium hydroxide storage tank is a double containment tanks and is provided with a leakage sensor that senses the presence of liquid within the secondary containment tank. An alarm is relayed to the plant SCADA should a leak occur in the tank.



# CONTROL STRATEGY 421

## B. Operator Controls:

Location	Control Item	Type
Pump control panel (on-board each pump)	Hand-Off-Auto Forward/Reverse Pump speed	Selector switch Pushbutton Touch pad
PLC/SCADA panel	Lead/Lag pump selection Flow pace control (pump speed proportional to plant influent flow) Plant flow value at which lag pump turns on	Screen option Screen option Screen option

## C. Control Modes:

1. Manual Control. The pump(s) are manually controlled by placing the pump(s) into MANUAL control via the pump's on board keypad. Pump(s) may then be started/stopped and speed adjusted using the keypad. Forward/reverse operation and rapid prime functionality are also available via the keypad.
2. Auto Control. The pump(s) may be automatically controlled by placing the pump(s) into AUTO via the pump's on board keypad. Pump(s) will start and stop based on remote signal from the Plant's SCADA/PLC. Speed control of pump will also be automatically adjusted by SCADA/PLC based on an operator adjustable percentage of influent plant flow. Lead/Lag pump is selected at the plant SCADA/PLC.

While in AUTO, the pump(s) will automatically stop should leak detection occur.

Pumps restart automatically after a power failure.

## D. Interlocks with Other Equipment: Plant Influent Flow Rate.

## E. Status Indications:

Operational statuses are displayed as follows:

Location	Status	Visual Indication
SCADA/PLC	Running Speed Auto	Screen display Screen display Screen display

## F. Alarm Indications:

Alarm conditions are displayed as follows:

Location	Status	Visual Indication
SCADA	Pump fault Calcium hydroxide spill	Screen display Screen display

## END OF CONTROL STRATEGY 411

Calcium Hydroxide Storage and Metering (Control Strategy 411)

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TITLE: 421 – Aeration Basins

AREA: Aeration Basins

PROCESS AND INSTRUMENTATION DIAGRAM: I421

RELATED EQUIPMENT:

Aeration Basin 1 Dissolved Oxygen Element: AE-4201A  
Aeration Basin 2 Dissolved Oxygen Element: AE-4202A  
Aeration Basin 1 pH Element: AE-4201B  
Aeration Basin 2 pH Element: AE-4202B  
Aeration Basin 1 Lateral Valve 1: MOV-4211  
Aeration Basin 1 Lateral Valve 2: MOV-4212  
Aeration Basin 1 Lateral Valve 3: MOV-4213  
Aeration Basin 1 Lateral Valve 4: MOV-4214  
Aeration Basin 1 Lateral Valve 5: MOV-4215  
Aeration Basin 1 Lateral Valve 6: MOV-4216  
Aeration Basin 1 Lateral Valve 7: MOV-4217  
Aeration Basin 1 Lateral Valve 8: MOV-4218  
Aeration Basin 1 Lateral Valve 9: MOV-4219  
Aeration Basin 1 Lateral Valve 10: MOV-4220  
Aeration Basin 1 Lateral Valve 11: MOV-4221  
Aeration Basin 2 Lateral Valve 1: MOV-4231  
Aeration Basin 2 Lateral Valve 2: MOV-4232  
Aeration Basin 2 Lateral Valve 3: MOV-4233  
Aeration Basin 2 Lateral Valve 4: MOV-4234  
Aeration Basin 2 Lateral Valve 5: MOV-4235  
Aeration Basin 2 Lateral Valve 6: MOV-4236  
Aeration Basin 2 Lateral Valve 7: MOV-4237  
Aeration Basin 2 Lateral Valve 8: MOV-4238  
Aeration Basin 2 Lateral Valve 9: MOV-4239  
Aeration Basin 2 Lateral Valve 10: MOV-4240  
Aeration Basin 2 Lateral Valve 11: MOV-4241

## AERATION BASINS

### A. General:

Control of the Aeration Basins is provided by the Aeration System Supplier from the Aeration System Control Panel.

Raw sewage and return activated sludge (RAS) flows will be evenly split to the two aeration basins with the flow splitting flumes at the headworks.

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Aeration Basins  
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Fine bubble membrane diffusers are attached to floating aeration air laterals which are moved across the basin propelled by air release from the diffusers. The moving aeration air laterals equipped with the diffuser assemblies provide efficient mixing of the basin contents as well as high oxygen transfer. A total of 11 aeration air laterals are located in each basin. Each air lateral has a motorized control valve which will automatically open and close to create alternating oxic and anoxic zones to allow denitrification in a single basin.

Mixed liquor will exit the tail end of the basins through an effluent weir which will minimize water surface fluctuations in the basin.

Each aeration basin has a dissolved oxygen probe which will be used to control the output of the blowers (Refer to Control Strategy 431). Each aeration basin also has a pH probe which will be used to monitor pH.

#### B. Operator Controls:

Location	Control Item	Type
Valve actuator	Hand-Off-Auto	Selector switch
SCADA/PLC	DO concentration	Digital setpoint

#### C. Control Modes:

1. Manual Control. Valves open when the Hand-Off-Auto selector switch is placed in the Hand position. Valves also have a hand wheel operator which can be used to manually throttle the valve in Hand position.
2. Auto Control. Activate by placing the Hand-Off-Auto switch in the Auto position. While in AUTO, the valve will be controlled automatically with the aeration system manufacturer's PLC logic.

The valves restart automatically after a power failure.

#### D. Interlocks with Other Equipment: Aeration Blowers.

#### E. Status Indications:

Operational statuses are displayed as follows:

Location	Status	Visual Indication
Valve actuator	Running	Green light
SCADA/PLC	Valve open Valve closed Aeration basin DO Aeration basin pH	Screen display Screen display Digital readout Digital readout

#### F. Alarm Indications:

Alarm conditions are displayed as follows:

Location	Status	Visual Indication
Valve actuator	Valve actuator fault	Amber light
SCADA	Valve actuator fault Aeration basin DO low Aeration basin DO high Aeration basin pH low Aeration basin pH high	Screen display Screen display Screen display Screen display Screen display

END OF CONTROL STRATEGY 421



CONTROL STRATEGY 431

TITLE: 431 – Aeration Air Blowers

AREA: Aeration Basins

PROCESS AND INSTRUMENTATION DIAGRAM: I431

RELATED EQUIPMENT:

Aeration Blower 1: BLO-4311  
Blower 1 Air Flow Meter: FE-4311  
Aeration Blower 2: BLO-4312  
Blower 2 Air Flow Meter: FE-4312  
Aeration Blower 3: BLO-4313  
Blower 3 Air Flow Meter: FE-4313  
Aeration System Blow-off Valve 1: MOV-4321  
Aeration System Blow-off Valve 2: MOV-4322

A. General:

Control of the Aeration Air Blowers is provided by the Aeration System Supplier from the Aeration System Control Panel.

Three, variable speed, high speed turbo blowers provide air to fine bubble diffusion equipment in the aeration basins.

Design of the aeration system is based on the use of three blowers (two duty and one standby). Space has been provided within the Blower Building for addition of a fourth blower.

During normal operation, Aeration Blower 1 will serve Aeration Basin 1 and Aeration Blower 2 will serve Aeration Basin 2. Aeration Blower 3 serves as a standby blower. Blower speed is automatically adjusted to maintain an operator adjustable setpoint for dissolved oxygen (DO) concentration within the aeration basin as measured by AE-4201 and AE-4202 (Refer to Control Strategy 421). An adjustable dead band is provided to prevent excessive DO swings, blower speed changes, and blower cycling.

The blowers are provided with high pressure and temperature alarm and other safety shutdown systems that are initiated when conditions exceed preset levels. In addition, each blower is provided with a pressure relief valve that prevents the buildup of excessive pressure within the blower discharge piping. These protective systems remain functional when operating in Hand.

Motorized aeration system blow-off valves are provided to automatically blow-off a portion of the blower discharge air during times when the aeration air demand at the basins is less than the minimum discharge capability of the blowers. The blow-off valves will be modulating type.

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Aeration Air Blowers  
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B. Operator Controls:

Location	Control Item	Type
Blower local control panel	Hand-Off-Auto Manual speed adjustment	Selector switch Touch pad
Valve actuator SCADA/PLC	Blower reset Hand-Off-Auto Blower selection Blower start/stop - time delay	Push button Selector switch Screen option Digital setpoint

C. Control Modes:

1. Blower Manual Control. Aeration Blowers operate continuously when the Hand-Off-Auto selector switch located at the blower local control panels is placed into the Hand position. Blower speed can be manually adjusted at the blower local control panel.
2. Blower Auto Control. The blowers operate automatically by placing the Hand-Off-Auto switch located at the blower local control panel in the Auto position. While in AUTO, plant operators designate in the plant's SCADA system the aeration basin DO concentration setpoint. Blower speed is then automatically controlled based on DO.
3. The blowers restart automatically after a power failure.
4. Aeration System Blow-off Valve Manual Control. Valves open when the Hand-Off-Auto selector switch is placed in the Hand position. Valves also have a hand wheel operator which can be used to manually throttle the valve in Hand position.
5. Aeration System Blow-off Valve Auto Control. Activate by placing the Hand-Off-Auto switch in the Auto position. While in AUTO, the valve will be controlled automatically with the aeration system manufacturer's PLC logic.
6. The Aeration System Blow-off Valves restart automatically after a power failure.

D. Interlocks with Other Equipment: Aeration Basin DO.

E. Status Indications:

Operational statuses are displayed as follows:

Location	Status	Visual Indication
Blower local control panel	Running	Green light
Valve actuator SCADA/PLC	Running Blower running Blower speed Blower auto Blower air flow rate Blower run time Valve position	Green light Screen display Digital readout Screen display Digital readout Digital readout Screen display

Aeration Air Blowers  
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F. Alarm Indications:

Alarm conditions are displayed as follows:

Location	Status	Visual Indication
Blower local control panel	Blower fault	Amber light
Valve actuator SCADA	Valve actuator fault Valve actuator fault Motor fault High discharge pressure High discharge temperature	Amber light Screen display Screen display Screen display Screen display

Motors turn off should a motor overload, high discharge pressure or high discharge temperature condition occur. Motors must be manually reset at the PLC panel before they will restart.

END OF CONTROL STRATEGY 431

Aeration Air Blowers  
(Control Strategy 431)

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## CONTROL STRATEGY 441

TITLE: 441 – Secondary Clarifiers and Scum Pumping

AREA: Secondary Clarifiers

PROCESS AND INSTRUMENTATION DIAGRAM: 1441

### RELATED EQUIPMENT:

Clarifier 1 Sludge Collector: COL-4410  
Clarifier 1 High Torque Switch: WSH-4410  
Clarifier 1 High-High Torque Switch: WSHH-4410A  
Clarifier 1 Shear Pin Switch: WSHH-4410B  
Clarifier 2 Sludge Collector: COL-4420  
Clarifier 2 High Torque Switch: WSH-4420  
Clarifier 2 High-High Torque Switch: WSHH-4420A  
Clarifier 2 Shear Pin Switch: WSHH-4420B

Scum Pump: P-4414  
Scum Pump Low Level Float: LSL-4414  
Scum Pump High Level Float: LSH-4414  
Scum Pump High-High Level Float: LSHH-4414  
Scum Pump High Temperature Sensor: TSH-4414  
Scum Pump Moisture Sensor: MS-4414

### SECONDARY CLARIFIER SLUDGE COLLECTORS

#### A. General:

Mixed liquor flows by gravity from the aeration basins to the mixed liquor flow splitting structure where it is evenly split to the two secondary clarifiers using cut-throat flumes. Isolation gates downstream of the flumes are used to take either of the secondary clarifiers out of service.

The secondary clarifier sludge collectors are manually controlled and run continuously unless turned off. High torque switches are provided that initiate alarm signals and shut the clarifier mechanisms off on high torque. At 110 percent of the continuous operating torque rating for the clarifier mechanism a high torque alarm is generated. At 120 percent of the continuous operating torque, a high-high torque signal is generated and the mechanism automatically shuts off. At 140 percent of the continuous operating torque, a backup shear pin switch breaks stopping the clarifier mechanism and a shear pin torque alarm is generated.

Return activated sludge (RAS) is pumped from the bottom of the clarifiers and returned to the aeration basin. See Control Strategy 451 for a description of the RAS pumping system.

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B. Operator Controls:

Location	Control Item	Type
MCC	On-Off (each clarifier)	Selector switch
MCC	High torque reset	Push button

C. Control Modes:

1. Manual Control. The clarifiers run continuously when the On-Off selector switch located at the MCC is placed in the On position.
2. Automatic Control. None except automatic shut down on high-high torque.

The clarifiers restart automatically after a power failure.

D. Interlocks with Other Equipment: None.

E. Status Indications:

Operational statuses are displayed as follows:

Location	Status	Visual Indication
MCC	Running	Green light
SCADA/PLC	Running Total run time	Screen display Digital readout

F. Alarm Indications:

Alarm conditions are displayed as follows:

Location	Status	Visual Indication
MCC	High-high torque Shear pin torque	Amber light Amber light
SCADA/PLC	High torque alarm High-high torque Shear pin torque	Screen display Screen display Screen display

Clarifier motors turn off on high-high torque (120 percent continuous torque) and shear pin torque (140 percent continuous torque) and must be manually reset at the MCC before they will restart.

SCUM PUMP

A. General:

Scum from the secondary clarifiers flows by gravity to the secondary clarifier scum pumping station. The station has one constant-speed, non-clog submersible pump. During normal operation, the pump turns on and off automatically based on wet well water level.

Preliminary wet well water level set points are contained in the following table:

Event or Location	Elevation, feet	Distance above Wet Well Floor, feet
High-high level float alarm	58.25	6.0
High level float - pump on	57.25	5.0
Low level float - pump off	54.25	2.0
Pump station floor	52.25	0.0

B. Operator Controls:

Location	Control Item	Type
Local control station (at pump)	Hand-Off-Auto	Selector switch
MCC	High temperature reset Moisture detection reset	Push button Push button

C. Control Modes:

1. Manual Control. The pump operates continuously when the Hand-Off-Auto selector switch located at the local control station is placed into the Hand position. The pump will run continuously until the selector switch is placed in the Off position.
2. Automatic Control. The pump operates automatically by placing the Hand-Off-Auto switch located at the local control station in the Auto position. Pump operation while in Auto mode is based on water level within the wet well.

The pump will automatically reset after a power failure.

D. Interlocks with Other Equipment: None.



# CONTROL STRATEGY 442

TITLE: 442 – Secondary Effluent Pumping

AREA: Secondary Clarifiers

PROCESS AND INSTRUMENTATION DIAGRAM: 1442

RELATED EQUIPMENT: Secondary Effluent Sluice Gate: GT-4450  
 Secondary Effluent Pump 1: P-4451  
 Secondary Effluent Pump 2: P-4452  
 Secondary Effluent Pump 2 High Temperature Switch: TSH-4452  
 Secondary Effluent Pump Station Wet Well Level Switch Low: LSL-4453  
 Secondary Effluent Pump Station Wet Well Level Switch High: LSH-4453  
 Secondary Effluent Pump Station Wet Well Level Element: LE/LIT-4454  
 Secondary Effluent to Polishing Ponds Flow Meter: FE/FIT-4455  
 Secondary Effluent to Chlorine Contact Basin Flow Meter: FE/FIT-4456

## SECONDARY EFFLUENT PUMPS

### A. General:

Two, variable speed, vertical turbine pumps are used to pump secondary effluent (SE) from the secondary effluent pump station wet well to either the polishing ponds via Polishing Pond 1 or to the chlorine contact basins.

During normal operation, the pumps operate automatically with the number of pumps running and speed controlled based on maintaining a set water surface level in the wet well or based on maintaining a set flow rate. Flow rate from the pumps is measured by the secondary effluent flow meter to the polishing ponds (FE-4455) or by the secondary effluent flow meter to the chlorine contact basins (FE-4456).

When maintaining a set water surface level in the wet well, if one pump is operating at maximum speed and the water elevation continues to rise above the set water surface level, the lag pump will turn on at minimum speed and the lead pump will slow down to match the pump speed of the lag pump. The pumps then operate in parallel modulating speed to maintain the set water surface level. When two pumps are running at minimum speed and the wet well drops below a set water surface elevation, the lag pump stops. The remaining pump continues to operate modulating speed as needed to maintain the set water surface level.

When maintaining a set flow rate, if one pump is operating at maximum speed for more than an adjustable time delay, the lead pump slows down to the minimum speed setpoint and the lag pump starts at the same speed. The pumps then operate in parallel modulating speed to maintain the flow rate setpoint. When two pumps are running, if the speed decreases and remains below an adjustable percent of maximum speed for more than an adjustable time delay, the lag pump stops. The remaining pump continues to operate modulating speed as needed to maintain the flow rate setpoint.

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Secondary Effluent Pumping  
 (Control Strategy 442)

## E. Status Indications:

Operational statuses are displayed as follows:

Location	Status	Visual Indication
Local control station (at pump) SCADA/PLC	Running	Green light
	Running	Screen display
	Auto	Screen display
	Total run time	Digital readout
	High water level	Screen display
	High-high water level	Screen display
	Low water level	Screen display

## F. Alarm Indications:

Location	Status	Visual Indication
MCC	High temp alarm	On pump protection relay
	Moisture alarm	On pump protection relay
SCADA/PLC	Motor overload	Screen display
	Motor high temp	Screen display
	Motor moisture detection	Screen display

Motors turn off on high temperature and must be manually reset at the PLC panel before they will restart. Moisture detection results in an alarm condition only but still requires a reset to clear the alarm.

## END OF CONTROL STRATEGY 441

Secondary Clarifiers and Scum Pumping  
 (Control Strategy 441)

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The secondary effluent sluice gate (GT-4450) has a motorized operator which will automatically open the gate if the water surface elevation in the wet well rises above a preset high level. Preliminary level settings are presented in the following table:

Event or Location	Water Surface Elevation, feet.	Water Surface Elevation, feet above wet well bottom
Top of Wall	67.75	17.75
High Water Alarm, GT-4450 opens	62.30	12.3
Lag Pump ON	61.00	11.0
Lead Pump ON	60.00	10.0
Pumps OFF	55.00	5.0
Pumping Station Invert	50.00	0.0

#### B. Operator Controls:

Location	Control Item	Type
GT-4450 actuator	Hand-Off-Auto	Selector switch
Adjustable frequency drive (AFD)	Hand-Off-Auto Manual speed adjustment Minimum speed setpoint	Selector switch Touch pad Touch pad
AFD panel	High motor temp reset	Push button
SCADA/PLC	Lead/lag pump selection Wet well level control Fixed flow rate Lag pump start/stop – time delay Lag pump stop – percent of maximum speed	Screen option Screen option Screen option Digital input Digital input

#### C. Control Modes:

1. Manual Control:
  - a. Valves open when the Hand-Off-Auto selector switch is placed in the Hand position. Valves also have a hand wheel operator which can be used to manually throttle the valve in Hand position
  - b. The pump(s) operates continuously when the Hand-Off-Auto selector switch located at the AFD is placed into the Hand position. The pump will run continuously at the last selected speed and will continue to run until the selector switch is placed in the Off position. Pump speed can be manually adjusted at the AFD.
2. Auto Control:
  - a. Activate by placing the gate actuator Hand-Off-Auto switch in the Auto position. While in AUTO, the gate actuator will be controlled automatically with the aeration system manufacturer's PLC logic.

Secondary Effluent Pumping  
(Control Strategy 442)

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- b. The pumps operate automatically by placing the Hand-Off-Auto switch located at the AFD in the Auto position. Pump operation (speed and number of pumps running) while in Auto mode is based either on maintaining a set water surface level in the wet well or at a constant flow rate as selected at the plant SCADA/PLC. The pump selected as lead pump will run continuously in Auto. If the wet well low level switch is activated all pumps will turn off.

The pumps and gate actuator will restart automatically after a power failure.

#### D. Interlocks with Other Equipment: None.

#### E. Status Indications:

Operational statuses are displayed as follows:

Location	Status	Visual Indication
Gate actuator	Running	Green light
AFD	Running	Green light
SCADA/PLC	Gate open Gate closed Running Auto Speed Flow rate Total run time Wet well level	Screen display Screen display Screen display Screen display Digital readout Digital readout Digital readout Digital readout

#### F. Alarm Indications:

Alarm conditions are displayed as follows:

Location	Status	Visual Indication
Gate actuator	Gate actuator fault	Amber light
AFD	AFD fault	Amber light
SCADA/PLC	Gate actuator fault Pump motor overload Pump motor high temperature Wet well low level Wet well high level	Screen display Screen display Screen display Screen display Screen display

Motors turn off on high temperature. They must be manually reset at the AFD panel before they will restart.

END OF CONTROL STRATEGY 442

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Secondary Effluent Pumping  
(Control Strategy 442)

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CONTROL STRATEGY 451

TITLE: 451 – RAS and WAS Pumping

AREA: Secondary Clarifiers and Solids Wasting

PROCESS AND INSTRUMENTATION DIAGRAM: I451

RELATED EQUIPMENT:

RAS Pump 1: P-4511  
RAS High Moisture Switch 1: MS-4511  
RAS High Temperature Switch 1: TSH-4511  
RAS Pump 2: P-4512  
RAS High Moisture Switch 2: MS-4512  
RAS High Temperature Switch 2: TSH-4512  
RAS Pump 3: P-4513  
RAS High Moisture Switch 3: MS-4513  
RAS High Temperature Switch 3: TSH-4513  
RAS Pump 4: P-4514  
RAS High Moisture Switch 4: MS-4514  
RAS High Temperature Switch 4: TSH-4514  
RAS Flow Meter 1: FE/FIT-4515  
RAS Flow Meter 2: FE/FIT-4516

WAS Pump: P-4611  
WAS High Pressure Switch 4: PSH-4611  
WAS High Temperature Switch: TSH-4611  
WAS Flow Meter: FE/FIT-4612

RETURN ACTIVATED SLUDGE PUMPS

A. General:

Four, variable speed, non-clog submersible pumps are used to pump return activated sludge (RAS) from the bottom of the clarifiers to the headworks upstream of the flow splitting flumes. Each clarifier has two dedicated RAS pumps.

During normal operation, the pumps operate automatically with the number of pumps running and speed controlled based on either a percent of plant flow (flow paced) or at a set flow rate. Each pair of pumps operates independently from the other. Flow rate for each pair of pumps is measured by RAS Flow Meters 1 and 2 (FE-4515 and FE-4516).

For each pair of pumps, if one pump is operating at maximum speed for more than an adjustable time delay, the lead pump slows down to the minimum speed setpoint and the lag pump starts at the same speed. The pumps then operate in parallel modulating speed to maintain the flow rate setpoint.

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For each pair, when two pumps are running, if the speed decreases and remains below an adjustable percent of maximum speed for more than an adjustable time delay, the lag pump stops. The remaining pump continues to operate modulating speed as needed to maintain the flow rate setpoint.

B. Operator Controls:

Location	Control Item	Type
Adjustable frequency drive (AFD)	Hand-Off-Auto Manual speed adjustment Minimum speed setpoint	Selector switch Touch pad Touch pad
AFD panel	High motor temp reset	Push button
SCADA/PLC	Lead/lag pump selection Flow pace control as percent of plant flow Fixed RAS flow rate Lag pump start/stop – time delay Lag pump stop – percent of maximum speed	Screen option Screen option Screen option Digital input Digital input

C. Control Modes:

- Manual Control. The pump(s) operates continuously when the Hand-Off-Auto selector switch located at the AFD is placed into the Hand position. The pump will run continuously at the last selected speed and will continue to run until the selector switch is placed in the Off position. Pump speed can be manually adjusted at the AFD.
- Auto Control. The pumps operate automatically by placing the Hand-Off-Auto switch located at the AFD in the Auto position. Pump operation (speed and number of pumps running) while in Auto mode is based either on plant flow (flow paced) or at a constant flow rate as selected at the plant SCADA/PLC. The pump selected as lead pump will run continuously in Auto.

The pumps will restart automatically after a power failure.

D. Interlocks with Other Equipment: None.

E. Status Indications:

Operational statuses are displayed as follows:

Location	Status	Visual Indication
AFD	Running	Green light
SCADA/PLC	Running Auto Speed Flow rate Total run time	Screen display Screen display Digital readout Digital readout Digital readout

F. Alarm Indications:

Alarm conditions are displayed as follows:

Location	Status	Visual Indication
AFD	AFD fault	Amber light
SCADA/PLC	Motor overload Motor high temperature Motor seal failure	Screen display Screen display Screen display

Motors turn off on high temperature. They must be manually reset at the AFD panel before they will restart.

WASTE ACTIVATED SLUDGE PUMP

A. General:

One, variable speed, positive displacement, rotary lobe type pump is used to pump waste activated sludge (WAS) from the RAS pump discharge header to the Biosolids Storage Basin.

During normal operation, wasting is either manually initiated from the plant SCADA/PLC or is automatically initiated based on an adjustable calendar. The WAS pump runs at the last selected speed (manually adjustable at the pump's AFD). Wasting continues until a preset volume of activated sludge (as measured by FE-4612) has been wasted at which point the pump turns off automatically.



B. Operator Controls:

Location	Control Item	Type
AFD	Hand-Off-Auto Manual speed adjustment	Selector switch Touch pad
AFD panel	High motor temp reset High pressure reset	Push button Push button
SCADA/PLC	Start wasting - manual Initiation Wasting calendar - fully automatic initiation Volume to waste	Screen option Screen option Screen option

C. Control Modes:

1. Manual Control. The pump operates continuously when the Hand-Off-Auto selector switch located at the AFD is placed into the Hand position. The pump runs continuously at the last selected speed and continues to run until the selector switch is placed in the Off position. Pump speed can be manually adjusted at the AFD.
2. Auto Control. The pump operates automatically by placing the Hand-Off-Auto switch located at the AFD in the Auto position. Wasting is then either manually initiated at the plant SCADA/PLC or is based on an adjustable calendar. The pump operates at the last selected speed (manually adjustable at the AFD) until the preset volume of WAS has been wasted at which point the pump turns off.

The pump restarts automatically after a power failure.

D. Interlocks with Other Equipment: None.

E. Status Indications:

Operational statuses are displayed as follows:

Location	Status	Visual Indication
AFD	Running	Green light
SCADA/PLC	Running Auto Speed Flow rate Total run time	Screen display Screen display Digital readout Digital readout Digital readout

RAS and WAS Pumping  
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F. Alarm Indications:

Alarm conditions are displayed as follows:

Location	Status	Visual Indication
AFD	AFD fault	Amber light
SCADA/PLC	Motor high temperature High discharge pressure	Screen display Screen display

Motors turn off on high temperature and high discharge pressure. They must be manually reset at the AFD panel before they will restart.

END OF CONTROL STRATEGY 451

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RAS and WAS Pumping  
(Control Strategy 451)

# CONTROL STRATEGY 831

TITLE: 831 – Tank Drain/Supernatant Pumping

AREA: Wastewater Utilities

PROCESS AND INSTRUMENTATION DIAGRAM: I831

RELATED EQUIPMENT: Tank Drain/Supernatant PS Wet Well Level Floats: LSL-8301, LSH-8301, LSHH-8301  
 Tank Drain/Supernatant Pump 1: P-8311  
 Tank Drain/Supernatant Pump 1 High Temperature Sensor: TSH-8311  
 Tank Drain/Supernatant Pump 1 Moisture Sensor: MS-8311  
 Tank Drain/Supernatant Pump 2: P-8312  
 Tank Drain/Supernatant Pump 2 High Temperature Sensor: TSH-8312  
 Tank Drain/Supernatant Pump 2 Moisture Sensor: MS-8312  
 Tank Drain/Supernatant Flow Meter: FE/FTI-8315

## A. General:

The tank drain/supernatant pumps are used to pump tank drainage from the process tanks and supernatant from the biosolids storage basin to the headworks. Tank drain/supernatant pumping is provided by two, constant speed non-clog submersible pumps. Under normal conditions, pumps are operated in a lead/lag configuration based on wet well level although both pumps can operate simultaneously should wet well water level exceed a preset value. Preliminary level settings are presented in the following table:

Event or Location	Water Surface Elevation, feet,	Water Surface Elevation, feet above wet well bottom
Top of Wall	67.25	21.00
High Water Alarm	65.50	19.25
Lag Pump ON	61.00	14.75
Lead Pump ON	55.25	9.00
Pumps OFF	49.25	3.00
Pumping Station Invert	46.25	0.00

## B. Operator Controls:

Location	Control Item	Type
Local control station	Hand-Off-Auto (each pump)	Selector switch
MCC panel	High temperature reset	Push button
SCADA/PLC	Lead/Lag pump selection	Screen option

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C. Control Modes:

1. Manual Control. The pump(s) operates continuously when the Hand-Off-Auto selector switch located at the local control station is placed into the Hand position. The pump(s) will continue to run until manually turned off. Level controls are disabled while in Hand mode.
2. Automatic Control. The pumps operate automatically by placing the Hand-Off-Auto switch located at the local control station in the Auto position. Pump operation while in Auto mode is based on water level within the wet well. Lead/lag pump selection may be made at the SCADA/PLC.

The pumps automatically restart after a power failure.

D. Interlocks with Other Equipment: None.

E. Status Indications:

Operational statuses are displayed as follows:

Location	Status	Visual Indication
Local control station	Running	Green light
MCC	Running	Green light
SCADA/PLC	Running	Screen display
	Auto	Screen display
	Lead/lag pump	Screen display
	Total run time	Screen display
	Flow	Digital readout
	Total flow	Digital readout

F. Alarm Indications:

Alarm conditions are displayed as follows:

Location	Status	Visual Indication
MCC	Pump fault	Amber light
	High temp alarm	On motor relay
	Moisture alarm	On motor relay
SCADA/PLC	Pump fault	Screen display
	Motor high temp	Screen display
	Motor moisture detection	Screen display
	Low low water level alarm (LSLL-8301)	Screen display
	High high water level alarm (LSHH-8301)	Screen display

Motors turn off with high temperature and must be manually reset at the MCC panel before they will restart. Moisture detection results in an alarm condition only, but still requires a reset to clear the alarm.

END OF CONTROL STRATEGY 831

Tank Drain/Supernatant Pumping (Control Strategy 831) 831 - 2 McKinleyville Community Services District  
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CONTROL STRATEGY 832

TITLE: 832 – Utility Water Pumping

AREA: Wastewater Utilities

PROCESS AND INSTRUMENTATION DIAGRAM: 1832

RELATED EQUIPMENT:

Utility Water Pump 1: P-8321  
Low Level Float Switch: LSL-8321  
Utility Water Pump 2: P-8322  
Utility Water Flow Meter: FE-8323  
Low Level Float Switch: LSL-8322  
Utility Water Pressure Transmitter: PIT-8324  
Utility Water Hydropneumatic Tank: PVL-8325

A. General:

The utility water pumps provide water for general non-potable water usage in the Plant. A small pressure tank serves to provide a more constant system pressure. One pump will meet the required water demand. The second pump is normally used for standby service but it will also be available should the demand exceed the capacity of one pump. Pump 1 is located in the south Chlorine Contact Basin. Pump 2 is located in the north Chlorine Contact Basin. If one of the chlorine contact basins is out of service, only one of the utility water pumps will remain in service.

B. Operator Controls:

MCC	Location	Control Item	Type
		On-Off-Auto	Selector switch

C. Control Modes:

1. Manual Control. Manual control including start/stop are accomplished at the MCC.
2. Auto Control. Pumps are placed in AUTO mode by selecting AUTO on the HOA switch at the MCC. While in AUTO, the utility water pumps will turn ON and OFF based on utility water system pressure (measured by PIT-8334) as follows:

Action	System Pressure
High pressure alarm	115 psig
Utility Water Pumps 1 and 2 Off	105 psig
Lead Utility Water Pump On	80 psig
Lag Utility Water Pump On	70 psig
Low pressure alarm	60 psig

The pumps will automatically alternate the lead pump. The pumps will also turn off on low water level which is set at 7.5 feet above the wet well (chlorine contact basin) floor.

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Utility Water Pumping  
(Control Strategy 832)

# CONTROL STRATEGY 833

TITLE: 833 – Ejector Pumping  
 AREA: Wastewater Utilities

PROCESS AND INSTRUMENTATION DIAGRAM: I833

RELATED EQUIPMENT: Ejector Pump Station Wet Well Level Floats: LSL-8330, LSH-8330, LSH-8330, LSH-8330  
 Ejector Pump 1: P-8331  
 Ejector Pump 1 High Temperature Sensor: TSH-8331  
 Ejector Pump 2: P-8332  
 Ejector Pump 2 High Temperature Sensor: TSH-8332

## A. General:

The ejector pumps are used to pump drainage from the Control Building and the Blower, Electrical, and Maintenance Building to the headworks. Ejector pumping is provided by two, constant speed non-clog submersible pumps. Under normal conditions, pumps are operated in a lead/lag configuration based on wet well level although both pumps can operate simultaneously should wet well water level exceed a preset value. Preliminary level settings are presented in the following table:

Event or Location	Water Surface Elevation, feet above sea level	Water Surface Elevation, feet above wet well bottom
Top of Wall	67.25	9.5
High Water Alarm	61.75	4.0
Lag Pump ON	61.25	3.5
Lead Pump ON	60.75	3.0
Pumps OFF	59.25	1.5
Pumping Station Invert	57.75	0.0

## B. Operator Controls:

Location	Control Item	Type
Local control panel	Hand-Off-Auto (each pump)	Selector switch

## C. Control Modes:

1. Manual Control. The pump(s) operates continuously when the Hand-Off-Auto selector switch located at the local control panel is placed into the Hand position. The pump(s) will continue to run until manually turned off. Level controls are disabled while in Hand mode.
  2. Automatic Control. The pumps operate automatically by placing the Hand-Off-Auto switch located at the local control panel in the Auto position. Pump operation while in Auto mode is based on water level within the wet well. Pumps automatically rotate between Lead and Lag position after each start/stop sequence.
- The pumps automatically restart after a power failure.

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Ejector Pumping  
 (Control Strategy 833)

3. The pumps will restart automatically after a power failure.

D. Interlocks with Other Equipment: None.

E. Status Indications:

Operational statuses are displayed as follows:

Location	Status	Visual Indication
MCC	Running	Green light
SCADA/PLC	Running Elapsed time Total run time Utility water flow rate	Screen display Digital readout Digital readout Screen display

F. Alarm Indications:

Alarm conditions are displayed as follows:

Location	Status	Visual Indication
MCC	Pump fault	Amber light
SCADA/PLC	Pump fault High system pressure Low system pressure Low water level Utility water flow meter fault	Screen display Screen display Screen display Screen display Screen display

## END OF CONTROL STRATEGY 832

Utility Water Pumping  
 (Control Strategy 832)

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D. Interlocks with Other Equipment: None.

E. Status Indications:

Operational statuses are displayed as follows:

Location	Status	Visual Indication
Local control panel SCADA/PLC	Running	Green light
	Pump 1 Running	Screen display
	Pump 2 Running	Screen display
	Total run time	Digital readout

F. Alarm Indications:

Alarm conditions are displayed as follows:

Location	Status	Visual Indication
Local control panel SCADA/PLC	Pump fault	Amber light
	High level	Amber light
	Pump fault	Screen display
	High water level alarm	Screen display

END OF CONTROL STRATEGY 831

Ejector Pumping  
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SECTION 17330B  
PLC INPUT/OUTPUT

Process ID	Device Prefix	Tag	Description	Type	Sheet	PLC
2200	FT	2201	Inlet Flow Transmitter	AI	I221	ELEC
2200	LSH	2202	RS Channel High Level Switch	DI	I221	ELEC
2200	LSH	2210	Screen SCN-2210 Upstream High Level Switch	DI	I221	ELEC
2200	YI	2210	Screen SCN-2210 in Auto	DI	I221	ELEC
2200	XI	2210	Screen SCN-2210 Running	DI	I221	ELEC
2200	XA	2210	Screen SCN-2210 Fault	DI	I221	ELEC
2200	XA	2205	Influent Sampler Fault	DI	I221	ELEC
2200	FC	2205	Influent Flowmeter Demanded Sampling Rate	AO	I221	ELEC
4100	XC	4121	Calcium Hydroxide Metering Pump 1 Call to Run	DO	I411	ELEC
4100	SC	4121	Calcium Hydroxide Metering Pump 1 Demanded Rate	AO	I411	ELEC
4100	SI	4121	Calcium Hydroxide Metering Pump 1 Speed	AI	I411	ELEC
4100	XI	4121	Calcium Hydroxide Metering Pump 1 Run	DI	I411	ELEC
4100	XA	4121	Calcium Hydroxide Metering Pump 1 Fault	DI	I411	ELEC
4100	YI	4121	Calcium Hydroxide Metering Pump 1 in Auto	DI	I411	ELEC
4100	XC	4122	Calcium Hydroxide Metering Pump 2 Call to Run	DO	I411	ELEC
4100	SC	4122	Calcium Hydroxide Metering Pump 2 Demanded Rate	AO	I411	ELEC
4100	SI	4122	Calcium Hydroxide Metering Pump 2 Speed	AI	I411	ELEC
4100	XI	4122	Calcium Hydroxide Metering Pump 2 Run	DI	I411	ELEC
4100	XA	4122	Calcium Hydroxide Metering Pump 2 Fault	DI	I411	ELEC
4100	YI	4122	Calcium Hydroxide Metering Pump 2 in Auto	DI	I411	ELEC
4100	LSH	4123	Calcium Hydroxide Waste Container High Level (Spill)	DI	I411	ELEC
4400	LSL	4414	Scum Pump P-4414 Basin Low Level Switch	DI	I441	ELEC
4400	LSH	4414	Scum Pump P-4414 Basin High Level Switch	DI	I441	ELEC
4400	LSHH	4414	Scum Pump P-4414 Basin High-High Level Switch	DI	I441	ELEC

PLC Input/Output

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## SECTION 17330B

## PLC INPUT/OUTPUT

Process ID	Device Prefix	Tag	Description	Type	Sheet	PLC
4400	XI	4414	Scum Pump P-4414 Running	DI	I441	ELEC
4400	YI	4414	Scum Pump P-4414 in Auto	DI	I441	ELEC
4400	XA	4414	Scum Pump P-4414 Motor Fault	DI	I441	ELEC
4400	MS	4414	Scum Pump P-4414 Moisture Sensor/Seal Failure	DI	I441	ELEC
4400	TSH	4414	Scum Pump P-4414 High Temperature Switch	DI	I441	ELEC
4400	XI	4410	Secondary Clarifier 1 Sludge Collector Running	DI	I441	ELEC
4400	XA	4410	Secondary Clarifier 1 Sludge Collector Fault	DI	I441	ELEC
4400	WSH	4410	Secondary Clarifier 1 Sludge Collector High Torque Switch	DI	I441	ELEC
4400	WSHH	4410A	Secondary Clarifier 1 Sludge Collector Torque Shutdown	DI	I441	ELEC
4400	WSHH	4410B	Secondary Clarifier 1 Sludge Collector Shear Pin	DI	I441	ELEC
4400	XI	4420	Secondary Clarifier 2 Sludge Collector Running	DI	I441	ELEC
4400	XA	4420	Secondary Clarifier 2 Sludge Collector Fault	DI	I441	ELEC
4400	WSH	4420	Secondary Clarifier 2 Sludge Collector High Torque Switch	DI	I441	ELEC
4400	WSHH	4420A	Secondary Clarifier 2 Sludge Collector Torque Shutdown	DI	I441	ELEC
4400	WSHH	4420B	Secondary Clarifier 2 Sludge Collector Shear Pin	DI	I441	ELEC
4400	SC	4451	Secondary Effluent Pump P-4451 Demanded Speed	AO	I442	ELEC
4400	XC	4451	Secondary Effluent Pump P-4451 Call to Run	DO	I442	ELEC
4400	YI	4451	Secondary Effluent Pump P-4451 in Auto	DI	I442	ELEC
4400	XI	4451	Secondary Effluent Pump P-4451 Running	DI	I442	ELEC
4400	XA	4451	Secondary Effluent Pump P-4451 Motor Fault	DI	I442	ELEC
4400	SI	4451	Secondary Effluent Pump P-4451 Speed	AI	I442	ELEC
4400	TSH	4451	Secondary Effluent Pump P-4451 High Temperature Switch	DI	I442	ELEC
4400	SC	4452	Secondary Effluent Pump P-4452 Demanded Speed	AO	I442	ELEC
4400	XC	4452	Secondary Effluent Pump P-4452 Call to Run	DO	I442	ELEC

PLC Input/Output

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## SECTION 17330B

## PLC INPUT/OUTPUT

Process ID	Device Prefix	Tag	Description	Type	Sheet	PLC
4400	YI	4452	Secondary Effluent Pump P-4452 in Auto	DI	I442	ELEC
4400	XI	4452	Secondary Effluent Pump P-4452 Running	DI	I442	ELEC
4400	XA	4452	Secondary Effluent Pump P-4452 Motor Fault	DI	I442	ELEC
4400	SI	4452	Secondary Effluent Pump P-4452 Speed	AI	I442	ELEC
4400	TSH	4452	Secondary Effluent Pump P-4452 High Temperature Switch	DI	I442	ELEC
4400	YI	4450	Secondary Effluent Discharge Gate in Remote	DI	I442	ELEC
4400	ZSO	4450	Secondary Effluent Discharge Gate Opened	DI	I442	ELEC
4400	ZSC	4450	Secondary Effluent Discharge Gate Closed	DI	I442	ELEC
4400	HSO	4450	Secondary Effluent Discharge Gate Call to Open	DO	I442	ELEC
4400	HSC	4450	Secondary Effluent Discharge Gate Call to Close	DO	I442	ELEC
4400	LSL	4453	Secondary Effluent Pump Station Low Level Switch	DI	I442	ELEC
4400	LSH	4453	Secondary Effluent Pump Station High Level Switch	DI	I442	ELEC
4400	LIT	4454	Secondary Effluent Pump Station Level Transmitter	AI	I442	ELEC
4400	FIT	4455	Secondary Effluent to Polishing Ponds Flow Transmitter	AI	I442	ELEC
4400	FIT	4456	Secondary Effluent to Chlorine Contact Basins Flow Transmitter	AI	I442	ELEC
4500	SC	4511	RAS Pump P-4511 Demanded Speed	AO	I451	ELEC
4500	XC	4511	RAS Pump P-4511 Call to Run	DO	I451	ELEC
4500	YI	4511	RAS Pump P-4511 in Auto	DI	I451	ELEC
4500	XI	4511	RAS Pump P-4511 Running	DI	I451	ELEC
4500	XA	4511	RAS Pump P-4511 Motor Fault	DI	I451	ELEC
4500	SI	4511	RAS Pump P-4511 Speed	AI	I451	ELEC
4500	TSH	4511	RAS Pump P-4511 High Temperature Switch	DI	I451	ELEC
4500	MS	4511	RAS Pump P-4511 Moisture Sensor/Seal Failure	DI	I451	ELEC
4500	SC	4512	RAS Pump P-4512 Demanded Speed	AO	I451	ELEC

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PLC Input/Output



## SECTION 17330B

## PLC INPUT/OUTPUT

Process ID	Device Prefix	Tag	Description	Type	Sheet	PLC
4500	XC	4512	RAS Pump P-4512 Call to Run	DO	I451	ELEC
4500	YI	4512	RAS Pump P-4512 in Auto	DI	I451	ELEC
4500	XI	4512	RAS Pump P-4512 Running	DI	I451	ELEC
4500	XA	4512	RAS Pump P-4512 Motor Fault	DI	I451	ELEC
4500	SI	4512	RAS Pump P-4512 Speed	AI	I451	ELEC
4500	TSH	4512	RAS Pump P-4512 High Temperature Switch	DI	I451	ELEC
4500	MS	4512	RAS Pump P-4512 Moisture Sensor/Seal Failure	DI	I451	ELEC
4500	SC	4513	RAS Pump P-4513 Demanded Speed	AO	I451	ELEC
4500	XC	4513	RAS Pump P-4513 Call to Run	DO	I451	ELEC
4500	YI	4513	RAS Pump P-4513 in Auto	DI	I451	ELEC
4500	XI	4513	RAS Pump P-4513 Running	DI	I451	ELEC
4500	XA	4513	RAS Pump P-4513 Motor Fault	DI	I451	ELEC
4500	SI	4513	RAS Pump P-4513 Speed	AI	I451	ELEC
4500	TSH	4513	RAS Pump P-4513 High Temperature Switch	DI	I451	ELEC
4500	MS	4513	RAS Pump P-4513 Moisture Sensor/Seal Failure	DI	I451	ELEC
4500	SC	4514	RAS Pump P-4514 Demanded Speed	AO	I451	ELEC
4500	XC	4514	RAS Pump P-4514 Call to Run	DO	I451	ELEC
4500	YI	4514	RAS Pump P-4514 in Auto	DI	I451	ELEC
4500	XI	4514	RAS Pump P-4514 Running	DI	I451	ELEC
4500	XA	4514	RAS Pump P-4514 Motor Fault	DI	I451	ELEC
4500	SI	4514	RAS Pump P-4514 Speed	AI	I451	ELEC
4500	TSH	4514	RAS Pump P-4514 Over Temperature Switch	DI	I451	ELEC
4500	MS	4514	RAS Pump P-4514 Moisture Sensor/Seal Failure	DI	I451	ELEC
4500	FIT	4515	RAS Flowmeter Transmitter for RAS Pumps P-4511 and P-4512	AI	I451	ELEC

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## SECTION 17330B

## PLC INPUT/OUTPUT

Process ID	Device Prefix	Tag	Description	Type	Sheet	PLC
4500	FIT	4516	RAS Flowmeter Transmitter for RAS Pumps P-4513 and P-4514	AI	I451	ELEC
4600	YI	4611	WAS Pump P-4611 in Auto	DI	I451	ELEC
4600	XI	4611	WAS Pump P-4611 Running	DI	I451	ELEC
4600	XA	4611	WAS Pump P-4611 Motor Fault	DI	I451	ELEC
4600	SC	4611	WAS Pump P-4611 Demanded Speed	AO	I451	ELEC
4600	XC	4611	WAS Pump P-4611 Call to Run	DO	I451	ELEC
4600	SI	4611	WAS Pump P-4611 Speed	AI	I451	ELEC
4600	PSH	4611	WAS Pump P-4611 High Pressure Switch	DI	I451	ELEC
4600	TSH	4611	WAS Pump P-4611 High Temperature Switch	DI	I451	ELEC
4600	FIT	4612	WAS Flowmeter Transmitter for WAS Pump P-4611	AI	I451	ELEC
8100	XI	8115	Generator EG-8115 Running	DI	I811	ELEC
8100	XA	8115A	Generator EG-8115 Shut Down Alarm	DI	I811	ELEC
8100	XA	8115B	Generator EG-8115 Warning Alarm	DI	I811	ELEC
8100	LSH	8112	Generator EG-8115 Fuel Leak Level Switch	DI	I811	ELEC
8100	LSL	8112	Generator EG-8115 Fuel Level Low Switch	DI	I811	ELEC
8100	XI	8121A	Transfer Switch ATS-8121 in Normal Mode	DI	I811	ELEC
8100	XI	8121B	Transfer Switch ATS-8121 in Standby	DI	I811	ELEC
8300	LSL	8301	Tank 8301 Low Level Switch	DI	I831	ELEC
8300	LSLL	8301	Tank 8301 Low-Low Level Switch	DI	I831	ELEC
8300	LSH	8301	Tank 8301 High Level Switch	DI	I831	ELEC
8300	LSHH	8301	Tank 8301 High-High Level Switch	DI	I831	ELEC
8300	XC	8311	Tank Drain Pump P-8311 Call to Run	DO	I831	ELEC
8300	YI	8311	Tank Drain Pump P-8311 in Auto	DI	I831	ELEC
8300	XI	8311	Tank Drain Pump P-8311 Running	DI	I831	ELEC

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PLC Input/Output

## SECTION 17330B

## PLC INPUT/OUTPUT

Process ID	Device Prefix	Tag	Description	Type	Sheet	PLC
8300	XA	8311	Tank Drain Pump P-8311 Motor Fault	DI	1831	ELEC
8300	MS	8311	Tank Drain Pump P-8311 Moisture Sensor/Seal Failure	DI	1831	ELEC
8300	TSH	8311	Tank Drain Pump P-8311 High Temperature Switch	DI	1831	ELEC
8300	XC	8312	Tank Drain Pump P-8312 Call to Run	DO	1831	ELEC
8300	YI	8312	Tank Drain Pump P-8312 in Auto	DI	1831	ELEC
8300	XI	8312	Tank Drain Pump P-8312 Running	DI	1831	ELEC
8300	XA	8312	Tank Drain Pump P-8312 Motor Fault	DI	1831	ELEC
8300	MS	8312	Tank Drain Pump P-8312 Moisture Sensor/Seal Failure	DI	1831	ELEC
8300	TSH	8312	Tank Drain Pump P-8312 High Temperature Switch	DI	1831	ELEC
8300	FIT	8315	Tank 8301 Flow Transmitter	AI	1831	ELEC
8300	LSL	8321	South Chlorine Contact Basin Low Level Switch	DI	1832	ELEC
8300	SI	8321	Utility Water Pump P-8321 Speed	AI	1832	ELEC
8300	XI	8321	Utility Water Pump P-8321 Running	DI	1832	ELEC
8300	YI	8321	Utility Water Pump P-8321 in Auto	DI	1832	ELEC
8300	XA	8321	Utility Water Pump P-8321 Motor Fault	DI	1832	ELEC
8300	SC	8321	Utility Water Pump P-8321 Demanded Speed	AO	1832	ELEC
8300	XC	8321	Utility Water Pump P-8321 Call to Run	DO	1832	ELEC
8300	LSL	8322	North Chlorine Contact Basin Low Level Switch	DI	1832	ELEC
8300	SI	8322	Utility Water Pump P-8322 Speed	AI	1832	ELEC
8300	XI	8322	Utility Water Pump P-8322 Running	DI	1832	ELEC
8300	YI	8322	Utility Water Pump P-8322 in Auto	DI	1832	ELEC
8300	XA	8322	Utility Water Pump P-8322 Motor Fault	DI	1832	ELEC
8300	SC	8322	Utility Water Pump P-8322 Demanded Speed	AO	1832	ELEC
8300	XC	8322	Utility Water Pump P-8322 Call to Run	DO	1832	ELEC

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## SECTION 17330B

## PLC INPUT/OUTPUT

Process ID	Device Prefix	Tag	Description	Type	Sheet	PLC
8300	FIT	8323	Utility Water Flow Transmitter	AI	1832	ELEC
8300	PIT	8324	Utility Water Pressure Transmitter	AI	1832	ELEC
8300	LAHH	8330	Ejector Pump Station High Level Alarm	DI	1833	ELEC
8300	LAHH	8330	Ejector Pump Station High Level Alarm	DI	1833	ELEC
8300	XA	8332	Ejector Pump Station Fault	DI	1833	ELEC
8300	XI	8331	Ejector Pump Station Pump 1 Running	DI	1833	ELEC
8300	XI	8332	Ejector Pump Station Pump 2 Running	DI	1833	ELEC
4300	ZSC	4301	Electrical PLC Control Panel Intrusion	DI		ELEC
4300	ZSC	4302	Electrical Room Intrusion	DI		ELEC
4300	ZSC	4303	Maintenance Room Intrusion	DI		ELEC
4300	ZSC	4304	Blower Room Intrusion	DI		ELEC
4300	XA	4305	Building Fire Alarm	DI		ELEC
	FI		Effluent Flow Transmitter	AI		REMOTE
	LI		Chlorine Contact Basin Level Transmitter	AI		REMOTE
	PI		Irrigation Pump Discharge Pressure	AI		REMOTE
	LI		Hydropneumatic Tank Level Probe	AI		REMOTE
	XA		Low Vacuum Alarm	DI		REMOTE
	XA		Chlorine Leak Detector Alarm	DI		REMOTE
	XA		Chlorine Solenoid Failure Alarm	DI		REMOTE
	EA		Power Failure Alarm	DI		REMOTE
	XA		Recirc Pump Low-Level Cutoff Alarm	DI		REMOTE
	XI		Recirc Pump Running	DI		REMOTE
	LSH		Vault Flood Switch	DI		REMOTE
	XA		Fire Alarm	DI		REMOTE
	ZSC		Building Intrusion Alarm	DI		REMOTE

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PLC INPUT/OUTPUT

Process ID	Device Prefix	Tag	Description	Type	Sheet	PLC
	LSL		Pond Low Level Switch	DI		REMOTE
	LSH		Pond High Level Switch	DI		REMOTE
	XC		Hydropneumatic Tank Solenoid Control	DO		REMOTE
	XC		Recirc Pump Call to Run	DO		REMOTE

END OF SECTION

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SECTION 17510

PANELS

PART 1 - GENERAL

1.01 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 16955: Control Devices.
- B. Section 17330: Programmable Logic Controllers.
- C. Section 16124: Signal Cable

1.02 DESCRIPTION

- A. Provisions: Requirements of Division 1 and Section 17010 form a part of this Section.
- B. Work Includes: This Section covers control panels shown on the Electrical or Instrumentation Drawings, or as specified in either Division 16 or 17, and sets minimum standards for all packaged unit panels specified in Divisions 11 to 15, unless modified under those sections.

1.03 REFERENCES

This section contains references to the following documents. They are a part of this section as specified and modified. Where a referenced document contains references to other standards, those documents are included as references under this section as if referenced directly. In the event of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

Unless otherwise specified, references to documents shall mean the documents in effect at the time of Advertisement for Bids or Invitation to Bid (or on the effective date of the Agreement if there were no Bids). If referenced documents have been discontinued by the issuing organization, references to those documents shall mean the replacement documents issued or otherwise identified by that organization or, if there are no replacement documents, the last version of the document before it was discontinued. Where document dates are given in the following listing, references to those documents shall mean the specific document version associated with that date, regardless of whether the document has been superseded by a version with a later date, discontinued or replaced.

- A. National Electrical Manufacturers Association (NEMA):
  - 1. ICS1 Industrial Control and Systems: General Requirements
  - 2. ICS2 Controllers, Contactors and Overload Relays rated 600 V
  - 3. ICS 4 Terminal Blocks for Industrial Control Equipment and Systems
  - 4. ICS6 Enclosures

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- B. Underwriters Laboratories, Inc. (UL):
1. UL 508A Industrial Control Equipment

#### 1.04 SUBMITTALS

- A. The following information shall be submitted in accordance with Section 01300:
1. A copy of this specification section, with addendum updates included, and all referenced and applicable sections, with addendum updates included, with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated, and therefore requested by the Contractor, each deviation shall be underlined and denoted by a number in the margin to the right of the identified paragraph, referenced to a detailed written explanation of the reasons for requesting the deviation. The Engineer shall be the final authority for determining acceptability of requested deviations. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no further consideration.
  2. Where applicable, a copy of the contract document control diagrams and process and instrumentation diagrams relating to the submitted equipment, with addendum updates that apply to the equipment in this section, marked to show specific changes necessary for the equipment proposed in the submittal. If no changes are required, the drawing or drawings shall be marked "no changes required". Failure to include copies of the relevant drawings with the submittal shall be cause for rejection of the entire submittal with no further review.
- B. Submit material or equipment data in accordance with the requirements of Section 16010.
- C. Shop Drawings: The Contractor shall provide:
1. Detailed PLC control panel layout, wiring and power supply drawings
  2. Manufacturer's data sheets for all equipment including all panel pieces and components required to make a complete and functional control panel.
  3. UL Certifications of the fabricator/panel shop to be used for construction of the "industrial control panels".
  4. Fabrication drawings for peripheral equipment or panels not currently detailed in the drawing set, including a dimensioned outline drawing to scale, showing space for conduits, etc.
  5. Seismic Anchorage Design, including layout and calculations, signed and sealed by a Professional Engineer, registered in the State of California. Refer to Section 01190 for requirements.
  6. Details of all panel accessories.
  7. Nameplate inscriptions.
  8. Connections to external equipment.

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9. Wire marking equipment and specifications for wire tagging materials.
  10. Panel load calculations.
  11. Arrange submittals in a logical manner. Use the device abbreviation identifications and equipment names as shown on the Drawings in order to expedite and facilitate review by the Engineer.
  12. Where equipment deviates in any way from that shown on the Drawings, provide a complete record and explanation of such deviations.
  13. All proposed equipment substitutions shall be clearly defined in a special section of the submittal called "Substitutions". All proposed substitutions shall be accompanied by the OEM documentation of what is designed in this specification and drawings as well as the OEM data sheets of the proposed substitution.
  14. Any suggested substitutions during the bid process shall not be considered "Engineer Approved".
- D. Spare Parts List: Include a spare parts list showing recommended parts and quantities as well as complete ordering information for replacement components. Provide instruction books for special control devices and special equipment installed in the control panels. Submit these to the Engineer prior to installation of the equipment.
- E. Manuals: Provide manuals as specified in Section 17010.
- #### 1.05 UL LABEL
- A. UL Label:
1. Each assembled control panel and terminal cabinet shall bear the UL label. The UL label shall apply to the enclosure, the specific equipment supplied with the enclosure, and the installation and wiring of the equipment within and on the enclosure. If required for UL labeling, provide ground fault interrupters, isolation transformers, fuses, and any other necessary equipment, even though such equipment is not indicated on the Drawings. The fabricator shall be an approved UL listed manufacturer and meet the requirements as listed in paragraph 1.04, B.3 above.

#### PART 2 - PRODUCTS

##### 2.01 CONSTRUCTION

- A. General:
1. Provide panels as shown on the Drawings. Control Panels shall conform to the requirements of UL 508A – Industrial Control Panels.
  2. Panels located in the electrical room and existing control building shall be NEMA 4X, 316 stainless steel.
  3. Any penetrations in a NEMA 4X cabinet shall keep the integrity of the NEMA 4X panel rating (i.e., panel mounted PC/HMI, control stations, process indicators, etc.).

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4. The panel itself shall conform to NEMA Standards ICS 1 and ICS 2. Control panels measuring 5 feet in height or less shall be supported via unistrut and wall mounted in areas shown on the Drawings. Dual door control panels shall be designed for floor mounting. All panels shall be wall-mounted or freestanding floor mounted, as shown. Provide sufficient access to the panels. The enclosures shall be code gauge steel of adequate strength, when complete, to withstand seismic forces equivalent to those noted in Section 01190. Enclosures shall conform to requirements of NEMA Standard ICS 6.
6. The enclosures shall have vertically hinged front doors; provide hinge on side of panel that ensures compliance with the 30-inch rule in NEC Paragraph 110-26. Freestanding enclosures shall have doors secured by keyed three point latches, except in corrosive locations. Mount the devices through the doors or on recessed plates. Provide nameplates indicated on the Drawings. Each component within the panel shall be securely mounted and arranged for easy servicing, such that all adjustments and component removal can be accomplished without disturbing other components. No fastening devices shall project through the outer surfaces of the cabinet and all components and terminals shall be mounted on mounting pans within the panels.

B. Safety Requirements: The electrical supply to each control panel shall be arranged to be disconnected by a single switch or circuit breaker, except for necessary foreign circuits as required by NEC and the AHJ.

C. Wiring: Factory wire the control panels. Cable all panel wiring by securing to the panel surfaces with plastic cable ties. Permanently identify each wire at each termination by means of a heat shrink numbered sleeve. Number all wires as shown in the detailed drawings. Provide black wire color for ac wiring with white neutral and green ground from panel boards. Provide red wiring for 120 Vac control wiring and blue wiring for DC wiring. Minimum wire size shall be 14 gauge, Type MTW or THHN, 600 volt, stranded copper wire except where prefabricated wire harnesses are used (typically between the PLC I/O card and the I/O terminal wiring in the panel).

1. Where wiring crosses hinged surfaces, provide an 18-inch "U" shaped hinge loop of extra flexible wires secured at both ends. Provide ring-type lugs for all panel wiring; spade-type lugs are unacceptable. Use ratchet type crimping tools that do not release until proper crimp pressure has been applied.

D. Terminal Blocks: Terminal blocks shall be rated 600 volts for signals greater than 30 V and 300 volts for signals less than 30 V, and shall conform to requirements of NEMA Standard ICS 4. The terminal block and terminal lug shall be compatible. Provide disconnecting terminals for any circuit within the control panel that can be energized when the branch circuit feeding the control panel, if any, is off. All installed PLC I/O modules shall be wired to panel field terminal blocks. All field wiring shall terminate on field side of the panel field terminal blocks; wiring directly to PLC I/O modules is not permitted. Provide terminals for all external (field) connections and provide at a minimum, 25 percent spare terminals. Identify each terminal permanently with the numbering scheme shown on the drawings. Terminals shall be Phoenix Contact UK Series, AB 1794, or equal. Note: Alternate IEC wiring systems from Phoenix Contact for high density wiring terminations shall be called out as a substitution and shall require approval prior to procurement.

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E. Nameplates: Provide nameplates as shown on the Drawings, and as specified in Section 17010. A "CAUTION" nameplate shall be attached to the outside of access doors warning of foreign voltages inside the panel (see "Safety Requirements").

F. Finish:

1. After fabrication all external welds shall be ground smooth. The entire unit shall be thoroughly degreased, then filed and sanded. All carbon steel surfaces shall be given a rust-inhibiting treatment or passivator, then one coat of synthetic primer, followed by two coats of synthetic enamel. The average overall finish shall be at least 3 mils in thickness. All damage to the finish during installation shall be touched up at the jobsite as approved.
2. Exterior panel color shall complement adjacent panels and shall be approved by the Owner. Sharp angled horizontal front edges of panels shall be protected by brushed and coated stainless steel angled strip with concealed fasteners.

G. Size and Supports:

1. Panels shall be of sufficient size to adequately enclose all instruments designated as "panel-mounted" plus ample interior clearance to allow for installation, general servicing, and maintenance of the instruments. Weight of instruments shall be supported by Unistrut; Fameit; Caline; or equal, channel supports. Panel size shall be as indicated on the Drawings or as required to include any approved substituted equipment.
2. Provide rigid supports for all devices. Supports shall not cause warping or bowing sides or mounting plates.
3. Should any approved panel equipment substitutions require a larger cabinet than shown on the Drawings, no additional cost shall be incurred by the Owner.

H. Mounting:

1. Attachment methods shall be detailed on panel fabrication drawing submittals. Heavy panels shall be attached by anchor bolts to the concrete floor. Seismic restraints shall be installed as specified by the manufacturer.
2. Mounting pans of rigid sheet steel shall be provided for interior components and accessories as required. A steel divider shall separate pneumatic sections from electrical sections. Devices having both electric and pneumatic connections shall be in the pneumatic section and connected to the electric section with waterproof flexible conduit.

I. Arrangement:

1. The instruments mounted in the panels shall have the nominal size and general arrangement shown. Panel layouts and nameplates shall conform to the approved submittal.
2. Space shall be provided for instruments indicated as furnished by others to be mounted and wired by the control panel manufacturer. These units shall be shipped to the control panel manufacturer in sufficient time for wiring. Coordination of instrument delivery shall be the responsibility of the Contractor. The instruments and controls to be located on each panel are shown on the instrumentation drawings, electrical schematics, and/or in the individual Specification.

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- J. Ventilation shall be provided to prevent internal panel temperatures from exceeding 140°F.
1. Louvers shall be provided, when required for cooling, near the bottoms and tops on the rear doors and side of panels. 80-mesh screens shall cover the insides of louvers.
  2. Provide a thermostatically controlled fan in each enclosure when louvers cannot dissipate heat adequately or cause sufficient flow to all panel areas. Ventilation fans shall be low acoustic type suitable for control rooms. Provide removable cleanable or disposable dust filter for each remote site enclosure.
  3. Provide heaters and circulating fans in all outdoor panels to prevent condensation.
  4. Provide air control cooling system for panels requiring less than 1,500 Btu/hr heat dissipation.
  5. Provide air conditioning for IP-65/NEMA 4/4X panels requiring heat removal.
- K. Cable Entry Plates:
1. For top entry panels, a gasketed 10-gauge steel cover plate shall be cut that is suitable for the number of conduits. Cable entry plates are not required for bottom, side, or back conduit entry unless the Contractor must specifically control the position, size, and location of cutouts.
  2. Cable entry plates shall mount to and be fastened along panel stiffeners and framing segments. Tee nut fasteners are preferred.
- L. Signal Ground Buses:
1. Provide each panel with at least one isolated signal ground bus. Provide a bus 1-inch wide by 1/4-inch thick, running from top to bottom. Provide the bus with tapped holes to accommodate ground connections from various devices in the rack. Provide separate ground buses for analog and discrete/digital signals.
  2. Connect all signal shield grounds within the panel to the ground bus(es) with ring-tongue connectors that bolt to the bus(es).
- M. Signal Ground Plate: For rack, multiple enclosure, or bay systems provide a separate 1/4-inch-thick isolated copper system ground plate. Mount this plate in a location central to all system components.
- N. Panel Lights and Receptacles: Panels shall be internally lighted by fluorescent or LED lamps, provided with guards and a toggle switch located convenient to each access door. One duplex GFI type receptacle shall be provided in each panel section.
- ## 2.02 PANEL HARDWARE
- A. All doors shall be set flush with hardware required to meet the NEMA rating associated with the environment the panel will be installed in.
- B. Supply a minimum of two sets of keys. Doors shall be labeled with "AUTHORIZED PERSONNEL ONLY" in 1-inch letters.
- C. Hinges shall be piano type. All hardware and handles shall be stainless steel.
- D. Leveling adjustments on each panel section shall be provided on freestanding panels.
- E. Status lights, selector switches, and pushbuttons shall be as specified in Section 16955.
- F. Provide a copy of the As-Built elementary control diagram(s) and wiring schematics for the control panel, enclosed in plastic and mounted inside the panel.
- G. Where noted on the Drawings provide rack-out devices and access plates to make panel access easier and safer. Panel fabricators shall add full extension drawer guides and adjust width of front access plates to assure access to all components and hardware.
- I. Floor stand kits shall not exceed 24 inches in height nor cause the panel to exceed 84 inches in overall height.
- ## 2.03 CONTROL PANELS AND ELECTRONIC RACKS
- A. General:
1. Steel control panels shall be formed of cold-rolled sheet steel of sufficient thickness and with stiffening as required for fabrication, shipping, erection, and service.
  2. Panels shall be fully enclosed, including top, with no visible seams on the front. Panel front construction shall be minimum 3/16-inch stretcher-leveled, cold-rolled steel with stiffeners as necessary to maintain a flatness of  $\pm 1/16$ -inch of any 2-foot span and  $\pm 1/8$ -inch over any 8-foot span with all equipment installed. All other sections shall be 12 gauge except doors shall be minimum 14 gauge and shall maintain the same specified flatness when closed and latched. When shown on the Drawings, filler panels shall extend to the ceiling.
  3. Cabinets shall be freestanding with adequate internal bracing to support the weight of instruments and wiring. The cabinet design shall be for front access. Doors shall be key locked with a minimum of two sets of keys supplied. Connections to and from the cabinets shall be through conduit through the bottom except when otherwise indicated on the electrical drawings.
  4. Heavy-duty industrial quality racks shall be 19- or 24-inch panel. Framing shall be at least 14-gauge cold rolled steel, and continuously welded, rather than spot welded, at the seams of each intersecting joint.
- B. Finish: After fabrication, all external welds shall be ground smooth. The entire unit shall be thoroughly degreased, then filled and sanded. All carbon steel surfaces shall be given a rust-inhibiting treatment or passivator, then one coat of synthetic primer, followed by two coats of synthetic enamel. The average overall finish shall be at least 3 mils in thickness. All damage to the finish during installation shall be touched up at the job site as approved.
- C. Exterior panel color shall complement adjacent panels and shall be approved by the Owner. Sharp angled horizontal front edges of panels shall be protected by brushed and coated stainless steel angled strip with concealed fasteners.

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## 2.04 MANUFACTURER

- A. Manufacturer of the control panel enclosures shall be Hoffman Engineering Company; or approved equal.

## PART 3 - EXECUTION

### 3.01 INSTALLATION

- A. Installation, testing, calibration, validation, startup, and instruction shall be in accordance with Section 17010.
- B. Install each control panel level and plumb, and secure by the favorably reviewed seismic mounting method. Doors shall swing freely and close tightly.
- C. Provide a 3-inch-high concrete pad for each field-mounted, freestanding control panel. Provide a 3½-inch-high I-beam kick panel for each control-room mounted, freestanding panel.
- D. Carefully repair any damage to the structure, components or finish to the satisfaction of the Engineer. Clean all nameplates.
- E. Exercise care at all times after installation of control panels to keep out foreign matter, dust, dirt, debris, or moisture. Use protective sheet metal covers, canvas, heat lamps, etc., as needed to ensure equipment protection.
- F. For all metal panels mounted on concrete walls or floors, install 1/8-inch shims, and paint the back sides and bottom of the panels with Mobil Hi-Build Bituminous Coating 35-J-10; Koppers Bitumastic Super Tank Solution; or equal. Film thickness shall be 10-mils minimum.

END OF SECTION

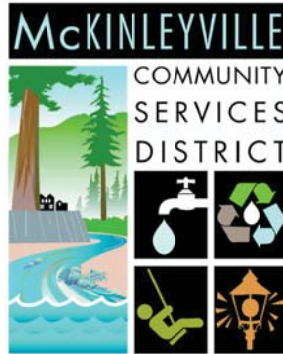
Panels

17510 - 8

McKinleyville Community Services District  
Wastewater Management Facility Improvements  
Bid Set  
1368004'00

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# McKINLEYVILLE COMMUNITY SERVICES DISTRICT WASTEWATER MANAGEMENT FACILITY IMPROVEMENTS



PREPARED FOR:  
**McKINLEYVILLE  
COMMUNITY  
SERVICES  
DISTRICT**

1656 SUTTER ROAD  
McKINLEYVILLE, CA 95519

MCSD CONTRACT NO. 2015-01

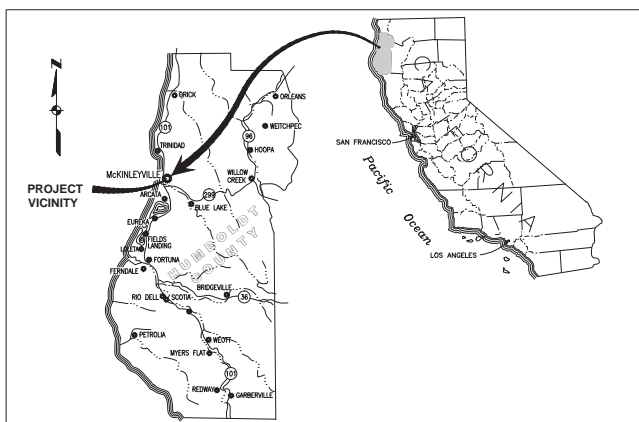
K/J PROJECT NO. 1368004

**FEBRUARY 2015**

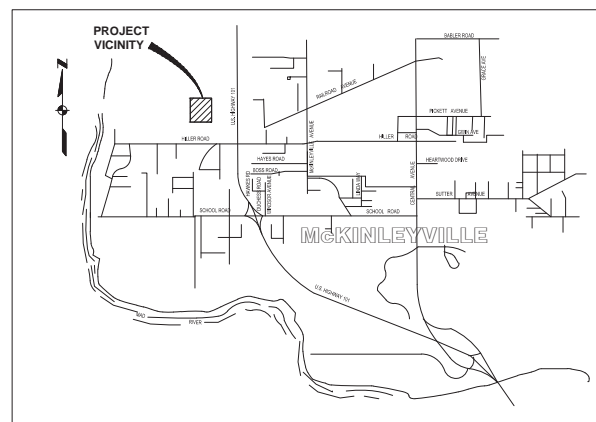
DRAWINGS

**Kennedy/Jenks Consultants**  
Engineers & Scientists

## CONTRACT DRAWINGS McKINLEYVILLE COMMUNITY SERVICES DISTRICT McKINLEYVILLE, CALIFORNIA WASTEWATER MANAGEMENT FACILITY IMPROVEMENTS



**REGION MAP**  
NO SCALE



**VICINITY MAP**  
NO SCALE

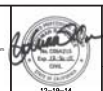
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NO.	REVISION	DATE	BY

### SCALES

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McKINLEYVILLE COMMUNITY SERVICES DISTRICT  
McKINLEYVILLE, CA  
**WASTEWATER MANAGEMENT FACILITY IMPROVEMENTS**  
Kennedy/Jenks Consultants  
SANTA ROSA, CALIFORNIA

**TITLE SHEET, REGION MAP AND VICINITY MAP**

FILE NAME  
1368004-0001  
JOB NO.  
1368004-00  
DATE  
DECEMBER 2014  
SHEET  
OF  
**G001**



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E431	BLOWER, ELECTRICAL, AND MAINTENANCE BUILDING POWER PLAN
E432	BLOWER, ELECTRICAL, AND MAINTENANCE BUILDING SIGNAL PLAN
E433	BLOWER, ELECTRICAL, AND MAINTENANCE BUILDING LIGHTING PLAN
E441	SECONDARY CLARIFIERS POWER AND SIGNAL PLAN
E831	TANK DRAIN AND SUPERNATANT PUMP STATION POWER AND SIGNAL PLAN
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0831	PROCESS AND INSTRUMENTATION TANK DRAIN & SUPERNATANT PUMPING
0832	PROCESS AND INSTRUMENTATION UTILITY WATER PUMPING
0833	PROCESS AND INSTRUMENTATION EJECTOR PUMPING

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McKENLEYVILLE, CA  
Kennedy/Jenks Consultants  
SANTA ROSA, CALIFORNIA

LIST OF SHEETS

FILE NAME  
1308004-0003  
JOB NO.  
1308004-00  
DATE  
DECEMBER 2014  
SHEET  
OF  
G002

NEW EQUIPMENT

FIRST TWO DIGITS REFER TO PROCESS AREA  
WHERE EQUIPMENT IS LOCATED. SEE LIST THIS SHEET

P-4512

SEQUENTIAL NUMBER OF EQUIPMENT IN PROCESS AREA

EXISTING EQUIPMENT

FUTURE EQUIPMENT

DRAWING AND PROCESS AREA DESIGNATION SYSTEMS

1. SHEETS ARE SUBDIVIDED BY DISCIPLINE AS FOLLOWS:  
G GENERAL  
C CIVIL  
S STRUCTURAL  
E ELECTRICAL  
I INSTRUMENTATION  
2. GENERAL AND STANDARD DETAIL SHEETS IN EACH DISCIPLINE ARE NUMBERED 1 TO 99. THE REMAINING SHEETS, AND EQUIPMENT, GENERALLY ARE NUMBERED IN ACCORDANCE WITH THEIR ASSOCIATED PROCESS AREA AS FOLLOWS:  
PROCESS AREA SHEET NUMBERS EQUIPMENT NUMBERS  
10 GENERAL PLANT 101 TO 199 1001 TO 1999  
20 PRETREATMENT 201 TO 299 2001 TO 2999  
30 PRIMARY TREATMENT 301 TO 399 3001 TO 3999  
40 SECONDARY TREATMENT 401 TO 499 4001 TO 4999  
50 TERTIARY TREATMENT 501 TO 599 5001 TO 5999  
60 DISINFECTION 601 TO 699 6001 TO 6999  
70 SOLIDS HANDLING 701 TO 799 7001 TO 7999  
80 PLANT UTILITIES 801 TO 899 8001 TO 8999

EQUIPMENT DESIGNATIONS

EQUIPMENT NUMBER PREFIXES

ABBREVIATIONS

ACU AIR CONDITIONING UNIT (SELF-CONTAINED)  
AD AIR DRIVER  
AF AIR FILTER (VENTILATION AND AIR CONDITIONING ONLY)  
AGT AGITATOR  
AHU AIR HANDLING UNIT (SELF-CONTAINED)  
ASC ADJUSTABLE SPEED CONTROLLER (ELECTRONIC)  
ASD ADJUSTABLE SPEED DRIVE (MECHANICAL)  
ATS AUTOMATIC TRANSFER SWITCH  
AV ANGLE VALVE  
BLO BLOWER  
BLR BOILER  
BP BACKFLOW PREVENTER  
BUV BUTTERFLY VALVE  
BV BALL VALVE  
CPR CHEMICAL FEEDER (CALCIUM HYDROXIDE, CHLORINATOR, SULFONATOR, ETC.)  
COL COLLECTOR  
COM COMBINATOR  
CON CONVEYOR (BELT, BUCKET, ELEVATOR, SCREW, ETC.)  
COP COMPACTOR (AIR, GAS, ETC.)  
CPU COMPUTER (SCREENINGS, ETC.)  
CRN CRANE (BARGE, JIB, ETC.), PLUS HOIST-ENTIRE PACKAGING  
CCK CHECK VALVE  
CYL CYLINDER (HYDRAULIC, PNEUMATIC, CHLORINE SUPPLY, ETC.)  
DA DEAERATOR  
DPC DIFFUSER FLOATING COVER  
DIS DISTRIBUTOR (ARMY TYPE, EJECTOR, EJECTOR, DIFFUSER, ETC.)  
DMP DAMPER  
DR DRIVE UNIT  
E ENGINE  
EB ENGINE-BLOWER MODULE  
EG ENGINE-GENERATOR MODULE  
FAN FAN  
FCU FAN COIL UNIT  
FCV FLOW CONTROL VALVE  
FOR FLOW CONTROL VALVE (HYDRAULIC, ETC.)  
FV FLOW CONTROL VALVE (NON SELF-ACTING)  
GV GLOBE VALVE  
GRN GRASSY BELT THICKENER  
GRD GRINDER  
GHT HEAT TREAT TAP  
GT GATE (BLUDE, SLIDE, FLAP, ETC.)  
GV GATE VALVE  
HEX HEAT EXCHANGER  
HND HANDHOSE (ELECTRICAL)  
HST HOST  
HOP HYDRAULIC OPERATOR  
HYR HEATER (BARGEHOSE, DUCT, ETC.)  
HT HEAT TREAT TAP  
INU INJECTOR (INDUCTOR)  
KVE TIME (K) CONTROLLED VALVE  
LEV LEVEL CONTROL VALVE  
LV LEVEL CONTROLLED VALVE (NON SELF-ACTING)  
LVR LOUVER  
MCC MOTOR CONTROL CENTER  
MH MANHOLE (ELECTRICAL)  
MME MISCELLANEOUS EQUIPMENT  
MOP MOTOR OPERATOR  
MTS MANUAL TRANSFER SWITCH  
MUX MULTIPLEXER  
MV MAG VALVE  
MIX MIXER  
ORT ORTOR REDUCTION TOWER  
P PUMP  
PBX PULL BOX (ELECTRICAL)  
PBD PANELBOARD  
PCHV PNEUMATIC CONTROL VALVE (SELF-ACTING)  
PCV PRESSURE CONTROL VALVE (NON SELF-ACTING)  
PCVY PNEUMATIC DIFFERENTIAL CONTROL VALVE  
PEJ PNEUMATIC EJECTOR  
PIL PROGRAMMABLE LOGIC CONTROLLER  
PML PANEL, CONTROL, PULSE, CABINET, CONSOLE, ETC.)  
POP PNEUMATIC OPERATOR  
PRV PRESSURE CONTROLLED VALVE (NON SELF-ACTING)  
PSV PRESSURE SAFETY VALVE (VACUUM OR PRESSURE RELIEF)  
PV PLUG VALVE  
PVL PRESSURE VESSEL (AIR RECEIVER, ETC.)  
SCW SWITCHBOARD (ELECTRICAL)  
SC SPEED CONTROLLER  
SCL SCALE  
SCN SCREEN BAY (ROTARY, ETC.)  
SEP SEPARATOR (SEDIMENTATION TRAP, DIMP TRAP, CYCLONE, STRAINER, ETC.)  
SLR SLURRY  
SMV SAMPLER  
STP SOUND TRAP  
SV SOLENOID VALVE  
SWG SWITCHGEAR  
T TANK (NONPRESSURIZED TYPE, IDEOSTER, STORAGE, ETC.)  
TBX TERMINAL BOX, BOARD, OR CABINET (ELECTRICAL, INSTRUMENTATION, TELEPHONE)  
TEL TELEPHONE EQUIPMENT  
TFR TRANSFORMER  
TSV TELESCOPIQUE VALVE  
UH UNIT HEATER  
US ULTRASONIC  
VIB VIBRATOR  
VHR WASHER (GRIT, ETC.)  
YV EVENT (Y) CONTROLLED VALVE (NON SELF-ACTING)  
A AND  
AT AT  
BY BY  
C CENTERLINE  
I CHANNEL  
D DIAMETER  
# NUMBER  
F PROPERTY LINE  
S SQUARE  
Z STRUCTURAL ANGLE  
AB ANCHOR BOLT  
AC AC  
AD ADJUSTABLE  
ADJ ADJUSTABLE  
AHU AIR HANDLING UNIT  
ANCH ANCHOR  
AL ALUMINUM  
APPROX APPROXIMATE  
APWA AMERICAN PUBLIC WORKS ASSOCIATION  
ARCH ARCHITECTURAL  
ARV AIR RELIEF VALVE (E), EXIST  
ASTM AMERICAN SOCIETY FOR TESTING AND MATERIALS  
ATS AUTOMATIC TRANSFER SWITCH  
AVERAGE AVERAGE  
AVR AMERICAN WATER WORKS ASSOCIATION  
B BEGINNING OF CURVE  
BOR BUILDING DRAIN  
BFL BLIND FLANGE  
BFP BACKFLOW PREVENTER  
BFV BUTTERFLY VALVE  
BLDG BUILDING  
BM BENCH MARK  
BO BLOWOFF  
BOD BIOLOGICAL OXYGEN DEMAND  
BOS BOTTOM OF STEEL  
BOT BOTTOM  
BR BRICK  
BS BALL BECKET  
BSS BALL AND SOCKET  
CAH CALCIUM HYDROXIDE  
GAS GALVANIZED  
CB GUTTER  
CBOD BIOCHEMICAL OXYGEN DEMAND  
C CENTER TO CENTER  
COP CONCRETE COLLINDER PIPE  
COWR CLOSED-LOOP COOLING WATER RETURN  
COWS CLOSED-LOOP COOLING WATER SUPPLY  
CHWR CHECKED  
CHWR CHECKED  
GATE GATE VALVE  
CI CAST IN PLACE  
CON CONSTRUCTION JOINT  
CL PIPE CLASH, CENTERLINE  
CLZ CHLORINE  
CLR CLEAR CLEARANCE  
CM CENTIMETER  
CMU CONCRETE MASONRY UNIT  
CMP CORRUGATED METAL PIPE  
CO COMPANY, CLEAN OUT  
COL COLOR  
COLR COLOR  
CONC CONCRETE  
CONSTR CONSTRUCTION  
CONT CONTINUOUS  
CPL COUPLING  
CPR CORRUGATED PLASTIC PIPE  
CPVC CHLORINATED POLYVINYL CHLORIDE  
CSTC CORRUGATED SURFACE TOP COUSING  
CT CERAMIC TILE  
CUPR COPPER, CUPR  
CUT CITY WATER  
D DEPTH  
DET DETAIL  
DF DIESEL FUEL  
DI DUCTILE IRON  
DA DIAMETER  
DP DUCTILE IRON PIPE  
DN DOWN  
DR DRAIN  
DWS DESIGN WATER SURFACE  
E ELECTRIC, EAST  
EA EACH  
EC END OF CURVE  
EF EACH FACE  
F FISH  
FG FINISH GRADE  
FH FINISH  
FL FLOW LINE  
FLX FLEXIBLE  
NORTH NORTH  
NC NORMALLY CLOSED  
NE NORTHWEST  
NOV NO  
NG NATURAL GAS  
NLS NOT IN CONTRACT  
NLC NOT IN CONTRACT  
NO NUMBER  
NO NORMALLY OPEN  
NON NON  
NONP NONPOTABLE WATER  
NRS NON-RISING STEM  
NST NATIONAL STANDARD THREAD  
NTS NOT TO SCALE  
NA NOT APPLICABLE  
G GAS  
GU GALVANIZED IRON  
GAL GALVANIZED STEEL  
GAL GALD  
GALLON  
OPER OPERATOR  
OPNG OPENING  
OPNG OPENING  
OSBY OVERSIZED SCREEN & YOKE  
OSA OUTSIDE AIR  
P PRESSURE SENSOR  
PE PLAN END, POLYETHYLENE  
PERM PERIMETER  
PH HYDROGEN ON  
PI PLASTIC IRRIGATION PIPE  
PK POINT KNOWN  
PL PLATE  
POC POINT OF CONNECTION  
PP POWER LOSS  
PPM POUNDS PER DAY  
PRESS PRESSURE  
PRV PRESSURE REDUCING VALVE  
PS PUMP STATION  
PSI POUNDS PER SQUARE INCH  
PSF POUNDS PER SQUARE FOOT  
PSS PRESSURIZED SANITARY SEWER  
PVC POLYVINYL CHLORIDE  
PAV PAVEMENT  
PVI POINT OF VERTICAL INTERSECTION  
R RADIUS  
RAS RETURN ACTIVATED SLUDGE  
RJ REINFORCED CONCRETE PIPE  
RD ROAD  
RECIRC RECIRCULATION  
RED REDUCER  
REF REFERENCE  
REG REGULATOR  
RENF REINFORCED, REINFORCED  
REQ REQUIRED  
RF RETURN FLOW  
RM RESTRAINED JOINT  
RPM REVOLUTIONS PER MINUTE  
RW RIGHT OF WAY  
RS RAPID INFILTRATION BASIN  
RBY RAY BEVERAGE  
S SEWER, SOUTH, SLOPE, SUBMERGED  
SA SAMPLE  
SE SOUTHEAST, SECONDARY EFFLUENT  
SEW SOUTHWEST  
SCN SANITARY SEWER  
SCFM STANDARD CUBIC FEET PER MINUTE  
SCH SCHEDULE  
SDR STANDARD DIMENSION RATIO  
SEC SECOND  
SEPTIC SEPTIC  
SEW SEWER  
SFT SQUARE FEET  
SHT SHEET  
SMH SANITARY SEWER MANHOLE  
SM SPACE, START POINT  
SPEC SPECIFICATIONS  
SQ SQUARE  
STA STATION  
STL STEEL  
STORM SD STORM DRAIN  
STD STANDARD  
STRUCT STRUCTURAL  
T THERMOSTAT  
TA TOP OF ASPHALT  
TBM TEMPORARY BENCH MARK  
TC TOP OF CONCRETE, TOP OF CURB  
TDB TOTAL DYNAMIC HEAD  
TEL TELEPHONE  
TBT TOP AND BOTTOM  
TSE TOP OF GRATING ELEVATION  
TN TOTAL, NITROGEN  
TNIN TOP OF CONCRETE  
TOP OF STEEL  
TOT TOP OF WALL  
TSS TOTAL SUSPENDED SOLIDS  
TURB TURBIDITY  
TYP TYPICAL  
UN LESS NOTED OTHERWISE  
UW UNDERGROUND (NONPOTABLE WATER)  
VAR VARIATION  
VF VERIFY IN FIELD  
VTR, V.T.R. VENT TO ROOF  
VERT VERTICAL  
W WEST, WATER, WIDTH  
WAS WATER ACTIVATED SLUDGE  
WTH WITH  
WO WITHOUT  
WM WATER METER  
WMF WATER RECLAMATION FACILITY  
WSP WATER SURFACE  
WTP WATER TREATMENT PLANT  
WTRB WATER TREATMENT  
WWTW WASTEWATER TREATMENT PLANT  
YD YARD

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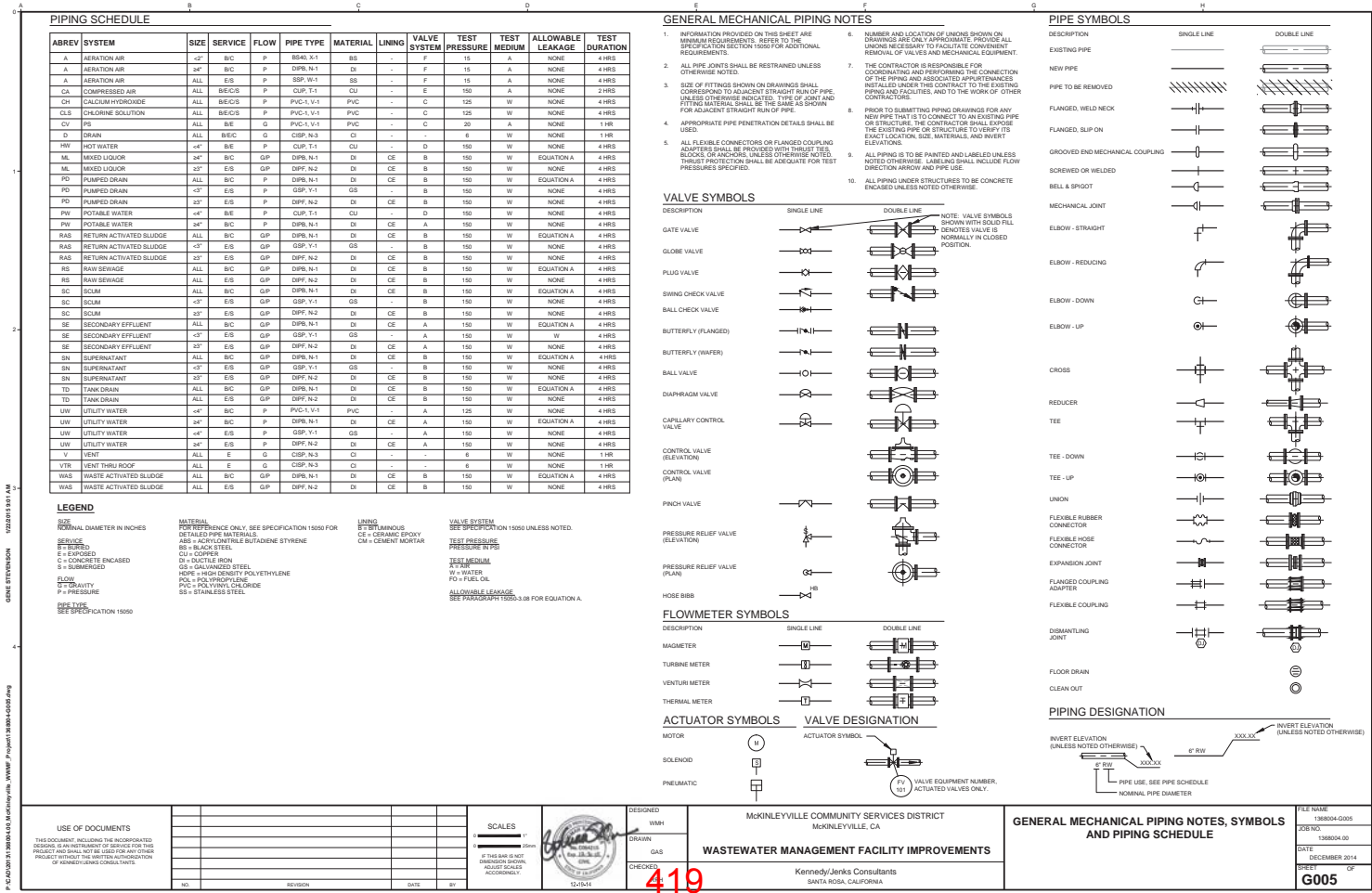
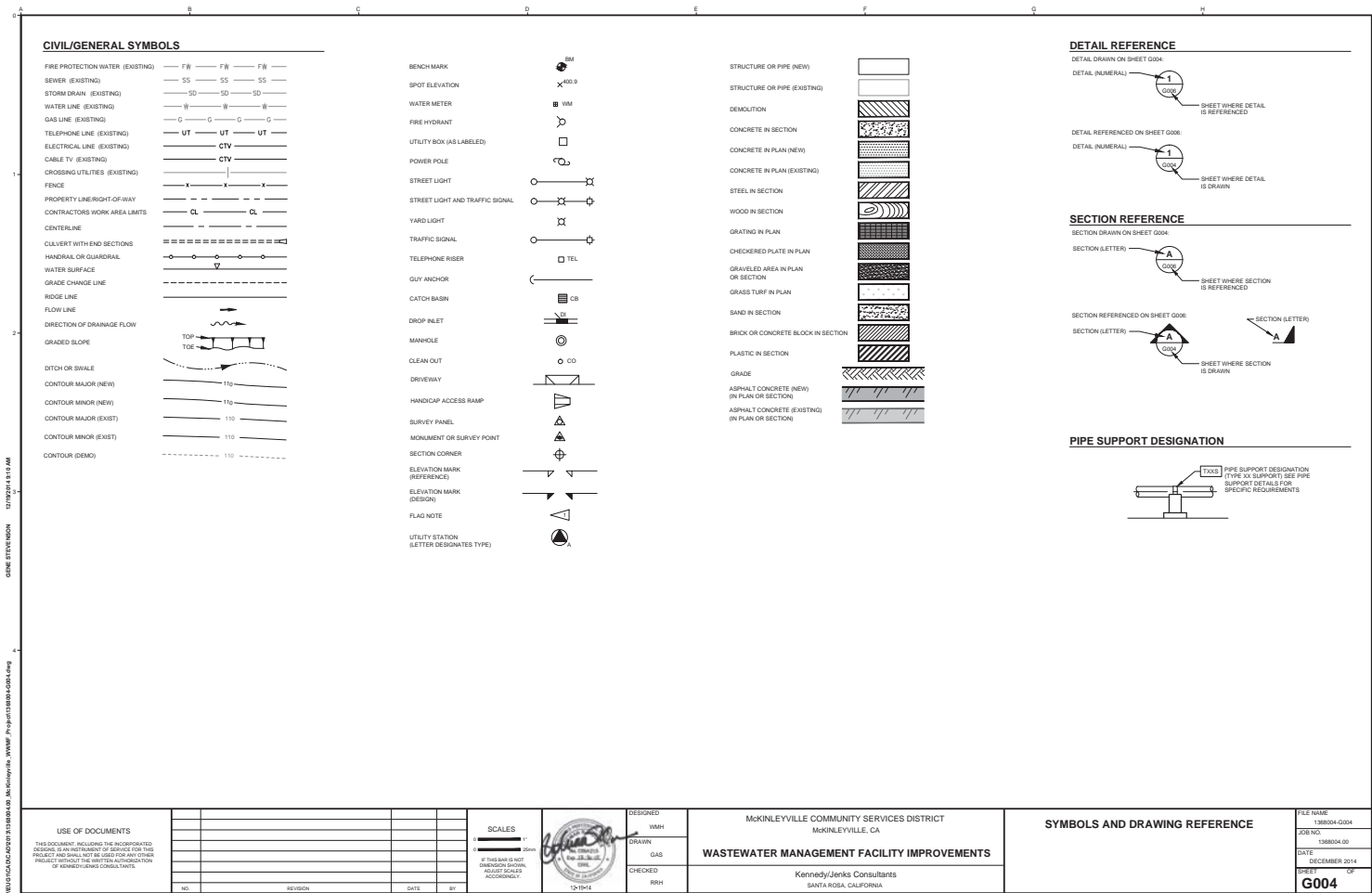
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McKENLEYVILLE, CA  
Kennedy/Jenks Consultants  
SANTA ROSA, CALIFORNIA

DESIGNATION SYSTEMS AND ABBREVIATIONS

FILE NAME  
1308004-0003  
JOB NO.  
1308004-00  
DATE  
DECEMBER 2014  
SHEET  
OF  
G003





WASTEWATER FLOW AND LOAD PROJECTIONS			EFFLUENT QUALITY LIMITS (NOTE 1)			DESIGN DATA			DESIGN DATA (CONT'D)			DESIGN DATA (CONT'D)		
ITEM	CURRENT VALUE	YEAR 2030	ITEM	VALUE		ITEM DESCRIPTION	VALUE		ITEM DESCRIPTION	VALUE		ITEM DESCRIPTION	VALUE	
POPULATION	14,500	19,415	CROD LIMITS			HILLER ROAD LIFT STATION PUMPS (EXISTING)	SELF PRIMING, NON-CLOG		SECONDARY TREATMENT CONTINUED			POLISHING PONDS AND WETLANDS		
FLOWS			MONTHLY AVERAGE, MG/L	30		TYPE			SECONDARY EFFLUENT PUMPS			POLISHING PONDS (EXISTING)		
AVERAGE DRY WEATHER FLOW (ADWF), MGD	1.02	1.37	WEEKLY AVERAGE, MG/L	45		NO. OF PUMPS	2		TYPE	VERTICAL TURBINE		TYPE	EARTHEN	
AVERAGE ANNUAL FLOW (AAF), MGD	1.17	1.53	MONTHLY AVERAGE, MG/L	30		DRIVE TYPE	CONSTANT SPEED		NO. OF PUMPS	2		NUMBER		
AVERAGE WET WEATHER FLOW (AWWF), MGD	1.29	1.69	WEEKLY AVERAGE, MG/L	45		STATION FIRM CAPACITY, GPM	896		DRIVE TYPE	ADJUSTABLE FREQUENCY DRIVE		VOLUME, MG		
MAX MONTH DRY WEATHER FLOW (DMDF), MGD	1.02	1.60	TOTAL COLIFORM	23		PUMP HP, EACH	20		PUMP CAPACITY, EACH, GPM	1,079		POLISHING POND 1	14.1	
MAX MONTH WET WEATHER FLOW (WMDF), MGD	1.40	2.13	MONTHLY MEDIAN, ORGANISMS PER 100 ML	23		LEVEL CONTROL	TRANS-DUCER		PUMP HP, EA	15		POLISHING POND 2	6.1	
PEAK DAY FLOW (PDF), MGD	2.26	3.08	SINGLE SAMPLE LIMIT, ORGANISMS PER 100 ML	240		TYPE			RAS PUMPS			POLISHING POND 3	4.7	
PEAK INSTANTANEOUS FLOW (PIF), MGD	2.88	3.77	PH RANGE (MINIMUM TO MAXIMUM)	6.5-8.5		TYPE			NO. OF PUMPS	4		POLISHING WETLANDS (EXISTING)		
LOADS (BASED ON AAF)			TOTAL CHLORINE RESIDUAL	0.01		TYPE	CENTRIFUGAL, NON-CLOG		DRIVE TYPE	ADJUSTABLE FREQUENCY DRIVE		TYPE	EARTHEN	
CBOD			MONTHLY AVERAGE, MG/L	0.02		NO. OF PUMPS	4		PUMP CAPACITY, EACH, GPM	275 TO 580		NUMBER	3	
AVERAGE, PPD	2,442	3,191	DAILY MAXIMUM, MG/L	0.02		STATION FIRM CAPACITY, MGD	1,014		PUMP HP, EACH	2		SURFACE AREA, ACRES		
MAXIMUM MONTH, PPD	5,499	4,569	TOTAL NITROGEN			PUMP HP	2500 TO 100		WAS PUMP			POLISHING WETLAND POND 4	2.1	
PEAK DAY, PPD	4,726	5,168	NITRATE-NITROGEN, MONTHLY AVERAGE, MG/L	10		LEVEL CONTROL	TRANS-DUCER		TYPE	ROTARY LOBE		POLISHING WETLAND POND 5	3.3	
TSS			AMMONIA-NITROGEN, MONTHLY AVERAGE, MG/L	<1		STAND-BY GENERATOR			NO. OF PUMPS	2		WETLAND POND 4 PUMPS (EXISTING)		
AVERAGE, PPD	2,196	2,807				TYPE	DIESEL ENGINE		DRIVE TYPE	ADJUSTABLE FREQUENCY DRIVE		TYPE	VERTICAL TURBINE	
MAXIMUM MONTH, PPD	4,234	5,964				OUTPUT, KW	500		PUMP CAPACITY, EACH, GPM	20 TO 100		NUMBER	2	
PEAK DAY, PPD	5,800	7,260				FUEL TANK CAPACITY, GAL	1,300		PUMP HP, EACH	7.5		DRIVE TYPE	ADJUSTABLE FREQUENCY DRIVE	
TN						FUEL TANK CAPACITY, RUN TIME, HRS	48		SCUM PUMP			PUMP CAPACITY, GPM	2,000	
AVERAGE, PPD	460	587				TRANSFER SWITCH	AUTOMATIC		TYPE	SUBMERSIBLE, NON-CLOG		PUMP HP, EACH	1	
MAXIMUM MONTH, PPD	470	625				HEADWORKS			DRIVE TYPE	CONSTANT SPEED		LEVEL CONTROL		
PEAK DAY, PPD	507	654				MECHANICAL SCREEN			PUMP CAPACITY, EACH, GPM	125		BIOSOLIDS STORAGE BASIN (BSB)		
AMMONIA-NITROGEN						TYPE	PERFORATED PLATE		PUMP HP, EACH	5		WAS PUMPED TO BSB		
AVERAGE, PPD	348	455				NO. OF SCREENS	1		DISINFECTION			AVERAGE WAS SOLIDS, PPD	1,340	
MAXIMUM MONTH, PPD	507	642				OPENING, INCHES	0.25		CHLORINE CONTACT BASINS (EXISTING)			VOLATILE SUSPENDED SOLIDS, PPD	1,380	
PEAK DAY, PPD	519	667				SCREEN CAPACITY, MGD	3.77		NUMBER	2		BIOSOLIDS STORAGE BASIN		
AKALINITY						SCREEN HP, EACH	1		LENGTH TO WIDTH RATIO			NUMBER		
MINIMUM DAY, MG/L	150	180				MANUAL SCREEN			COB 1 AND COB 2 IN SERIES	185		LOADING RATE REQUIRED, PPD VS50/100 SF		
MINIMUM MONTH, MG/L	220	220				TYPE	BAR		COB 2	80		SURFACE AREA	29	
AVERAGE ANNUAL, MG/L	273	273				OPENING, INCHES	0.75		WATER DEPTH, FT	6.5		SURFACE AREA PROVIDED, SF	63,050	
MAXIMUM MONTH, MG/L	310	310				SCREEN CAPACITY, MGD	3.77		VOLUME, TOTAL, GAL	133,648		WATER CAP DEPTH, FT	194,340	
PEAK DAY, MG/L	340	340				SECONDARY TREATMENT			COB 1	51,804		WATER CAP VOLUME, MG	2.25	
AKALINITY TO TON RATIO (MG/L TO MG/L)	4.7	4.7				ASBATION BASINS			COB 2	8,024		SLUDGE BLANKET DEPTH, MAXIMUM, FT	3	
AVERAGE ANNUAL	5.0	5.0				TYPE	EARTHEN, LINED		DETENTION TIME, MIN (YEAR 2030 FLOWS)			SLUDGE BLANKET VOLUME, MAXIMUM, MG	5.68	
						NO. OF BASINS, TOTAL	2		WITH COB 2 ONLY IN SERVICE	33		TOTAL LIQUOR VOLUME, MG	7.90	
						VOLUME, EACH, MG	1.6		PEAK DAY FLOW (PDF)	33		BLANKET, PERCENT	6	
						SIDE WATER DEPTH, FT	13.8		AVERAGE DRY WEATHER FLOW (ADWF)	30.1		MAXIMUM SOLIDS STORAGE CAPACITY OF BSB, DRY LBS	3,763,768	
						MIXED LIQUOR SUSPENDED SOLIDS, MG/L	5,000		PEAK INSTANTANEOUS FLOW (PIF)	138		SOLIDS IN STORAGE, PPD	1,488	
						SOLIDS RETENTION TIME, DAYS (NOTE 2)	40		WITH COB 1 AND COB 2 IN SERVICE	41		LIQUOR TYPE	80 ml H2O2	
						HYDRAULIC RETENTION TIME, DAYS (NOTE 2)	1.5		AVERAGE DRY WEATHER FLOW (ADWF)	30.1		BSB STORAGE AVAILABLE	6.5	
						PIR RATIO	0.06		PEAK DAY FLOW (PDF)	33		DAYS	2,530	
						BLOWERS			PEAK INSTANTANEOUS FLOW (PIF)	138		YEARS	6.5	
						TYPE	VARIABLE SPEED HIGH SPEED TURBO		CHLORINATORS (EXISTING)	2		SOLIDS MINERAL USE	273	
						NO. OF BLOWERS	3		CAPACITY, PPD	18,200, 18,400		ANNUAL SOLIDS PRODUCTION, DRY TONS/YEAR		
						BLOWER CAPACITY, EACH, SCFM	1,790		SULFONATION (EXISTING)	1				
						MINIMUM AIR FLOW OUTPUT, EACH, SCFM	850		NUMBER	1				
						MAXIMUM DISCHARGE PRESSURE, PSIG	2.5		CAPACITY, PPD	200				
						BLOWER HP, EACH	100							
						CALCIUM HYDROXIDE (ALKALINITY ADDITION)								
						NO. OF TOTES	4							
						VOLUME, EACH, GAL	300							
						CONCENTRATION, PERCENT	45							
						MAXIMUM MONTHLY USE, GPM	47							
						NO. OF FEED PUMPS	2							
						FEED PUMP TYPE	PERISTALTIC							
						SECONDARY CLARIFIERS								
						NO. OF CLARIFIERS	2							
						DIAMETER, FT	50							
						SIDE WATER DEPTH, FT	16							
						SURFACE AREA, EACH, SQ FT	1,262							
						PEAK DAY OVERFLOW RATE, GPD/SQ FT	794							
						PEAK INSTANTANEOUS OVERFLOW RATE, GPD/SQ FT	858							
						PEAK SOLIDS LOADING RATE, PPD/SQ	30							
						RECHARGE HP, EACH	6.5							

