SECTION 16000

ELECTRICAL SPECIFICATIONS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. The work includes furnishing all materials, labor and equipment to install complete electrical system as shown on the Drawings and specified herein.

1.2 GENERAL

A. The Drawings are diagrammatic and do not show every detail of construction. The Contractor is expected to thoroughly review the plans and the requirements of the systems and provide all items necessary for a complete and operational system in conformance with the plans, diagrams and intended usage, subject to the acceptance of the Engineer.

B. Contractor shall pay for and obtain all necessary permits, deposits, licenses, and inspections. Confirm prices prior to bidding. Utility fees to bring three phase primary power to the site will be paid by the owner.

C. Coordinate prior to bidding, electrical equipment items that are to be furnished by others, but installed by the electrical contractor, and items to be furnished and installed by others, but connected by the electrical contractor. Including but not limited to: control wiring, telecommunications equipment, equipment options necessary for PLC communications, starters, starter aux contacts, pump motors, disconnects, thermostats, float switches, pressure switches, solenoids, flowmeters, equipment racks, trenches, rubbish removal, etc.

B. The electrical installations shall conform to the requirements of the latest edition of the National Electric Code (NEC), Life Safety Code, Energy Code, local codes and regulations, and the power company having jurisdiction.

C. For any conflict in the drawings and/or specifications and/or codes, and/or referenced documents, the more stringent requirement shall apply. Any such conflict shall be brought to the attention of the engineer for resolution prior to the work.

D. All materials and devices shall be new and display the UL approval where applicable.

1.3 SHOP AND SETTING DRAWINGS

A. Before commencing any work or providing any materials, the Contractor shall submit for acceptance by the Engineer, shop drawings as required by these Specifications.

B. Each drawing or cut shall be property identified as required.

C. Shop drawings shall indicate complete physical characteristics, dimensions, manufacturer's ratings and any other data necessary to determine the suitability of the equipment for the use intended.

D. Where equipment other than that shown on the Drawings and specifically mentioned in the Specifications is to be furnished in lieu of that mentioned, the Contractor shall submit with shop drawings of the equipment showing disposition of the equipment and any changes or work required to properly install the equipment furnished in accordance with SECTION 01340.

1.4 ELECTRICAL SYSTEM STUDIES

A. Fault coordination study showing circuit breaker characteristics for short circuit and for ground faults.

B. IEEE 519 harmonics protection study to show that voltage and current harmonics at the service entrance point of common coupling will meet IEEE 519 requirements.

C. IEEE 519 harmonics study to show that voltage and current harmonics at each VFD will not adversely affect power factor correction capacitors that are provided on other equipment.

D. Submit Reports:
Protective coordination study.
Harmonics protection study.

1.5 SERVICE WORK

A. Coordinate work with the Utility Company. Contact the utility company for power availability, construction schedule, and service equipment requirements. The new 3 phase primary power extension costs to the Lostine site shall be paid by the owner. **Prior to bidding**, contact the utility company to find out exactly what material and services will be provided by the utility company and which materials are to be provided by the Contractor, and the costs. The contractor shall be responsible for all power costs during the construction period up to the time of final acceptance. Single phase power is available near the Lostine site. Utility power is NOT available at Imnaha.

1.6 SITE WORK

A. Prior to bid, the Contractor is expected to thoroughly inspect the site for existing conditions that could affect trenching, dewatering and shoring of trenches.

B. Locate all buried utilities prior to excavation. All inspection fees and all cost associated with repair of damaged utilities shall be the responsibility of the Contractor.

1.7 PROJECT CONDITIONS

A. Existing Conditions

If the existing conditions prohibit proper installation or installation as shown on the drawings, Contractor shall contact the Engineer for a solution.

B. Protection, insurance

Contractor shall protect all electrical items and shall replace items which are damaged or stolen or vandalized during construction.

C. All expenses incurred by the Owner in trouble shooting systems and problems caused by inadequate workmanship or unauthorized deviations from the contract documents including materials or equipment substitutions on the part of a contractor shall be borne by Contractor.

1.10 WARRANTY

A. The Contractor shall furnish a written certificate guaranteeing materials, equipment and labor furnished to be free of defects for a period of one (1) year from the date of final acceptance of the work by the Engineer, and further agrees that if defects appear within stipulated guarantee period, same shall be replaced or made good without charge.

B. Where inspections of the work are required by State or Local authorities, obtain certificates if inspection of the work by such authorities, and these certificates (in triplicate) shall be submitted to the owner.

1.12 GUARANTEE

A. In entering into a contract covering this work, the contractor accepts the specifications and guarantees that the work will be carried out in accordance with the requirements of this specification or such modifications as may be made under the contract documents.

B. Contractor further guarantees that the material will be of the best procurable and that none but experienced workman familiar with each particular class of work will be employed.

C. Contractor further guarantees to replace and make good at his own expense any defects which may develop within one (1) year after final payment and acceptance by the Engineer, due to faulty workmanship or material, upon receipt of written notification from Engineer.

1.13 PERMITS AND FEES

A. Each Contractor shall obtain and pay for all permits, deposits, fees, inspections, service installations, etc., required by municipalities, etc., for his respective part of the work.

B. Where inspections of the work are required by local or state authorities, notify same at appropriate times for inspections. Obtain certificates of inspection by such authorities and submit same (in triplicate) before final certificate for payment is issued.

PART 2 EXECUTION

2.1 INSTALLATION

A. Cooperate with other entities engaged in or working near the project. Execute work in a manner not to interfere with other contractors or other activities.

B. Coordinate work with other contractors regarding location of equipment so there is no interference between installation or progress of any contractor.

C. At project completion, remove all marks, stains, droppings, shipping labels, and other foreign matter from all finished items. Clean all equipment and surfaces to the original finish, or to condition acceptable for occupancy to the Engineer. Turn over keys and equipment manuals to the owner.

END OF SECTION

SECTION 16010
ELECTRICAL: BASIC REQUIREMENTS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Basic requirements for electrical systems.

B. Related Sections include but are not necessarily limited to:
   1. Division 1 - General Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Aluminum Association, Inc. (AA):
      a. 1, Aluminum Standards and Data.
   2. American Iron and Steel Institute (AISI).
   3. American National Standards Institute (ANSI):
      a. C2, National Electrical Safety Code.
   4. ASTM International (ASTM):
      a. A123, Standard Specification for Zinc Coating (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
      b. A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   5. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
   6. Underwriters Laboratories, Inc. (UL).

B. Where Underwriters Laboratories, Inc. (UL) test procedures have been established for the product type, use UL or ETL Testing Laboratories (ETL) approved electrical equipment and provide with the UL or ETL label.

1.3 DEFINITIONS

A. For the purposes of providing materials and installing electrical work the following definitions shall be used.
   1. Outdoor area: Exterior locations where the equipment is normally exposed to the weather and including below grade structures, such as vaults, manholes, handholes and in-ground pump stations.
   2. Architecturally finished interior area: Offices, laboratories, conference rooms, restrooms, corridors and other similar occupied spaces.
   3. Non-architecturally finished interior area: Pump, chemical, mechanical, electrical rooms and other similar process type rooms.

4. Highly corrosive and corrosive area: Areas identified on the Drawings where there is a varying degree of spillage or splashing of corrosive materials such as water, wastewater or chemical solutions; or chronic exposure to corrosive, caustic or acidic agents, chemicals, chemical fumes or chemical mixtures.
5. Hazardous areas: Class I, II or III areas as defined in NFPA 70 (NEC).
6. Shop fabricated: Manufactured or assembled equipment for which a UL test procedure has not been established.

1.4 SUBMITTALS

A. Shop Drawings:
   1. See Section 01340 for requirements for the mechanics and administration of submittal process.
   2. See individual specification sections for submittal requirements for products defined as equipment.
   3. General requirements:
      a. Provide manufacturer's technical information on products to be used, including product descriptive bulletin.
      b. Include data sheets that include manufacturer's name and product model number.
         1) Clearly identify all optional accessories.
      c. Acknowledgement that products are UL or ETL listed or are constructed utilizing UL or ETL recognized components.
      d. Manufacturer's delivery, storage, handling and installation instructions.
      e. Product installation details.
      f. See individual specification sections for any additional requirements.

B. Operation and Maintenance Manuals:
   1. See Section 01340 for requirements for:
      a. The mechanics and administration of the submittal process.
      b. The content process of Operation and Maintenance Manuals.

C. When a Specification Section includes products specified in another Specification Section, each Section shall have the required Shop Drawing transmittal form per Section 01340 and all Sections shall be submitted simultaneously.

1.5 DELIVERY, STORAGE, AND HANDLING

A. See Section 01600.

B. Protect nameplates on electrical equipment to prevent defacing.

1.6 AREA DESIGNATIONS

A. Designation of an area will determine the NEMA rating of the electrical equipment enclosures, types of conduits and installation methods to be used in that area.
   1. Outdoor areas:
      a. Wet.

b. Also, corrosive and/or hazardous when specifically designated on the Drawings or in the Specifications.

2. Indoor areas:
   a. Dry.
   b. Also, wet, corrosive and/or hazardous when specifically designated on the Drawings or in the Specifications.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Refer to specific Division 16 sections and specific material paragraphs below.

B. Provide all components of a similar type by one manufacturer.

2.2 MATERIALS

A. The following metals are toxic to fish, and shall not contact fish water:
   1. copper
   2. brass
   3. bronze
   4. cadmium
   5. lead
   6. zinc

B. Electrical Equipment Support Pedestals and/or Racks:
   1. Approved manufacturers:
      a. Modular strut:
         1) Unistrut Building Systems.
         2) B-Line.
         3) Globe Strut.
   2. Material requirements:
      a. Modular strut:
         1) Galvanized steel: ASTM A123 or ASTM A153.
         2) Stainless steel: AISI Type 316.
         3) PVC coated galvanized steel: ASTM A123 or ASTM A153 and 20 mil PVC coating.
      b. Mounting hardware:
         1) Galvanized steel.
         2) Stainless steel.

C. Field touch-up of galvanized surfaces.
   1. Zinc-rich primer.
      a. One coat, 3.0 mils, ZRC by ZRC Products.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install and wire all equipment, including prepurchased equipment, and perform all tests necessary to assure conformance to the Drawings and Specifications and ensure that equipment is ready and safe for energization.

B. Install equipment in accordance with the requirements of:
   1. NFPA 70 (NEC).
   2. ANSI C2.
   3. The manufacturer's instructions.

C. In general, conduit routing is not shown on the Drawings.
   1. The Contractor is responsible for routing all conduits including those shown on one-line and control block diagrams and home runs shown on floor plans.
   2. Conduit routings and stub-up locations that are shown are approximate; exact routing to be as required for equipment furnished and field conditions.

D. When complete branch circuiting is not shown on the Drawings:
   1. A homerun indicating panelboard name and circuit number will be shown and the circuit number will be shown adjacent to the additional devices (e.g., light fixture and receptacles) on the same circuit.
   2. The Contractor is to furnish and install all conduit and conductors required for proper operation of the circuit.
   3. The indicated home run conduit and conductor size shall be used for the entire branch circuit.

E. Do not use equipment that exceed dimensions or reduce clearances indicated on the Drawings or as required by the NFPA 70 (NEC).

F. Install equipment plumb, square and true with construction features and securely fastened.

G. Install electrical equipment, including pull and junction boxes, minimum of 6 IN from process, air and water piping and equipment.

H. Install equipment so it is readily accessible for operation and maintenance, is not blocked or concealed and does not interfere with normal operating and maintenance requirements of other equipment.

I. Device Mounting Schedule:
   1. Unless indicated otherwise on the Drawings, mounting heights are as indicated below:
      a. Light switch (to center): 48 IN.
      b. Receptacle in architecturally finished areas (to center): 18 IN.
      c. Receptacle on exterior wall of building (to center): 18 IN.
      d. Receptacle in non-architecturally finished areas (to center): 48 IN.
      e. Telephone outlet in architecturally finished areas (to center): 18 IN.
      f. Telephone outlet for wall-mounted phone (to center): 54 IN.
      g. Safety switch (to center of operating handle): 54 IN.
      h. Separately mounted motor starter (to center of operating handle): 54 IN.
      i. Pushbutton or selector switch control station (to center): 48 IN.
      j. Panelboard (to top): 72 IN.

J. Avoid interference of electrical equipment operation and maintenance with structural members, building features and equipment of other trades.
   1. When it is necessary to adjust the intended location of electrical equipment, unless specifically dimensioned or detailed, the Contractor may make adjustments in equipment locations in accordance with the following without obtaining the Engineer's approval:
      a. 1 FT at grade, floor and roof level in any direction in the horizontal plane.
      b. 1 FT for equipment other than lighting at ceiling level in any direction in the horizontal plane.
      c. 1 FT for lighting fixtures at ceiling level in any direction in the horizontal plane.
      d. 1 FT on walls in a horizontal direction within the vertical plane.
      e. Changes in equipment location exceeding those defined above require the Engineer's approval.

K. Provide electrical equipment support system per the following area designations:
   1. Dry areas:
      a. Galvanized system consisting of: Galvanized steel channels and fittings, nuts and hardware.
      b. Field touch-up cut ends and scratches of galvanized components with the specified primer during the installation, before rust appears.
   2. Wet areas:
      a. Galvanized system consisting of: Galvanized steel channels and fittings, nuts and hardware.
      b. Field touch-up cut ends and scratches of galvanized components with the specified primer during the installation, before rust appears.
   3. Corrosive areas:
      a. Stainless steel system consisting of: Stainless steel channels and fittings, nuts and hardware.
      b. PVC coated steel system consisting of: PVC coated steel channels and fittings with stainless steel nuts and hardware.
   4. Highly corrosive areas:
      a. PVC coated steel system consisting of: PVC coated steel channels and fittings with stainless steel nuts and hardware.

L. Provide all necessary anchoring devices and supports rated for the equipment load based on dimensions and weights verified from approved submittals, or as recommended by the manufacturer.
   1. Do not cut, or weld to, building structural members.
   2. Do not mount safety switches or other equipment to equipment enclosures, unless enclosure mounting surface is properly braced to accept mounting of external equipment.

M. Provide corrosion resistant spacers to maintain 1/4 IN separation between metallic equipment and/or metallic equipment supports and mounting surface in wet areas, on below grade walls and on walls of liquid containment or processing areas such as sumps, Clarifiers, etc.

N. Do not place equipment fabricated from aluminum in direct contact with earth or concrete.

O. Screen or seal all openings into equipment mounted outdoors to prevent the entrance of rodents and insects.

P. Do not use materials that may cause the walls or roof of a building to discolor or rust.

Q. Identify electrical equipment and components in accordance with Section 10400.

3.2 FIELD QUALITY CONTROL

A. Verify exact rough-in location and dimensions for connection to electrified equipment, provided by others.

B. Replace equipment and systems found inoperative or defective and re-test.

C. The protective coating integrity of support structures and equipment enclosures shall be maintained.
   1. Repair galvanized components utilizing a zinc rich paint.
   2. Repair painted components utilizing touch up paint provided by or approved by the manufacturer.
   3. Repair PVC coated components utilizing a patching compound, of the same material as the coating, provided by the manufacturer of the component.
   4. Repair surfaces which will be inaccessible after installation prior to installation.

D. Replace nameplates damaged during installation.

3.3 DEMONSTRATION

A. Demonstrate equipment in accordance with Section 16980.

END OF SECTION

SECTION 16050

BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. Work includes furnishing all labor, materials and equipment necessary to complete the installation of all electrical systems as specified herein and as shown on the Drawings.

B. Electrical Contractor shall provide:

1. Raceway, conduit, wiring and all electrical work shown or specified including electrical power distribution system.
2. Feeders and branch circuits to all electrically powered equipment provided by other contractors, including disconnects.
3. Instrumentation and Alarm System.
4. Telephone System Conduit and wiring.
5. Fire Alarm System.

1.2 RELATED WORK

A. Specified Elsewhere:

1. SECTION 01340 – Submittals
2. SECTION 13441 – Hatchery Alarm, Monitoring and Control
3. SECTION 13500 – PLC
4. SECTION 16000 – Electrical Specifications
5. SECTION 16010 – Basic Electrical Requirements
6. SECTION 16125 – Heat Tracing Cable
7. SECTION 16195 - Electrical Identification Systems
8. SECTION 16265 - VFDs
9. SECTION 16400 - Service and Distribution
10. SECTION 16450 - Secondary Grounding
11. SECTION 16460 - Transformers
12. SECTION 16471 - Panelboards
13. SECTION 16472 - Switchboards
14. SECTION 16480 - Motor Starters

15. SECTION 16500 - Lighting
16. SECTION 16612 - Generator Systems
17. SECTION 16721 - Fire Alarm Systems
18. SECTION 16740 - Telephone Systems
19. SECTION 16910 – Process Instrumentation and Alarm
20. SECTION 16960 - Testing Electrical Systems
21. SECTION 16980 - Electrical Systems Demonstrations

1.3 SYSTEM DESCRIPTION

A. Basic materials include:

1. Raceways
2. Fittings
3. Sealing
4. Wire and cables
5. Boxes
6. Circuit and Motor Disconnects
7. Supporting Devices

B. Provide all new materials, without blemish or defect, in accord with standards specified and U.L. listed or labeled.

1.4 QUALITY ASSURANCE

A. Regulatory Requirements

1. ANSI C1/NFPA to comply with: National Electric Code (NEC).

1.5 REFERENCES

A. Specified references, or cited portions thereof, current at date of bidding documents unless otherwise specified, govern the work. In event of conflict between referenced standards and contract documents, notify Engineer immediately. Confirm notification in writing. Do not proceed with the work until Engineer issues written instructions.

B. American National Standards Institute (ANSI)

1. C80.1 - Specification for Rigid Steel Conduit, Zinc-Coated.
2. C80.3 - Specification for Electrical Metallic Tubing, Zinc-Coated.
3. C80.4 - Specification for Fittings for Rigid Metal Conduit and Electrical Metallic Tubing.

C. American National Standards Institute/National Fire Protection Association (ANSI/NFPA): ANSI C1/NFPA 70 - National Electrical Code (NEC).

D. Underwriters Laboratories, Inc. (UL): All materials UL listed and labeled.

E. National Electrical Manufacturers Association (NEMA)

1. FB-1 - Conduit and Cable Assemblies.
2. KS-1 - Switches.
3. OS-1 - Sheet Steel Outlet Boxes, Device Boxes, Covers and Box Supports.
4. TC-2 - Electrical Plastic Tubing and Conduit.
5. TC-3 - PVC Fittings for Use With Rigid PVC Conduit and Tubing.
6. WC-5 - Thermoplastic Insulated Wire and Cable
7. 250 - Enclosures for Electrical Equipment

1.6 SUBMITTALS

A. Submit in accordance with SECTION 01340:

1. Conduit
2. Wire
3. Sealing
4. Boxes
5. Expansion Fittings
6. Surface Raceway System.
7. No submittal required for conduits and fittings, wire and cables; pull and junction boxes when using specified materials.

B. In accordance with DIVISION 1: Submit project record documents for electrical installations.

1.7 COORDINATION

A. The General Contractor shall coordinate the work of all assigned contractors.

1. Electrical contractor shall confer with the General Contractor and the other Contractors regarding the location and size of pipes, equipment, fixtures, conduit, ducts, openings, switches, outlets, etc., in order that there may be

no interferences between the installations or the progress of the work of any Contractor the project.

2. Drawings do not show all fittings, support, connections and appurtances necessary for proper installation of a working system. These will be installed whether or not shown.
3. The layout shown on the Drawings is diagrammatic, but shall be followed as closely as other work will permit. No changes from these Drawings to make the work conform to the Building construction shall be made without acceptance from the Engineer. All proposed changes shall be shown on shop drawings. Before ordering, purchasing or installing equipment, verify exact dimensions by field measurements. All work shall fit in place. If directed by the Engineer, the Contractor shall, without extra charge, make reasonable modifications in the layout to prevent conflict.

4. The Engineer reserves the right to change the location of any equipment 5 feet and any piping, ductwork, conduit, etc., 10 feet in any direction without extra charge, provided such changes are made before installation.

5. Unless explicitly stated to the contrary, each Contractor shall furnish and install each item of equipment or material hereinafter specified, complete with all necessary fittings, supports, trim, piping, insulation, etc., as required for a complete and operating installation.

6. All materials and equipment shall be new and all work shall be executed with the maximum speed consistent with good workmanship. Provide materials and equipment promptly after notice to proceed, and proceed with work in progress with the other contractors on the project. Perform all work in a manner that will not cause interferences or delays to, or interfere with, the progress of other contractors.

7. All equipment and materials shall be installed according to the manufacturer's instructions unless otherwise specifically directed by the contract documents.

8. Items of equipment may be specified in the singular. However, provide and install the number of items of equipment indicated on the Drawings or as required for a complete system.

9. In case of interconnection of the work of two or more contractors, each Contractor shall verify pertinent data on shop drawings and site conditions. Any errors due to failure to perform said verification shall be promptly rectified by the parties involved.

1.8 DELIVERY, STORAGE AND HANDLING

1. Materials shall be suitably packaged by manufacturer to prevent damage during shipment. Damaged materials will not be acceptable for use.

2. Store materials on site in clean, dry storage area; when outside, elevated above grade and enclosed with durable watertight wrapping.

3. Handle all materials carefully to prevent damage. Minor scratches, marks or blemishes to finish shall be repaired to satisfaction of Engineer.

1.9 LINES AND LEVELS

A. Determine all grades, maintain necessary lines and levels throughout the progress of the work, and assume full responsibility for their correctness. Where levels are indicated on the Drawings, work shall be installed at those levels unless prior written approval to change is obtained from the Engineer.

PART 2 PRODUCTS

2.1 RACEWAYS

A. Conduit

1. Steel Rigid Metal. ANSI C80.1 & UL-6.
2. Intermediate Metal. ANSI C80.1 & UL-6
3. Steel Flexible Metal. UL-1.
4. Steel Liquidtight Flexible. UL-1.

B. Tubing

1. Steel Electrical Metallic. Comply with ANSI C80.3 & UL 797.

C. Surface Raceway System

1. One-piece raceway.
2. Two-piece raceway.

D. Approved manufacturers:

1. Allied Tube & Conduit Corp., Harvey, IL.
2. Anamet, Inc., Waterbury, CT.

3. Electri-Flex Co., Roselle, IL.
4. ETP, Div. of Berger Industries, Inc., Maspeth, NY.
5. Carlon, Div. of Lamson Sessions Co., Beachwood, OH.
6. Certain-Teed Corp., Pipe & Plastics Group, Valley Forge, PA.
7. International Metal Hose, Bellevue, OH.
8. LTV Steel Co., Cleveland, OH.
9. Steelduct Conduit Products Div., Sawhill Tubular Div., Cyclops Corp., Sharon, PA.
10. Triangle Wire & Cable, Inc., Lincoln, RI.
11. Wheatland Tube Co., Wheatland, PA.
12. The Wiremold Company, West Hartford, CT.
13. Carlon, Division of lamson & Sessions Co., Beachwood, OH.
14. Hubbell Premise Wiring, Inc., Stonington, CT.

2.2 FITTINGS

A. Rigid and IMC

1. ANSI C80.4.
2. Locknuts; steel or malleable iron.
3. Bushings; insulating or insulated throat type.
4. Couplings; threaded or gland compression steel or die cast type. Set screw or indentor type not acceptable.

B. Electrical Metallic Tubing

1. Couplings and Connectors; Steel or die cast compression type. Set screw or indented type not acceptable.

C. Flexible

1. Connectors; malleable iron, threadless, squeeze clamp type for non-jacketed conduit.

2. Connectors; steel or malleable iron compression type with insulated throat and "O" ring assembly for liquidtight conduit.

D. Surface Metal Raceway System

1. Provide connectors, couplings, support clips, boxes and conduit adapters for a complete assembly.

E. Approved manufacturers:

1. Appleton Electric Co., Chicago, IL.
2. Crouse-Hinds Co., Syracuse, NY.
3. EFCOR Family of Companies, East Farmingdale, NY.
4. O-Z/Gedney, Unit of General Signal Corp., Terryville, CT.
5. Killark Electric Mfg. Co., St. Louis, MO.
6. Raco, Inc., South Bend, IN.
7. Thomas & Betts Corp., Raritan, NY.
8. The Wiremold Company, West Hartford, CT.
9. Carlon, Div. of Lamson & Sessions Co., Beachwood, OH.
10. Hubbell Premise Wiring, Inc., Stonington, CT.

2.3 SEALING

A. Fire Seal

1. Seal penetrations of fire-rated walls, floors or ceilings by raceways for compliance with NEC 300-21. Fill void around raceway. Sleeves shall be heavy wall steel pipe, anchored to building construction and finished plumb with wall, ceiling or floor lines. Acceptable products:

a.	Dow Corning Corp., Midland, MI-.	Fire Stop
b.	Nelson Electric, Tulsa, OK.	Flameseal
c.	Thomas & Betts Corp., Raritan, NY.	Flamesafe
d.	Three M Co., St. Paul, MN.	Fire Barrier

2. Smoke and fire stop fittings may be used instead of above sealant. Approved manufacturers:

a. General Signal Corp./O-Z/Gedney Co., Terryville, CT., - Series CFS

B. Thermal Seal

1. Seal penetrations of thermally insulated equipment or rooms to prevent heat transfer. Seal exterior of raceway with fiberglass or other material compatible to equipment or room and accepted by Engineer. Seal interior or raceway with duct sealing compound at entry to equipment or room.

C. Water Seal

1. Seal penetrations of perimeter walls or floors below grade to prevent entry of water. Use materials compatible with wall or floor construction and accepted by Engineer.

2. Seal penetrations of roof shall be sealed with flashings compatible with roof design and approved by Roofing System Manufacturer and accepted by Engineer.

2.4 WIRE AND CABLE

A. Construction

1. Conductors

a Uncoated, annealed copper in accordance with ASTM Standards.

b. Number 8 and larger shall be concentric standard and conform to ASTM Standards.

c. Minimum of #12 AWG unless otherwise noted in these specifications or on the drawings.

d. The direct-current resistance shall not exceed by more than 2% the values given in IPCEA Standards.

e. Cables in panels, switchboards, wireways, and other large enclosures, shall be bundled and tied with cable ties.

2. 600 Volt general use cable THHN/THWN

a. UL listed for general use at a maximum of 600 volts and a maximum temperature of 90˚C in dry locations and 75˚C in wet locations and be constructed in accordance with UL Standards for thermoplastic insulated wires.

b. Insulation shall be polyvinylchloride compound (PVC) in compliance with UL & ANSI Standards. Have an overall nylon jacket UL listed for use on THHN/THWN wire.

3. 600 Volt General Use Cable (#4 AWG & Larger) XHHW

a. UL listed for general use at a maximum of 600 volts and a maximum temperature of 90˚ C in dry locations and 75˚ C in wet locations, be constructed in accordance with UL Standards for rubber insulated wires and cables.

b. Have a white opaque mylar tape (strand shield) or an extruded mylar, or other, strand shield under the insulation. Insulation shall be a cross-linked polyethylene compound in compliance with UL and ANSI Standards.

4. Color Coding

a.

System	*Phase A*	*Phase B*	*Phase C*	*Neutral*
480Y/277	Brown	Orange	Yellow	Gray
208Y/120	Black	Red	Blue	White
240/120	Black	Red	Blue	White

Ground - Bare Copper or Green
Switch leg-return - Purple
3 Way & 4 Way Switch Travelers - Pink

b. Colors shall be integrally pigmentation color coding for #10 and smaller wires. For #8 and larger, tape shall be applied to the wire. Tape shall be applied in a spiral half-lap manner over exposed conductor portions in manholes, boxes, panels, switchboards, and other enclosures.

5. Splices in Handholes

a. All cable splices in handholes shall be electrically and mechanically secure.

b. Splices shall be watertight and completely submersible.

c. Splices in power cables shall consist of a crimp type butt connector for each conductor, covered with a thermo-fit dual wall heat shrink tube over each connector and a heat shrink submersible jacket over the entire assembly.

d. Splices in multiconductor control cable shall consist of a crimp type butt conductor for each conductor, covered with a thermo-fit dual wall heat shrink tube over each connector and a heat shrink submersible jacket over the entire assembly.

6. S.O. Cords

a. UL listed type S.O. or SOW - A.

b. 90 degree minimum temperature rating.

c. UL outdoor rated.

d. Stranded conductors, minimum wire size shall be #12, with a ground wire, unless otherwise noted or required by code.

7. Low Voltage Cable

a. UL listed for the purpose specified or noted on drawings.

8. Underground Warning Tape

a. Made of acid and alkali resistant .0035 inch thick polyethylene film, 6 inches wide, with a tensile strength of 1750 PSI length wise, 1500 PSI cross-wise and an elongation of 350, be bright yellow or red and read 'CAUTION BURIED ELECTRIC LINE' over entire length, black printing shall be overcoated to prevent fading.

9. Direct Burial Cable - 600V - Type USE/RHH/RHW

a. UL listed for direct burial use at 75˚ C.

b. Insulation shall be a cross-linked polyethylene compound in compliance with UL and ANSI Standards.

10. Fiber optic cable shall be per the recommendation of the manufacturer of the device using it (PLC modem, or PIT tag reader, or phone company).

B. Approved manufacturers:

1. Anaconda Metal Hose, American Brass Div., Hinsdale, IL.
2. Cablec Corp., Independence, MO.
3. Collyer Insulated Wire Div., Gulf-Western Manufacturing Co., Lincoln, RI.
4. General Electric Co., Schenectady, NY.
5. Okonite Co., Ramsey, NJ.
6. Pirelli Cable Corp., Union, NJ.
7. Triangle PWC, Inc., New Brunswick, NJ.

C. Joints and Splices

1. Wire No. 8 or smaller: Compression or crimp type with insulating wrap cover, or insulated twist-on spring connector. Approved products:

a. Ideal Industries, Inc., Sycamore, IL.
b. ITT Holub Industries, Sycamore, IL.

c. Buchanan Div., Elastimold Div., Amerace Corp., Hackettstown, NJ.

d. 3-M Co., St. Paul, MN.

e. Thomas & Betts Corp., Raritan, NY.

2. Wire No. 6 or larger: Mechanical compression or bolted type connector covered with insulating tape or heat shrinkable insulation equal to conductor insulation. Approved manufacturers:

a. AMP Products Co., Schaumberg, IL.

b. Anderson Electrical Connectors, Leeds, AL.

c. Burndy Corp., Norwalk, CT.

d. General Electric Co., Schenectady, NY.

e. General Signal Corp./O-Z/Gedney Co., Terryville, CT.

f. Ideal Industries, Inc., Sycamore, IL.

g. ITT Blackburn, St. Louis, MO.

h. ITT Weaver, St. Louis, MO.

i. 3-M Co., St. Paul, MN.

j. Thomas & Betts Corp., Raritan, NY.

2.5 BOXES

A. Outlet Boxes

1. Hot dipped galvanized, 1.25 oz./sq. ft., sherardized or cadmium plated. UL514.

2. Interior boxes: Sheet steel with conduit knockouts, attached lugs for locating.

3. Exterior boxes or exposed interior in wet/damp locations: Cast aluminum, deep type, corrosion proof fasteners, watertight, gasketed, threaded hubs.

4. For suspended or surface mounted fixtures:

a. 4 in. octagonal or square according to devices used, minimum of 1-1/2 in. deep, deep boxes for poured concrete ceilings. Furnished with fixture studs. Installed with plaster rings on suspended ceilings. 4 in. octagonal or square for all exposed conduit work with fixture extension pan or deep fixture canopy to enclose the box. Use #14 stranded, type AF, 300 volt wire in pipe pendants.

5. For recessed fixtures

a. 4 in. octagonal or square. A minimum of 1-1/2 in. deep. Complete with blank cover. Wire in Greenfield: #12 type THHN, 600 volt.

6. Switch and Receptacle Boxes

a. Wall - (4) in. square for up to two devices. Solid gang boxes for over two devices. Complete with required depth tile ring where used in exposed tile, concrete, block or paneled walls. Complete with raised plaster ring where used in plastered walls. Install with 1/2 in. raised galvanized device covers where used for exposed conduit work.

7. Provide corrosion resistant steel knockout closures for unused openings.

B. Conduit Bodies

1. Galvanized cast metal of type, shape and size to fit location.

2. Constructed with threaded conduit ends, removable cover, corrosion resistant screws.

C. Approved manufacturers:

1. Appleton Electric Co., Chicago, IL.
2. Pyle-National Co., Chicago, IL.
3. Crouse-Hinds Co., Syracuse, NY.
4. General Electric Co., Schenectady, NY.
5. General Signal Corp./O-Z/Gedney Co., Terryville, CT.
6. Hoffman Engineering Co., Div. of Federal Cartridge Corp., Anoka, MN.
7. Killark Electric Mfg. Co., St. Louis, MO.
8. Midland-Ross, Pittsburgh, PA.
9. Raco, Inc., South Bend, IN.
10. Square D Co., Distribution Equipment Div., Lexington, KY.
11. Thomas & Betts Corp., Raritan, NY.
12. Carlon, Division of Lamson & Sessions Cp., Beachwood, OH.

2.6 CIRCUIT AND METER DISCONNECTS

A. Safety Switches

1. Heavy duty enclosed safety switch, surface mounted, fusible or non-fused as specified, rated at 600 v., UL listed.

2. Quick-make, quick-break mechanisms, position of blades visible with cover open.

3. Operating handle integral part of enclosure base with position easily identified, handle lockable in “off” position with padlocks.

4. Meet NEMA Enclosed Safety Switch Standard KS-1 for H.D. type.

5. Current carrying parts of high conductivity copper with silver-tungsten type contact surfaces.
6. Positive pressure reinforced fuse clips for fused type.

7. Enclosures (Except where noted otherwise)

   a. Outdoor: NEMA 3R
   b. Indoor: NEMA 1

8. Approved manufacturers:

   a. Crouse-Hinds Co., Syracuse, NY
   b. Gould, Inc., Circuit Protection Div., Newburyport, MA
   c. Square D Co., Distribution Equipment Div., Lexington, KY
   d. Cutler Hammer
   e. Allen Bradley

2.7 SUPPORTING DEVICES

A. Suspended conduits less than 1 inch

1. For exposed construction, provide strap type hangers supported from beam clamps or threaded rods. Approved manufacturers:

   a. Minerallac Electric Co., Elk Grove, IL.
   b. Crouse-Hinds Co., Syracuse, NY.
   c. Midwest Electric Products, Inc., Mankato, MN.
   d. Thomas & Betts Corp., Raritan, NY.

2. For conduits suspended above ceilings, anchor to building structural steel. When span exceeds NEC limits, provide channel steel between framing members. Tie wiring of conduit to air ducts, or other piping not permitted. Plumber's perforated strap not permitted.

B. Suspended Conduit 1 inch or larger

1. Provide threaded rod with "U" type hangers for single conduit.

2. Anchor threaded rod to inserts in concrete or beam clamp on steel structure.

3. Provide trapeze hanger assemblies and threaded rod for two or more conduits. Acceptable products:

   a. Husky Storage Systems, Inc., Cleveland, OH. - HP-200
   b. Midland-Ross Corp., Electric Products Div., Pittsburgh, PA. - B-901
   c. Unistrut Building Systems, Wayne, MI. - P-1000

C. Surface Mounted Conduit

1. Provide one-hole galvanized steel straps for conduits 1 in. or less. Approved manufacturers:

   a. Appleton Electric Co., Chicago, IL.
   b. Midland-Ross, Pittsburgh, PA.
   c. Raco, Inc., South Bend, IN.

2. Provide clampbacks on exterior walls below grade or in wet areas.

3. For conduit larger than 1 in., use malleable iron pipe straps.

4. For multiple conduits, provide channel anchored to wall with conduit attached to channel with split pipe clamps.

D. Anchoring

1. Hollow Masonry: Toggle bolts or spider type expansion anchors.
2. Solid Masonry: Lead expansion anchors or preset anchors.
3. Concrete: Self-drilling anchor or powder driver studs.
4. Metal: Machine screws, bolts or welded studs
5. Wood: Wood screws.

PART 3 EXECUTION

3.1 INSTALLATION

A. Cooperate with other contractors engaged in project. Execute work in a manner not to interfere with other contractors or Nez Perce Tribe operation.

B. Coordinate work with other contractors regarding location and size of pipes, raceways, ducts, openings, switches, outlets, so there is no interference between installation or of progress of any contractor.

C. Install all equipment with ample space allowed for removal, repair, or changes to equipment. Provide ready accessibility to removable parts of equipment and to all wiring without moving equipment installed or already in place. Provide access panels for all devices installed above non-accessible ceilings or within walls or partitions.

D. Provide sleeves for all electrical conduits passing through walls, partitions, ceilings and floors. Provide sleeves of sufficient length to extend through full thickness of wall construction with ends flush. Extend floor sleeves one inch above finish floor.

E. In mechanical and electrical equipment spaces, expose ceiling outlets and conduit with due consideration to ventilating ducts and mechanical piping. Where numerous ducts occur, install conduits and outlets after ventilating ducts. Puncturing of duct work or hanging equipment such as light fixtures, ceiling hangers, conduits, from duct work is prohibited, unless specifically noted otherwise.

F. Where cutting is required to facilitate construction, patch and repair, cut items to original state. Do not cut structural work without prior written approval of Engineer.

G. Cut holes through concrete and masonry in new and existing structures with a diamond core drill or concrete saw. Pneumatic hammer, impact electric, hand or manual hammer type drills not allowed, except where permitted by Engineer because of limited work space.

H. Layout holes in advance. Notify Engineer prior to drilling through structural sections, for determination of proper layout.

I. Where conduits, wireways, and other electrical raceways pass through fire partitions, fire walls or walls and floors, install a fireseal that provides an effective barrier against spread of fire, smoke and gases to maintain integrity of rating of partition wall or floor. Pack fireseal material tight and completely fill clearances between raceways and openings.

J. Where electrical equipment is located on damp or wet walls or locations as directed, it shall be "stand-off" mounted 1/2 in. from the wall in a manner so that the rear of the equipment is freely exposed to the surrounding air.

K. Make floor, exterior wall and roof seals watertight. Sleeve walls and floors which are cored for installation of conduit with steel tubing, grouted and space between the conduit and sleeve fill as specified herein.

L. At project completion, clean all equipment to the original finish. Remove all shipping labels.

M. Provide touch-up painting of all equipment marred in any way during shipment or installation.

N. At sites within the jurisdictional boundaries of the U.S. Forest Service, paint all exposed bare metal or galvanized surfaces green in accordance with SECTION 09900.

O. Paint all exposed bare metal surfaces at other sites a color selected by the Engineer in accordance with SECTION 09900.

3.2 CONDUIT

A. Conduit Schedule

1. Minimum Conduit Size: 3/4 in. unless otherwise specified. Install switch legs in 1/2 in. conduit where in accordance with NEC. When surface metal raceway is used, the minimum free area available must match 3/4" and 1/2" conduit respectively.

B. Application

1. RGS

a. Used for service entrances.

b. Used in concrete or used underground where noted.

c. May be used for all raceways except where other type is specified to be used or is required by codes.

2. EMT

a. May be used anywhere permitted by NEC, except where these specifications require other type, shall be used.

3. PVC (Schedule 40)

a. May be used for buried distribution outside of the building where permitted by codes and shown on the Drawings. Elbows and conduits to above grade shall be RGS. PVC conduit shall not be exposed.

b. Where PVC conduit transitions from underground to exterior the conduits shall transition by means of pre-made couplings from plastic

to rigid steel. Such transition shall be made a minimum of twelve (12) inches below finished grade.

c. Ground wire must be run in conduit for all power runs.

4. Flex

a. May be used where permitted by code when other conduit type is not practical.

b. Used for final connection to portable or vibrating equipment where LT type is not required.

5. LT

a. Used for final connection of motors and where called for on the drawings or required by NEC.

C. Installation

1. Joints shall be cut square, reamed smooth, and drawn tight. Bends or offsets shall be made with standard conduit ells, field bends made with a bender or hickey, or hub-type conduit fittings. Number of bends per run shall conform to NEC limitations. Bends shall conform to NEC radius requirements and shall not have kinks or flat spots.

2. Concealed conduits shall be run in a direct line with long sweep bends and offsets. Exposed conduits shall be run parallel to and at right angles to building lines.

3. Continuous from outlet to outlet and from outlets to cabinets, pull or junction boxes, and shall be secured to all boxes and locknuts and bushings in such a manner that each system shall be electrically continuous throughout. Conduit ends shall be capped to prevent entrance of foreign materials during construction.

4. Conduit terminals at cabinets and boxes shall be rigidly secured with locknuts and bushings as required by NEC. On all conduit 1.25 in. trade size and larger, insulated bushings shall be installed.

5. Installed complete before conductors are pulled in.

6. Securely supported as required by NEC, and with-in 2 feet of box, couplings and each side of offsets or bends. Horizontal and vertical conduit runs shall be supported by one-hole heavy duty malleable iron straps, clamp backs, or

other devices with suitable bolts, expansion shields (where needed) or beam-clamps for mounting to building structure or special brackets.

7. Adjustable hangers may be used to suspend conduits when separately located. If adjustable trapeze hangers are used to support groups of parallel conduits, U-bolt or similar type clamps shall be installed at each elbow.

8. The use of perforated straps or tie wire for supporting or strapping conduits will not be permitted.

9. The required strength of the supporting equipment, and the size and type of anchors, shall be based on the combined weight of conduit, hangers and cables.

10. Sealing locknuts shall be used on boxes and cabinets which are other than NEMA 1 construction.

11. RGS

    a. Threaded, unless rigid compression fittings are used.

    b. Running threads will not be permitted.

    c. Conduit ends shall have bushings installed.

12. PVC

    a. Joints shall be properly sealed to make them watertight and installed as recommended by the manufacturer.

    b. Where used for other than buried it shall have expansion rings between boxes and on each run over 30 foot.

13. Hangers

    a. Straps shall only be used on conduits run on walls or columns.

    b. Spacing shall be as required by NEC.

14. Sleeves

    a. Contractor shall lay out and install electrical work in advance of the installation of walls and ceilings.

    b. Install sleeves as required for conduit runs.

c. Install inserts and pack sleeves with packing to maintain fire rating of building.

d. Sleeves and conduit that pass through exterior walls and through floors on grade shall be watertight.

15. Underground Conduits

a. Ground shall be excavated in open trenches, the width, depth and direction necessary for the proper installation of the underground work.

b. Multiple runs shall have manufactured spacers installed on a minimum of one per eight foot of run.

c. Multiple runs shall have joints staggered one foot apart minimum.

d. Conduits shall be installed a minimum of 30 in. below finished grade.

e. Minimum spacing between conduits for multiple runs shall be one inch.

f. Conduit shall be bedded firmly and continuously on sand or pea gravel and provide a minimum of 6 inches of covering of sand or pea gravel on all sides of conduit.

g. Conduits encased in concrete shall have a minimum of 2" thick concrete covering.

h. Maintain all trenches and excavations free of standing water.

i. Backfill all trenches in 8 inch layers and compact by tamping and puddling. Backfill material shall be clean dirt, free of solid material (rocks, concrete, brick, or other debris). Installation shall be accepted by Engineer prior to backfilling.

j. Provide adequate barricades, signs, lights, etc. while excavations are open.

k. Provide warning tape at 12 inch depth.

3.3 WIRE AND CABLE

A. Drawing are diagrammatic in showing circuitry to and between devices, fixtures, and equipment. Provide all phase conductors, neutrals, grounds, switch legs and travelers as required for a complete and operable system.

B. Wire and cable shall be suitably protected from weather and damage during storage and handling and shall be in first-class condition when installed. Conductors shall be soft-drawn copper with insulation and outer covering as noted. Conductor sizes shall be Standard American Wire Gauge sizes (**NO ALUMINUM WIRE SHALL BE ALLOWED**)

C. Make conductors continuous from outlet to outlet. Do not make splices except in outlet or junction boxes. Make all feeder cables continuous from origin to panel or equipment terminations without running splices in intermediate pull or boxes, unless specifically indicated on the Drawings or accepted in writing by Engineer.

D. Do not exceed conduit fill established by the National Electrical Code for number of conductors installed in a raceway.

E. All wire shall be copper. Use minimum wire sizes in no case less than shown on the drawings or specified herein.

1. Control and Signal: #14 AWG.

2. Branch Circuits: #12 AWG.

F. Do not pull any cable or wire in a raceway until conduit system is complete and internal raceway has been cleaned. Strain on cables shall not exceed manufacturer's recommendations during pulling. Use pulling lubricant, compatible with insulation and covering, that will not cause deterioration of insulation or jacket covers of cables or conductors. Use pulling lubricant recommended by wire manufacturer.

G. Provide each cable or conductor in panels, pullboxes or troughs with a permanent pressure-sensitive label with suitable numbers or letter for easy identification. Identify control wires at each end and in junction boxes with designated wire numbers corresponding to control schematic drawings.

H. Provide wires and cables entering equipment or panels with enough slack to eliminate stretched, angular connection. Neatly arrange wiring, bundle and fan out to termination panels. Make minimum bending radius for conductors in accord with National Electrical Code.

I. Support all conductors in vertical raceways in accord with National Electrical Code.

J. Leave at least 6 in. loops or ends at each outlet for installation of devices or fixtures. Roll up all wires in outlet boxes not for connection to fixture or device at that outlet, connect together and tape.

K. Upon completion of cable and wire installation, but before termination to equipment, test each wire for grounds and short circuits. Replace or correct defective wiring.

L. Ground wire of correct size shall be provided for each conduit run.

M. Provide properly sized conductors to prevent exceeding a 3% voltage drop and increase conduit sizes as required by NEC.

N. All circuits in all distribution equipment shall be neatly grouped and tied with seine twine, Ty-Rap or wrap tabs.

O. Direct Burial Cable

1. Where called for, direct burial cables shall be UL Listed for this purpose (UF, SE, URD, UD), shall be installed in open trenches, run in straight lines, be 36 inches below finished grade, be laid in pea gravel or sand (minimum of 12 inches cover on all sides), have a warning tape marker installed 12 inches below grade and installed the full length of run. Be installed in conduit under all paved surfaces (conduit shall extend 36 inches beyond paving) and when entering buildings, pole bases, vaults, manholes, etc., be backfilled and tamped so ground will not settle beyond intended finish grade.

2. Cables shall be installed by the method of using mobile reel handling equipment such that cables will be laid in trench, cable shall not be dragged into place, cables shall be snaked slightly in the trench to allow for ground movement, cables of the same circuit shall be grouped and be wrapped 36" O.C.. The contractor may submit other methods of installation for acceptance by the Engineer for consideration.

P. Identification

1. Each cable (feeder, branch circuit) or conductor group in panels, pullboxes, troughs or outlet boxes shall have a permanent pressure sensitive label with suitable numbers (circuit number) and panel designation letter for easy identification.

Q. S.O. Cords

1. A liquid tight strain relief cord connector shall be used wherever an S.O. cord enters a pull or junction box.

R. Fiber Optic Cable

1. Contractor to install fiber optic cable, provide splices, terminations, and connections as recommended by cable manufacturer using the proper equipment to provide the communication link as specified herein and on the Drawings. Instrumentation subcontractor shall assume overall responsibility for ensuring proper communication capability between the programmable logic controller and the Remote I/O racks.

2. All fiber optic cable shall be installed in conduit. For fiber-optic cable installed in same duct as electrical cables, avoid placing excessive crushing forces on fiber optic cables.

3. Provide sufficient clearance to allow the fiber optic cable to be pulled through the conduit without excessive friction or binding and do not exceed manufacturer's recommended maximum pulling force. Pulling forces must be applied to the cable members and not to the fiber.

4. Bends in the conduit and any fittings through which the cable must be pulled should not require the cable to make a bend with a radius of less than 6 inches. Fittings shall not cause the cable to make sharp bends or be pressed against corners.

5. Long vertical cable runs shall be avoided, if possible.

6. Leave enough slack in the cable in the conduit to prevent tensile loads on the cable.

7. Connectors and Splices

a. Install low-loss connectors suitable for the application as recommended by the cable and/or equipment manufacturer(s). Connectors and splices shall be installed using the procedures and equipment recommended by the cable manufacturer (s).

3.4 BOXES

A. The location of all boxes shall be coordinated prior to rough-in.

B. Recessed unless otherwise noted on the drawings, face of box (or extension ring) shall be flush with wall finish, be plumb, have all unused openings closed with knock-out closures.

C. Boxes shall be accessible.

D. Installed per NEC requirements for area in which it is being installed.

E. Thru wall boxes shall not be permitted.

F. The covers for surface mounted boxes shall be of the same material as the box.

G. Surface mounted boxes 10 ft. above floor or less shall be cast type, unless otherwise noted.

H. In masonry shall be masonry type, or 4-inch square box with proper mud/tile ring.

3.5 DISCONNECTS AND STARTERS

A. Supply motor or load from individual branch circuit in separate branch conduit except where otherwise shown.

B. Make all final connections to motors with flexible conduit, not less than 18 in. or more than 24 in. long. Provide ground wire to motor frame. Adequately support conduit at each motor.

C. Verify proper direction of rotation of all motors.

D. Provide nameplates or legends indicating equipment served or the function of all disconnects, combination starters, and control devices furnished. Size nameplates or legends relative to the device. Make from engraved phenolic compound, and properly secure the device.

E. Starters and other devices furnished with equipment shall be installed by contractor furnishing them, including all power field wiring between equipment and starters. Contractor furnishing equipment shall be fully responsible for providing adequate and correct wiring diagrams and instructions.

F. Motor sizes shown in schedules and their locations may differ from that provided, dependent upon manufacturer. Provide connections of proper capacity at proper locations regardless of those differences.

3.6 RACEWAY SUPPORT AND HANGERS

A. Securely fasten raceways in place and support from ceiling or walls at spacings not exceeding:

MATERIAL	MAX. SPACING OF SUPPORTS
1/2 in. through 1 in. Trade Size Conduit	6 ft.
1 1/4 in. through 1 1/2 in. Trade Size Conduit	8 ft.
2 in. to 4 in. Trade Size Conduit	10 ft.
Flexible Metal Conduit	4 1/2 ft.
Cable Trays	10 ft.
Wireways	5 ft.
1/2 in. through 1 in. Trade Size Ent	3 ft.

B. Support rigid, IMC or EMT conduits within 3 ft. of every outlet box, junction box, pull box, cabinet or termination. Support flexible conduit within 12 in. of every outlet box or fitting.

C. Support vertical runs or conduits at each floor level and at interval not to exceed 10 ft.

D. Support conduits by pipe straps, wall brackets, hangers, or ceiling trapeze. The use of perforated iron or wire for supporting conduits is prohibited. Fasten with wood screws or screw nails to wood; by toggle bolts on hollow masonry units, by concrete inserts, or expansion steel conduits on steel. Do not weld conduits or pipe straps to steel structures unless specifically indicated.

E. The load applied to fasteners or hangers shall not exceed one-third the proof test load of the fasteners or hangers.

F. For fasteners attached to concrete, use vibration and shock resistant type.

G. In partitions of light steel construction, use sheet metal screws.

H. In suspended-ceiling construction, all conduits are to be mounted independent of ceiling suspension system. All fixture whips and conduit shall be not lay on ceiling or suspension system.

I. Where two or more conduits one inch trade size or larger run parallel, trapeze hangers may be used consisting of threaded solid rods, washers, nuts and galvanized "L" angle or channel iron. Individually fasten conduits to the cross member of every other trapeze hanger with one hole straps or clamp backs with proper size bolts, washers and nuts. When adjustable trapeze hangers are used, use U-bolt type clamps at end of conduit runs, at each elbow and at each third intermediate hanger to fasten each conduit.

J. Make hangers of durable materials suitable for the application involved.

K. Fabricate all screws, bolts, washers and miscellaneous hardware used for conduit supports from rust-resisting metal. Trapeze hangers shall have hanger assemblies protected with galvanized finish.

L. Install UL approved expansion fittings complete with grounding jumpers were conduits cross building expansion joints.

END OF SECTION

SECTION 16125
HEAT TRACING CABLE

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Heat tracing cable as required for heat tracing of pipes as indicated on the Drawings.

B. Related Sections include but are not necessarily limited to:
   1. Division 1 - General Requirements.
   2. Division 15 - Mechanical.
   3. Section 16010 - Electrical: Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. National Electrical Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000 Volt Maximum).

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Section 01340 for requirements for the mechanics and administration of the submittal process.
   2. Product technical data:
      a. Power requirements for each circuit based upon actual length of heat trace and maintained temperature.
      b. Circuit breaker rating based upon inrush current at minimum expected start-up temperature.
      c. Length of heat tape for each pipe size and run.
      d. Coordinate and verify length and Watts/FT of heat tape required based upon pipe size and insulation thickness.
         1) Include the calculations to support the heat tape output.
      e. See Section 16010 for additional requirements.
   3. Fabrication and/or layout drawings:
      a. Wiring diagrams showing physical locations of thermostats and heat trace power supply.

B. Operation and Maintenance Manual:
   1. See Section 01340 for requirements for:
      a. The mechanics and administration of the submittal process.
      b. The content of Operation and Maintenance Manuals.

C. Miscellaneous:
   1. See Section 01340 for requirements for the mechanics and administration of the submittal process.
   2. Test reports: Megger test results.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Shall be stored such that they are not exposed to sunlight or other UV rays.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
   1. Thermon.
   2. Chemelex Division; Raychem Corp.
   3. Chromalox.
   4. Tempco,
   5. Hotfoil
   6. Nelson

B. Submit request for substitution.

2.2 HEAT TRACING

A. Design Parameters:
   1. Pipe diameter, length and material: See Drawings and Division 15 Specifications.
   2. Flange, valve, pipe support size: See Drawings and Division 15 Specifications.
   3. Pipe insulation type and thickness: See Drawings and Division 15 Specifications.
   4. Temperatures requirements:
      a. Low ambient temperature for the specific location: -37 degrees F.
      b. Maintain temperature (thermostat set point):
         1) Water lines: 40 DegF.
      c. High temperature exposure with power off: 107 DegF.
   5. Wind factor for the specific location: all heat trace is in vaults. 0 MPH.
   6. Electrical requirements:
      a. Voltage: 120 V.
      b. Circuit breaker: Field coordinate if other than 20A GFEPCI type.
   7. Safety factor: 10 percent.

B. Self-regulating or power-limiting parallel circuit construction consisting of an inner core of conductive material between parallel copper bus wires, with inverse temperature - conductivity characteristics with metal overbraid.

C. Thermostats adjustable between 35 and 200 DegF minimum with maximum differential range of 9 DegF, furnished complete with NEMA 4 enclosures in all areas, stainless steel temperature bulb and capillary.

D. Capillary shall be armored if installation cannot be physically protected from kinking.

E. All necessary or required components and accessories, such as power connection boxes, end seals, straps, tape and fitting brackets.

PART 3 EXECUTION

3.1 PREPARATION

A. Install materials after piping has been tested and approved.

3.2 INSTALLATION

A. Insulate and heat trace wet pipe systems where indicated on Drawings.
   1. Install temperature switch as high as practical in vault.

B. Install materials in accordance with manufacturer's instructions.
   1. Each circuit shall not exceed the manufacturer's recommended maximum length.

C. For metallic piping:
   1. Heat tracing shall be installed completely wired.
   2. Cut heat trace to lengths as required and secure to pipe with glass or polyester fiber tape.

D. For non-metallic piping:
   1. Allow for extra heat trace output because non-metallic pipe has a lower heat transfer. Heat tracing shall be installed completely wired.
   2. Cut heat trace to lengths as required and secure to pipe with aluminum tape through out the length of the trace.

E. Protection and Control Requirements:
   1. Protection by a GFEPCI circuit breaker.
   2. Breaker amperage rating shall be coordinated with Contractor when different than the Contract Drawings.

3.3 TESTING

A. Megger the cables at the manufacturers recommended voltage level three (3) times.
   1. Before installation.
   2. After attachment to pipe but before insulation is installed.
   3. After pipe insulation is installed but before energization.

END OF SECTION

SECTION 16195

ELECTRICAL IDENTIFICATION SYSTEMS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. Work includes furnishing all labor, materials and equipment necessary to complete electrical identification as specified herein.

B. Base Bid:

1. Electrical Contractor shall provide identification of:

a. Panelboards.
b. Safety switches.
c. Starters.
d. Systems equipment.
e. Conduit system including boxes.
f. Wiring system.
g. Sensors (HVAC).
h. Control Panels.
i. Conduit System including boxes.
j. Wiring System.

1.2 RELATED WORK

A. Specified elsewhere

1. SECTION 01340 - Submittals
2. SECTION 16050 - Basic Electrical Materials and Methods
3. SECTION 16400 - Service & Distribution
4. SECTION 16460 - Transformers
5. SECTION 16471 - Panelboards
6. SECTION 16472 - Switchboards
7. SECTION 16480 - Motor Starters
8. SECTION 16721 - Fire Alarm System
9. SECTION 16910 - Process Instrumentation and Alarm

1.3 QUALITY ASSURANCE

A. Comply with:

1. ANSI A 13.1, Identification of Piping Systems.
2. National Electric Code (NEC).
3. Local Rules & Regulations.

1.4 REFERENCES.

A. Specified references, or cited portions thereof, current at date of bidding documents unless otherwise specified, govern the work. In event of conflict between referenced standards and contract documents, notify Engineer immediately. Confirm notification in writing. Do not proceed with the work until the Engineer issues written instructions.

1. American National Standards Institute (ANSI): ANSI A13.1 - Identification of Piping Systems.

2. National Fire Protection Association (NFPA): NFPA 70 - National Electrical Code (NEC).

3. Underwriters Laboratories, Inc. (UL): All products UL listed and labeled.

4. Manufacturer's Catalogs: Specification manufacturer's catalogs are incorporated by reference to same force and effect as if repeated herein in full.

1.5 SUBMITTALS

A. Submit in accordance with SECTION 01340.

1. Actual legend plate lettering
2. Proposed annunciator panel legends
3. Product data on wire labels and terminal labels

PART 2 PRODUCTS

2.1 EQUIPMENT IDENTIFICATION PLATES

A. Provide plates for all equipment (panels, starters, disconnect switches, etc.) consisting of machine engraved laminated plastic. Plate field shall be black with white core.

1. Size of plate shall be commensurate with lettering thereon.

2. Lettering for major items of equipment, such as a switchboard, shall be 1/2" in height. Lettering for smaller items, such as a switches, shall be 1/4" in height.

3. Wording on plate shall contain information as appropriate and acceptance by the Engineer.

2.2 CONDUIT/BOX IDENTIFICATION SYSTEM

A. Identification of conduits shall be by either identification markers or color coding.

1. Identification Markers:

a. Shall be standard pipe markers with black lettering on safety orange background.

b. Markers shall identify voltage and functional use of the conduit, such as: "120.208 lighting", "120.208 receptacles", "120.208 HVAC," "low voltage fire alarm".

B. Identification of Boxes:

1. Each box cover above ceiling or exposed in room that receives no ceiling shall be color coded as follows:

Service	Color
120/208	Orange
277/480	Yellow
Fire alarm	Red
Low voltage	White

2. Each box cover that receives color coding shall receive identification of item served and circuit in black one inch high letters:

Service	Abbreviation
Lighting	LTG
Receptacles	RECPT
Fire alarm	FA
Low voltage controls	CNTL
Heating, vent. and A.C.	HVAC

3. Provide a 8-1/2 x 11 inch framed legend of color codes in EACH Mechanical Room.

PART 3 EXECUTION

3.1 INSTALLATION/APPLICATION/PERFORMANCE

A. Equipment Labels:

1. Install at each major item of equipment and on control devices with rivets.

2. Furnish labels on equipment including, motor starters, manual motor starters, relays, disconnect switches, remote pushbuttons, distribution panels, pilot lights, selector switches, transformers.

3. Panelboard directories shall be as specified in SECTION 16471.

B. Wire and Cable:

1. Color coded and shall be labeled with wire labels as specified in SECTION 16050.

C. Special Use Wiring Devices:

1. Cover plates, engraved to clearly indicate their use.

D. Overcurrent Devices:

1. Clearly indicate what they feed. This may be by means of the typewritten panel schedules mounted inside of the front doors or by engraved laminated labels.

END OF SECTION

SECTION 16265
VARIABLE FREQUENCY DRIVES - LOW VOLTAGE

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Variable frequency drives (VFDs) for operation of 460 Vac, 3 PH, 60 Hz induction motors.

B. Related Sections include but are not necessarily limited to:
   1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 1 - General Requirements.
   3. Section 09900 - Painting and Protective Coatings.
   4. Section 16195 – Electrical Identification Systems.
   5. Section 13441 – Hatchery monitoring and control.
   6. Section 13500 - Programmable Logic Controller (PLC) System.
   7. Section 16010 - Electrical: Basic Requirements.
   8. Section 16490 - Overcurrent and Short Circuit Protective Devices.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American National Standards Institute (ANSI):
      a. C62.41, Guide for Surge Voltages in Low Voltage AC Power Circuits.
      b. C62.45, Guide on Surge Testing for Equipment Connected to Low Voltage AC Power Circuits.
   2. Canadian Standards Association (CSA).
   3. ETL Testing Laboratories (ETL).
   4. Institute of Electrical and Electronic Engineers (IEEE):
      a. 519, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
   5. National Electrical Manufacturer's Association (NEMA):
      a. ICS 6, Enclosures for Industrial Controls and Systems.
      b. MG-1, Motors and Generators.
   6. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code.
   7. Underwriters Laboratories, Inc. (UL):
      a. 508, Industrial Control Equipment.

B. Qualifications:

1. Provide drives that have the standard factory configuration of the variable speed drive listed and labeled by Underwriters Laboratories, Inc. (UL), ETL Testing Laboratories (ETL), or that shall be capable of field inspection and subsequent field labeling by a UL-recognized field inspector. Where drives and controlling equipment are mounted in a custom enclosure, UL listed components shall be furnished.
2. VFD Supplier shall maintain an authorized service organization within 300 miles of the project site.

C. Coordination:
1. VFD manufacturer shall verify with the driven equipment manufacturer that the VFD and the drive motor are compatible and that the VFD will operate the driven equipment motor over its required operating range and will do so without exceeding the motor or VFD safety factors.
2. VFD shall be supplied complete with all required control components.
   a. VFD manufacturer shall review the application and provide, at no additional cost to the Owner, the hardware and software necessary to allow the VFD to control the driven equipment motor over its required operating range. These may include, but are not limited to, analog and digital interface modules, communication interface modules, feeder circuit power output filters or chokes which may be required due to VFD to motor feeder length, switches, lights and other devices.
3. Verify plan dimensions with equipment space requirements as indicated on the Drawings.
   a. Equipment which exceed the allotted maximum dimensions may not be acceptable.
   b. Equipment which reduces clear space below the minimums established by the NEC will not be acceptable.
4. Contractor shall coordinate submittal with submittals from the motor manufacturer and the equipment manufacturer to provide concurrent submittals.

D. VFD manufacturer shall clearly identify conditions that will limit the operation of, or cause damage to, the VFD. These shall include, but are not limited to:
1. Line side overvoltage.
2. Line side voltage imbalance.
3. Line side surge magnitude and duration.
4. Location of VFD enclosure with respect to external cooling air flow.

1.3 SUBMITTALS

A. Shop Drawings:
1. See Section 16010.
2. Product technical data:
   a. Rated VFD input kVA and current.
   b. Rated output kVA and current.
   c. Overload current.
   d. Percent efficiency and power factor at 50, 75, and 100 percent speed.

e. Maximum BTU heat release data and verification of the drive cooling requirements.
f. Panel interior, and front and side exterior views, with details showing maximum overall dimensions of VFD and isolation transformer (if provided).
g. Locations and sizes of electrical connections, ground terminations, and shielded wire usage.
h. Harmonic calculations by the VFD manufacturer with detailed drawings and/or information showing how protection is applied to comply with harmonic limits.
i. Identification and location of closest authorized service organization.

3. Certifications:
   a. Submit with Shop Drawings:
      1) Manufacturer's experience.
      2) Compliance with IEEE 519.
      3) Compliance with "Factory Tests".
      4) That the VFD can withstand the same level of fault current as that imposed on the equipment feeding the VFD.
   b. Submit prior to shipment:
      1) From the VFD manufacturer and each VFD driven equipment manufacturer that the specific application has been reviewed and that the combination will satisfy the drive duties required with the actual motor furnished.
      2) That the testing described under "Factory Tests" in Part 2 has been successfully completed.
   c. Submit after installation:
      1) That the critical frequency of the drive system has been identified and the VFD has been set to lockout these frequencies.
      2) Installation test reports that show:
         a) Each VFD is operational.
         b) Each VFD and its driven equipment motor is compatible.
         c) Each VFD responds correctly to the input control signals.
      3) That by on-site field measurements the VFD is not introducing harmonics to the power distribution system in excess of those recommended by IEEE 519.

B. Operations and Maintenance Manuals:
   1. See Section 01340.
   2. Troubleshooting procedures with a cross-reference between symptoms and corrective recommendations.
   3. Connection data to permit removal and installation of recommended smallest field-replaceable parts.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following Manufacturers are acceptable:
   1. ASEA-Brown Bovari (ABB).
   2. Cutler-Hammer.
   3. General Electric Company.
   4. Allen-Bradley Group.
   5. Reliance Electric.
   6. Square D Company.
   7. Toshiba.

B. Submit request for substitution.

2.2 TYPE OF DRIVE

A. Pulse-Width Modulated (PWM) type with IGBT transistors.

2.3 PERFORMANCE AND DESIGN REQUIREMENTS

A. Application:
   1. Speed reference input to the VFD shall be a 4-20 ma signal. The VFD shall accept this signal to control pump speed proportionally.

   2. well pump #1 VFD, as shown on the drawings, includes a complete magnetic bypass that isolates the VFD when in the bypass mode. Transfer to the bypass mode shall be automatic in the event of the VFD failure or transfer to the bypass switch mode shall be manual by selector switch at the CACP (Central Alarm Control Panel).
   3. Operator controls shall be mounted on the front of the enclosure and shall consist of start and stop pushbuttons, bypass/VFD selector switch, Auto/Manual selection and manual speed adjustment capability.

   4. VFD(s) shall be of sufficient capacity and shall provide a quality output waveform for stepless motor control from 10 to 100 percent of base speed for
      a. Chilled water pumps: NEMA Design B squirrel cage inverter duty rated induction motors
      b. Submersible well pumps: special purpose submersible pump squirrel cage induction motor.
   5. The drives shall be suitable for Variable Torque (VT) applications.
   6. VFDs shall be designed to operate successfully under the following conditions:
      a. Ambient:
         1) Generator room:Temperature: -40 to +50 DegC
         2) Water Treatment Room Temperature: 0 to +41 Deg C
         3) 95 percent non-condensing relative humidity.
      b. Elevation: 4100 FT above MSL.
      c. Input power to VFD:
         1) 460 Vac (+10 percent).
         2) 3 PH, 60 Hz (+3 percent).

d. Line voltage imbalance +5 percent of rated voltage.

B. Performance:
1. The VFD shall have the following capabilities:
a. Well #1 and Well #2, The VFD shall be a pulse width modulated (PWM) design that has a carrier frequency closely coordinated with the load filter requirements.
b. The VFD shall maintain a 120% current overload capability for sixty seconds with automatic stall prevention and voltage boost to prevent nuisance tripping during load or line side transient conditions
c. Voltage rating:
1) 480 Vac, 3 PH, 60 Hz.
d. Continuous current rating:
1) 100 percent of rated VFD current shall be equal to or greater than the motor full load nameplate rating including motor service factor.
2) The VFD shall be rated for continuous duty at its carrier frequency on the motor full load currents listed in NEC Table 430.250.
e. Current overload capacity: 110 percent for 1 min.
f. Efficiency:
1) 97 percent at full speed and full load.
2) 93 percent at 1/2 speed and full load.
3) Efficiency shall be determined excluding isolation transformer and input and output reactor losses.
g. Power Factor:
1) No less than 94 percent throughout its speed range.
h. Frequency drift:
1) + 0.5 percent of set frequency.
i. Speed regulation (motor dependent):
1) 3 percent.
j. Speed range:
1) 10:1.
k. Critical frequency lockout:
1) Minimum of three.
l. Continued operation with momentary voltage dips of 25 percent of rated voltage for a 4 second duration.
m. Volts/Hertz ratio; constant over the entire operating range of the VFD except:
1) When operating under voltage boost.
2) At frequencies over 60 Hz.
n. Automatic restart with one restrike following a power outage.
o. Spinning load restart: Synchronization of VFD starting frequency with spinning or coasting load.
p. The Well #1 VFD shall have a bypass starter.
2. The VFD shall be supplied with line side and load side reactors:
a. Minimum impedance:
1) 2.5 percent, or as required for to meet IEE519 requirements.
b. Current overload:

1) 150 percent for 1 min.

c. Insulation temperature rating:
   1) 180 DegC.
d. Copper windings.
e. Saturation current rating:
   1) 3.5 to 5 times rated current.
f. Hi-potential rating:
   1) 2500 Vac line to ground and line to line, for 1 min.
g. The VFD shall have a DC link reactor which will reduce harmonics at the input. If a DC link reactor is not provided, an AC input line reactor or isolation transformer shall be provided. In either case, the input filter must reduce harmonics to the IEEE-519 criteria.
h.
i. Noise reducing:
   1) Epoxy over cast coil.
   2) Extra dips and bakes of varnish over continuous wound coil.

C. The VFD shall be provided with the following adjustments:
   1. Independent maximum and minimum speed.
   2. Independent linear acceleration and deceleration time.
   3. Volts/Hertz ratio.
   4. Voltage boost.
   5. Process follower gain, offset and bias.
   6. Torque limit.
   7. Overcurrent trip point.

D. The VFD shall have the power circuit designed such that the power circuit components are protected:
   1. Input protection:
      a. Line side molded case circuit breaker type disconnect.
         1) Fault current interrupting rating equal to or greater than the withstand or interrupting rating of the equipment feeding the VFD.
         2) Padlockable in the OFF position.
         3) Overcurrent and short circuit device per Section 16490.
      b. Undervoltage trip:
         1) Auto restart.
         2) Ride through a momentary power dip, magnitude and duration as previously specified.
         3) Ride through a one cycle loss of power.
      c. Incoming line transient suppression.
      d. Loss of phase trip:
         1) Auto restart.
      e. Reverse phase trip:
         1) Manual restart.
      f. Overvoltage trip:
         1) Auto restart.
         2) Relay installed in the VFD.
   2. Internal protection:

a. Surge suppression and power device snubbers.
b. Power devices rated at 2.5 times line voltage.
c. Instantaneous overcurrent trip with manual reset.
d. DC bus overvoltage trip with manual reset.
e. Power device overtemperature trip with manual reset.
f. Control logic circuit malfunction trip with manual reset.

3. Output protection:
   a. Inverse-time overload trip:
      1) Auto restart.
   b. Overvoltage trip:
      1) Auto restart.
   c. Overfrequency trip:
      1) Auto restart.
   d. Short circuit trip:
      1) Line to line and line to ground.
      2) Auto restart.
   e. Ground fault trip:
      1) Manual restart.

2.4 OPERATOR AND REMOTE CONTROL INTERFACE

A. Control circuits shall be 115 Vac supplied by CPT in the VFD.
   1. CPT shall have minimum additional capacity of 60 VA greater than that required by control devices.
   2. CPT shall have two fuses on the primary side and one fuse on the secondary side.
   3. CPT shall have surge protection on the primary side independent of any other surge protection in the VFD.

B. Operator interface:
   1. Door mounted sealed keypad, membrane type with LED or LCD display.
      a. Messages shall be in English and engineering units.
      b. Drive operating parameters shall be programmable.
      c. Menu driven.
      d. Password security.
      e. Display fault and diagnostic data.
      f. Operating parameters, fault and diagnostic data maintained in non-volatile memory with historic log of fault and diagnostic data.
   2. Manual-Off-Auto control and speed reference selector switch.
   3. Manual speed adjustment.
   4. Manual start and stop control.
   5. Indicating lights:
      a. POWER ON.
      b. VFD RUN.
      c. VFD FAULT.
   6. Speed indication:
      a. Calibrated in percent.
      b. Open-loop, function of VFD frequency.

7. Diagnostic indicators located externally on the face of the drive shall show the type of fault responsible for drive warning, shutdown or failure. On occurrence of more than one condition each shall be recorded or indicated by the diagnostics.

C. Remote Control Interface:
   1. PLC interface via RS485 serial communications port:
      a. Capability to:
         1) Start-Stop VFD.
         2) Control VFD Speed.
         3) Access fault and diagnostic data.
   2. Analog and discrete inputs:
      a. As required per Section 13441.
      b. Isolated process follower with offset, gain and span adjustment for accepting a remote 4-20 mA DC speed reference signal.
      c. Drive enable permissive.
         1) Per Section 13441.
            a) From low-low level float switch.
            b) From local disconnect auxiliary contact.
   3. Analog and discrete outputs:
      a. As required per Section 13441.
      b. 4-20 mA DC output for remote speed indication, as a function of frequency, calibrated 0 to 100 percent.
      c. Drive FAULT contacts.
      d. Drive RUNNING contacts.
      e. Drive selector switch in AUTO status contacts.
   4. Contacts:
      a. Contacts shall be rated 2 A inductive at 120 Vac.
      b. All contacts shall be wired to terminal boards.

2.5 HARMONIC PROTECTION REQUIREMENTS

A. Each VFD shall be designed and provided with all necessary equipment to protect the VFD and the power system ahead of the VFD from voltage and current distortion. The VFD manufacturer shall provide harmonic filters as required.
   1. In accordance with and as defined by IEEE 519:
      a. Each VFD shall be designed to operate from a power bus that may contain up to 5 percent voltage distortion.
      b. Each single or multiple set of VFDs powered from the same bus shall be designed to limit percent distortion factor to a maximum total of 5 percent voltage distortion.
      c. Current distortion limits shall not exceed the values listed in Table 10.3 of IEEE 519.
      d. Line-to-line notching at the input to the drive shall have a maximum notch depth of 20 percent and a maximum notch area of 22,800 volt-microseconds reflected back to the power source.

2. The Point of Common Coupling (PCC) for all harmonic calculations and field measurements for both the voltage and current distortion shall be defined as the primary (line side) connection of each VFD.

2.6 EQUIPMENT CONSTRUCTION

A. Fabrication and Assembly:
   1. Each VFD system shall be shop assembled in an enclosure for remote mounting, and shall utilize interchangeable plug-in printed circuit boards and power conversion components wherever possible. Shop assembly shall be performed by the VFD manufacturer or his authorized agent. Systems fabricated or assembled in whole or in part by parties other than the VFD manufacturer or his authorized agent will not be acceptable.
   2. Reactors and/or filters, where required, shall be mounted within or in an ancillary enclosure adjacent to the drive enclosure, or with the Engineer's permission may be mounted in a separate enclosure.
   3. Cooling fans shall be provided to run when drive is running.
   4. Enclosures for separately mounted VFD's:
      a. NEMA Type 1 for installation in Electrical Rooms.
      b. NEMA Type 12 for installation in other unclassified areas.

B. Wiring:
   1. The wiring in the VFD shall be neatly installed in wire ways or with wire ties where wire ways are not practical. Where wire ties are used, the wire bundles are to be held at the back panel with a screw-mounted wire tie mounting base. Bases with a self-sticking back will not be allowed.
   2. All plug-in contacts shall be gold-plated.
   3. Terminal blocks shall be complete with marking strip, covers and pressure connectors. They shall be nonbrittle, interlocking, track-mounted type. Screw terminals will not be allowed. A terminal shall be provided for each conductor of external circuits plus one ground for each shielded cable. For free-standing panels, 8 IN of clearance shall be provided between terminals and the panel base for conduit and wiring space. Not less than 25 percent spare terminals shall be provided. Terminals shall be labeled to agree with identification indicated on the suppliers submittal drawings. Each control loop or system shall be individually fused, and all fuses or circuit breakers shall be clearly labeled and located for easy maintenance.
   4. All grounding wires shall be attached to the enclosure sheet metal with a ring tongue terminal. The surface of the sheet metal shall be prepared to assure good conductivity and corrosion protection.
   5. Wiring shall not be kinked or spliced and shall have markings on both ends or be color coordinated. Markings or color coordination shall comply with the manufacturer's drawings.
   6. With the exception of electronic circuits, all interconnecting wiring and wiring to terminals for external connection shall be stranded copper, insulated for not less than 600 V, with a moisture-resistant and flame-retardant covering rated for not less than 90 DegC.

C. Nameplates:

1. All devices mounted on the face of the drive shall be provided with a suitable nameplate as specified in Section 16010. Push buttons, selector switches, and pilot lights shall have the device manufacturer's standard legend plate. All other devices shall have an engraved, laminated plate. All lettering shall be a minimum of 3/16 IN high and shall be white or silver on a black background.
2. Relays, terminals and special devices inside the control enclosure shall have permanent markings to match identification used on manufacturer's wiring diagrams.
3. Use stainless steel screws to attach nameplates.

D. Painting: Equipment, after being phosphate washed, shall be thoroughly cleaned and given at least one coat of rust-inhibiting primer on all inner surfaces prior to fabrication.

2.7 SOURCE QUALITY CONTROL

A. Factory Tests:
1. Conduct all standard tests in accordance with NEMA and ANSI standards to ensure conformance to Specification requirements.
2. Prior to final assembly:
   a. Inspect incoming components.
   b. Test and inspect power devices.
   c. Circuit cards:
      1) Component and functional tests:
      2) Burn-in chamber or temperature cycling test.
      3) System test after burn-in, or temperature cycling.
3. After final assembly:
   a. Continuity and insulation test of 480 Vac circuits.
      1) Test voltage shall be 2500 Vdc.
   b. Continuity and insulation test of 120 Vac circuits.
      1) Test voltage shall be 500 Vdc.
   c. Drive tests:
      1) Burn-in complete drive at full load for 24 HRS.
      2) Verify all auxiliary circuits operation.
      3) Monitor output variables.
   d. Systems test:
      1) Provide inputs to field connections and simulate on-site operation.
      2) Test all auxiliary equipment.

B. The VFD supplier shall warrant the VFD system to have sufficient capacity to operate successfully under all normal operating conditions, and its use shall in no way diminish the five year mechanical equipment warranty.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions and as indicated on the Drawings.

B. Verify the installed motor nameplate electrical requirements do not exceed the VFD capacity.

C. Provide services of manufacturer's representative to perform start-up services.

3.2 START UP

A. Pre-startup services:
   1. Shall be completed a minimum of 30 days prior to the startup and demonstration period described in Section 01410. Also see 16980.
   2. Shall consist of:
      a. Physical and electrical installation check.
      b. Final adjustments and calibration of drive parameters.
      c. VFD operation from simulated input signals.
   3. Shall be complete when VFD(s) are fully operational.

B. Startup and demonstration services:
   1. Supervise startup of all units including recheck of settings made during the pre-startup tests.
      a. Perform all work in the presence of the Owner's designated representatives.
   2. Simulate operation of the VFD and its associated control and instrumentation system in both the manual and automatic modes.
      a. Ensure compatibility of VFD with associated control and instrumentation signals.
   3. Simulate VFD failures and demonstrate troubleshooting aids.
   4. Instruct Owner's designated personnel:
      a. Minimum of 8 hours at the jobsite.
      b. Include both field and classroom instruction.
      c. Instructions shall include proper operation and maintenance procedures including, but not limited to:
         1) Lubrication.
         2) Troubleshooting.
         3) Repair and replacement.
         4) Parts inventory.
         5) Maintenance records.

C. Perform onsite field measurement of harmonics at the PCC.
   1. For each individual VFD.
   2. For the maximum number of VFDs that will be operational at the same time.

D. Perform onsite field measurement of the maximum voltage peak, measured line-to-line, at the terminals of each motor fed from a VFD.
   1. Use a high speed oscilloscope to produce a plot of Voltage (Y axis) versus Time (X axis).
      a. Time shall be measured in microseconds.
   2. Tests shall be performed at full voltage and speed.

a. Peak voltage shall not exceed 1200 V line-to-line.
b. Peak voltage in excess of 1200 V line-to-line:
    1) Contractor shall coordinate with the VFD manufacturer to solve the problem and at no cost to the Owner.
        a) VFD manufacturer shall increase the impedance of the output line reactor, or provide an output filter, to limit the motor terminal voltage peak to 1200 V or less, line-to-line.
        b) Contractor shall perform a complete retest of all affected drives.

E. Record all data necessary for the preparation of required test reports.

3.3 SPARE PARTS

A. Provide manufacturer's recommended spare parts.

B. When not included in the recommended spare parts provide for each type and rating of drive:
    1. Complete set of all plug-in drive components.
    2. One set of 3 of each type power fuse.
    3. One set of 12 of each type control fuse.
    4. One main control board.
    5. One inverter module.
    6. One inverter snubber module.
    7. One inverter base drive module.
    8. One set of other field replaceable components.

C. Spare parts shall be labeled and packed in containers suitable for storage.

D. Spare parts utilized during pre-startup or startup and demonstration testing shall be immediately restocked, at no cost to the Owner.

END OF SECTION

SECTION 16400

SERVICE AND DISTRIBUTION

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. The work includes furnishing all labor, materials and equipment necessary to complete the installation of service and distribution systems as shown on the Drawings and specified herein.

B. Contractor shall provide:

1. Electrical service and distribution equipment, materials and labor as specified herein, as shown on the drawings or as required for a complete system.

C. Install the exterior meter base and CT cabinet, conduits, transformer vault, and transformer ground grid per specifications of Pacific Power and Light Co.

D. Work by Others

1. Furnishing and installing of conductors for primary service to the utility transformer (in 4” conduit furnished by contractor) and CTs and meter shall be by the Utility Company.

2. Primary transformer.

1.2 SYSTEM DESCRIPTION

A. The system shall consist of all electrical service and distribution equipment and materials installed per the latest edition of the NEC and all applicable building codes to form a complete functional electrical system of proper voltage, capacity and location to serve the project.

B. Service Characteristics shall be as shown on the Drawings.

1.3 QUALITY ASSURANCE

A. Requirements of regulatory agencies:

1. Tests by independent agencies whose classifications and requirements have general acceptance as regulatory:

   a. U.L.
   b. JIC
   c. ANSI
   d. NEMA
   e. FM
   f. ASTM
   g. IPCEA
   h. IEEE
   i. EUSERC

PART 2 PRODUCTS (See individual sections)

2.1 ELECTRICAL REQUIREMENTS

A. Surge Arresters

1. Service Entrance

   a. Service voltage 277/480 volt, WYE; maximum joule rating 6,328 per phase and 11,592 joules/system; peak surge shall be 96,000 amperes/phase and 192,000 amperes/system; UL 1449 clamping voltage (L-N) shall be 1,200 volts, max.; 15 db (EMI/RFI) noise reduction.

   b. Shall have replaceable surge modules, L-L, L-N, L-G and N-G. Provide two spare replacement modules with unit.

   c. Provide 3 spare surge arrester replacement modules.

   d. Acceptable Manufacturers:

1)	Intermatic	UG 40 Series
2)	Current Technology	MP Series
3)	Liebert	LCG Series
4)	Cutler-Hammer	Clipper

2. Surge Arrester Terminal Cabinet Location and Distribution Panelboards

   a. Suitable for use at the voltage/phase connections shown.

b. Where mounted adjacent to a distribution panelboard, provide a 100A, 3 pole fused disconnect to allow service of the unit.

c. Where mounted at a surge arrester terminal cabinet, provide an engraved legend plate for each unit showing panel and circuit number.

d. Acceptable Manufacturers:

1)	Joslyn	Heavy Duty (1265, 1455 or 1456)
2)	Intermatic	UG 28 Series
3)	Current Technology	DPA Series

PART 3 EXECUTION

3.1 INSTALLATION/APPLICATION/PERFORMANCE/ERECTION

A. Electrical Contractor shall thoroughly familiarize himself with existing conditions via an on site inspection of the site and building(s) for which work is to be accomplished prior to bidding.

1. Main disconnect shall have an engraved label reading "Main Service Disconnect".

B. Utility Company providing power shall be contacted for power availability. Routing requirements shall be verified and coordinated to assure timely and proper power availability when and where needed for the project.

C. AC Lighting/Surge Arresters:

1. Main service equipment shall have lightning arresters installed on main service conductors incoming to main distribution panel.

2. Mount the arresters as close as possible to the main lugs and the neutral bus assembly. Use the shortest and straightest path possible to connect the arrester to the power system, avoiding sharp bends or loops in the wire.

D. Underground Service

1. Enclosed in a raceway as shown on drawings.

2. Raceway shall be bonded to main service device cabinet and grounding system.

3. Installation shall be watertight, including where conduits pass through walls or floors.

END OF SECTION

SECTION 16450

SECONDARY GROUNDING

PART 1 GENERAL

1.1 DESCRITPTION OF WORK

A. The work shall includes furnishing all materials, labor and equipment to install secondary grounding system as shown on the Drawings and specified herein.

B. Electrical Contractor shall provide:

1. Grounding for Separately Derived Systems

2. Grounding for Control Circuitry.

3. A completely grounded system (equipment and system grounds) as herein specified as required by the NEC and as shown on the drawings. The installation shall comply with Article 250 of the latest edition of the NEC.

1.2 RELATED WORK

A. Specified elsewhere:

1. SECTION 16050 – Electrical Basic Materials and Methods.

2. SECTION 16950 - Testing Electrical Systems.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Comply with National Electric Code.

2. Comply with Public Authorities having jurisdiction.

1.4 REFERENCES.

A. Specified references, or cited portions thereof, current at date of bidding documents unless otherwise specified, govern the work. In event of conflict between referenced standards and contract documents, notify Engineer

immediately. Confirm notification in writing. Do not proceed with the work until the Engineer issues written instructions.

1. National Fire Protection Association (NFPA): NFPA 70 - National Electrical Code (NEC).

2. Underwriters Laboratories, Inc. (UL): All products UL listed and labeled.

1.5 SUBMITTALS

A. Submit in accordance with SECTION 01340.

1. Submit three copies of all test results, with list of persons presents.

2. Notify Engineer 48 hours prior to scheduled tests.

PART 2 PRODUCTS

2.1 MATERIALS (Acceptable Products)

A. Ground Rods 5/8 inch by 8 foot:

ITT Weaver	W-3410
McGraw Edison	DN4C10 or DN8C10
Joslyn	J8350 or J9170
XIT	K2-10
Blackburn	7510
Oliver	79450
Hubbard	9450
Knight	S1034
Carolina Galvanizing Corp.	P-3410

B. Connectors - Rod to Conductor:

Burndy	Type CR1, CR2 or CR3
Anderson	VCRC-86
T & B	Ground Grid Compression Connector
Erico-Cadwell	Type GR, GT or GB
Thermoweld	Type CR1, CR2 or CR3
Weaver	Type GRD
Blackburn	Type GRD

C. Connectors for cable to cable or to bus, etc.:

Burndy	Hylink/Hylug
Anderson	Versacrimp
T & B	Color Keyed
Panduit	Panterm
3M	Scotchlok, 20000 and 40000 Series
Blackburn	Type AL, LCN

D. Ground Straps (Water, meter shunt, fence grounding):

Anderson	Type GB with GC clamp
Burndy	Type B with GG clamp
O.Z.	Type BJ

E. Pipe Connector:

O.Z.	Type ABG or CG
Anderson	Type GC-111 or 116
Burndy	Type GAR

F. Grounding Bushings:

O.Z.	Type IGB
T & B	#3870 thru #3999
Appleton	Type GIB (Threaded)

2.2 FABRICATION AND MANUFACTURER

A. Ground Rods:

1. Non-rusting, copper rods, 5/8 inch by 8 foot minimum size. Copper to be bonded to a steel core. Minimum copper thickness of 10 mill.

2. Rod may be an electrolytic type, UL listed under UL467J, and comply with ANSI C33.8.

B. Connections:

1. One piece seamless construction with integral solid center barrier, shall be copper for copper to copper connections.

2. UL listed, meet or exceed UL 486 secureness and pullout requirements.

C. Ground Straps:

1. Tinned copper braid.

2. Strapped to pipes with pipe clamps that are corrosion resistant, hot dipped galvanized malleable iron saddle and steel U-bolts and nuts.

D. Pipe Connectors:

1. High strength corrosion-resistant ground connector, with silicon bronze hardware.

E. Grounding Bushings:

1. Corrosion-resistant bronze with a mechanical connection for joining a ground wire to a threaded conduit

PART 3 EXECUTION

3.1 INSTALLATION/APPLICATION/PERFORMANCE/ERECTION

A. Ground Rods:

1. Installed vertically with top 18 inches below finished grade or as shown on Drawings.

2. Connection to rod shall be with a nonreversible mechanical compression type connector or a molecular weld (exothermic reaction) connection.

3. Connections shall be made in accordance with connector manufacturers installation instructions.

B. Protective Coating:

1. Connections shall be coated with a protective urethane seal coat after connections are complete. Apply four coats at 15 to 20 minute intervals or in accordance with manufacturers' application instructions.

C. Connections:

1. Made with compression type connectors or a molecular weld connection.

2. Made in accordance with manufacturers installation instructions.

D. Ground Straps:

1. Installed on all piping where a meter, expansion joint, or dielectric unions are used in all water and conduit systems or other location where a bonding jumper is required by NEC.

E. Grounding Bushings:

1. Installed on all conduits which contain a ground wire or conduits used for main feeders or subfeeders and as required by NEC.

F. Contact surfaces shall be thoroughly cleaned prior to connections being made.

G. Grounding conductors shall be installed to permit the shortest most direct path to ground.

H. Ground conductors shall be installed in conduit where not enclosed in a cabinet.

I. Solidly ground all electrical equipment.

J. A main building ground, bare copper conductor, shall be run in conduit from the main service to a driven groundfield outside the building as shown on the drawings or as required by NEC. The use of stranded copper or aluminum wire is strictly prohibited. The main building ground shall be extended to the water service (and fire protection service metal piping and to a main effectively grounded main structural steel member) of the building. Provide a properly sized bonding shunt strap around the meter(s). Multiple ground rods shall be a minimum of 8 feet apart.

K. Panelboards and Disconnects.

1. Main Service Disconnect device (panelboard - disconnect switch) and first panelboard or disconnect switch on secondary side of the utility transformer shall have the neutral and equipment ground bonded together. All other electrical equipment shall have the neutral isolated from the equipment ground.

2. Ground bars in panelboards and switchboards shall have sufficient lugs for each overcurrent device and incoming equipment ground conductor. Ground bar shall be bonded to device enclosure.

L. Transformers:

1. Dry type indoor transformers shall be grounded as follows:

a. A ground conductor shall run from neutral tap on secondary side of transformer to a ground rod or the main service ground, to a main water line and to a grounded structural column (if avail.). Bond the neutral to the equipment ground lug in the transformer. First panel or disconnect on a secondary side of transformer shall have the ground bar isolated from the neutral. A ground wire shall extend from each ground bushing on the liquid tight conduits to the equipment ground lug.

3.2 FIELD QUALITY CONTROL

A. Ground resistance shall be measured using suitable ground resistance measuring equipment.

B. Resistance measurement shall be from the system neutral connection at the service entrance to a convenient ground reference point. The ground reference point should be located to minimize the effects of other existing grounding electrodes.

C. Ground resistance shall not exceed 10 OHMS. When resistance exceeds 10 OHMS, one of the following measures shall be taken to reduce the ground resistance:

1. Drive and bond additional ground rods at two rod length intervals.

2. Treat the soil in the vicinity of the electrode with metallic salts.

3. Remove soil from around the electrode and replace with bentonite. Use a U.L. approved electrolytic chemical ground rod.

4. All resistance tests shall be taken no sooner than 48 hours after a measurable rainfall.

END OF SECTION

SECTION 16460

TRANSFORMERS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. The work includes furnishing all labor, materials and equipment necessary for installation of transformers as shown on the Drawings and specified herein.

B. Electrical Contractor Provide: All dry type transformers specified herein and shown on the Drawings.

1.2 RELATED REQUIREMENTS

A. Specified elsewhere

1. SECTION 01340 – Submittals
2. SECTION 03300 – Cast-in-Place Concrete
3. SECTION 16050 – Basic Electrical Materials & Methods
4. SECTION 16450 – Secondary Grounding
5. SECTION 16471 - Panelboards

1.3 QUALITY ASSURANCE

A. Regulatory Requirements

1. Codes:

a. Latest Edition, National Electrical Code (NEC).

2. Standards or tests by independent agencies whose classifications and requirements have general acceptance as regulatory:

a. National Electrical Manufacturer's Association (NEMA).

b. American National Standards Institute (ANSI).

3. Referenced standards, specifications, catalogs:

a. NEMA TRI-1974.

b. ANSI C57.12.22 and C57.12.90.

c. UL 506.

4. Isolation transformers shall meet or exceed all specifications in applicable sections of the following standards and codes: NEMA, IEEE 389, 587, ASME, ANSI C84.1, NEC and UL 506.

1.4 SUBMITTALS - Submit in accordance with SECTION 01340.

A. Shop Drawings

1. Submit detailed drawing listing or showing the following:

a. Primary and secondary voltages

b. Frequency

c. Primary and secondary connections

d. KVA and phase

e. Taps (number and location)

f. Insulation Class

g. Temperature Rise

h. Sound Level.

i. Maximum Ambient Temperature

j. Mounting

k. Enclosures and Dimensions

l. Conduit Area

m. Wiring Diagram

PART 2 PRODUCTS

2.1 MATERIALS (Acceptable Products)

A. Dry Type Transformers

1.	Square D	Sorger
2.	ACME	Optimiser
3.	Gould ITE	Dry Type
4.	Jefferson	Powerformer, Dry Type
5.	Sola	Hevi-Duty
6.	Siemens	

7. General Electric
8. Cutler-Hammer

2.2 FABRICATION AND MANUFACTURER

A. Dry type Transformers

1. Single phase transformers shall be 480 volt primary and 240/120 volt secondary as shown on the drawings.

2. Three phase transformers shall be 480 volt delta primary and 208Y/120 volt secondary as shown on the drawings.

3. Transformers 3-15 KVA single phase shall have 2 - 5% full capacity below normal taps. Transformers 25-167 KVA single phase shall have 2 - 2.5% full capacity above normal taps and 4 - 2.5% full capacity below normal taps.

4. Transformers 3-15 KVA three phase shall have 2 - 2.5% full capacity above normal taps and 2 - 2.5% full capacity below normal taps.

5. Transformers shall be 115˚C temperature rise above a 40^{o} C ambient. All insulating materials shall be in accordance with NEMA St 20 Standards for a 220˚C, UL component recognized insulation system.

6. Transformer coils shall be of continuous wound construction and shall be impregnated with non-hydroscopic, thermo-setting varnish. Materials utilized must have a minimum of two years of proven field usage. Transformer impedance shall be a minimum of 3%.

7. All cores to be constructed of high grade, non-aging silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Magnetic flux densities are to be kept significantly below the saturation point. The core laminations shall be clamped together with steel angles. The completed core and coil shall then be bolted to the base of the enclosure but isolated therefrom by means of rubber, vibration-absorbing mounts. There shall be no metal-to-metal contact between the core and coil and the enclosures. On transformers 500 KVA and smaller, the vibration isolating system shall be designed to provide a permanent fastening of the core and coil to the enclosure. Sound isolating systems requiring the complete removal of all fastening devices will not be acceptable.

8. Transformers 15 KVA and larger shall be in heavy gauge, sheet steel, ventilated enclosure. The ventilating openings shall be designed to prevent accidental access to live parts in accordance with UL, NEMA, and NEC Standards for ventilated enclosures. Transformers 25 KVA through 75

KVA shall be designed so they can be either floor or wall mounted. Above 75 KVA they shall be floor mounted design.

9. The entire transformer enclosures shall be degreased, cleaned, phosphatized, primed and finished with a baked enamel.

10. temperature rating shall be 115˚C rise above a 40˚C ambient.

11. The core of the transformer shall be grounded to the enclosure by means of a flexible grounding conductor sized in accordance with applicable NEMA and NEC Standards.

12. Sound levels shall be guaranteed by the manufacturer not to exceed the following when tested per NEMA and ANSI Standards: 0-9 KVA - 40DB; 10-50 KVA - 45DB; 51-150 KVA - 50DB; 151-300 KVA - 55DB; 301-500 KVA - 60DB.

13. Transformers shall be listed by UL for the specified temperature rise.

14. Terminals shall have compression (crimp) connectors for external leads or connections.

15. Transformers shall include a permanent metal nameplate which indicate KVA, phase, voltage, taps, wiring diagrams, insulation and temperature rise, and manufacturer catalog number.

16. Transformers shall be UL Listed and Labeled. Transformers shown mounted outdoors, shall be suitable for outdoor use, complete with weather shield.

PART 3 EXECUTION

3.1 INSTALLATION/APPLICATION/PERFORMANCE/ERECTION

A. Transformers shall be set level and square or plumb and level if wall mounted.

B. Transformers shall be rigidly secured on vibration isolators. Conduit shall not be permitted for support. Provide a concrete pad when mounted outdoors.

C. Transformers shall be mounted in accordance with manufacturer's recommendations for free air space around enclosure. Equipment and other materials shall not be mounted or stored on top of enclosures.

D. Connections shall be made with liquidtight conduit.

3.2 ADJUST AND CLEAN

A. Prior to acceptance of work, all nuts, bolts and screws shall be tightened to manufacturer's recommended specifications.

B. Transformer enclosure ventilation openings shall be cleaned and free of extraneous obstructions.

C. Enclosure cover plates shall be in place prior to acceptance.

END OF SECTION

SECTION 16471

PANELBOARDS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. The work includes furnishing all labor, materials and equipment necessary for installation of panelboards as shown on the Drawings and specified herein.

B. Electrical Contractor shall provide:

1. Provide complete panelboards including boxes, interiors, circuit breakers, trims, and associated accessories to provide complete and functional panelboard assemblies specified herein or shown on electrical Drawings.

1.2 RELATED WORK

A. Specified Elsewhere

1. SECTION 01340 – Submittals.
2. SECTION 16050 - Basic Electrical Materials & Methods.
3. SECTION 16450 - Secondary Grounding.

1.3 QUALITY ASSURANCE

A. Regulatory Requirements

1. ANSI C1/NFPA to comply with: National Electric Code (NEC).

1.4 REFERENCES

A. Specified references, or cited portions thereof, current at date of bidding documents unless otherwise specified, govern the work. In event of conflict between referenced standards and contract documents, notify Engineer immediately. Confirm notification in writing. Do not proceed with the work until Engineer issues written instructions.

1. American National Standards Institute (ANSI).
2. American National Standards Institute/National Fire Protection Association (ANSI/NFPA): ANSI C1/NFPA 70 - National Electrical Code (NEC).

3. National Electrical Manufacturers Association (NEMA).
4. FS W-C-375 - Circuit Breakers, Molded Case, Branch Circuit and Service.
5. NEMA AB 1 - Molded Case Circuit Breakers.
6. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 242, Protection and Coordination of Industrial and Commercial Power Systems (Buff Book).

1.5 SUBMITTALS

A. Submit in accordance with SECTION 01340:

1. Shop Drawings

a. Reports:

1) Short circuit study report.

2) Protective coordination study report.

b. Submit detailed drawing of all panelboards indicating schedules and ratings of circuit breakers, bus, lugs, enclosures, surge suppressors and associated accessories.

c. One-line diagrams shall be submitted for all panelboards.

d. Indicate all dimensions and verify that equipment will fit into locations shown.

e. Finish and mounting (flush, surface, outdoor) shall be clearly indicated.

f. Indicate UL Labeling for application required.

2. Manufacturer's Literature:

a. Submittal shall include drawings showing: Concealed hinges and trim clamp construction, catalog cuts of breaker types to be used and other accessories.

1.6 DELIVERY, STORAGE AND HANDLING

A. Materials shall be suitably packaged by manufacturer to prevent damage during shipment. Damaged materials will not be acceptable for use.

B. Store materials on site in clean, dry storage area; when outside, elevated above grade and enclosed with durable watertight wrapping.

C. Handle all materials carefully to prevent damage. Minor scratches, marks or blemishes to finish shall be repaired to satisfaction of Engineer.

PART 2 PRODUCTS

2.1 MATERIALS (Acceptable Products)

	Square D	Siemens	Westinghouse
A.	*Type A Panelboard: 240 volt maximum panelboard:*		
	NQOD	CDP7	Pow-R-Line
B.	*Type B Panelboard: Max. 480 volt panelboard with branches above 60 amperes*:		
	I-Line	CDP6	Pow-R-Line
C.	*Type C Panelboard: Max. 480 volt panelboard with branches below 60 amperes*:		
	NFB	NHB	Pow-R-Line

2.2 FABRICATION AND MANUFACTURER

A. Panelboards - General

1. Have a typewritten directory, under transparent plastic to identify each circuit load and location.

2. A laminated bakelite nameplate shall be attached to the outside of the panelboard via screws or rivets to indicate device name, voltage and phase. Nameplates shall have black 1/4 inch letters on a white background.

3. Circuit breakers of the bolt-on type.

4. Dead front construction and enclosed in a steel cabinet as specified in UL 50 and NEC Section 384-18.

5. Gutters shall be sized in accordance with UL 67 and NEC Section 373-6 and 384-3g.

6. Copper ground bus installed, bus to have provisions for a main ground conductor, size as noted on Drawings or as required by NEC and have branch lugs of sufficient quantity for number of circuits in the panelboard.

7. Bus structure shall be based on UL 67 for size, rating and heat rise.

8. Trims shall be of the type with concealed hinges and trim clamps with no exposed screws or bolts, and have keyed locks. All locks to be keyed alike, GE 75. Panel trims shall not be capable of being removed when the door is locked.

9. Have either main lugs or main breaker as shown on drawings. Lugs or main breakers shall be of proper size and type to accept cable as specified and shown on drawings, and be UL Listed as suitable for the type conductors specified.

10. When utilized for service entrance shall be UL Labeled.

11. Neutral bars shall be of the solid type.

12. Panelboard, as a complete unit, shall have a circuit current rating equal to or greater than the integrated equipment rating shown on the panelboard schedule on drawings. This rating shall be established by testing with the overcurrent devices mounted in the panelboard. Method of testing shall be per UL Standard 67. Panelboards shall be marked with their maximum short circuit rating at the supply voltage and be UL Listed.

13. Minimum width shall be 20 inches wide.

14. Two section panelboards shall have identical cabinet dimensions.

15. Bus bars shall be of solid copper construction.

16. Copper isolated ground bus as indicated on Drawings.

B. Circuit Breakers - General

1. Circuit breakers shall conform to the following:

   a. Quick-make, quick-break.
   b. Inverse time tripping characteristics.
   c. Overcenter, trip-free, toggle-type operating mechanisms.
   d. Positive handle indication.
   e. Permanent trip unit containing individual thermal and magnetic trip elements.
   f. Operating handle which assumes a center position when tripped.
   g. Calibrated for operation in an ambient temperature of 40˚ C.
   h. Suitable for mounting and operating in any position.
   i. UL Listed for panelboard and meet NEMA standard ABI-1975.

j. Terminations UL Listed for type of wire specified.

k. Minimum UL Listed interrupting ratings (RMS sym. amps) shall be as shown on the Drawings.

l. "HACR" rated for all heating, air conditioning, ventilation and refrigeration.

C. 240 volt maximum panelboards

1. Bus bar connections to branch circuit breakers shall be distributed phase type.

2. Current-carrying parts of the bus assembly shall be plated.

3. Circuit breakers shall be bolt-on, quick-make, quick-break, thermal-magnetic, trip indicating.

4. Branch circuit breakers feeding receptacles shall have sensitive instantaneous trip settings for not more than 10 times the trip rating of the breakers to prevent repeated arcing shorts.

D. 480/277 Volt Panelboards

1. Bus structure and main lugs or main circuit breaker shall have current ratings as shown on the drawings. Such ratings shall be established by heat rise tests conducted in accordance with UL Standard 67.

2. Circuit breakers shall be bolt-on, quick-make, quick-break, thermal magnetic and trip indicating.

3. Bus shall be distributed phase sequence type.

PART 3 EXECUTION

3.1 INSTALLATION/APPLICATION/PERFORMANCE/ERECTION

A. Installed plumb and level.

B. When flush mounted, shall be rigidly secured and set so that flush trim will be flush with finished wall surfaces.

C. When surface mounted, shall be rigidly secured to walls.

D. Location and mounting of panelboards shall be coordinated with all trades prior to setting in place.

E. Wiring shall have rounded corners and be tied off with cable ties.

F. Wall mounted panels less than 72 inches high shall have top of panel at 6' 6" above floor.

3.2 ADJUST AND CLEAN

A. Prior to acceptance of work by Engineer, panelboard locks and trim shall be adjusted to work properly.

B. All lugs, bolts, clamps and screws shall be tightened to manufacturer's specifications.

C. All directories shall be typed and in place.

1. Each circuit must identify room(s) served and item served (LTG., RECEPTS, HVAC, etc).

D. All keys shall be turned over to the owner.

END OF SECTION

SECTION 16472

SWITCHBOARDS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. The work includes furnishing all materials, labor and equipment for installation of switchboards as shown on the Drawings and specified herein.

B. Electrical Contractor shall provide complete switchboards including enclosures, interiors, circuit breakers, and all accessories to provide complete and functional switchboard assemblies as specified herein and shown on the Drawings.

1.2 SUBMITTALS

A. Submit following in accordance with SECTION 01340:

1. Shop Drawings: Indicated front and side views of enclosures with overall dimensions shown; conduit entrance locations and requirements; nameplate legends; size and number of bus bars per phase, neutral and ground; and switchboard instrument details.

2. Product Data: Provided electrical characteristics including voltage, frame size and trip ratings, fault current withstand ratings, and time-current curves of all equipment and components.

3. Provide copies of Legend Plate schedule.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Switchboards:

1. Square D
2. Cutler Hammer
3. Westinghouse
4. Siemans

5. General Electric

2.2 SWITCHBOARD (MDP)

A. General

1. The switchboard shall meet the latest requirements of Underwriters Laboratories standard #891, NEMA PB2 and National Electric Code. The switchboard(s) shall be furnished with an Underwriters Laboratories label.

2. The switchboard framework shall be fabricated on a steel base or base assembly consisting of formed steel and commercial channel welded or bolted together to rigidly support the entire shipping unit for moving on rollers and floor mounting. The framework is to be formed code gauge steel, rigidly welded and bolted together to support all coverplates, bussing, and component devices during shipment and installation.

3. All switchboards shall be design for front accessibility only and shall be located as shown on the drawings.

4. Switchboard shall be of required number of vertical sections bolted together to form one metal enclosed rigid switchboard. The sides, top and rear shall be covered with removable, screw-on code gauge steel plates. Switchboard shall include all protective devices and equipment as shown on the Drawings or in this Specification with necessary interconnections, instrumentation and control wiring.

5. Each section of the switchboard shall be wired and tested at the factory and ready for installation when received at the site.

6. Switchboard shall have the rating and arrangement as shown on the drawings.

7. All groups of control wires shall be provided with terminal blocks with numbering strips.

8. The arrangement within the assemblies shall permit maximum accessibility to all parts, busses and incoming and outgoing cables.

9. The switchboard bussing shall be plated copper and of sufficient cross-sectional area to continuously conduct rated full load current with maximum temperature rise of 50˚ C, above ambient temperature of 40˚C.

10. Each switchboard, as a complete unit, shall be given a single short circuit current rating by the manufacturer. Such ratings shall be established by the

actual tests by the manufacturer, in accordance with UL specification, on equipment constructed similarly to the subject switchboard.

11. Each switch, and all control equipment shall have engraved laminated nameplates.

12. All steel surfaces shall be chemically cleaned and treated to provide a bond between paint and metal surfaces. All hardware shall be high tensile strength and shall be cadmium plated. Switchboard to be factory finished in manufacturer's standard color.

13. The distribution sections shall be completely enclosed, self-supporting metal structures containing circuit breakers and associated equipment as shown on the drawings.

14. The bus bars shall be rigidly braced to comply with the integrated equipment rating of the switchboard. The end section is to have bus bar provisions for future addition of a switchboard section. The provisions shall include the bus bars installed on the extreme side of the switchboard and prepunched to facilitate future bolted splice plates. The horizontal main bus bar supports, connections, and joints are to be bolted or welded. Minimum main bus bar bracing shall be 150,000 Amps RMS symmetrical. A 50% copper ground bar shall extend the entire length of the switchboard, and solidly grounded to each vertical section.

B. Metering:

1. Provide multi-function, panel mount metering system within distribution section.

2. Face of meter shall consist of three LCD displays, one each for volts, amps and power. Face shall also contain push buttons for selection of functions displayed.

3. Meter shall be capable of monitoring the following: Line-to-line and line-to-neutral voltage of all phases, current on each phase and neutral, KW, KVAR, KVA, Power Factor, total KWH, total KVAH, and K Factor.

4. Provide shorting block, accessible from the front of the switchboard for connection of the CT's. The P.T. shall be protected by accessible fuses.

PART 3 EXECUTION

3.1 PREPARATION

A. Provide a 4” concrete housekeeping pad.

3.2 INSTALLATION

A. Install switchboard in location shown on drawings, in accordance with manufacturer’s written instructions and NEMA PB2.1.

B. Switchboard shall be installed plumb, level and rigidly secured to walls and floor with bolts and proper anchors.

C. Switchboards shall be anchored to slab or pad as shown on the drawings, with bolts and anchors as recommended by the manufacturer.

D. All wiring in switchboard shall have rounded corners, be neatly placed and be tied off with cable ties.

E. Tighten accessible bus connections and mechanical fasteners after placing switchboard.

3.3 FIELD QUALITY CONTROL

A. Breakers shall be operated through an open-close cycle and checked for proper operation, alignment and contact.

B. Instrumentation shall be checked and inspected for proper connections, workmanship and identification.

C. All ground connections shall be tightly secured and tested for continuity prior to energization.

D. Check tightness of accessible bolted bus joints using calibrated torque wrench.

E. Calibrate all adjustable breaker settings to provide proper coordination with upstream and downstream devices.

F. After energization and under actual load conditions, all power cable terminations and bus splices shall be tested for proper connections, identification and tested.

3.4 ADJUSTING

A. Adjust all operating mechanisms for free mechanical movement.

B. Tighten bolted bus connections in accordance with manufacturer’s instructions.

3.5 CLEANING

A. Touch up scratched or marred surfaces to match original finish.

END OF SECTION

SECTION 16480

MOTOR STARTERS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. Work includes furnishing all labor, materials and equipment necessary to install motor starters as specified herein and as shown on the Drawings.

B. In general, the following items should be furnished as components of specified equipment and excluded from this specification. This should be coordinated and verified by the contractor:

1. Motors which are an integral part of equipment specified.

2. Starters which are an integral part of equipment specified.

3. Power wiring from starter to motor when the starter is an integral part of equipment specified.

4. Control and interlock wiring for specified equipment except as specified on electrical drawings.

5. All control devices in addition to starters specified.

1.2 RELATED WORK

A. Specified elsewhere:

1. SECTION 16050 - Basic Electrical Materials & Methods
2. SECTION 16195 - Electrical Identification Systems
3. SECTION 16265 - VFDs
4. SECTION 16450 - Secondary Grounding
5. SECTION 16960 - Testing Electrical Systems

1.3 QUALITY ASSURANCE

A. Regulatory Requirements

1. Motor shall be in accord with NEMA MG-1 & MG-13, U.L. recognized construction.

2. Power & Control Wiring in accord with NEC.

1.4 REFERENCES

A. Specified references, or cited portions thereof, current at date of bidding documents unless otherwise specified, govern the work. In event of conflict between referenced standards and contract documents, notify Engineer immediately. Confirm notification in writing. Do not proceed with the work until the Engineer issues written instructions.

B. National Electrical Manufacturers Association (NEMA):

1. NEMA MG-1.
2. NEMA MG-13.

C. National Fire Protection Association (NFPA): NFPA 70 - National Electrical Code (NEC).

D. Underwriters Laboratories, Inc. (UL):

1. All products UL Listed and labeled.

E. Manufacturer's Catalogs: Specification manufacturer's catalogs are incorporated by reference to same force and effect as if repeated herein in full.

1.5 SUBMITTALS

A. Submit in accordance with SECTION 01340:

1. Shop Drawings

a. Submit detailed drawing of all magnetic combination, magnetic reduced voltage starter wiring diagrams, label schedules and all accessories and how they attach to the starter. Wiring diagrams must be prepared specifically for this job, showing all external connections to field devices, and showing connections to the control and instrumentation systems. Shop drawing will not be considered acceptable until all systems are fully coordinated.

2. Product Data

B. Submit in accordance with SECTION 01730:

1. Operation and Maintenance Data.

PART 2 PRODUCTS

2.1 MATERIALS (Acceptable Products)

		Square D	Cutler Hammer	Allen Bradley	Siemens
A.	Manual Starter	2510 Type M	9115	Bull. 609	MSP
B.	Magnetic Starters	8536	A10 CR386	Bull. 509	SXL
C.	Combination Magnetic StarteR	8538	A30/40/70/80	Bull. 512	SCN/SCF
D.	Variable Frequency Drives	See 16265			

2.2 FABRICATION AND MANUFACTURER

A. Manual Starter

1. Double break silver alloy contacts, red pilot, and provisions for the addition of 1 - N.O. or 1 N.C. additional interlock. Overload relays shall be trip-free, and the starter shall be inoperative if any thermal units are removed. Thermal units shall be melting alloy. Enclosures shall be NEMA 4.

B. Magnetic Starter

1. Straight-through wiring, double-break silver alloy contacts through size 6, electrically operated coil interchangeable melting alloy thermal units, one for each phase conductor. Shall be inoperative if any thermal unit is removed. Shall include primary and secondary fused control circuit transformer of sufficient VA capacity to power all control circuit elements fed from the control circuit transformer plus 50 VA minimum spare capacity. Control circuit transformer secondary voltage shall be 120 volts unless otherwise listed on drawings. Have provisions for four additional electrical interlocks in addition to holding circuit interlock. A minimum of 1 N.O. additional interlock is required on all starters. On-Off and Start-Stop pushbuttons, and pilot light shall be provided. Enclosures shall be NEMA 1 for general purpose indoor applications, and NEMA 4 for exterior applications. Entire unit shall be UL Labeled.

C. Combination Magnetic Starter

1. Quick make and break, visible blade disconnect with Class R fuse clips. The disconnect handle shall always be in control of the disconnect device with the door open or closed. Disconnect handle shall be clearly marked as to whether disconnect device is ON or OFF. Starters shall have straight-through wiring, double-break silver alloy contacts, electrically operated coil, and three interchangeable melting alloy thermal units. Be inoperative if any thermal unit is removed. Include primary and secondary fused control circuit transformer of sufficient VA capacity to power all control circuit elements fed from the control circuit transformer plus 50 VA minimum spare capacity. Control circuit transformer secondary voltage shall be 120 volts unless otherwise listed on drawings. Have provisions for four additional interlocks in addition to holding circuit interlock. A minimum of (1) N.O. additional interlock is required on all starters. Cover mounted Hand-Off-Auto selector switches, and pilot light shall be provided. Starter enclosures shall be NEMA 1 for general purpose indoor applications and NEMA 4 for exterior applications. Entire unit shall be UL Labeled.

D. Magnetic starters shall have provisions for four additional interlocks in addition to holding circuit interlocks. Additional interlocks shall be of sufficient current carrying capacity and voltage rating for the circuit in which it is utilized.

E. Control transformers shall be minimum of: 70 VA for up to and including size 1, 150 VA for size 2, 250 VA for size 3, and 350 VA for size 4.

F. Finish

1. Manufacturer's standard finish shall be furnished.

G. Thermal Unit Selection

1. For motors mounted above grade, use NEMA style melting alloy thermal overload relays, Class 20, with manual reset.

2. For submersible motors, or motors mounted in a different ambient temperature than the starter, use Class 20, ambient compensated NEMA style bimetallic thermal overload relays.

3. If other type of thermal overload is required by the equipment manufacturer, it shall be the responsibility of the Contractor supplying the equipment to provide and install the proper overload protection to insure full equipment warranty at no additional cost to the Owner.

H. Conductance Relays

1. Conductance relays, used to level controls, leak detectors, and hi/lo level alarms shall be DPDT, plug in type relays, 120 volt coils, with 0 - 1 meg. ohm factory setting sensitivity. The relays shall include a 11 pin octal base. Warrick series 16M (low level) or 2800 (seal leak) or Patriot B/W Controls Series 52 or equal.

2. The liquid level sensor used in conjunction with the above relays shall be cable suspended S.S. probe, complete with a protective plastic shield. Warrick Series W or B/W Controls 6013-W7.

3. The probes shall be suspended from multi-wire suspension fittings, suitable for the application.

PART 3 EXECUTION

3.1 INSTALLATION/APPLICATION/PERFORMANCE/ERECTION

A. Starters shall be rigidly mounted and secured. Support by conduit shall not be permitted.

B. Individual starters shall be mounted with their tops at six feet above finished floor unless otherwise noted on drawings.

C. Wiring shall be neatly bundled and tied after complete installation.

D. Electrical Contractor provide:

1. Motor feeders and safety switches (disconnects).

2. Conduit and wire to:

a. Starter when specified as integral part of equipment.

b. Motor and starter when starter specified is provided by Electrical Contractor.

E. Control and interlock wiring shall be provided by contractor providing controlled equipment; i.e., Plumbing Contractor provides for plumbing equipment, Mechanical Contractor provides for heating, air conditioning, refrigeration and temperature control systems, other contractors for equipment they provide. Electrical Contractor provides when specified and shown on electrical drawings.

F. Conduit and wire shall be installed in accordance with NEC and Division 16 of this Manual.

G. Control and interlock wiring includes that from the holding coil of magnetic starters or undergrounded load side of manual starters to all manual and automatic control devices specified for safety or operation of the system.

H. Coordinate with exact requirements as called out on shop drawings of equipment provided by others.

3.2 IDENTIFICATION

A. Starters shall be identified as to device and use via an engraved laminated nameplates with black 1/4 inch letters on a white background affixed to the device by screws or rivets.

B. Motor nameplates shall be checked for full load current rating and allowable temperature rise to determine correct overload thermal units for each motor.

C. Provide in accordance with SECTION 16195.

3.3 OPERATION AND TEST

A. Contractor providing equipment shall be responsible for operation of motors associated with equipment.

B. Electrical Contractor and Contractor furnishing equipment jointly test and verify correct phasing and rotation of motors. Corrective phasing work by Electrical Contractor.

C. With equipment operating under normal load the Electrical Contractor shall measure and record motor voltage and amperage for each phase. Verify that measurements are within nameplate ratings. Record complete nameplate data for each motor and record voltage and amperage readings for each motor. List thermal overload element for each motor. Submit data in tabular form for review by Engineer, and include a copy of test results in Operational and Maintenance Manual.

END OF SECTION

SECTION 16490
OVERCURRENT AND SHORT CIRCUIT PROTECTIVE DEVICES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Low voltage circuit breakers.

B. Related Sections include but are not necessarily limited to:
   1. Division 1 - General Requirements.
   2. Section 16010 - Electrical: Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
      a. 242, Protection and Coordination of Industrial and Commercial Power Systems (Buff Book).
      b. 399, Power System Analysis (Brown Book).
   2. National Electrical Manufacturers Association (NEMA):
      a. AB 1, Molded Case Circuit Breakers.
   3. Underwriters Laboratories, Inc. (UL):
      a. 489, Molded Case Circuit Breakers and Circuit Breaker Enclosures.
      b. 943, Ground Fault Circuit Interrupters.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Section 16010.
   2. Reports:
      a. Short circuit study report.
      b. Protective coordination study report.

B. Operation and Maintenance Manual:
   1. See Section 01340.

C. Miscellaneous:
   1. Ground fault protection system test reports signed by the projects supervising electrical foreman.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Circuit breakers:

a. Cutler-Hammer.
b. General Electric Company.
c. Square D Company.
d. Siemens.

B. Submit requests for substitution.

2.2 CIRCUIT BREAKERS

A. Molded case type:
1. General:
a. Standards: NEMA AB 1, UL 489.
b. Unit construction.
c. Over-center, toggle handle operated.
d. Quick-make, quick-break, independent of toggle handle operation.
e. Manual and automatic operation.
f. All poles open and close simultaneously.
g. Three position handle: On, off and tripped.
h. Molded-in ON and OFF markings on breaker cover.
i. One-, two- or three-pole as indicated on the Drawings.
j. Current and interrupting ratings as indicated on the Drawings.
k. Bolt on type.
2. Thermal magnetic type:
a. Inverse time overload and instantaneous short circuit protection by means of a thermal magnetic element.
b. Frame size 150 amp and below:
1) Non-interchangeable, non-adjustable thermal magnetic trip units.
c. Frame sizes 225 to 250 amp:
1) Interchangeable and adjustable instantaneous thermal magnetic trip units.
d. Ground Fault Circuit Interrupter (GFCI) Listed:
1) Standard: UL 943.
2) One- or two-pole as indicated on the Drawings.
3) Class A ground fault circuit.
4) Trip on 5 mA ground fault (4-6 mA range).
e. HACR listed:
1) Heating, air conditioning and refrigeration applications.
3. Solid state trip type:
a. Inverse time overload, instantaneous short circuit and ground fault protection by means of a solid state trip element, associated current monitors and flux shunt trip mechanism.
b. Frame size 400 amp to 1200 amp:
1) Standard rating.
2) Interchangeable current sensor or rating plug.
3) Adjustable long time pick-up setting. Adjustable from 50 to 100 percent of the current sensor or rating plug.
4) Adjustable short time pick-up setting.
5) Adjustable instantaneous pick-up.

6) Fixed ground fault pick-up, when indicated on the Drawings.

c. Frame size 1600 amp and above:
   1) 100 percent rated.
   2) Interchangeable current sensor or rating plug.
   3) Adjustable long time pick-up setting. Adjustable from 50 to 100 percent of the current sensor or rating plug.
   4) Adjustable long time delay setting.
   5) Adjustable short time pick-up setting.
   6) Adjustable instantaneous pick-up setting.
   7) Adjustable ground fault pick-up setting, when indicated on the Drawings.
   8) Adjustable ground fault delay setting, when indicated on the Drawings.

4. Motor circuit protector:
   a. Adjustable instantaneous short circuit protection by means of a magnetic or solid state trip element.
   b. Sized for the connected motor.

B. Insulated Case Type:
1. Inverse time overload, instantaneous short circuit and ground fault protection by means of a solid state trip element, associated current monitors and two-step stored energy trip mechanism.
2. Standards: NEMA AB 1, UL 489.
3. 100 percent rated.
4. Manually operated (MO) unless electrically operated (EO) is indicated on the Drawings.
5. Current and interrupting ratings as indicated on the Drawings.
6. Selective override circuit on breakers with short time settings and without instantaneous settings that allow selectivity up to the breakers RMS symmetrical short time rating. The selective override circuit shall allow the breaker to ride through a fully offset (asymmetrical) fault equal to its RMS symmetrical short time rating in a system having an X/R ration of 6.6 with a maximum single phase peak current of 2.3 times the RMS symmetrical short time range.
7. Frame size 400 amp and above:
   a. Interchangeable current sensor or rating plug:
   b. Adjustable long time pick-up setting. Adjustable from 50 to 100 percent of the current sensor or rating plug.
   c. Adjustable long time delay setting.
   d. Adjustable short time pick-up setting.
   e. Adjustable instantaneous pick-up setting.
   f. Adjustable ground fault pick-up setting, when indicated on the Drawings.
   g. Adjustable ground fault delay setting, when indicated on the Drawings.

PART 3 EXECUTION

3.1 INSTALLATION

A. Current and interrupting ratings as indicated on the Drawings.

B. Series rated systems not acceptable.

C. Devices shall be ambient temperature compensated.

D. Circuit Breakers:
   1. Molded case circuit breakers shall incorporate the following, unless indicated otherwise on the Drawings:
      a. Frame sizes 250 amp and less shall be thermal magnetic type.
      b. Frame sizes 400 amp and larger shall be solid state trip type.
         1) Current sensor or rating plugs long time pick-up setting shall be set so that the indicated trip level is near the 75 percent trip point.
      c. Frame sizes 1000 amp and above shall include integral ground fault protection, when indicated on the Drawings.
      d. Motor circuit protectors sized for the connected motor.
   2. Insulated case circuit breakers shall incorporate the following, unless indicated otherwise on the Drawings:
      a. Current sensor or rating plugs long time pick-up setting shall be set so that the indicated trip level is near the 75 percent trip point.
      b. Frame sizes 1000 amp and above shall include integral ground fault protection, when indicated on the Drawings.

3.2 FIELD QUALITY CONTROL

A. Adjustable Circuit Breakers:
   1. Set all circuit breaker adjustable taps as defined on the Drawings.
   2. Set all circuit breaker adjustable taps as defined in the coordination study.
   3. Test and verify all circuit breaker trip functions using a test set provided by the manufacturer for that purpose for circuit breakers 1200 A and above.

B. Ground Fault Protection System:
   1. Single source system:
      a. Main breaker coordinated with individual feeder breakers using the residual sensing method.
      b. The main and feeder breakers shall utilize four individual current sensors, the phase sensors are integral to the circuit breaker and the neutral sensor is external to the circuit breaker.

C. Ground Fault Protection System Testing:
   1. Performance test installed ground fault protection system as required by the NFPA 70.
   2. Use high current injection method to test system.
   3. Test report shall indicated:
      a. Device settings.
      b. Tripping time in cycles for each device.
      c. Test current.

d. Date of test.
e. Name of certified testing firm that performed the test.

END OF SECTION

SECTION 16500
INTERIOR AND EXTERIOR LIGHTING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Material and installation requirements for:
      a. Interior building lighting fixtures.
      b. Exterior building and site lighting fixtures.
      c. Lamps.
      d. Ballasts.
      e. Lighting poles.
      f. Lighting control.

B. Related Sections include but are not necessarily limited to:
   1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 1 - General Requirements.
   3. Section 03300 – Cast-In-Place Concrete.
   4. Section 16010 - Electrical: Basic Requirements.
   5. Section 16050 – Basic Electrical Materials and Methods.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American National Standards Institute (ANSI):
      a. C82 Series, Standards for Electric Lamp Ballasts.
      b. O5.1, Wood Poles - Specifications and Dimensions.
   2. Certified Ballast Manufacturers (CBM).
   3. Code of Federal Regulations (CFR):
      a. 47 CFR 18, Industrial, Scientific and Medical Equipment.
   4. Institute of Electrical and Electronics Engineers (IEEE):
      a. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
   5. National Electric Manufacturers Association (NEMA):
      a. 250, Enclosures for Electrical Equipment (1000Volts Maximum).
      b. LE 4, Recessed Luminaires, Ceiling Compatibility.
   6. National Fire Protection Association (NFPA):
      a. 101, Life Safety Code.
   7. Underwriters Laboratories, Inc. (UL):
      a. 198C, High-Interrupting-Capacity Fuses, Current Limiting Type.
      b. 844, Electric Lighting Fixtures for Use in Hazardous (Classified) Locations.
      c. 924, Emergency Lighting and Power Equipment.
      d. 935, Fluorescent Lamp Ballasts.

e. 1029, High Intensity Discharge Lamp Ballasts.
f. 1570, Fluorescent Lighting Fixtures.
g. 1571, Incandescent Lighting Fixtures.
h. 1572, High Intensity Discharge Lighting Fixtures.

8. United States Department of Energy (USDOE):
   a. EPACT, the National Energy Policy Act.

1.3 SUBMITTALS

A. Shop Drawings:
   1. See Section 01340 for requirements for the mechanics and administration of the submittal process.
   2. See Section 16010.
   3. Product technical data:
      a. Identify fixtures by Fixture Schedule number.
      b. Fixture data sheet including:
         1) Photometric performance data including candlepower distribution and coefficient of utilization (CU) table.
         2) Fixture EPA's for pole mounted fixtures.
      c. Pole data shall include:
         1) Pole wind loading.
         2) Anchor bolt template.
      d. UL nameplate data for fixtures used in Class 1 Division 2 areas.
      e. Provide ballasts schedule indicating manufacturer, model number, voltage and type of ballast to be furnished with each fixture type.

      f. Provide lamp schedule indicating manufacturer, model number, voltage, color temp. K rating, CRI, rated average life hours, initial and mean lumens and number of lamps for each fixture type.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
   1. Lighting fixtures: See Fixture Schedule.
   2. Lamps:
      a. Osram/Sylvania.
      b. General Electric.
      c. Philips.
   3. Ballasts: Fixture manufacturer's standard.
   4. Dimming Ballasts: Universal
   5. Poles: Fixture manufacturer's standard.

B. Submit requests for substitution.

2.2 GENERAL REQUIREMENTS

A. All lighting fixtures and electrical components:
   1. UL labeled.
   2. Fixtures complete with lamps and ballasts.
   3. Rated for area classification as indicated on Drawings.
      a. In Class I, Division 1 and 2 areas, the temperature rating of the luminairs and lamp combination shall not exceed the auto-ignition temperature of the atmosphere in which the fixture is used.

B. Provide all recessed fixtures with gaskets of rubber, fiberglass, or equivalent material to prevent light leaks around flush trim. Provide recessed fixtures with trim gaskets cemented in proper position.

C. Reflector coating having a minimum 89 percent reflectance factor.

D. No live parts normally exposed to contact.

E. When intended for use in wet areas: Mark fixtures "Suitable for wet locations."

F. When intended for use in damp areas: Mark fixtures "Suitable for damp locations" or "Suitable for wet locations."

2.3 LIGHT FIXTURES

A. Incandescent:
   1. UL 1571.
   2. Lamp base.
      a. Less than or equal to 300W: Medium base.
      b. Greater than 300W: Mogul base.
   3. Visibly marked to indicate maximum lamp wattage that can be used with the fixture.

B. Fluorescent:
   1. UL 1570.
   2. NEMA LE 4 for recessed locations.
   3. Lenses: As indicated in Fixture Schedule, with the following minimums:
      a. Troffer: 100 percent virgin acrylic, conical shaped, female 0.1875 IN, square based prisms, aligned 45 degrees to the length and width, 0.125 IN nominal thickness.
   4. Finish: Manufacturer's standard polyester, acrylic enamel or epoxy powder coating applied after fabrication. Manufacturer's standard color or special color specified in Fixture Schedule.
   5. Prewired and provided with lamps that are properly mated to the ballast operating characteristics.

C. High Intensity Discharge:
   1. UL 1572.
   2. Finish: Manufacturer's standard polyester, acrylic enamel or epoxy powder coating applied after fabrication. Manufacturer's standard color or special color specified in Fixture Schedule.

3. Prewired and provided with lamps that are properly mated to the ballast operating characteristics.
4. Provided with safety chain.

D. Exit Signs and Emergency Lighting Units:
1. UL 924.
2. NFPA 101.

2.4 LAMPS

A. Incandescent:
1. Type as indicated in fixture schedule.
2. Meet the current Federal Energy Standards (EPACT 1992).

B. Fluorescent:
1. T12 (430 mA) rapid-start medium bipin lamps.
a. Correlated color temperature of 3500 degrees Kelvin.
b. Minimum color rendering index (CRI) of 70.
c. Minimum initial lumen ratings for each lamp type shall be:
1) 2750 lumens for 48 IN, 34 watt F40T12 lamp.
2. T8 (265 mA) rapid-start medium bipin lamps.
a. Correlated color temperature of 3500 degrees Kelvin.
b. Minimum color rendering index (CRI) of 70.
c. Minimum initial lumen ratings for each lamp type shall be:
1) 2800 lumens for 48 IN, 32 watt F32T8 lamp.
2) 5700 lumens for 96 IN, 59 watt F96T8 lamp.
3. T5 rapid-start 4 pin (2G11 base) compact fluorescent lamps.
a. Correlated color temperature of 3500 degrees Kelvin.
b. Minimum color rendering index (CRI) of 80.
c. Minimum initial lumen ratings for each lamp type shall be:
1) 1800 lumens for 12.8 IN, 24 or 27 watt F27BX lamp.
4. T4 twin-tube, quad-tube, and/or triple twin-tube compact fluorescent lamps.
a. Correlated color temperature of 3500 degrees Kelvin.
b. Minimum color rendering index (CRI) of 80.
c. Minimum initial lumen ratings for preheat 2-pin twin-tube lamps with a G23 or GX23 base shall be:
1) 580 lumens for 6.5 IN, 9 watt CF9TT lamp.
2) 800 lumens for 7.1 IN, 13 watt CF13TT lamp.
d. Minimum initial lumen ratings for rapid-start 4-pin quad-tube lamps with a G24q-1, G24q-2 or G24q-3 base shall be:
1) 900 lumens for 5.2 IN, 13 watt CF13QT lamp.
2) 1160 lumens for 5.8 IN, 18 watt CF18QT lamp.
3) 1700 lumens for 6.5 IN, 26 watt CF26QT lamp.
e. Minimum initial lumen ratings for rapid-start 4-pin triple twin-tube lamps with a GX24q-2 or GX24q-3 base shall be:
1) 1120 lumens for 4.6 IN, 18 watt CF18TTT lamp.
2) 1610 lumens for 5.2 IN, 26 watt CF26TTT lamp.
3) 2200 lumens for 5.8 IN, 32 watt CF32TTT lamp.

C. High Intensity Discharge (HID) Lamps:
   1. Metal halide lamps:
      a. Correlated color temperature of 4000 degrees Kelvin.
      b. Minimum color rendering index (CRI) of 65.
   2. High pressure sodium lamps:
      a. Correlated color temperature of 2100 degrees Kelvin.
      b. Minimum color rendering index (CRI) of 21.
      c. High pressure sodium lamps are designated on the lighting Fixture Schedule by the prefix HPS.
   3. Uncoated (clear) unless identified as coated in the fixture schedule.
   4. The specified fixture in the fixture schedule shall dictate the required lamp operating position and base type.
   5. Provide lamps that have the correct bulb shape for the fixture specified.

2.5 BALLASTS

A. Fluorescent Electromagnetic Ballasts:
   1. UL 935.
   2. High-efficiency energy saving electromagnetic core and coil design.
   3. CBM certification for full light output.
   4. Operate lamps at a frequency of 60 Hz.
   5. Power factor: Greater than 90 percent.
   6. Input current with Total Harmonic Distortion (THD) of less than 10 percent.
   7. Lamp current crest factor: Less than 1.7, in accordance with lamp manufacturer's recommendations and ANSI C82.1.
   8. Ballast factor: Greater than 0.925 for rapid start 265 mA (T8) and 430 mA (T12) ballasts per ANSI C82.1.
   9. Audible noise rating: Greater than or equal to Class A for rapid start 265 mA (T8) and 430 mA (T12) ballasts.
   10. Coil temperature not to exceed 65 DegC (150 DegF) temperature rise over 40 DegC (105 DegF) ambient. Maximum case temperature not to exceed 90 DegC (195 DegF).
   11. Meet the requirements of the Federal Communications Commission Rules and Regulations, Part 18 (47 CFR 18), for non-consumer equipment for EMI and RFI.
   12. Meet all applicable ANSI and IEEE standards regarding harmonic distortion and transient protection such as IEEE C62.41, Cat. A, for transient protection.
   13. Underwriters' Laboratories (UL) listed (Class P).
   14. Fully encapsulated (potted) to ensure maximum thermal and structural integrity.
   15. Contain no polychlorinated biphenyls (PCB's).

B. Fluorescent High Frequency Electronic Ballasts, and dimming ballasts:
   1. UL 935.
   2. "High Frequency" electronic operating lamps at a frequency of 20 KHz or higher without visible flicker.
   3. Power factor: Greater than 90 percent.

4. Input current total harmonic distortion (THD) of less than 20 percent.
5. Lamp current crest factor: Less than 1.7, in accordance with lamp manufacturer's recommendations and ANSI C82.11.
6. Instant start with lamps wired in parallel.
7. Support a sustained short to ground or open circuit of any output leads without damage to the ballast.
8. Ballast Factor: Greater than 0.85 per ANSI C82.11.
9. Audible noise rating: Class A or better.
10. Operation in ambient temperatures up to 40 DegC (105 DegF) without damage.
11. Light output to remain constant for a line voltage fluctuation of +5 percent.
12. Meet the requirements of the Federal Communications Commission Rules and Regulations, Part 18 (47 CFR 18), for non-consumer equipment for EMI and RFI.
13. Meet ANSI C82.11 standards regarding harmonic distortion.
14. Meet IEEE C62.41 Cat. A for transient protection.
15. Comply with all applicable state and federal efficiency standards.
16. Underwriters' Laboratories (UL) listed (Class P).
17. Contain no Polychlorinated Biphenyls (PCB's).
18. Dimming ballasts must start at freezing temperature
19. Dimming ballasts must be coordinated with the dimming system. 0-10 volt control of addressable ballasts are acceptable.

C. High Intensity Discharge Ballasts:
   1. ANSI C82.4, UL 1029.
   2. Metal halide:
      a. Input voltage variation: +10 percent.
      b. Maximum lamp regulation spread: 20 percent.
      c. Minimum power factor: 90 percent.
      d. Starting current: Not greater than operating current.
      e. Maximum input voltage dip: 40 percent.
      f. Crest factor: 1.5 to 1.8.
      g. Types:
         1) Lead-type regulators: Constant wattage autotransformer (CWA) and pulse start.
         2) Lag-type regulators: Magnetic regulator and pulse start.
      h. Contain no Polychlorinated Biphenyls (PCB's).
   3. High pressure sodium:
      a. Input voltage variation: +10 percent.
      b. Maximum lamp regulation spread: 30 percent.
      c. Minimum power factor: 90 percent.
      d. Starting current: Not greater than operating current.
      e. Maximum input voltage dip: 20 percent.
      f. Crest factor: 1.6 to 1.8.
      g. The Volts-Watts trace shall be within the lamp manufacturer's trapezoid.
      h. Types:
         1) Lead-type regulators: Constant wattage autotransformer (CWA).

2) Lag-type regulators: Magnetic regulator and regulated lag.

i. Ballast shall not contain Polychlorinated Biphenyls (PCB's).

4. Ballasts for interior use:
   a. Encased and potted type.
   b. Audible noise rating of B or better.
   c. Built-in automatic resetting thermal protection switch.
5. Ballasts for exterior use:
   a. Starting temperature: -20 DegF.

2.6 MECHANICALLY HELD LIGHTING CONTACTORS

A. Acceptable manufacturers:
   1. Square D Class 8903
   2. Allen Bradley Bulletin 500LP
   3. G.E. CR160MB
   4. or approved equal.

2.7 FLUORESCENT DIMMING SYSTEM IN HATCHERY BUILDING ROOM 117

A. Technical requirements
   1. there are 67 fixtures in 7 zones. Zone “a” is dimmable from rocker switches at several doors, and by timeclock or software timer. The other 6 zones are dimmable from 6 rocker switches near the control panel, and by timeclock or software timer.
   2. Either 0 – 10 volt control or addressable control are acceptable, coordinate with electronic ballast specification above.

B. Programming requirements
   1. The dimmer, initiated by a time-of-day astronomic clock (or software), shall be capable of ramping up the lights at dawn over a period of 15 minutes. Ramping up shall change the luminance from 0% to a programmable set-point ranging from 10% to 100%.
   2. The dimmer, initiated by a time clock, shall be capable of dimming the lights at dusk over a period of 15 minutes. Dimming shall change the luminance from pre-existing output to 0%
   3. There must be a capability for each zone to be automatically dimmed separately from other zones.
   4. Rocker switches (up/down), one for each zone, to be located at the north wall, and zone “a” at the doors specified, to dim or brighten quickly from existing light level (thereby overriding the time clock).
   5. There must be a capability to disable any zone from the time clock.

2.8 LIGHT POLES

A. As scheduled or noted on the Drawings.

B. Must be modified by adding a weatherproof light switch.

C. Galvanized steel Poles:
   1. Pole cross section: square.
   2. Designed for 70 mph constant velocity wind at the base with a 1.3 wind gust factor.
   3. Additional features: handhole, grounding lug, galvanized anchor bolts, anchor bolt covers.

2.9 MAINTENANCE MATERIALS

A. Furnish a minimum of 2 or 10 percent of total of each type and wattage of lamps, whichever is greater.

B. Furnish a minimum of 10 percent of total of each type and amperage of fuses for fixtures indicated to be fused.

C. Spare parts are to be stored in a box clearly labeled as to its contents.

PART 3 EXECUTION

3.1 INSTALLATION

A. Coordinate fixture types with ceiling construction. Provide mounting hardware for the ceiling system in which the fixture is to be installed.

B. Fasten lighting fixtures supported by suspended ceiling systems to ceiling framing system with hold down clips.

C. Provide mounting brackets and/or structural mounting support for wall-mounted fixtures.
   1. Do not support fixture from conduit system.
   2. Do not support fixture from outlet boxes.

D. Provide pendant incandescent, compact fluorescent, and/or HID fixtures with swivel hangers which will allow fixture to swing in any direction but will not permit stem to rotate.
   1. Provide hangers with enclosure rating (NEMA 1, 4, or 7) equal to enclosure requirements of area in which they are installed.
   2. Swivel hangers for fixtures in mechanical equipment areas: Shock absorbing type.
   3. Secure HID fixtures with safety chain.

E. Pendant mounted, open, industrial fluorescent fixtures:
   1. shall be supported by conduit or by approved chains:
      a. Hardwired to ceiling mounted junction box.

F. Locate fixtures in accordance with reflected ceiling plans.

G. Locate in exact center of tile when indicated. Relocate misplaced fixtures and replace damaged ceiling materials.

H. Mount lighting fixtures at heights indicated in Section 16010 or per fixture schedule or as indicted on Drawings.

I. Install exterior fixtures so that water can not enter or accumulate in the wiring compartment.

J. Where indicated provide 2-level control of 3 and/or 4 lamp fluorescent fixtures. Provide 2 ballasts per fixture and control inside lamp(s) in each fixture by one switch or set of switches and the outside 2 lamps by a second switch or group of switches.

K. Ground fixtures and ballasts.

3.2 POLE INSTALLATION

A. Steel and Aluminum Poles:
   1. Mounted on cast-in-place foundations, as detailed on Drawings.
      a. Concrete and reinforcing steel, in accordance with Section 03200, 03300, 03370 or precast per 03400.
   2. Protect pole finish during installation. Repair damage to pole finish with manufacturer approved repair kit.

B. Ground poles as indicated on the Drawings.

C. Conductors:
   1. See Section 16050 for required underground conductors.
   2. #12 AWG minimum.

D. Overcurrent and Short Circuit Protection:
   1. Protect each phase with a UL Class CC fuse:
      a. Size: 3 times load current.
      b. Standard: UL 198C.
   2. Fuseholder:
      a. Watertight, in-line and break-a-way style.
      b. Accept up to a 30 A, 600 V fuse.
      c. Neutral conductor shall utilize a fuseholder with a solid copper rod.
      d. Conductor terminal: Adequate size for the installed conductors.

3.3 LIGHTING CONTROL

A. Exterior wall mounted and pole mounted fixtures controlled with individual switches, as detailed on Drawings.

3.4 ADJUST AND CLEAN

A. Replace all inoperable lamps with new lamps prior to final acceptance.

B. Aim all emergency lighting units, so that, the path of egress is illuminated.

END OF SECTION

SECTION 16612

GENERATOR SYSTEMS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. Work includes furnishing all labor, materials and equipment for installing generator systems as specified herein and as shown on the Drawings.

B. Provide a standby engine-generator set of the latest commercial type and design. The generator set shall be complete with necessary switchgear, controls, and accessories to automatically supply continuous electricity during a utility failure.

1.2 SYSTEM DESCRIPTION

A. Includes engine, generator, muffler, engine controls, batteries, battery charger, fuel tanks, annunciator panel and automatic transfer switch.

B. The owner has specifically requested two 2,000 gallon dual wall fuel tanks.

1.3 QUALITY ASSURANCE

A. Manufacturer

1. The engine and generator shall be product of one manufacturer who has been regularly engaged in the design and production of generator sets for a minimum of ten years. The entire unit shall be factory assembled and tested.

B. Supplier

1. It is essential that the engine-generator supplier maintain a local parts and service facility within 100 miles of this installation. The supplier must carry sufficient inventory to cover not less than 80% parts service within 24 hours and 95% within 48 hours. Further, the supplier shall have factory trained service representatives to furnish all installation, test and start-up supervision necessary for final approval and acceptance as well as perform maintenance and repair on all components as required.

C. Testing - Manufacturer

1. The generator set shall be tested at the manufacturers' facility and shall meet the following tolerances:

Limits = % of

Item		Units	Nominal Spec.
a.	Corrected Power:		
	Diesel	KW	+/- 3%
	Natural Gas	KW	+/- 5%
b.	Test Speed	RPM	+ 0
c.	Test Power	KW	+/- 1%
d.	Frequency Stability	HZ	+/- 0.2%
e.	Line to Line Voltage	VOLTS	+/- 4%
f.	Test Voltage	VOLTS	+/- 1%
g.	Line Current	AMPS	+/- 3%
h.	Overshoot	%	107% High Idle RPM
i.	Speed Drop:	RPM	+/- 10%
j.	All Other Governors	RPM	+/- 1%
k.	Voltage Stability	%	+/- 0.5%
l.	Low Idle	RPM	+/- 50%

D. Testing - Supplier

1. Prior to acceptance of the equipment it shall be tested at full rated load through the use of resistance load banks. The test shall be performed at the suppliers' facility and must prove that the generator set is free of any defects and will perform to the specifications claimed by the supplier.

2. All consumables necessary for the test shall be furnished by the supplier.

3. Block loading (50%, 75% & 100% loads) shall be done in the presence of the Engineer or his appointed representative, and shall be for a period of four hours.

4. Transient responses, including voltage dips, frequency dips and recovery time period, shall be measured and agree with the manufacturers data.

1.4 SUBSTITUTIONS

A. Proposed deviations from the specifications shall be treated as follows:

Requests for substitutions shall have Engineer written acceptance a minimum of 10 days prior to the order date.

B. Complete manufacturer's catalog data shall accompany each request.

C. Approved substitutions shall be by published addenda only to allow all bidders the opportunity to provide substitute equipment.

1.5 PRODUCT DELIVERY, STORAGE & HANDLING

A. Material shall be stored in a dry heated location at a minimum of 40˚ F.

1.6 SUBMITTALS: Submit in accordance with SECTION 01340.

A. Shop Drawings

1. Submit detailed drawings of prime mover, generator, generator mated with engine, skid, muffler, batteries, battery charger, controls and automatic transfer switch.

2. Information furnished in submittal data:

a. Make and model of engine and generator.

b. Makes and models of switchgear and other major auxiliary equipment, including automatic transfer switch, vibration isolators, etc.

c. Manufacturer-produced dimension drawings of the complete engine-generator set clearly showing entrance points for each of the interconnections required.

d. Manufacturer-published kilowatt output curve and published fuel consumption curve.

e. Unit ventilation and combustion air requirements.

f. Manufacturer-published transient response data of the complete engine-generator set upon 50%, 75% and 100% block loads at 1.0 pf. Data shall include maximum voltage dips, maximum frequency dips and recovery time periods.

g. Locations and descriptions including name, address and phone number of the supplier's parts and service facilities including parts inventory and number of qualified generator set service personnel.

h. Actual electrical diagrams, including schematic diagrams and interconnection wiring diagrams for all equipment to be supplied.

i. Manufacturer warranty statements.

j. Engine altitude duration curve.

k. Generator motor starting curves showing the voltage dips versus starting KVA.

l. Manufacturer-published service manuals for engine, generator, and switchgear.

B. Maintenance Data & Operating Instructions:

1. Copies of shop drawings and manufacturer's published service manuals shall be in accordance with SECTION 01730.

1.7 WARRANTY

A. Equipment furnished under these specifications shall be guaranteed against defective parts and workmanship for a period of two years from date of acceptance of the system and shall include labor and travel time for necessary repairs at the job site. Running hours shall not be a limiting factor for the system warranty.

PART 2 PRODUCTS

2.1 MATERIALS

A. Generator Set: Caterpillar, Onan, Kohler

2.2 FABRICATION & MANUFACTURE

A. Generator

1. Rating

a. The generator shall be rated for continuous standby service at the ratings shown on the Drawings for 60 Hz operation, at 1800 rpm.

2. Type

a. The generator shall be single-bearing, synchronous type, wet wound, tropicalized, and built to NEMA standards. Class F insulation shall be used on the stator and rotor.

b. The generator shall incorporate reactive droop compensation for parallel operation and shall also include a resettable thermal protector and fuse for exciter/regulator protection against extended low power factor loads and faults.

c. The generator rotor shall be dynamically balanced within 0.0005 in. peak-to-peak amplitude displacements at both ends of shaft and shall sustain 25% overspeed.

3. Regulator

a. An automatic volts-per-hertz type, solid-state exciter/regulator, manufactured by the generator manufacturer shall be included and shock mounted inside the generator. Voltage regulation shall be +/- 1% from no load to full rated load. Readily accessible voltage droop, voltage level, and voltage gain controls shall be included in the module. Voltage level adjustment shall be minimum of +/- 10%.

b. The module shall include the following protective features:

1) Current limit circuits shall restrain the exciter field current while allowing full forcing voltage to be applied to obtain rapid response during transient conditions or service overloading on the generator.

2) A time-delay circuit shall sense the current limit operation and cut off all field current to the generator after ten seconds.

c. Regulator shall be designed to use in conjunction with the solid state variable speed controller specified for this job. Provide additional regulator filtering to prevent voltage surges caused by wave form distortion.

4. Current Boost

a. The generator shall be capable of supporting 300% rated current for ten seconds for selective tripping of downline protection devices when short circuit occurs.

5. To prevent distortion feedback, three phase voltage sensing shall be required.

B. Engine

1. The engine shall be water-cooled, in-line or Vee type, operating with the fuel type shown on the Drawings.

2. The engine shall be equipped with fuel, lube oil, intake air filters, lube oil cooler, engine mounted fuel pump fuel priming pump, service meter, gear-driven water pump, and instruments, including a fuel pressure gauge, water temperature gauge, and lubricating oil pressure gauge.

3. The engine governor shall maintain frequency regulation within +/- 3% from no load to full rated load. Steady-state operating band shall be +/- 0.33%.

4. The engine governor shall maintain isochronous frequency regulation from no load to full rated load. Steady-state operating band shall be +/-0.25%. The governor shall be capable of remote speed adjustment.

5. The engine shall use a Woodward isochronous governor with zero to full speed hydraulic actuation. Regulation shall be adjustable from 0 to 7%. The governor shall be capable of remote speed adjustment.

6. The engine-generator set shall be mounted on a structural steel subbase and shall be provided with suitable spring-type vibration isolators. The isolators shall have an operating efficiency better than 90%.

7. Protective Devices

   a. Pre-alarms provided for low jacket water temperature, low lube oil pressure, and high jacket water temperature in accordance with NFPA 76A. Safety shutoffs for high water temperature, low oil pressure, electrical overspeed, and engine overcrank shall be provided.

8. Engine exhaust system shall be sized for a minimum of 100% engine operating exhaust gas flow at 80% of the manufacturer's rated back pressure.

   a. Engine Exhaust Connector. The engine exhaust system connector shall be an 18" long seamless stainless steel flexible exhaust tubing with 150# ASA drilled flat carbon steel plate flanges rated for temperatures up to 1500^{o} F.

   b. Exhaust Piping. The exhaust piping shall be Schedule 40 black steel pipe with butt-welded fittings and weld-neck flanges. There shall be a minimum of two (2) saddle type pipe hangers on the interior exhaust

pipe. Insulation shall be 1" thick foam-glass high temperature pipe insulation.

c. Muffler. The muffler shall be an end inlet design for vertical upflow installation. It shall have 150# ASA drilled flat carbon steel flanges on the exhaust gas connections and a "drain plug" coupling welded to the low "inlet" head. It shall be fabricated of aluminized steel coated with backed on high heat resistant Silicon black paint. The muffler shall have a minimum attenuation level range of 25-35 dBa.

d. Rain Cap. The rain cap shall be made of cast aluminum with stainless steel pivot bolt with a brass bushing hinge. It shall have a clumping collar for attachment to the end of the exhaust pipe.

e. Muffler Supports. The muffler and exhaust pipe shall be supported from the block wall as shown on drawings.

9. Glycol-Water-Mix

a. Propylene glycol and water shall be mixed in proportions of 50% propylene glycol and 50% water.

b. Propylene glycol shall be provided in bulk quantities and shall have dyes added at the factory. Corrosion inhibitors shall be added per engine manufacturer's recommendations.

c. Propylene glycol shall be of an industrial grade specifically developed and manufactured for use in commercial and industrial type engine systems.

d. "Automotive" types of propylene-glycol will not be allowed.

C. Automatic Starting System

1. Starting Motor

a. The engine shall be equipped with a 24-volt electric starting system with positive engagement drive and of sufficient capacity to crank the engine at a speed which will start the engine under operating conditions.

b. The starting pinion will disengage automatically when the engine starts. The starting system shall incorporate an automatically reset circuit breaker for anti-butt engagement.

2. Automatic Controls

a. Fully automatic generator set start-stop controls in the generator control panel shall be provided.

b. Controls shall provide shutdown for low oil pressure, high water temperature, overspeed, overcrank, and two, form C auxiliary contacts for activating accessory items.

c. Controls shall include one 30 second cranking cycle with lockout and manual reset feature.

3. Jacket Water Heater

a. An engine-mounted thermal circulation tank-type immersion water heater incorporating an adjustable thermostatic switch shall be furnished to maintain engine jacket water to 90˚ F (32.2˚ C) in a still air, ambient temperature of 30˚ F (-1.1˚).

b. The heater shall be 3 kW at the voltage shown on the Drawings.

4. Battery and Battery Charger

a. A lead/acid storage battery set of the heavy-duty diesel starting type shall be provided. Battery voltage shall be compatible with the starting system.

b. The battery set shall be rated no less than 220 ampere hours.

c. A battery rack constructed in conformance with N.E.C. requirements and necessary cables and clamps shall be provided.

d. Batteries shall be capable of cranking engine at rated ambient for a minimum of five minutes.

e. A current limiting, float-equalize charger shall be furnished to automatically recharge batteries. The charger shall float at 2.17 volts per cell and equalize at 2.33 volts per cell. It should include overload protection, silicon diode full wave rectifiers, voltage surge suppressors, DC ammeter and fused AC output. AC input voltage shall be 120 volts or 240 volts, single phase. Amperage output shall be no less than 5 amperes. Charger shall be wall-mounting type in NEMA 1 enclosure.

D. Main Line Circuit Breaker

1. A main line molded case, rated at 104˚ F (40˚ C) ambient temperature shall be installed for phase overloads and/or short circuit protection. This rating shall include at least 10% additional capacity for overload and operating temperature rise over 104˚ F (40˚ C).

2. It shall operate both manually for normal switching functions and automatically during overload and short circuit conditions.

3. The trip unit for each pole shall have elements providing inverse time delay during overload conditions and instantaneous magnetic tripping for short circuit protection.

4. Generator/exciter field circuit breakers do not meet the above electrical standards and are unacceptable for line protection.

5. The circuit breaker shall have a battery voltage operated shunt trip wired to safety shutdowns to open the breaker in the event of an engine failure and shall meet the Underwriters Laboratories standards.

E. Generator Control Panel

1. Control panel shall be obtained from same manufacturer as generator set and shall include factory warranty and manufacturer's parts and service support.

2. A generator-mounted NEMA 1-type, vibration isolated, dead front, 14-gauge, steel control panel shall be provided. The control panel shall contain, but not be limited to, the following equipment:

   a. Illuminating lights and switch.

   b. AC voltmeter, 3-1/2 in. (9 cm), 2% accuracy.

   c. AC ammeter, 3-1/2 in. (9 cm), 2% accuracy.

   d. Ammeter-voltmeter, phase selector switch.

   e. Frequency meter, 3-1/2 in. (9 cm), dial type (45-65 Hz).

   f. Automatic starting controls as specified.

   g. Voltage level adjustment rheostat.

   h. Dry contacts for remote alarms wired to terminal strips.

   i. Fault indicators for low pressure, high water temperature, overspeed, and overcrank.

   j. Four-position function switch marked "auto," "manual," "off/reset," and "stop."

   k. Hinged, solid protective cover with provision for padlock.

F. Automatic Load Transfer Switches

1. Automatic transfer switches shall be provided by the generator set manufacturer which includes factory warranty and manufacturer's parts and service support.

2. The amperage rating of the automatic load transfer switches shall be equal to or greater than the higher of either source circuit breaker.

3. Each automatic transfer switch shall be mechanically held on both the emergency and the normal side and rated for continuous duty in an unventilated enclosure. The switches shall be double throw with the main contacts rigidly and mechanically interlocked to ensure only two possible positions - normal and emergency. A manual operator must be provided to enable one hand manual operation.

4. Each automatic transfer switch shall be motor operated, high instantaneous circuit breaker type. So- called linear-actuated or solenoid-operated switches are disallowed and will not be considered.

5. Each transfer switch shall be listed under UL 1008 in NEMA 1 enclosure.

6. Accessories for transfer switches: each automatic load transfer switch specified above shall include the following:

   a. Engine starting contacts to provide for generator starting from each unit independent of the other.

   b. Full phase protection. Three-phase relays shall be field adjustable, close differential type with 92 to 95% pickup and 82 to 85% dropout. Relays are to be connected across live lines.

   c. Four-position mode selector switch marked "test," "auto," "off," and "engine start."

   d. Voltage and frequency monitor on generator output to prevent transfer prior to proper output parameters.

   e. Adjustable 0.5 to 6 second time delay on engine starting to override momentary outages and nuisance voltage dips.

   f. Adjustable 2 to 30 minute time delay on retransfer of load to normal with 5 minute cool- down timer wherein the generator set runs unloaded after retransfer to normal source.

g. Plant exerciser to start and run the generator set without load each 168 hours for a 30-minute interval.

h. One auxiliary single-pole double-throw contact on emergency breaker and one single-pole double-throw auxiliary contact on normal breaker.

i. Three pilot lights, to indicate the normal and emergency position of the transfer switch and mode selector switch in "off" position.

j. Isolated (ungrounded) neutral bus.

k. The automatic transfer switch shall communicate to the site PLC system with an RS485 communication link. The automatic transfer switch operating status and alarm information shall be displayed on the site PLC graphics. Coordinate with section 13441.

l. The automatic transfer switch shall have a relay that closes upon “not in auto” condition. This will be a discrete input to the site PLC system.

G. Annunciator Panel

1. A panel shall be provided for remote mounting to give audible and visual warning of fault or alarm conditions in the generator set, for the following alarm conditions:

   a. Low oil pressure.
   b. High water temperature.
   c. Overspeed.
   d. Low fuel.
   e. Overcrank.
   f. Low battery voltage.
   g. High battery voltage.

2. The annunciator shall be equipped with an alarm silence button, a lamp test button, and an alarm horn.
3. The annunciator shall close a relay upon any of the conditions listed in G.1. for use by the site alarm system.
4. The annunciator shall communicate to the site PLC system by an RS485 communication link. The site PLC system shall have a display graphic that mimics all indicators and data displayed on the generator annunciator (coordinate with section 13441).
5. The annunciator shall have a separate relay output that closes upon low fuel alarm. This will input into the site PLC system.

5. The panel shall conform with the requirements of the National Electrical Code, Section 700-12, and the National Fire Protection Association publication, NFPA No. 110 (as required for hospital use).

H. Pre-alarm Module

1. A generator control panel-mounted pre-alarm module shall be provided to meet NFPA 110 (as required for hospital use). It shall provide audible and visual alarm warning of impending fault conditions and provide audible warning on fault shutdown.

PART 3 EXECUTION

3.1 INSTALLATION/APPLICATION/PERFORMANCE/ERECTION

A. Generator Unit Assembly

1. Generator shall be bolted to flywheel of engine and assembled as a unit on a rigid steel channel skid.

2. Mount unit on concrete housekeeping pad as shown on drawings.

3. Entire unit shall be mounted on steel spring type vibration isolators with rubber pads. Anchor isolators if recommended by manufacturer. Isolators shall provide a minimum of 85% vibration attenuation.

4. All final electrical & piping connections to the unit shall be made with flexible connections.

5. System shall be installed as shown on the drawings, and in a neat and workman like manner. Lines shall be installed parallel with and at right angles to wall & floor.

B. Control Panel and Automatic Transfer Switch.

1. Install - location shown on plan. The unit shall be fully accessible to all serviceable parts including wire lugs when installed in the location shown. Provide wall access panels if required.

2. The control panel shall have a relay that opens when the generator is running. This will be for the controls that open the room motorized dampers.

C. Scheduled Oil Sampling

1. In order to forecast and minimize engine down-time, the supplier of the equipment shall provide an oil sampling analysis kit which operating personnel shall utilize for Scheduled Oil Sampling.

2. The laboratory to which oil samples will be sent shall be located at and a part of the local generator set supplier's facility and shall be open to inspection during normal working hours. Independent laboratories not a part of the engine supplier's facility are disallowed as to conformance with this specification.

3. Scheduled Oil Sampling shall be of the atomic absorption spectrophotometry method and shall be accurate to within a fraction of one part per million for the following elements:

   a. Iron
   b. Chromium
   c. Copper
   d. Aluminum
   e. Silicon
   f. Lead

4. In addition, the sample shall be tested for the presence of water, fuel dilution, and antifreeze.

5. All equipment needed to take oil samples shall be provided in a kit at the time of acceptance and shall include the following:

   a. Sample extraction gun (1).
   b. Bottles (10).
   c. Postage-paid mailers (10).
   d. Written instructions.

6. Immediate notification shall be provided to the Engineer when analysis shows any critical reading. If readings are normal, a report showing that the equipment is operating within established parameters shall be provided.

7. This Scheduled Oil Sampling kit shall be made available, at additional cost, to the Owner beyond the mandatory starter kit specified previously and shall be optional for Owner to continue this service after the starter kit has been depleted.

D. Start-Up & Instructions

1. On completion of the installation, start-up shall be performed by the generator set manufacturer - trained dealer service representative.

2. Parts books covering the engine, generator, and major auxiliary equipment shall be provided to the Engineer at this time.

3. Procedures on operating and maintenance of the standby power system shall be explained to operating personnel.

4. After all testing is complete, refill the fuel tank. The Contractor is responsible for providing a full fuel tank.

END OF SECTION

SECTION 16721
FIRE ALARM SYSTEM

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Material and installation requirements for:
      a. Fire Alarm Control Panel.
      b. Signal Initiating Devices.
      c. Notification Appliances.
      d. Miscellaneous Devices.

B. Related Sections include but are not necessarily limited to:
   1. Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
   2. Division 1 - General Requirements.
   3. Section 15970 - Instrumentation and Control for HVAC Systems.
   4. Section 16010 - Electrical: Basic Requirements.

1.2 QUALITY ASSURANCE

A. Referenced Standards:
   1. American with Disabilities Act Accessibility Guidelines (ADAAG).
   2. FM Global (FM):
      a. All applicable standards.
      b. All components FM approved.
   3. National Fire Protection Association (NFPA):
      a. 70, National Electrical Code (NEC).
      b. 72, National Fire Alarm Code.
   4. Underwriters Laboratories, Inc. (UL):
      a. 38, Manually Activated Signaling Boxes.
      b. 268, Smoke Detectors for Fire Protective Signaling Systems.
      c. 268A, Smoke Detectors for Duct Applications.
      d. 464, Audible Signaling Appliances.
      e. 497B, Protectors for Data Communication and Fire Alarm Circuits.
      f. 521, Heat Detectors for Fire Protective Signaling Systems.
      g. 864, Control Units for Fire Protective Signaling Systems.
      h. 1971, Visual Signaling Appliances.
   5. Building code:
      a. International Code Conference (ICC):
         1) International Building Code (IBC) and associated standards, 2003 Edition including all County, and State of Oregon amendments, referred to herein as Building Code.

B. Design Criteria:

1. Provide a complete fire alarm system as described in the Contract Documents and according to criteria of the Authority(ies) Having Jurisdiction (AHJ), NFPA and ADAAG.
   a. Where system requirements described in the Contract Documents exceed those of the AHJ and/or NFPA, meet the requirements of both.
2. The Contract Drawings indicate a preliminary layout of the type, location and quantity of devices based on NFPA.
   a. At a minimum, make the following adjustments to the Contract Drawing as required by the AHJ and/or NFPA and/or ADAAG and the manufacturer:
      1) Location and spacing of notification appliances.
         a) Candela of strobes associated with the spacing.
      2) Location and spacing of initiating devices.
3. Complete fire detection and alarm system design wiring diagrams, interface wiring diagrams, and operational details by system manufacturer or authorized technical representative.
4. Submit documents after design has been approved by Authority Having Jurisdiction (AHJ).

C. Design Criteria:
   1. The fire alarm system shall be designed by a National Institute for Certification in Engineering Technologies (NICET) Level 3 or 4 fire alarm technician.
      a. If required by state regulations, a professional engineer shall seal drawings submitted to the AHJ.
   2. Provide a complete fire alarm system as described below and according to criteria of the Authority(ies) Having Jurisdiction (AHJ), NFPA, ADAAG and Building Code.
      a. Where system requirements described below exceed those of the AHJ and/or NFPA, meet the requirements of both.
      b. Hatchery Building
         1) Master FACP in hatchery entrance hall as indicated on the Drawings.
         2) FAA in hatchery entrance hall Room as indicated on the Drawings.
         3) Automatic telephone dialing device for communicating supervisory, trouble and alarm conditions to off-site third party.
         4) Dry contact output relays for connection to hatchery SCADA Control System for supervisory, trouble and alarm conditions.
         5) Manual pull station adjacent to exit doors.
         6) Smoke detector coverage for:
            a) All areas except those where smoke detectors are impractical.
         7) Heat detectors, or explosion proof heat detectors, for all other areas:
            a) Fixed temperature heat detector for garage area, and freezer
         8) Duct smoke detector for:
            a) Supply duct of Air Handling Units,
            b) Relay/Control modules for AHU shutdown.
         9) Sprinkler system:

a) Tamper switch on all valves.
b) Flow switch on each riser.

10) Alarm horns and/or strobe lights throughout the building.

3. Complete fire detection and alarm system design wiring diagrams, interface wiring diagrams, and operational details by system manufacturer or authorized technical representative.
4. Submit documents after design has been approved by Authority Having Jurisdiction (AHJ).

D. Service Organization Qualifications:
1. Offer an annual maintenance contract including complete service and equipment costs for maintenance of complete system.
2. Ten years experience minimum serving fire alarm systems.
3. Provide for 24 HR emergency service.

1.3 DEFINITIONS

A. For the purposes of providing materials and installing electrical work the following definitions shall be used.
1. Outdoor Area: Exterior locations where the equipment is normally exposed to the weather and including below grade structures, such as vaults, manholes, handholes and in-ground pump stations.
2. Architecturally Finished Area: Offices, laboratories, conference rooms, restrooms, corridors and other similar occupied spaces.
3. Non-architecturally Finished Area: Pump, chemical, mechanical, electrical rooms and other similar process type rooms.
4. Hazardous areas: Class I, II or III areas as defined in NFPA 70.
5. Shop Fabricated: Manufactured or assembled equipment for which a UL test procedure has not been established.

1.4 SYSTEM DESCRIPTION

A. Automatic and manual, analog addressable, general alarm and non-coded evacuation alarm, supervised, closed-circuit, 24 Vdc microprocessor based fire detection and alarm system.

B. Provide components including but not limited to following:
1. Main fire alarm control panel (FACP).
2. Remote fire alarm annunciator (FAA).
3. Analog addressable heat sensors.
4. Analog addressable smoke sensors.
5. Analog addressable duct smoke sensors.
6. Sprinkler system waterflow sensor circuits.
7. Sprinkler system pressure sensor circuits.
8. Main, post indicator valve and O, S & Y sprinkler valve tamper switch circuits.
9. Fan control relays associated with the HVAC control system.
10. Combination fire alarm horns with strobe.
11. General alarm strobes.

12. Addressable manual pull station.
13. Fire alarm system wire, with all wiring in conduit.
14. Fire pump alarm supervised circuiting.

C. Basic Performance:
1. Signal Line Circuits (SLC) shall be wired Class B (NFPA Style B).
2. Notification Appliance Circuits (NAC) shall be wired Class B (NFPA Style Y).
3. Each SLC shall be limited to only 80 percent of its total capacity at the time of initial installation.

1.5 SUBMITTALS

A. Shop Drawings:
1. See Section 01340 for requirements for the mechanics and administration of the submittal process.
2. Product technical data:
a. Provide Submittal data for all products specified in PART 2 of this Specification.
b. Battery calculations.
c. Voltage drop calculations.
d. Description of system operation.
e. Name of local service organization.
f. Entire system approved by AHJ.
3. Fabrication and/or layout drawings:
a. Plan drawing(s) showing type and locations of all fire alarm devices.
1) Indicate salient features of each device (e.g., weatherproof, strobe candela rating).
b. Wiring diagrams and riser diagrams.

B. Operation and Maintenance Manuals:
1. See Section 01340 for requirements for:
a. The mechanics and administration of submittal process.
b. The content of Operation and Maintenance Manuals.

C. Miscellaneous:
1. Field test reports.

1.6 AREA DESIGNATIONS

A. Designation of an area will determine the NEMA rating of the electrical equipment enclosures, types of conduits and installation methods to be used in that area.
1. Outdoor areas:
a. Wet.
b. Also, corrosive and/or hazardous when specifically designated on the Drawings or in the Specifications.
2. Indoor areas:
a. Dry.

b. Also, wet, corrosive and/or hazardous when specifically designated on the Drawings or in the Specifications.

PART 2 PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable.
   1. Fire alarm system:
      a. ADT
      b. Honeywell
      c. Edwards Systems Technology.
      d. Gamewell.
      e. Notifier.
      f. Pyrotronics.
      g. Siemens Cerberus Division.
      h. Silent Knight.
      i. SimplexGrinnell.
      j. Wheelock.
   2. Manufacturer must have local service organization.

B. Submit request for substitution.

C. All Equipment:
   1. UL listed as a product of a single manufacturer under appropriate category.
   2. Equipment shall not be modified or installed to alter or void UL label or listing.
   3. FM approved.
   4. Approved by Fire Marshal, when required by state or local codes.

2.2 FIRE ALARM CONTROL PANEL (FACP)

A. FACP shall perform operations as described in Fire Alarm System Operation:

B. The FA system shall have 100 point minimum initiating device capacity with the capability to add additional 100 point minimum initiating device control modules.

C. Construction shall be modular with solid-state, microprocessor-based electronics.
   1. An 80-character LCD display shall indicate alarms, supervisory service conditions and any troubles.

D. Keyboards or keypads shall not be required to operate system during fire alarm conditions.

E. Provide necessary switches, relays, indicator lamps, wiring terminals, etc., to provide complete operation supervising, control, and testing facilities for entire system.

F. FACP shall allow for loading or editing special instructions and operating sequences as required.
   1. System shall be capable of on-site programming to accommodate and facilitate expansion, building parameter changes or changes as required by local codes.
   2. All software operations shall be stored in a non-volatile programmable memory within FACP.

G. System shall have provisions for disabling and enabling all circuits individually for maintenance and testing purposes.

H. System shall be capable of logging and storing 300 events in an alarm log and 300 events in a trouble log.
   1. These events shall be stored in a battery protected random access memory.
   2. Each recorded event shall include time and date of that event's occurrence.
   3. System shall have capability of recalling alarms, trouble conditions, acknowledgments, silencing and reset activities in chronological order for purpose of recreating an event history.

I. FACP shall be listed under UL 864.

J. FACP shall be in an enclosed metal cabinet with glass door specifically designed for public areas.
   1. Mounting: Semi-flush.
   2. Finish: Red baked enamel.

K. Each addressable device shall be represented individually in FACP.
   1. Indicate TROUBLE by a discreet LCD readout for each supervised circuit.
   2. Indicate ALARM by a discreet LCD readout for each alarm initiating addressable device.
   3. Include individual supervisory and alarm relays in each circuit arranged so that ground or open condition in any circuit or group of circuits, will not affect proper operation of any other device.

L. FACP shall include the capability to report alarm and trouble conditions via a telephone line to a third party alarm reporting services.

M. FACP shall include a system testing capability to help ensure that zoning and supervision have been maintained throughout system.
   1. Actuation of the enable walk test program at FACP shall activate "Walk-Test" mode of system which shall cause the following to occur:
      a. City connection circuit shall be disconnected.
      b. Control relay functions shall be bypassed.
      c. FACP shall indicate a trouble condition.
      d. Alarm activation of any initiation device shall cause audible signals to activate for 2 seconds.
      e. FACP shall automatically reset itself after code is complete.
      f. Any momentary opening of alarm initiating or alarm indicating circuit wiring shall cause audible signals to sound continuously for 4 seconds to indicate trouble condition.

g. System shall have 7 distinctive walk test groups such that only a portion of system need be disabled during testing and an alarm in any other area will be processed normally.

N. General Alarm Circuits: Positive non-interfering type so that a second device can be annunciated simultaneously, or closely following first zone.

O. Power Supply:
1. 120 Vac dedicated circuit from panelboard to integral 24 Vdc regulated power supply in FACP and battery charger.
a. The power supply shall provide all panel and peripheral device power needs.
2. If the FACP cannot provide power for the required number of notification appliances a power extender shall be used.
a. An additional 120 Vac dedicated circuit from a panelboard shall be used to power the power extenders power supply and battery charger.

P. Battery:
1. Low maintenance sealed type, for fire alarm use with automatic battery charger.
2. Batteries shall be capable of operating maximum normal load of system for 24 HRS and then capable of operating system for 5 minutes in alarm condition.
3. Size batteries for the total maximum number of devices that can be connected to the FACP not the install number of devices.
4. The notification appliance power extender shall have the same battery requirements as the FACP.

2.3 FIRE ALARM ANNUNCIATOR PANEL (FAA)

A. Annunciator provides remote annunciation using a two-line 40 character, back-lit, alphanumeric, LCD readout.
1. The readout shall display, in descriptive English language; system status, alarm type, supervisory conditions, troubles, and location.

B. LED's and a tone-alert audible indication is provided for alarm, supervisory on trouble conditions.
1. Each condition has an acknowledge push-button switch that silences the tone-alert but leaves the LED on until all conditions are returned to normal.

C. FAA shall be an enclosed metal cabinet designed for public areas:
1. Mounting: Flush.
2. Finish: Beige baked enamel.

2.4 SIGNAL INITIATING DEVICES

A. Addressable Manual Pull Stations:
1. Pull-type with handle which shall lock in a protruding manner to facilitate quick visual identification of activated station.
a. Key reset after operation.
b. Non-coded.

c. Single action.

2. High impact red Lexan with operating directions in white letters.
   a. Semi-flush mounted in architecturally finished areas.
   b. Surface mounted in non-architecturally finished areas.
   c. Surface mounted with clear Lexan weatherproof protective shield in areas designated as wet or in areas indicated in the schedules herein.
3. Stations shall be keyed alike with FACP.
4. Standards: UL 38.

B. Addressable Sensor Base:
   1. Plug-in arrangement:
      a. Sensor and associated encapsulated electronic components are mounted in a module that connects to a fixed base with a twist-locking plug connection.
      b. The plug connection requires no springs for secure mounting and contact maintenance.
      c. Terminals in the fixed base accept building wiring.
      d. Sensor construction shall have a mounting base with a twist-lock detecting head that is lockable.
      e. The locking feature must be field removable when not required.
      f. Removal of the sensor head shall interrupt the supervisory circuit of the fire alarm detection loop and cause a trouble signal at the Control Unit.
   2. LED that will flash each time it is scanned by the Control Unit.
      a. When the Control Unit determines that a sensor is in an alarm or a trouble condition, the Control Unit shall command the LED on that sensor's base to turn on steady indicating that abnormal condition exists.
      b. Sensors which do not provide a visible indication of an abnormal condition at the sensor location shall not be acceptable.
   3. Magnetically actuated test switch to provide for easy alarm testing at the sensor location.
   4. Each sensor shall be scanned by the Control Unit for its type identification to prevent inadvertent substitution of another sensor type.
      a. The Control Unit shall operate with the installed device but shall initiate a "Wrong Device" trouble condition until the proper type is installed or the programmed sensor type is changed.
   5. Addressability: Sensors include a communication transmitter and receiver in the mounting base having a unique identification and capability for status reporting to the FACP.
   6. Provide auxiliary relays in base to provide local control of equipment as described under system operation.
      a. Provide separate 24 volt supply to sensors with auxiliary relays to guarantee that sufficient power will be available to operate relays.

C. Analog Addressable Heat Sensors:
   1. Fixed temperature type or combination rate-of-rise and fixed temperature type.

2. Rated at 135 DegF for ordinary areas where normal ceiling temperatures do not exceed 100 DegF, or rated 190 DegF for up to 150 DegF ceiling temperatures.
3. Self-restoring: Sensors do not require resetting or readjustment after actuation to restore them to normal operation.
4. The sensor's electronics shall be immune from false alarms caused by EMI and RFI.
5. Quantity and spacing:
   a. Smooth ceilings: In accordance with UL rating.
   b. Non-smooth ceilings: In accordance with State Fire marshal's requirements.
   c. High hazard areas: As indicated.
6. Layout is based on 30 FT spacing for fixed-type and 50 FT spacing for combination type for smooth ceiling.
7. Standards: UL 521.

D. Analog Addressable Smoke Sensors:
1. Photoelectric type, dual chamber products of combustion sensors.
2. An infrared sensor light with matching silicon cell receiver and actuated by the presence of visible products of combustion.
3. Self-restoring: Sensors do not require resetting or readjustment after actuation to restore them to normal operation.
4. The sensor's electronics shall be immune from false alarms caused by EMI and RFI.
5. Standards: UL 268.

E. Air Duct Smoke Sensor:
1. Duct smoke sensors shall utilize analog addressable photoelectric type sensor as specified herein.
2. Duct housing mounted directly to outside of duct with a sampling tube extended across duct to sample air movement.
3. Duct housing couplings slotted to insure proper alignment of sampling and exhaust tubes.
   a. Tube lengths as required per duct width.
4. Sensor housing shall have an alarm LED visible through front cover.
5. Remote red LED alarm indicator on ceiling adjacent to sensors above ceilings.
6. Standards: UL 268A.

F. Addressable Monitor Modules:
1. Provides addressability and supervision to a conventional initiating device (e.g., tamper switches, pressure switches, flow switches).
   a. The conventional initiating device shall be wired Class B, Style B.
2. Integral or remote LED shall be provide that will flash each time it is scanned by the Control Unit.
   a. When the Control Unit determines that a monitor module is in an alarm or a trouble condition, the Control Unit shall command the LED on that sensor's base to turn on steady indicating that abnormal condition exists.

G. Sprinkler System Sensors:
   1. Provide monitor module as specified herein for waterflow sensor(s).
      a. Waterflow sensor(s) provided by Division 15.
   2. Provide monitor module as specified herein for pressure sensor(s).
      a. Pressure sensor(s) provided by Division 15.
   3. Provide monitor module as specified herein, for tamper switches associated with main water valve, post indicator valve (PIV) or OS&Y valves.
      a. Tamper switches provided by Division 15.

2.5 AUTOMATIC CONTROL DEVICES

A. Addressable Relay/Control Modules:
   1. Allows FACP to control a remotely located Form "C" contact (e.g., HVAC fans, dampers, fire shutters, elevator capture).

2.6 NOTIFICATION APPLIANCES

A. Alarm Horns:
   1. Electric-vibrating polarized type, operating on 24 Vdc, with provision for housing the operating mechanism behind a grille.
   2. Horns produce a sound pressure level of 85 dB, measured at 10 FT.
   3. Housing: Red with white "FIRE" lettering.
      a. Semi-flush or flush mounted in architecturally finished areas.
      b. Surface-mounted in non-architecturally finished areas.
   4. Horns shall be weatherproof in areas designated as wet or in areas indicated in the schedules herein.

B. Alarm Strobes:
   1. White tamper resistant lexan lens with 24 Vdc xenon strobe.
   2. Provide Candela rating as required per ADAAG and synchronize of multiple strobes when required.
   3. Housing: Red with white "FIRE" lettering.
      a. Semi-flush or flush mounted in architecturally finished areas.
      b. Surface-mounted in non-architecturally finished areas.
   4. Strobes shall be weatherproof in areas designated as wet or in areas indicated in the schedules herein.

C. Combination Audio/Visual Devices:
   1. Shall be mounted in an integral unit and shall have the same features as the individual units specified herein.

D. Alarm Bells:
   1. Heavy-duty vibrating type, operating on 24 Vdc.
   2. Gong: 6 IN producing a sound pressure level of 85 dB, measured at 10 FT.
   3. Housing:
      a. Red.
      b. Semi-flush or flush mounted in architecturally finished areas.
      c. Surface mounted in non-architecturally finished areas.
      d. Weatherproof in areas designated as wet.

E. Standards: UL 464, UL 1971.

2.7 MISCELLANEOUS DEVICES

A. Isolated Loop Circuit Protector (Transient Suppression):
   1. Hybrid solid state high performance suppression system.
      a. Do not use gas tubes, spark gaps or other suppression system components which might short or crowbar the line resulting in interruption of normal power flow to connected loads.
   2. Line-to-line response time of less than one (1) nanosecond capable of accepting a 2000 amps (8 x 20 usec pulse) at 28 V.
   3. Line-to-ground response time of less than 1 nanosecond capable of accepting a 2000 amps (8 x 20 usec pulse) to earth.
   4. Shield-to-ground shall be capable of accepting a 5000 amps (10 x 50 usec pulse) to earth.
   5. Standard: UL 497B.

2.8 WIRING

A. Conduit:
   1. 1/2 IN minimum.
   2. See Section 16050.

B. Conductors:
   1. Insulation type per NEC 760.
   2. 120 Vac and power supply connections: 12 GA, minimum.
   3. Low-voltage general alarm circuits: 14 GA, minimum.
   4. Low-voltage signal initiating circuits: 18 GA, minimum.
   5. Annunciator and data communication circuits: As required by manufacturer, UL listed.
   6. Use larger wire sizes when recommended by equipment manufacturer and per voltage drop calculations.

C. Outlet Boxes: See Section 16050.

2.9 SYSTEM OPERATION

A. Activation of any signal initiating device, except tamper switches, shall cause the following:
   1. General audible horns and/or bells to sound, visual strobes to strobe and automatic control devices to operate.
   2. Alarm information shall be displayed at the FACP LCD displays.

B. All fire alarm signals are automatically locked in at FACP and remote LCD displayed annunciators until originating device is returned to normal and FACP is manually reset.
   1. Audible alarm signals shall be silence-able from FACP allowing for re-initiation following a subsequent alarm.
      a. Silencing of alarm signals shall not impair ability of system to continue to perform as specified.

C. Air Handling Equipment Fan Control:

1. De-energize indicated air-handling equipment and interlocked exhaust fans, upon operation of any alarm initiating device via relay/control module and all smoke dampers shall close.
2. See Section 15970 for mechanical equipment sequence of operation and coordinate all fan controls.
3. Fans shall not restart until FACP is manually reset.

D. Activation of any system trouble shall initiate the following:
   1. Common audible trouble signal shall sound and common trouble light shall illuminate at FACP and any remote annunciators.
   2. FACP shall indicate specific device.

E. Audible trouble signal shall be silenceable by FACP.
   1. Visual trouble indication remains until trouble condition is corrected.
      a. A subsequent trouble condition received after manually silencing shall cause audible trouble signal to resound.
      b. Restoration of system to normal causes audible trouble signal until silencing switch is returned to normal position.
      c. Trouble signal will be initiated under following conditions:
   2. Open on an initiation or alarm indicating circuit.
   3. Open in wiring to remote LCD annunciator(s).
   4. Ground fault condition.
   5. Auxiliary manual control switch out of normal position.
   6. Loss of 120 volt operating power to FACP, transponders, or remote LCD annunciators.
   7. Low or no battery voltage condition.
   8. Main sprinkler valve is closed.
   9. Post indicator valve is closed.
   10. Any sprinkler or standpipe O, S & Y valve is closed.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install all fire alarm equipment and wiring in accordance with local and national codes and NFPA 72.

B. Install all wiring in raceways:
   1. Install raceways and boxes in accordance with Section 16050.
   2. The inside of all boxes are to be painted red.

C. Install all components as indicated and in accordance with manufacturer's wiring diagrams, instructions and recommendations.

D. Make all fire alarm wiring continuous from terminal to terminal or from terminal to device pigtail lead.
   1. Circuit splices not permitted.
   2. Wiring joints, only when required at device pigtail leads shall utilize Scotchlok insulate conical spring connector.

E. Color code all wiring by type of device.
   1. Coordinate colors with Owner.

F. Installation of equipment and devices that pertain to other work in contract shall be closely coordinated with appropriate subcontractors.
   1. Coordinate 8 IN minimum square access door with rubber gasket in duct approximately 2 FT upstream from smoke sensor for testing and servicing with Division 15.

G. Cover all smoke detectors with plastic bags immediately after installation to maintain cleanliness.

H. Device Mounting Schedule:
   1. Dimensions are to center of item unless otherwise indicated.
   2. Mounting heights as indicated below unless otherwise indicated on Drawings.
      a. Manual pull stations: 48 IN.
      b. Notification appliances: 80 IN.
      c. Control panels and remote annunciators: 72 IN to top.

3.2 TESTING

A. Obtain services of a factory trained representative of system manufacturer to supervise installation and its progress, supervise final connections to equipment and provide testing to assure that system is in proper operating condition, and is in compliance with all applicable regulations.

B. Test system to satisfaction of Engineer and state and local fire authorities in accordance with NFPA 72, state and local codes and manufacturer's requirements.

3.3 INSTRUCTION

A. Manufacturer shall provide an authorized representative to instruct and train Fire Department personnel and Owner's personnel in operation of system.

END OF SECTION

SECTION 16740

TELEPHONE SYSTEMS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. The work includes furnishing all materials, labor and equipment to install telephone systems as shown on the Drawings and specified herein.

B. The contractor will:

1. Provide all materials to form a complete raceway and telephone wire system ready for installation of telephone and instruments.

2. Provide all conduit, boxes, telephone instrument wiring, terminal boards, phone jacks and receptacles.

3. Provide main service entry conduit(s) as shown on drawings or as per telephone company recommendations. Install pull lines in empty conduit(s).

C. Work by others:

1. Installation of main service cabling to the telephone equipment location.

2. Telephone equipment.

1.2 QUALITY ASSURANCE

A. Qualifications

1. Of Testing Agency:

a. All equipment and devices shall be listed by Underwriter Laboratories (U.L.). The system shall comply with all applicable provisions on the latest edition of N.E.C. and N.F.P.A. 70.

1.3 SUBMITTALS

A. Submit following in accordance with SECTION 01340.

1. Submit product data on telephone wire and telephone jacks.

PART 2 PRODUCTS

2.1 MATERIALS (Acceptable Products)

A. See other applicable sections

B. Terminal Boards: 3/4 inch X 4 foot X 4 foot plywood

PART 3 EXECUTION

3.1 INSTALLATION/APPLICATION/PERFORMANCE/ERECTION

A. Furnish and install all conduit and boxes shown on the drawings and install pull lines (minimum 17 lbs. test tensile strength) in empty conduit to allow phone co. to install pull tapes for pulling cables.

B. Install 4-conductor inside/outside telephone station cables from each phone outlet to the telephone terminal board. Leave 6 feet of slack cable coiled at the telephone terminal board. All cables shall be clearly labeled.

C. Telephone cable shall be 4-conductor, 22-gauge, solid copper conductors with high density PE insulation and PVC jacket.

D. Each pair shall be terminated on appropriate outlets, terminal blocks or patch panels. No cable shall be unterminated or contain unterminated elements. Pairs shall remain twisted together to within the proper distance from the termination as specified in EIA ANSI/TIA/EIA-568-A. Conductors shall not be damaged when removing insulation. Wire insulation shall not be damaged when removing outer jacket.

E. Provide RJ11 telephone jacks in all telephone outlets. Coverplates shall be stainless steel in office areas and weatherproof in all other areas.

F. Conduit shall be minimum of 3/4 inch trade size unless otherwise noted on the Drawings.

G. Provide all conduit with bushings, main service conduit with grounding bushing.

H. Install a ground lug at main service location, connect a #6 ground wire to the main building equipment ground system.

I. Provide 2 - 20 amp duplex receptacles at telephone board, for phone equipment.

J. Ground all conduit and boxes back to nearest equipment ground point.

END OF SECTION

SECTION 16910

PROCESS INSTRUMENTATION AND ALARM

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. The work includes furnishing all labor, materials and equipment necessary to complete the installation of a complete and functional instrumentation and alarm system.

B. The work includes furnishing Hatchery Central Alarm Control Panels (CACP), temperature transmitters, RTDs, level transmitters, horns, strobes, PLC and display screens, UPS, float switches, temperature switches, and alarm radio-autodialer. PLC includes interconnections with other equipment, such as flowmeters provided under 15270, genset, transfer switch, chiller, and fluid cooller. At Imnaha site: see paragraph 1.3-F.

C. The work described in this Section consists of providing equipment instruments and interconnecting wiring for the alarm and monitoring systems at each site.

D. The work includes all items, all software, all programming, calibration and adjustments required for a complete and operating system. System programming is the responsibility of the Instrumentation contractor. Transmitter calibration is the responsibility of the Instrumentation Contractor.

E. The work includes preparation and submission of shop drawings, record drawings and other required submittals. Work includes a complete set of system's wiring diagrams showing all wire numbers and field connections. The wiring number system shall be developed by the contractor.

F. The work includes verifying installation of the equipment with the appropriate manufacturer's representative to ensure full compliance with all standards.

G. The work includes calibrating flowmeters which connect to the PLC (the flowmeter actuators are specified in DIVISION 15, and shall be provided by the supplier providing the flow meters).

1.2 RELATED WORK

A. Specified elsewhere:

SECTION 01340 - Submittals
SECTION 01410 - Testing and Adjustment
SECTION 01730 - Operating and Maintenance Data
SECTION 13441 – Hatchery alarm, monitoring and controls
SECTION 13500 - PLC
SECTION 15270 - Flowmeters
SECTION 16000 - Electrical Specifications
SECTION 16050 - Basic Electrical Materials & Methods
SECTION 16195 - Electrical Identification Systems
SECTION 16500 - Lighting

1.3 GENERAL REQUIREMENTS

A. System Responsibility

1. The system shall be furnished as a unit with undivided responsibility for a complete and satisfactory operation with a single manufacturer of national repute in the field of instrumentation and control. The system shall be completely assembled and tested at the Instrumentation contractor's shop prior to shipment, and demonstrated in the presence of an Engineer’s representative, if the Engineer so chooses.

2. The system shall be installed by the Contractor under the supervision of a qualified factory representative of the Instrumentation contractor. The cost of supervision shall be included in the price bid for the system.

B. Experience

1. The equipment shall be from a manufacturer of national reputation in the field of telemetering and control. Manufacturer shall be able to demonstrate with installations of similar size, style and type, their ability to perform as specified.

C. Service Facilities

1. The Instrumentation contractor shall maintain service facilities staffed with qualified representatives. The representatives shall be factory-trained and qualified to service the proposed equipment.

D. The following are pre-approved Instrumentation Contractors

1. B&E Electric

E. 9012 Grace
Spokane, WA 99212
Attn: Ron Brossart
Phone: (509) 927-9350

2. TSI
2303 196th S.W.
Lynnwood, Washington 98036
Attn: Don Bernhard
Phone: (425) 775-5696

3. Instrument Control Systems
13005 16th Ave N #100
Plymouth, Minn. 55441
Attn: Mike Voelker
Phone: 763-559-0568

4. Control Engineers
1109 Main Street, #310
Boise, ID 83702
Phone: (208) 433-9997

E. Any other Instrumentation contractor to be considered for this project must submit adequate written documentation and photographs to engineer, installed systems of comparable size and complexity prior to bidding for acceptance. A list of client phone numbers and contact individuals must also be provided along with project descriptions. Approved substitutions will be by published addenda only to allow all bidders the opportunity to provide substitute Instrumentation Contractor.

F. Basic Requirements:

1. The system for the Hatchery Complex shall consist of the following:

a. Hatchery building central alarm/control panel (CACP), including PLC annunciator, display panel, alarm indicators, switches, relays, power supplies, dialer, audible alarm signals, surge protectors, fans, terminals and wireway.

b. PLC Data acquisition system hardware and software and programming, as defined in section 13500 and 13441.

c. Remote sensors, transducers and transmitters for analog data.

d. Remote sensors and interconnections with equipment specified in other sections for status and alarms.

e. Interconnecting cable as required.

f. A method for the Manager to view and print status and datalog history and flow trends.

2. At the Imnaha sites the instrumentation shall consist of alarm panel and all alarm panel circuits, horn, float switches, motor starter with low level cutoff relay, flowmeter connections, well depth probe, datalogger and interconnections.

1.4 SUBMITTALS - Submit in accordance with SECTION 01340.

A. Material and Equipment Lists. As soon as practicable and within 30 days after the date of Notice to Proceed and before starting installation of any materials or equipment, the Contractor shall submit to the Engineer for acceptance a complete list of materials and equipment to be incorporated in the work. This list shall include catalog numbers, cuts, and other descriptive data as may be required. No consideration will be given to partial lists submitted from time to time. Acceptance of materials will be based on manufacturer's published data; acceptance of materials and equipment will be tentative subject to submission of complete shop drawings indicating compliance with the contract documents.

B. Shop Drawings. After receiving tentative acceptance of the equipment on the materials list and before installation of any of these items, the Contractor shall submit complete shop drawings and such other descriptive data as Owner may require to demonstrate compliance with the contract documents. All shop drawings shall be submitted at one time in order to demonstrate that these items of equipment have been properly coordinated and will function properly with each other. Shop drawings shall be furnished for the following items:

1. Each panel enclosure.
2. System block diagram.
3. Equipment wiring diagrams.
4. Interconnection diagrams.
5. Outline dimensions of all equipment.
6. Instrumentation sensors.
7. Mounting details for proposed sensors, specific for the individual locations of the sensors.

C. The contractor may propose deviations from the Contract drawings and specifications if, in the contractor's opinion, this is an improvement to the project's instrumentation/alarm system. All proposed deviations are subject to review and acceptance by the Engineer. Do not proceed with the deviations until the Engineer issues written instructions.

D. Prior to shipment of the hatchery alarm control panel and PLC, submit printouts of the proposed graphics, complete with a description of display features and operation. Provide printout of ladder logic/function block controller program. Provide key to symbols and registers as required to interpret program. See sections 13500 and 13441.

1.5 DELIVERY

A. The material shall be delivered in the manufacturer's original containers, plainly labeled with the manufacturer's names and brands. The material shall be stored in safe, dry locations and shall not be unpacked until needed for installation.

1.6 SUPERVISION AND START-UP

A. During and after installation of the system, the contractor furnishing the equipment shall provide adequate supervision as well as start-up service. During the 120-hour test (SECTION 01410) the Instrumentation contractor shall be on-site to make all programming and software adjustments as may be required for the proper operation, monitoring and alarming of the hatchery. The Instrumentation contractor shall provide instruction to the operating personnel and provide a minimum of three field visits to the sites at 3-month intervals to insure proper adjustments and operation of the equipment during the first year of service from the date of acceptance of the system.

1.7 OPERATION AND MAINTENANCE MANUAL

A. Instrumentation Supplier shall provide 3 copies each of the Operation and Maintenance Manual for each site. Manual shall include:

1. See section 01340.
2. A detailed narrative description of the system architecture, inputs, outputs, signaling, auxiliary function, annunciation, intended sequence of operation, expansion capability, application considerations and limitations.
3. Operator instructions for basic system operations including procedures for alarm acknowledgment, system reset, interpreting system output and auxiliary function controls.
4. Maintenance procedures that are available to owner.
5. Maintenance requirements established by each equipment manufacturer, programming assistance, troubleshooting guides.
6. parts ordering, field service requirements, and any service contracts
7. location and phone numbers of service centers and 24 hour hotlines.
8. A detailed description of routine maintenance and testing as required and recommended and as would be provided under a maintenance contract, including a testing and maintenance schedule and detailed testing and maintenance instructions for each type of device installed. This information shall include:

9. A listing of the individual system components which require periodic testing and maintenance.
10. Step-by-step instructions detailing the requisite testing and maintenance procedures and the intervals at which those procedures should be performed, for each type of device installed.
11. A service directory, including a list of individual's names and telephone numbers for whoever should be called to obtain service on the PLC system.

B. The manuals shall constitute the basis for the Training Sessions required elsewhere in this specification, and as such shall be both specific to this system, containing a minimum of superfluous information and suitable for that purpose.

C. The manuals shall be written, compiled and edited specifically for this project and the system installed. Unedited manufacturer's catalog data sheets and/or equipment manuals are unacceptable as content for this submittal.

1.8 SYSTEMS DESCRIPTION

A. The PLC and Hatchery Central Alarm Control Panel (CACP) system shall consist of:

1. PLC (including surge protectors, UPS, DC power supply, touch screen display and radio-alarm dialer, local buzzer and acknowledge pushbutton), as defined in section 13500.
2. CACP (including, chime, surge protectors, touch screen display for alarm annunciation and alarm disable functions, and may contain a DC power supply for the incubation flowmeter).
3. Personal Computer (PC) for datalogging, alarm history and retreiving analog trends. With printers.
4. Level transmitters.
5. Float switches.
6. Temperature transmitters and RTDs.
7. Indoor horns.
8. Flowmeters and Flow Transmitters.
9. Remote I/O cabinets, if any.
10. Remote sensors and interconnections with equipment specified in other sections for status and alarms.
11. Interconnecting conduit, wire, cable and fiber optic cable as required.

B. System Architecture

1. The PLC, see section 13441 and 13500, is to provide graphic interface, alarm logging and analog trends. Software must also be provided to allow printing of alarm history log and of flow trends. An interface card and software and interconnecting cable shall be provided for the manager's PC computer. The interface card in the PC will be compatible with the PLC's protocol (e.g.: Modbus Plus, DH485 or RS485) and the software shall be the same software that runs the CACP display.

2. Alarm Bypass capability must be provided to bypass alarms on any equipment or system that can be taken out of service for extended periods. Each bypassed alarm must be clearly indicated on the display panel to indicate that the alarm circuit has been manually disabled.

3. Hatchery Alarm Horn Controls. A method must be provided to silence the outdoor and indoor horns, and to set duration of the horn blasts as well as time delays from the alarm occurrence to when the horn sounds.

4. Hatchery Dialer Controls. A method must be provided to assign the alarm outputs to one of eight dialer channels. Dialer time delays must also be provided. The dialer must not dial out acknowledged alarms. A method must be provided to acknowledge alarms over the phone

5. Hatchery Alarm and Monitoring System

   a. Primary alarm annunciation and control is provided by the PLC display panel, panel chime and horns, the radio-alarm dialer, and the acknowledge and reset pushbuttons on the control alarm panel.

   b. Alarm Sequence

      1) Basic alarm sequence for alarms:

Condition	Alarm Display	Audible
Normal	Off	Off
Alarm	Flash	On
Acknowledge	Steady On	Off
Return to Normal	Off	Off

      2) An incoming alarm would be displayed on the hatchery annunciator, and sound the panel chime and announce the alarm voice message over radio. Panel chime shall sound until the alarm is acknowledged.

3) After a two-minute time delay, the alarm horns will sound. The outdoor alarm horn will sound for a 4 minute duration, or until the alarm is acknowledged.

4) If the alarm is not acknowledged at the hatchery panel within 2 minutes, the alarm will be output to the appropriate dialer channel. The dialer will annunciate the alarm via phone lines. Each channel will have a prerecorded message. The alarm conditions may be acknowledged, but not reset, from a telephone.

5) Once the alarm input returns to normal the alarm condition resets. (It is expected that field device deadbands can be adjusted to avoid nuisance alarms.)

6) Submit annunciator legend nomenclature for approval.

c. Alarm Signals. The dialer shall be programmed to annunciate alarms with eight separate messages. The Contractor shall submit a list of these messages for approval.

d. contact the Hatchery Manager for a list of phone numbers to be dialed by the alarm dialer.

6. Lightning Surge Protection shall be provided on all outdoor circuits.

1.9 DESCRIPTION OF OPERATOR INTERFACE

A. Graphic Interface. In order to monitor and display the PLC inputs defined by the plans and as specified herein, the Contractor shall make a submittal listing the proposed graphic screen displays for acceptance by the Engineer. As a minimum, the following graphic screens shall be provided. In addition to the screens listed below, a main screen directory shall be provided, and each screen should have a "help" screen. If the minimum requirements specified herein deviate from the manufacturer's standard equipment, then it should be submitted to the Engineer for review and acceptance.

1. Headtank and Flow Rates. This screen should graphically show the level of the headtank in relation to the outlet elevation of the raceways and hatchery feed lines. It should display the flow rates in GPM of each of the flow meters. Each of these flow rates shall be programmed with 2 alarm set points for high and low flow alarms. Flow rates in the alarm range will display red. The water temperatures should also be displayed on this screen.

2. Active Alarm Screen. This screen(s) should display active alarm conditions including time of activation and alarm message.

3. Alarm Bypass. Provide a method to disable individual alarm points, so they will not alarm.

4. Historical Alarm Log. Showing date, time, message and time cleared, time acknowledged.

5. Trends. This screen should graphically display the headtank water level, flowmeter flows, and water temperature variations over time. The latest seven months data must be available for display.

B. Alarm Sequence

1. The Alarm Sequence shall be as described in 1.8.B.5. This is ISA 18.1 sequence A.

2. The date and time of each occurrence and subsequent response shall be documented by the system. Reports shall be periodically generated.

C. System Power Supply

1. Provide batteries, inverters, power supplies, relays and all accessories as required to provide continuous power to the Hatchery alarm and monitoring system. The power source(s) shall be capable of completely powering the alarm system for up to 6 minutes without line power. Sufficient power shall be provided to operate all sensors, and horns.

2. In the event of a utility power failure, or momentary power interruptions, the alarm system shall document the power failure, but a general alarm shall not sound. If power is lost to the alarm system for more than 20 seconds (presumably due to a breaker trip) the system should sound an alarm to indicate power loss to the system,

PART 2 PRODUCTS

2.1 MATERIALS (ACCEPTABLE PRODUCTS)

A. Auto Dialer capable of announcing a pre recorded voice message over the phone, to a list of eight successive telephone number, and over a radio frequency. Must have the capability to acknowledge an alarm over the phone.

Zetron 1550
Or equivalent

B. Programmable Logic Controller (PLC)

1. see specification 13500

Communication to remote I/O racks shall be by fiber optic modems.

C. Video Control Panel shall be a flat panel color touch screen industrial computer.

1. see specification 13500.

D. Personal Computer for datalogging, alarm history, and analog trends:
1. see specification 13500

E. Control Relays, 3PDT

Potter & Brumfield	KUP Series or KRPA
Square D	Class 8501, Type KU or Type R
Struthers Dunn	Frame A283
IDEC	RH Series
Allen-Bradley	Type HA or HF
Realco	C2-A

Inductive devices powered by low current switches or relays (such as reed float swtiches or PLC output relays) shall have surge protection as follows.

Inductive loads require either a diode for DC circuits (IN 4004) across the load or a varistor for AC circuits (GE model V130LA10A or equal) across the switch.

F Pilot Devices

Cutler Hammer	File E20, 1020T
Allen Bradley	Bulletin 800T
Square D	Class 9001, Type K

G. Alarm Horns

1. Horns shall be weatherproof and be capable of a sound level of at least 100 dB at 10 feet.

2. Acceptable Manufacturers:

Edwards
Federal Electric

G. Panel Chimes

1. UL listed.

2. 86 dBA maximum volume.

3. Built in volume control. Devices requiring outboard amplifiers or tone generators are not acceptable.

H. Time Delay Relays

Diversified Electronics
Allen-Bradley
Infitel
National controls Corp.

I. Time Clocks and Contactors. See Section 16500.

J. Float Alarm Switches

1. Outdoor float alarm switches shall be mechanical tilt floats, without mercury, UL recognized. With a deadband of 3" or more to reduce nuisance alarms .
2. Headtank float alarm switches shall have a deadband of 6" or more.
3. Incubation mix box Float Alarm Switches shall have a permanent magnet equipped float that moves between stops with liquid level to magnetically actuate a dry reed, hermetically sealed switch within the sealed stem of the unit. All fittings shall be stainless steel and floats shall be Buna N rubber or stainless steel fabricated as shown on the drawings. Switches shall be UL recognized. Water that flows to fish shall not be exposed to copper, zinc or cadmium.
    a) Interposing relays are required if switched load exceeds the switch rating.
    b) Provide surge protection of reed switches with inductive loads (see relay specifications above).

4. Manufacturers

    a. pond, raceway and headtank mechanical tilt floats
    GEMS Warrick tilt float
    Anchor Scientific Eco-Float

    b. For incubation mix box headers use either:

    Barksdale 0111-510 – Stainless steel Bilge level switch
    Barksdale BLS-270001-Stainless steel

    - Since the incubation mix box alarms are wired in series, a method must be provided to disable the alarms from mix boxes that are not being used. The bilge level switch mentioned above has a handle that can be propped up with a clip or wedge.

5. Sump float Switches at

a. the intake vault sump may be provided by the sump pump vendor.

b. the clarifier sump may be provided by the sump pump vendor. This starter will alternate pumps.

N. Remote Temperature Sensor and Transmitter. Temperature shall be measured by platinum resistance temperature detectors having approximately 100 ohms resistance at 32 ˚ F and an accuracy of +/- 2 ˚ F. The probes shall be three-wire and connected to resistance-to-current transmitters. The resistance-to-current transmitters shall provide 4 - 20 ma output as the temperature detector changes from 32 ˚ to 100 ˚ F. All components shall be solid-state and the output accuracy shall be +/- 0.5%. Units shall be housed in weatherproof cases.

0. Continuous level sensor for headtank.

1. Sensor shall be for water applications, with a sensing length as required by Drawings.

2. Sensor assembly shall be complete with two-wire current transmitter for the level sensor, to provide a 4-20 ma output signal.

3. The sensor must be mounted in a stilling well.

4. Provide a surge arrestor near the transmitters.

5. Acceptable Manufacturers:

Drexelbrook	509-015 with weighted cable and spacers for stilling well.
Princo	Model L2631 with Model L113 flexible probe and spacers

P. Thermostat for Freezer High Temperature Alarm

1. Manufacturer provided alarm contact, or a temperature switch.

2. Thermostat shall be UL listed.

3. Thermostat shall have metal housing with setpoint adjustment and indication. Housing shall have knockouts for connection to rigid conduit, or shall be mounted to electrical junction box.

4. Setpoint shall be adjustable and include the range 0˚F to 30˚F.

5. An engraved nameplate "High Temperature Alarm" shall be mounted on or near the thermostat.

Q. Control Cabinets

1. The cabinets shall be of a modular type with each section fabricated from 12-gage sheet steel, or equivalent. If lighter gage steel is used, it shall be formed to provide structural strength equal to that of 12-gage steel. All structural seams ground flush and smooth. Internal welds shall be cleaned and removed of all scale.

2. Doors shall be fabricated from smooth sheet metal with folded edges and other reinforcement as necessary to provide and required rigidity and flatness. Hinges shall be concealed. Doors shall open and close without binding and be held in the closed position with a suitable latch. Metal surfaces shall have all burrs and sharp edges removed and shall be smooth without blemishes.

3. Parts to be painted shall be thoroughly cleaned of rust, slag, oils, grease or other foreign material. All steel surfaces shall be given a prime coat of air or oven drying metal primer. Interior surfaces shall be given not less than one finish coat and exterior surfaces less than two finish coats. The finish color shall be a selected by the Engineer prior to fabrication.

4. Outdoor cabinets and cabinets located in unheated headtanks must be NEMA 4 and contain a 30-watt control panel heater (Hoffman D-AH301 or approved equal) to prevent condensation on components. Mount heater at bottom, 6" away from heat sensitive components.

R. Surge Arrestor.

1. PLC: as specified in 13500.

2. Lightning Surge Protection on other 120 VAC equipment

   Joslyn 1260-21
   MCG 400 Series
   or approved equal

4. Analog 4-20 mA transmitters where cathodic protection is not used. Joslyn 1669, Amber Industries 1360C-25 or Rosemount 470 at the transmitter, and Joslyn 1820 or MCG Electronics DLP-10 at the PLC or approved equal.

5. 24V DC circuits Joslyn 1035-20, MCG Electronics DLP, or approved equal.

6. Manufacturers

MCG Electronics	1-800-851-1508
Amber Industries	1-972-490-9801
Joslyn Electronics	1-800-752-8068
Rosemount	1-612-941-5560

S. Uninterruptible Power Supply

a. Sized per paragraph 1.9.C.1.

b. Sealed, maintenance free batteries.

c. Battery monitoring and alarm input.

d. Manufactured by Sola, Liebert, Deltec, APC or Best.

U. PC Software

As specified in 13500.

W. Well depth hydrostatic Pressure Transmitters

1. The pressure transmitter shall be a two-wire 4-20mA loop powered capable of measuring within 1% of span.

2. Acceptable Manufacturer:

Druck
Instrumentation NW
Ametek- US Gauge, Model SST
Gems series 2200, 2400 or 2600
Sensotec
Global Water
Keller PSI
KWK Technologies
Or equivalent

3. Materials:
Probe: stainless steel, titanium or Hastelloy
4. Pressure range that is capable of reading maximum depth at full scale
5. Design:
Factory fabricated integral cable
Accurate to within 0.5% of full scale
Surge protection,
4-20mA output proportional to level
Two wire transmitter compatible with a 24 volt DC excitation
6. Provide a termination enclosure that includes desiccant cartridge for the barometric vent.

X. Buffer tank hydorstatic level transmitter.
1. same as above but surge protection is not required.

X. Undervoltage Monitor

1. 208 three phase with adjustable trip point:
Diversified Electronics SLA-230-ALE

Z. Process Controllers

1. Single loop PID Controllers requiring thermocouple, RTD or milliamp inputs and a milliamp output shall be Foxboro 731C or approved equal

2. Dual PID Controllers for Cascade loops or split-range outputs shall be Foxboro 743 CB or approved equal.

PART 3 EXECUTION

3.1 INSTALLATION/APPLICATION/PERFORMANCE/ERECTION

A. System Wiring

1. All Control Cable wiring shall be installed per Division 16.

2. All instrumentation components shall be wired in full compliance with Division 16 requirements.

B. Field Wiring

1. All field wiring shall be connected to the terminals provided in the Instrumentation cabinets.

2. All wiring shall have permanent sensitive labels with wire designations in each pull box, handhole, and instrumentation cabinet. Wire designations must be clearly indicated on As-Built Drawings.

3. Wiring shall be neatly installed with rounded corners, and be tied off with cable ties.

4. Permanently labeled terminals and wires will be provided for all remote site equipment. The numbering system will be identical for all interchangeable equipment.

C. Equipment Installation

1. Boxes and Cabinets shall be installed as indicated on the plans on the surface level and plumbed and affixed to the surface with S.S. expansion inserts in concrete and S.S. machine screws or stainless steel nuts and bolts to tapped holes in metal surfaces. Supports and brackets shall be provided as shown on the drawings or as required to provide a neat and securely mounted system installation.

2. Interconnections between equipment shall be made per manufacturer's wiring diagrams and requirements. All wiring shall be clearly labeled.

D. Tests. After the monitor and alarm system installation is complete and at such time as the Engineer may direct, the Contractor shall conduct an operating test for approval. The equipment shall be demonstrated to operate in accordance with the requirements of this specification. The test shall be performed in the presence of the Engineer or an authorized representative. The Contractor shall furnish all instruments and personnel required for the tests. All defective material and workmanship disclosed as a result of tests and inspections given herein shall be corrected at no extra cost to Owner

E. Spare Parts. The Instrumentation Contractor shall provide the following spare parts.

1. Lostine River Hatchery:

   a. Package of 10 spare lamps of each type

   b. Two (2) spare control relays of each type.

   c. One spare DC power supply at the PLC

   d. Fuses - Ten (10) of each type used.

   e. One (1) - spare discrete input PLC module.

   f. One (1) - spare analog input PLC module.

   g. One (1) – relay out PLC module. (1705 only)

2. Imnaha site:

   a. Two (2) spare lamps of each type.

   b. One (1) spare relay of each type.

F. Training. Conduct three (3) training sessions of two hours each to familiarize the hatchery personnel with the features, operation and maintenance of the new systems. Training sessions shall be scheduled by the owner at a time mutually agreeable to the Contractor.

END OF SECTION

SECTION 16960

TESTING ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. The work includes furnishing all labor, materials and equipment necessary for testing electrical systems as specified herein.

B. Perform tests as hereinafter specified.

1.2 SUBMITTALS

A. Submit three copies of all test results in accordance with SECTION 01340, with list of persons present.

PART 2 PRODUCTS

2.1 MATERIALS (Acceptable Products)

A. Provide test equipment, temporary wiring, labor and materials required to perform tests.

PART 3 EXECUTION

3.1 TESTS

A. 600 Volt Cable

1. Tested for proper phasing.

B. Wiring Devices

1. 20 amp 125 volt receptacles shall be tested with a receptacle circuit tester for proper connection of ground wire, correct polarity and fault in any of the three connections. Voltage at the end of each circuit over 100 foot in length shall be checked and recorded under load (load shall be on device farthest to overcurrent device and be 1440W - such as an electric heater or similar resistance load).

2. Power receptacles shall be checked for proper phase connections, ground continuity and voltage.

C. Motors

1. Inspected for damage, moisture, alignment, lubrication, oil leaks, and phase identification.

2. Tested for correct rotation and where reverse rotation could damage equipment, the motor shall be mechanically uncoupled before testing.

3. Pass a minimum megger test with the windings at ambient temperature. Megger test shall be applied on three phase motors between all phases tied together and ground. Single-phase motors shall have a megger test applied between phase and neutral conductor tied together and ground.

4. Minimum acceptable megger readings and megger voltage are listed below:

MOTOR	MEGGER VOLTAGE	MINIMUM MEGGER READING *MEGOHMS*
3 phase induction motor	500	2
1 phase induction motor	500	1

5. Non-induction type motors, special application motors shall be megger tested as recommended by the motor manufacturer.

6. Operating load tests shall be run on all motors and the individual phase current readings taken.

7. Motor shall be run long enough to prove satisfactory performance under operating load, including but not limited to: temperature, lubrication, alignment and vibration.

8. Electrical Contractor shall make complete and accurate records of all motor parameters and test results.

D. Starters

1. Voltages shall be verified to assure that proper voltage is being fed to motors controller and control circuit elements before energization of starters.

2. Operated with motor disconnect to assure that wiring of circuitry properly energizes and de-energizes to starter.

3. Motor wiring shall be checked for proper phase connections and motor rotation, check and record motor running full load current for all 3/4 hp and larger motors, and verify with nameplate ratings.

4. Submit test data showing motor name, nameplate voltage, phase, HP, nameplate full load amps, actual running full load amps, fuse size used, size of overload heaters installed, and disconnect and starter size installed.

E. Panelboards and Switchboards

1. A complete record of the current in each phase feeder to each piece of equipment from switchboards and panelboards shall be made under full load. Submittal shall include panelboard name, location and each feeder current and voltage.

2. A complete operational test shall be made of all switchboards and distribution panelboards to assure that equipment is in proper operating condition.

3. Ground connections shall be tightly secured and tested for continuity prior to energization.

4. Switchboard bus structure shall be megger tested prior to energization. Care shall be exercised so as not to damage other equipment in switchboard, i.e., all switches should be open, etc.

F. Disconnects

1. Given an operational test.

2. Voltages on line and load side of all disconnects shall be tested to assure that proper voltage is being applied to terminals.

G. Dry Type Transformers

1. Primary and secondary voltages shall be tested to determine that specified voltages are being fed to and from the transformer before equipment being fed by transformer is energized. Buck and boost transformers shall also be tested under full load for proper voltages, both at transformer and at load, if voltage is not within 10% of specified voltage de-energize equipment and notify the Engineer.

2. Grounding shall be tested and verified to conform with the latest edition of NEC and SECTION 16450.

H. Generators

1. Performance and temperature rise data submitted by the manufacturer shall be the result of actual test of the same or duplicate generator. Temperature rise data shall be the result of full load, 0.8 power factor heat runs at the rated voltage and frequency specified. This testing shall be done in accordance with MIL-STD-705 and IEEE standard 115.

2. Before the equipment is installed, a factory test log of the generator set showing a minimum of 3/4 hour testing with 1/2 hour at 10% present rated load at 0.8 power factor, continuously, shall be submitted to the purchaser. Voltage and frequency stability and transient response at 1/4, 1/2 and full load shall also be recorded. Normal preliminary engine and generator tests shall have been performed before unit assembly.

3. Prior to acceptance of the installation, the equipment shall be subjected to an on site test at full load with resistive load banks for a minimum of 4 hours. All consumables necessary for this test operation shall be furnished by the Electrical Contractor. Any defects which become evident during this test shall be corrected at no expense to the BPA. Maintain a test log and submit prior to acceptance of work.

4. Field testing shall be performed by the Manufacturer's Representative and the Electrical Contractor.

I. The resistance between ground and absolute earth shall not exceed 10 ohms and shall be measured by the Electrical Contractor in the presence of the Engineer before equipment is placed in operation. Maintain a test log and submit prior to acceptance of work.

J. Any unusual conditions shall be called to the attention of the Engineer.

1. Do not subject ground fault breakers, receptacles, dimmers or other electronic equipment to megger tests.

K. Fire alarm, automatic transfer switches

1. Field testing shall be performed by a factory trained engineer and the Electrical Contractor.

2. Each item in the systems shall be tested for proper operation and performance.

3. Factory shall certify system has been properly installed, wired, and the entire system is functioning properly.

END OF SECTION

SECTION 16980

ELECTRICAL SYSTEMS DEMONSTRATION

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

A. The work includes furnishing all labor, materials and equipment necessary for the electrical systems demonstration as specified herein.

B. Perform demonstrations as hereinafter specified.

1.2 QUALITY ASSURANCE

A. Qualifications of Demonstrators:

1. Shall be fully trained in the type of system to be demonstrated.

PART 2 PRODUCTS (Not applicable)

PART 3 EXECUTION

3.1 DEMONSTRATION OF COMPLETED SYSTEMS

A. Demonstrations required on the following systems:

1. Panelboards and Switchboards
2. Motor Controls
3. Lighting Systems
4. Fire Alarm Systems
5. Generator Systems
6. Instrumentation and Alarm Systems

B. Each system shall be demonstrated once only (unless otherwise noted under system) after completion of testing and acceptance.

C. The demonstration shall be held upon completion and acceptance of all systems at a date to be agreed upon in writing by the Engineer.

D. Demonstrate the functions and location of each system.

E. Demonstrate by "Start-Stop Operation" how to operate the controls, reset protective devices, replace fuses, set time switches and what to do in case of an emergency.

END OF SECTION