

SECTION 16010

ELECTRICAL

PART 1 – GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall install, ready for use, the electrical system, as specified herein and shown on the Contract Drawings. This document describes the function and operation of the system and particular components, but does not necessarily describe all necessary devices. All components and devices shall be furnished and installed as necessary to provide a complete, operable and reliable system for accomplishing the functions and meeting the performance set forth hereinafter.
- B. Furnish all required labor, materials, project equipment, tools, construction equipment, safety equipment, transportation, test equipment, incidentals and services to provide a complete and operational electrical system, as shown on the Contract E-Series Drawings, included in these Specifications, or necessary for a fully operating facility. See Appendix "B" for "Device Index" for this project.
- C. Examine the Specifications and Drawings for mechanical equipment and provide all starters, circuit breakers, switches, pushbuttons and appurtenances which are not specified to be with the mechanical equipment. Erect all electrical equipment not definitely stated to be erected by others, furnish and install conduit, wire and cable and make connections required to place all equipment in complete operation.
- D. The major areas in the scope of work shown on E-series Contract Drawings, including both the furnishing and installation are:
 - 1. Motor controls.
 - 2. Micro Logic Controller (mLC) and Operator Interface (OI) hardware and programming for controlling the pumps, and other miscellaneous devices.
 - 3. Instrumentation and other miscellaneous devices. This includes all wiring and cables.
 - 4. Installation of primary devices, equipment and instruments are not completely detailed on Contract Drawing plan sheets. Use Device Indexes and Contract Drawings installation details for installation and mounting requirements.
 - 5. All necessary miscellaneous shut off, sample, manifold and calibration valves to sensors.
 - 6. Conduits and the field interconnection wiring between motor control centers, panelboards, controls, lighting, receptacles, and equipment provided under all other Divisions, etc.
 - 7. Provide all necessary hardware, fittings, and devices to connect the designated equipment and wiring.

8. Trenching, backfilling, and compaction for all underground conduit routes, concrete pads and pull boxes.
 9. Grounding system and equipment grounding.
 10. Concrete pads and supports for electrical and instrumentation equipment.
 11. Remove and dispose of all excess dirt, paving, concrete, and other materials from site work.
- E. Existing sites are limited in space. It is the Contractor's responsibility to provide an electrical and instrumentation package to fit in the allocated space.
 - F. Contractor shall coordinate with Owner prior to cutover of any system.
 - G. The following specifications incorporate specific equipment and devices that are standards of the Owner because of their serviceability, because of the local availability of labor, parts and materials, or because of the ability of the Owner to umbrella the equipment under existing maintenance contracts.
 - H. All electrical work shall conform with the National Electric Code (NEC) 2008 issue. Nothing on the Drawings or in the Specifications shall be construed to permit work or materials not conforming to these codes and standards.
 - I. All panels, panelboards, panelboard transformers, PLC hardware, etc. shall be supplied by one System Supplier. All panels and instrumentation listed in Division 16 Appendix Indexes shall be supplied by the same System Supplier. This includes, but is not limited to all work necessary to select, furnish, supervise installation, calibrate, program, and place into operation all transmitters, instruments, controllers, alarm equipment, monitoring equipment, and accessories as specified herein.
 - J. The System Suppliers listed below have been determined to meet minimum qualifications specified in this Division and are pre-qualified by the Owner for providing supplier bids as System Suppliers on the project. Other System Suppliers may submit, prior to bid opening, a statement of qualifications listing relevant experience on similar projects completed to Owner. The Owner will list additional pre-qualified System Suppliers in an addendum two weeks prior to bid opening.
 1. Bruce Whittle Electric (phone 209 736-0465)
 2. Krug-Bixby-Long Associates (KBL) (phone 510 887-1117)
 3. MCC Control Systems (formerly Meyer Control Corporation), (phone 707 449-0341)
 4. Tesco (phone 916 395-8800)
 5. Technical Systems Inc (phone 425 775-5696)

1.02 RELATED WORK IN OTHER SECTIONS

- A. The following is covered in other sections in the Contract Documents and are part of Division 16.
 1. Section 16605 – Electrical System Analysis.

- B. Provide an electrical system that interfaces to work performed under other Mechanical and Equipment Sections of these Specifications and Drawings.

1.03 CONTRACT DOCUMENTS

- A. The Contract Drawings and Specifications are intended to be descriptive of the type of electrical system to be provided. Any error or omission of detail in either shall not relieve the Contractor from the obligation there-under to install in correct detail any and all materials necessary for a complete and operational system at no additional cost.
- B. The Contract Drawings are generally diagrammatic. Exact locations of electrical products shall be verified in the field with the Engineer. Except where special details on drawings are used to illustrate the method of installation of a particular piece or type of equipment or materials, the requirements or descriptions in this Section shall take precedence in the event of conflict.
- C. Location at facilities of equipment, inserts, anchors, panels, pull boxes, conduits, stub-ups, and fittings for the electrical system are to be determined by the Contractor and Engineer at time of installation. Contractor shall make minor adjustments to location of electrical equipment, required by conditions and in coordination with other trades, at no additional cost to Owner.
- D. The Contractor shall examine the architectural, mechanical, structural, electrical and instrumentation equipment provided under other Sections of this Contract in order to determine the exact routing and final terminations for all conduits and cables. The exact locations and routing of cables and conduits shall be governed by structural conditions, physical interferences, and the physical location of wire terminations on equipment. Conduits shall be stubbed up as near as possible to equipment.
- E. All equipment shall be installed and located so that it can be readily accessed for operation and maintenance. The Engineer reserves the right to require minor changes in location of equipment, without incurring any additional costs.
- F. Where conduits are shown as "home runs" on the Contract Drawings or stated to be furnished but not explicitly shown as part of the scope of work, the Contractor shall provide all fittings, boxes, wiring, etc. as required for completion of the raceway system, in compliance with the NEC and the applicable Specifications in this Section.
- G. No changes from the Contract Drawings or Specifications shall be made without written approval of the Engineer. Should there be a need to deviate from the Contract documents, submit written details and reasons for all changes to the Engineer for favorable review.
- H. The resolution of conflicting interpretation of the Contract documents shall be determined by the Engineer.

- I. The Contractor shall coordinate with other Suppliers on the project for a complete and operable system.

1.04 COORDINATION

- A. The Contractor shall coordinate the electrical work with the other trades, code authorities, utilities, and the Engineer, with due regard to their work and towards promotion of a rapid completion of the project. If any cooperative work must be altered due to lack of proper supervision of such, or failure to make proper provisions, then the Contractor shall bear expense of such changes as necessary to be made in work of others.
- B. Manufacturer's directions and instructions shall be followed in all cases where such is not shown on the Contract Drawings or herein specified.
- C. The electrical and instrumentation modifications and additions are to be made at the operational treatment plant. The Contractor shall schedule all the required work with the Owner, including each shutdown period. Each shutdown shall be implemented to minimize disruption of the existing operations. The work to be provided under this Contract shall not disrupt any of the existing operations without prior approval from the Owner.
 1. The Contractor shall limit all unscheduled shutdown periods to less than 1 hour and only with prior approval of the Owner.
 2. Carry out scheduled shut downs only after the time, date, and sequence of work proposed to be accomplished during shutdown has been favorably reviewed by the Owner. Submit shutdown plans at least two (2) days in advance of when the scheduled shutdown is to occur.
 3. The Owner reserves the right to delay, change, or modify any shutdown, at any time and at no additional cost to the Owner, when the risk of such a shutdown would jeopardize the operation of system or effluent regulations.
- D. Schedule within 20 days after award of Contract all service installations and connections with Utilities. Delays due to lack of effort by the Contractor, which delay the project completion for lack of utility services, will not be considered valid and Contract liquidated damages will be assessed.
- E. Meet with the Owner for a four-hour PLC/OI Preliminary Design Review meeting at the Owners facility.
 1. Ensure that the Contractor Project Manager, System Supplier Engineer, System Supplier and PLC/OI software programmer, Engineer & Owner are all in attendance.
 2. Provide PLC/OI software preliminary design submittals for review and discussion ten (10) working days prior to meeting.
 3. System Supplier to demonstrate OI screen color and graphic layout by bringing a configured PLC and OI to the meeting.
 4. System Supplier to demonstrate complete understanding of PLC control sequence of operations and OI setup.

5. System Supplier to assign action items with required completion date.
Contractor to submit report of completed action items to the Owner on or before designated date.
- F. Meet with the Owner for a four-hour PLC/OI Critical Design Review meeting at the Owner's facility prior to start of any factory test.
1. Ensure that the Contractor Project Manager, System Supplier Engineer, System Supplier and PLC/OI software programmer, Engineer & Owner are all in attendance.
 2. Provide preliminary PLC/OI Software Operations and Maintenance Manual.
 3. System Supplier to demonstrate the complete PLC/OI setup. All station display and setpoint parameters will be checked for completeness by bringing a configured PLC/OI to the meeting.
 4. System Supplier to demonstrate all OI screens for review and comment.
 5. System Supplier to assign action items with required completion date.
Contractor to submit report of completed action items to the Owner on or before designated date.
- G. The Contractor shall schedule all activities, manage all technical aspects of the project, coordinate submittals and drawings, and attend all project meetings associated with this Section.
- H. The Contractor shall supervise all work in this Section, including the electrical system general construction work, from the beginning to completion and final acceptance.
- I. The Contractor shall supervise and coordinate all work in this Section to ensure each phase of the project, submittal, delivery, installation, and acceptance testing, etc. is completed within the allowable scheduled time frames.
- J. The Contractor shall be responsible for obtaining, preparing, completing, and furnishing all paper work for this Section, which shall include transmittals, submittals, forms, documents, manuals, instructions, and procedures.

1.05 INSPECTIONS

- A. All work or materials covered by the Contract documents shall be subject to inspection at any and all times by the Owner and Engineer. If any material does not conform to the Contract documents, or does not have a favorably reviewed submittal status, then the Contractor shall, within three days after being notified by the Owner, remove said material from the premises; and if said material has been installed, the entire expense of removing and replacing same, including any cutting and patching that may be necessary, shall be borne by the Contractor.
- B. Work shall not be closed in or covered over before inspection and approval by the Engineer. All costs associated with uncovering and making repairs where non-inspected work has been performed shall be borne by the Contractor.

- C. The Contractor shall cooperate with the Engineer to provide assistance at all times for the inspection of the electrical system under this Contract. The Contractor shall remove covers, provide access, operate equipment, and perform other reasonable work which, in the opinion of the Engineer, will be necessary to determine the quality and adequacy of the work.

1.06 JOB CONDITIONS

- A. The Contractor shall make all arrangements and pay the costs thereof for temporary services required during construction of the project, such as temporary electrical power and telephone service. Upon completion of the project, Contractor shall remove all temporary services and Contractor-owned equipment, material and wiring from the site.
- B. The Contractor shall provide adequate protection for all equipment and materials during shipment, storage and construction. Equipment and materials shall be completely covered with two layers of plastic and set on cribbing six inches above grade so that they are protected from weather, wind, dust, water, or construction operations. Equipment shall not be stored outdoors without the approval of the Engineer. Where equipment is stored or installed in moist areas, such as unheated buildings, etc., provide an acceptable means to prevent moisture damage, such as a uniformly distributed heat source to prevent condensation.

1.07 SUBMITTAL AND DRAWING REQUIREMENTS

- A. Six (6) copies of electrical submittals shall be submitted for favorable review by the Engineer, per this subsection. They shall be complete, giving all details of connections, wiring, instruments, enclosures, materials and dimensions. Standard sales literature will not be acceptable.
- B. A copy of the appropriate Division Specification Sections, with addendum updates included and with each paragraph check-marked to indicate specification compliance or marked to indicate requested deviations from specification requirements. Check marks (✓) shall denote full compliance with a paragraph as a whole. If deviations from the specifications are indicated and, therefore, requested by the Contractor, each deviation shall be underlined and denoted by a unique number in the margin to the right of the identified paragraph. The remaining portions of the paragraph not underlined will signify compliance on the part of the Contractor with the Specifications. The submittal shall be accompanied by a detailed, written justification for each numbered item explaining variance or non-compliance with specifications. Failure to include a copy of the marked-up specification sections, along with justification(s) for any requested deviations to the specification requirements, with the submittal shall be sufficient cause for rejection of the entire submittal with no review.

- C. The electrical submittals shall include but not be limited to data sheets and drawings for each product, together with the technical bulletin or brochure. The electrical submittals shall include:
1. Product (item) name used herein and on the Contract Drawings.
 2. The Manufacturer's model or other designation.
 3. Tag name/number per the drawing, schedules and indexes.
 4. Index Binder Tab Dividers.
 5. Detail electrical one line, elementary and loop diagrams and interconnection diagrams showing all wiring requirements for each system. General sales literature will not be acceptable. The part or model number with options to be provided shall be clearly identified. Where more than one item or catalog number appears on a catalog cut, the specific item(s) or catalog numbers(s) proposed shall be clearly identified.
 6. Complete documentation with full description of operation.
 7. Location of assembly at which it is installed.
 8. Input-output characteristics.
 9. Range, size, and graduations as required.
 10. Physical size with dimensions and mounting details.
 11. Enclosure fabrication and color.
 12. Enclosure layout and elevation drawings to scale.
 13. Quantity and quality requirements for electric power, air, and/or water supply.
 14. Materials of construction of components.
 15. Nameplate schedule.
 16. Interconnect Diagram.
 17. Bill of Materials: A complete Bill of Materials list shall be provided on the inside of the front cover. The Contractor shall provide Bill of Materials for electrical components, formatted as shown in Appendix "A." The System Supplier shall submit a separate set of Bill of Materials for the motor panel, spare parts and another listing all field equipment. Generic names or part numbers used by a distributor or Systems House are not acceptable; originating Manufacturer's name and part number shall be listed.
 18. A separate instrument data sheet shall be provided for each instrument, per ISA S20 standards or approved equal. Data sheets shall be printed on blue or pink paper. Provide an index with proper identification and cross-referencing of each data sheet.
 19. Submit CD disk copies of all submitted drawings in AutoCAD format.
 20. For each resubmittal, provide a copy of submittal comments and a separate letter, on Company letterhead, identifying how each submittal comment has been addressed in the resubmittal.

- D. All Drawings shall be drawn using AutoCAD, drawn in a professional manner and submitted on 11" x 17" sheets. Shop Drawings shall be provided with minimum drafting details, as illustrated on the Contract "electrical" series drawings. Diagrams shall carry a uniform and coordinated set of wire colors, wire numbers, and terminal block numbers. The shop Drawings shall include:
1. Electrical one-line diagrams detailing all devices associated with the power distribution system. The following applicable information or data shall be shown on the one-line diagram: location, size and amperage rating of bus; size and amperage rating of wire or cable; breaker ratings, number of poles, and frame sizes; generator receptacle; manual transfer switch, utility metering, voltage, amperage, number of wires and phases; fault interrupt ratings; ground size and connections; neutral size and connections; power fail and other protective devices; fuse size and type; distribution transformer; panelboard; starters; contactor size and overload range; motor full load amperage of submitted motor and horsepower; rating for miscellaneous loads; etc. Submit a list for each piece of equipment containing the motor voltage, phase and full load amps with one-lines for verification of accuracy of submitted one line drawings.
 2. Elementary diagrams shall be provided for all relay logic, power supplies, PLC I/O and other wiring. All elementary diagrams shall be drawn in JIC EMP/EGP format and standards similar to those shown on the E-Series elementary diagrams showing ladder rung numbers and coil & contact cross referencing numbers.
 3. Analog and digital I/O loop diagrams shall be provided showing the wiring requirements for each instrument loop. Graphic symbols shall conform with ISA S5.4 drawing standards. A loop diagram shall be furnished for each analog and digital I/O process and all PLC I/O cards. Loop diagrams shall include the following as a minimum:
 - a. The loop diagram shall be drawn with sufficient detail to express control philosophy. The diagram shall show all components and accessories of the instrument loop, highlighting special safety and other requirements. These diagrams shall be arranged to emphasize device elements and their functions as an aid to understanding the operation of a system and for maintaining or troubleshooting that system.
 - b. A separate drawing shall be prepared for each analog and digital card. Each card shall be arranged on the diagram in the same order as the physical arrangement of the card terminations. All termination points on the diagram shall be shown with the actual equipment identification, device and relay terminal number or letter, and I/O point P&ID English descriptor and tag name. A separate drawing shall be prepared for each card.
 - c. Energy sources - electrical power, air supply, pneumatic and hydraulic fluid supply, designating voltage, current, pressure, etc. shall be shown in detail on the diagram. Input and output signals (e.g., 1-5 VDC, 4-20 mA DC, 3-15 psig, etc.), power and instrument supplies to devices (e.g. 120 VAC, 24 VDC, 80 psig, etc.) shall be shown.

- d. Engineering units shall be shown on the diagram. Each wire label, equipment identification terminal number or letter and color code shall be shown. Signal and DC polarities shall be shown.
- e. All spare wires, cables and termination points shall be shown. All jumpers, grounding, shielding, power supply details shall be shown.
- 4. Enclosure and Elevation layout diagrams for MCC/Electrical Panels/Pedestal; show all front panels, sidepan and backpan devices drawn to scale. Show fabrication methods and details, including material of construction, paint color, support & latching mechanisms, fans & ventilation system, and conduit entrance areas.
- 5. Interconnection Diagram - An interconnection diagram shall be furnished for each electrical and instrumentation system. Each interconnection diagram shall include the following as a minimum:
 - a. Interconnect drawings shall be prepared for all equipment by the System Supplier.
 - b. The diagrams shall be utilized by the electrician during all phases of installation and connection of all conductors to ensure coordination of equipment interconnect.
 - c. The diagrams shall show wiring as field labeled at the end of the project when as-builts are submitted.
 - d. Each wire labeling code as actually installed shall be shown. The wiring labeling code for each end of the same wire must be identical.
 - e. All device and equipment labeling codes shall be shown.
 - f. Interconnections shall be shown point to point with identified lines. Diagrams of the wireless or wire schedule type are not acceptable. Bundled wires shall be shown as a single line with the direction of entry/exit of individual wires clearly shown. Interconnect diagrams shall not be combined with loop or elementary diagrams.
 - g. All terminations points on the diagram shall be shown with the actual equipment identification terminal number or letter. This identification of terminations includes terminal blocks, junction boxes, all devices, computer I/O points, etc.
 - h. Diagrams shall include raceway numbers, raceway size, cable numbers, wire color code, and wire numbers.
 - i. Each wire and cable size and color code shall be shown. Each conduit route with the conduit label and conduit size shall be shown. Wire and cable routing through conduits, wireways, manholes, handholes, junction boxes, terminal boxes and other electrical enclosures shall be shown with the appropriate equipment labels. All spare wires, cable, and termination points shall be shown. Cable shields shall be shown.
 - j. Labeling codes for terminal blocks, terminals, wires, cables, panels, cabinets, instruments, devices, and equipment shall be shown.
 - k. Schematic symbols shall be used for field devices, showing electrical contacts. Signal and DC circuit polarities shall be shown.
 - l. The diagrams shall show all other Contract and supplier sheet numbers, for reference, that are associated with each device that is interconnected.

- m. Attached to each interconnect, a copy of all the support documents used in preparing interconnects shall be submitted. This includes current issues of panel schematics, elementary diagrams, panelboard schedules, conduit schedules, one-line diagrams, connection diagrams, terminal block diagrams, submittals, contract drawings, vendor drawings and all other data used to develop the interconnection diagram as noted in the "Reference Documents" corner of interconnect drawings.
- n. Interconnects shall include list of all applicable reference drawings, request for clarifications, field instructions and change orders. All deletions and additions of equipment, conduits, wire, and cables shall be clearly shown. Clearly state why termination data is not available. Statements should point to applicable area and be placed in a bold box.
- o. Field wiring shall not start before the interconnection drawings have been submitted by the Contractor and approved by the Owner.
- p. Do not show the same wires or jumpers on the elementary or loop and interconnection diagrams. All jumper, shielding and grounding termination details not shown on the connection diagrams shall be shown on the interconnection diagrams.
- q. Interconnection diagrams shall be submitted and approved by the Owner for each electrical and instrumentation system. The Contractor shall not pull in any wires into conduits that do not have approved interconnects. If the Contractor pulls in wire without Owner approval of associated interconnect drawings, the Contractor will not be reimbursed for labor for re-pulling in wires even if there was an error in wire fill or sizing. Also, if the Contractor pulls in wire without Owner approval of associated interconnect drawings, then all progress payments for that particular area of work will be withheld until approved interconnect drawings are in use.
- r. All interconnection diagrams shall be prepared by a System Supplier under the supervision of or by a State of California Registered Electrical Engineer and shall bear that Engineer's professional stamp and signature for all Interconnection Drawings submitted for approval, including as-builts and those used in the field installation. Engineer's stamp missing from interconnection drawings will be sufficient grounds to reject entire interconnection drawing submittal without review. All deletions and additions of equipment, wire, and cables shall be clearly shown. Interconnects shall include list of all applicable reference Drawings, request for clarifications, field instructions, and change orders. Failure to provide backup references or signed and stamped drawings may be grounds for immediate rejection.
- s. Example format of Interconnection diagram is shown on Contract "E" Series Drawings or may be obtained from the Engineer.
- t. Interconnection Drawings shall use bundled wire format as shown on example interconnect Contract Drawing. Interconnect drawings submitted with wiring of a single conduit run separated onto multiple interconnect drawings will be rejected without review. A single conduit run with wiring shown on separate interconnect drawings will be allowed only after written approval is given by the Engineer for each conduit run prior to submitting the associated interconnect drawings.

- u. Only field wiring between switchboards, MCCs, Panelboards, Control Panels, and other electrical and instrumentation devices or equipment shall be shown on interconnection drawings. No internal panel wiring shall be shown on interconnect drawings except jumper or other wiring to be installed in field by Electrical Contractor.
- v. Interconnect Drawings along with the corresponding support documents shall be submitted in a separate submittal package. Interconnect drawings submitted with non interconnect drawing packages will be rejected. The latest support documents shall be obtained by system supplier from Contractor for all non-division 16 instruments, panels, and equipment, and included with interconnect drawing submittal. Support documents shall have their submittal number marked in upper right hand corner.
- w. Provide a notes section on each interconnect drawing. In the note section, provide a detailed list of any variances from the Contract conduit schedule necessary for completing the interconnections (i.e. wire fill changes, conduit additions, etc). Change orders regarding wire fill, conduit schedule and errors in plans regarding conduits and wires may not be processed until interconnect drawings have been received for such work.
- x. The field electrician shall mark-up all interconnection diagrams during installation to show accurate as-built wiring, conduits runs, terminations, etc. If interconnection drawings are not properly as-built, the Electrical Contractor will have cost deducted from the Contract for the Owner to field verify and prepare as-built interconnection drawings amount. The amount of the deduction shall be determined on a time and material basis. The cost of such work shall be \$120.00 per hour plus expenses.
- y. The system supplier shall be responsible to collect all information necessary to complete each interconnection drawing. This includes making field trips to collect all terminal connection data for new and existing, panels, switchboards, panelboards, instruments, equipment and electrical panels.
- z. An index of drawings shall be provided with each Interconnection submittal listing the unique sheet number and the description of the interconnect drawing (e.g. Sheet 4321-IC1004 Pump 1004 Interconnect Drawing).
- aa. Provide conduit and interconnect drawing cross reference indexes. Interconnect Conduit Index shall list all conduits listed in the Conduit & Wire Routing schedule and its associated Interconnection Drawing number. An Interconnection Drawing Index shall list all Interconnection drawings and the conduits shown on that specific drawing. These two indexes shall be at the front of all interconnection drawing submittals.
- bb. Interconnection submittals that contain more than two motor control panels/centers shall have heavy duty dividers with permanent plastic labeled index tabs separating each group of drawings.

6. Submit full size drawing of all nameplates and tags, as specified herein, to be used on project. The Engineer has the right to adjust nameplate engraving titles during submittals at no additional cost to the Owner. Submittal to include the following:
 - a. Dimensions of nameplate.
 - b. Exact lettering and font for each nameplate.
 - c. Color of nameplate.
 - d. Color of lettering.
 - e. Materials of construction.
 - f. Method and materials for attachment.
 - g. Drawing showing location of nameplate on each panel.
- E. Each submittal shall be bound in a three-ring binder, which is sized such that when all material is inserted the binder is not over 3/4 full. Binder construction shall allow easy removal of any page without complete manual disassembly; spiral ring type binders are not acceptable.
 1. Each binder shall be appropriately labeled on the outside spine & front cover with the project name, contract number, equipment supplier's name, specification section(s), and major material contained therein.
 2. An index shall be provided at the inside of the front cover. This index shall itemize the contents of each tab and sub tab section. Also list the project name, contract number and equipment supplier's name, address, phone number, and contact person on the index page. Index dividers (tabs) shall be provided to separate each section.
 3. All copies shall be clear and legible. Data sheets shall be provided for each instrument, with an index and proper identification and cross-referencing.
 4. Field equipment shop documents, panel equipment shop documents, drawings, and bill of materials shall be grouped under separate tabs. Catalog cuts shall be ordered in the same sequence as their corresponding Contract specification subsection.
 5. Failure to provide submittals with heavy duty permanent plastic labeled index tabs may be grounds for immediate rejection without review.
 6. Drawings shall be submitted in a separate hole-punched binder that covers the entire 11" X 17" length of the Drawing:
 - a. Shop Drawings with less than 20 sheets total in the submittal, may be provided in an 11½-inch by 17½-inch reinforced folder.
 - b. All Interconnection Drawings or Shop Drawings of 20 sheets or more shall be provided in separate heavy duty three-ring binder to allow drawings to be easily removed. Binder shall be Cardinal D-Ring Easy Open Ledger Binder with locking D-Rings or approved equal.
 - c. Failure to provide drawing submittal in correct binder format may be grounds for immediate rejection without review.
 - d. Each drawing title block shall contain the English description name for drawing contents (i.e. Lift Pump No. 1 Interconnect Drawing) and sheet number. All pages and drawings in the submittal shall be numbered sequentially (with no number skipped) in lower right hand corner.
 - e. Drawings that are "C" or "D" size shall be folded, with the title block visible and placed in reinforced clear plastic pockets.

- F. Exceptions to the Contract Specifications or Drawings shall be clearly defined by the Equipment Supplier.
1. Data shall contain sufficient details so a proper evaluation may be made by the Engineer. Contractor shall provide separate letter (located in the front of the submittal) detailing specific exceptions to the Contract Specifications or Drawings.
 2. Exceptions that are noted in the marked-up Drawings or Specifications, but not listed on the Exceptions/Clarifications letter, will be considered as non-responsive and not accepted as changes to the Contract Documents
- G. The Supplier shall coordinate submittals with the work so that project will not be delayed. This coordination shall include scheduling the different categories of submittals, so that one will not be delayed for lack of coordination with another.
- H. No material or equipment shall be allowed at the job site until the submittal for such items has been favorably reviewed by the Engineer and marked "No Exceptions Taken" or "Make Corrections Noted."
- I. The equipment specifications have prepared on the basis of the equipment first named in the Specifications. The Supplier shall note that the second named equipment, if given, is considered acceptable and equal equipment, but in some cases additional design, options, or modifications may be required, at no additional cost, to meet Specifications.
- J. The decision of the Engineer governs what is acceptable as a substitution. If the Engineer considers it necessary, tests to determine equality of the proposed substitution shall be made, at the Supplier's expense, by an unbiased laboratory satisfactory to the Engineer.
- K. Electrical submittals shall be complete giving all details of connections, wiring, instruments, enclosures, materials and dimensions. Standard sales literature will not be acceptable.
- L. Request for information (RFIs) shall not be included in submittals. RFI's shall be submitted separately in its individual submittal number.
- M. Resubmittals shall be provided with a copy of the previous submittal comments and a separate letter, on company letterhead, identifying how each submittal comment has been addressed in the resubmittal.

1.08 CHANGE ORDER PRICING

- A. All change order pricing by Contractor or System Supplier shall be broken out into the following minimum categories:
1. Labor per hour listed per discipline, i.e. Engineer, Drafter, Estimator, Programmer, Secretarial, etc.
 2. Materials and equipment itemized per component and quantity.
 3. Rentals, travel, per diem, etc.

4. Tax.
5. Shipping.
6. Overhead and profit.

B. Lump sum change order pricing is not acceptable.

C. If Contractor or System Supplier refuses to provide a change order with broken out pricing, the Engineer reserves the right to obtain independent estimates from other Contractors or System Suppliers. The Contractor or System Supplier who refused to provide the change order with broken out pricing will be charged for the preparation of the independent estimates.

PART 2 – PRODUCTS

2.01 QUALITY

- A. It is the intent of the Contract Specifications and Drawings to secure the highest quality in all materials and equipment in order to facilitate operation and maintenance of the facility. All equipment and materials shall be new and the products of reputable suppliers having adequate experience in the manufacture of these particular items. For uniformity, only one manufacturer will be accepted for each type of product.
- B. All equipment shall be designed for the service intended and shall be of rugged construction, of ample strength for all stresses which may occur during fabrication, transportation, erection, and continuous or intermittent operation. All equipment shall be adequately stayed and braced and anchored and shall be installed in a neat and workmanlike manner. Appearance and safety, as well as utility, shall be given consideration in the design of details. All components and devices installed shall be standard items of industrial grade, unless otherwise noted, and shall be of sturdy and durable construction suitable for long, trouble free service. Light duty, fragile and competitive grade devices of doubtful durability shall not be used.
- C. Products that are specified by manufacturer, trade name or catalog number established a standard of quality and do not prohibit the use of equal products of other manufacturers when a listing "or approved equal" is given provided they are favorably reviewed by the Engineer prior to installation.
- D. Underwriters Laboratories (UL) listing is required for all substituted equipment when such a listing is available for the first named equipment.
- E. When required by the Contract specifications or requested by the Engineer, the Contractor shall submit equipment or material samples for test or evaluation. The samples shall be furnished with information as to their source and prepared in such quantities and sizes as may be required for proper examination and tests, with all freight and charges prepaid. All samples shall be submitted before shipment of the equipment or material to the job site and in ample time to permit the making of proper tests, analyses, examinations, rejections, and resubmissions before incorporated into the work.
- F. All equipment shall be designed and constructed so that in the event of a power interruption, the equipment specified hereunder shall resume normal operation without manual resetting or operator interaction when power is restored.
- G. Signal transmission from remote or field electric and electronic devices shall be 4-20 mA, sourced by a 24 VDC loop supply from the panel that is to receive the signal. Nonstandard transmission methods such as impulse duration, pulse rate, and voltage regulated will not be permitted except where specifically noted.

- H. Outputs of equipment that are not of the standard signals as outlined, shall have the output immediately raised and/or converted to compatible standard signals for remote transmission.
- I. It is the System Supplier's responsibility to visit jobsite to collect and document existing conditions and equipment device part numbers in order for all similar called out new equipment to match existing.

2.02 NAMEPLATES & TAGS

A. Equipment exterior nameplates - Nameplate material shall be rigid laminated black phenolic with beveled edges and white lettering; except for caution, warning, and danger nameplates the color shall be red with white lettering. The size of the nameplate shall be as shown on the drawings. No letters are allowed smaller than 3/16". All phenolic nameplates located outdoors shall be UV resistant. Securely fasten nameplates in place using two stainless steel screws if the nameplate is not an integral part of the device. Epoxy cement or glued on nameplates will not be acceptable. Engrave the nameplates with the inscriptions as approved by the Engineer in the submittal.

1. For each major piece of electrical equipment provide a manufacturer's nameplate showing the Contract specified name and number designation, the manufacturer's name, model designation, part number, serial number, and pertinent ratings such as voltage, amperage, # of phases, range, U.L listing, etc.
2. For each device with a specific identity (pushbutton, indicator, instrument, etc.) mounted on the exterior or deadfront of a piece of equipment provide a nameplate with the inscription as shown in the Contract documents. Where no inscription is indicated in the Contract documents, furnish nameplates with an appropriate inscription providing the name and number of device.
3. For all receptacles and switches, provide a faceplate engraved or stamped with the panelboard and circuit number it is fed from. Also, include on faceplate or on a separate nameplate for each light switch identification use such as "OUTSIDE BUILDING LIGHTS," "PERIMETER LIGHTS," "MCC ROOM," etc.
4. All field instruments and devices shall be labeled with designation shown on P&ID diagrams.
5. All transformers and panelboards shall have nameplates with 1/2" high letters and be engraved with designations as shown on one-line Drawings.
6. All safety and disconnect switches shall have nameplates with 1/2" high letters and be engraved with designations as shown on one-line drawings.

B. Equipment Interior Nameplates

1. Nameplate material shall be clear plastic with black machine printed lettering as produced by a KROY or similar machine; except caution, warning, and danger nameplates shall have red lettering.
2. The size of the nameplate tape shall be no smaller than 2" in height with 3/8" lettering unless otherwise approved by the Engineer.

3. Securely fasten nameplates in place on a clean surface using the adhesion of the tape. Add additional clear glue to hold the nameplate securely in place when necessary. Nameplates shall not be attached to wireways or gutters.
4. For each device with a specific identity (relay, module, power supply, fuse, terminal block, etc.) mounted in the interior of a piece of equipment provide a nameplate with the inscription as shown in the Contract documents. Where no inscription is indicated in the Contract documents, furnish nameplates with an appropriate inscription providing the name and number of device used on the submittal drawings.
5. Stamp the nameplates with the inscriptions as approved by the Engineer in the submittal.

C. Equipment Tags

1. When there is no space or it is impractical to attach an engraved phenolic nameplate with screws, as is the case with most field devices and instruments, the Contractor shall attach a tag to the equipment with the same inscriptions as specified above in paragraph A.
2. The tag shall be made from stainless steel material and the size of the nameplate shall be no smaller than 3/8"h x 2"w with 3/16" machine printed or engraved lettering unless otherwise approved by the Engineer.
3. The tag shall be attached to the equipment with stainless steel wire of the type normally used for this purpose. SST wire shall be crimp connected. Twisting ends together is not acceptable.

D. Engrave or machine print the tags with inscriptions as approved by the Engineer in the nameplate submittal.

E. Provide temporary labels for all instruments and devices immediately when installed. Temporary labels shall be provided with 1/2" letters minimum and labeled with P&ID tag number.

2.03 COMPONENTS

A. FUSES

1. Fuses used in circuits 200 VAC and above shall be time- delay type FNQ or approved equal, 13/32" x 1-1/2", and have an interrupting rating of 10,000 AIC at 500 VAC. Fuse holders shall be of the barrier type and rated 600 VAC.
2. Fuses used in 120 VAC shall be time-delay type MDL or approved equal, 1/4" x 1-1/4", and have a rating of 250 VAC. Fuse-holders shall be of the terminal block type.
3. Fuses used in signal and 24 VDC circuits shall be fast acting type ABC or approved equal, 1/4" x 1-1/4", and have a rating of 250 VAC. Fuse-holders shall be of the terminal block type.
4. Fuses shall be sized in conformance with the NEC.

B. SWITCHES AND PUSHBUTTONS

1. Switches (HS) and pushbuttons (PB) for general purpose applications shall be water and oil tight as defined by NEMA 13, corrosion resistant as defined by NEMA ICS 6-110.58, U.L. listed, standard 30 mm diameter, with round plastic clamp ring. Switches shall be Allen-Bradley 800T, or approved equal.
2. Switches and pushbuttons shall have contacts rated 10 amperes continuous and 600 VAC.
3. Manufacturer's standard size legend plates shall be provided and engraved to specify each switch and pushbutton function. The legend plate color shall be black.
4. Selector switch handles and pushbutton caps shall be black.
5. Selector switches for hand-off-auto (HOA) applications shall have the hand position to the left, off in center, and auto in the right position.

C. RELAYS AND TIMERS

1. General: Relays and timers shall be provided with N.O. or N.C. contacts as shown on the Contract drawings. All spare contacts shown shall be provided. Contacts shall be rated 10 amps minimum at 120 VAC, 60 Hz unless otherwise stated. Supply power or coil voltage shall be 120 VAC unless shown otherwise on the Contract drawings. Relays and timers shall be designed for continuous duty. All relays shall be U.L. listed. The following is a summary of abbreviations associated with relays and timers:
 - CR - Control relay
 - TR - Timing relay
 - TDOE - Time delay on energization
 - TDOD - Time delay on de-energization
2. Control relays (CR) shall be plug-in type with indicating lights and clear see-through sealed or enclosed housing to exclude dust. Sockets for plug-in relays shall be standard industrial type octal 8 or 11 pin with barrier pressure screw terminals. Provide IDEC Type RR, Potter and Brumfield KU, or approved equal. Two form-C contacts (minimum) shall be provided on each relay.
3. Time delay relays (TR) shall be solid state plug-in relays with a timer adjustable over the range 1 second to 3 minutes unless other ranges are indicated or required. Provide LED timer energized indicator lamp. Sockets for plug-in timers shall be standard industrial type octal 8 or 11 pin with barriered pressure screw terminals. Time delay relays shall be IDEC RTE, SSAC TD, or approved equal.

D. INDICATING LIGHTS

1. Indicating Lights for general purpose applications shall be water and oil tight as defined by NEMA 13, corrosion resistant as defined by NEMA ICS 6-110.58, U.L. listed, High intensity multi-chip LEDs, full voltage (unless shown otherwise), standard 30 mm diameter, with round plastic lens and miniature bayonet lamp base. Indication lights shall be Allen-Bradley 800T or approved equal.

2. Manufacturer's standard size legend plates shall be provided and engraved to specify each light's function. The legend plate color shall be black.
3. Indicating lights designated "PTT" shall be provided with a push-to-test switch and wiring.
4. Indicating light type and color of lens shall be as shown on the Drawings or specified in the Contract documents. Lamp color will be as follows:
 - a. Open/On Green
 - b. Closed/Off Red
 - c. Alarm Amber
 - d. Power On White

E. CIRCUIT BREAKERS

1. Circuit breakers shall be of the indicating type, providing ON, OFF and TRIPPED positions of the operating handle. Circuit breakers shall be quick-make, quick-break, with a thermal-magnetic (TM) action, except when protecting motor feeders where motor circuit protector (MCP) breakers with adjustable magnetic trip shall be used. Circuit breakers shall be the bolted on type. The use of tandem or dual circuit breakers in a normal single-pole space to provide the number of poles or spaces specified are not acceptable. All multiple-pole circuit breakers shall be designed so that an overload on one pole automatically causes all poles to open. Circuit breakers and motor circuit protectors shall be manufactured by Eaton, G.E. or approved equal.
2. Each 480 volt or 240V circuit breaker shall have a minimum interrupting capacity of 42,000 amperes. Each 120 volt breaker shall be rated for a minimum 10,000 amperes interrupting capacity. Breakers shall be sized as shown on Drawings and as necessary for the supplied equipment.
3. Fused disconnects shall not be used in place of breakers.

F. TERMINAL BLOCKS

1. CONTROL PANEL TERMINAL BLOCKS
 - a. Terminal blocks to be clamp type, 6mm spacing, 600 volt, minimum rating of 30 amps, and mounted on DIN rail, Entrelec M4/6 colored. DIN rail shall be same type as used for the relays. Install an extra DIN rail on each type of terminal strip with 4 terminals for future additions.
 - b. Provide terminal blocks with "follower" plates which compress the wires and have wire guide tangs for ease of maintenance. Terminal blocks which compress the wires with direct screw compression are unacceptable. All power, control and instrument wires entering and leaving a compartment shall terminate on terminal blocks with wire numbers on terminals and on both ends of the wires.

- c. Terminal Tags and Markers: Each terminal strip shall have a unique identifying alphanumeric code at one end (i.e.: TB1, TB2, etc.) and plastic marking strip running the entire length with a unique number for each terminal. On each terminal strip, terminal numbers shall be assigned starting with #1 at one end, incrementing in alphanumerical order (i.e.: 1,2,3,4....). Numbers shall be assigned to all blocks except grounding blocks. Fuse blocks shall be assigned unique tag numbers such as FU1, FU2. No two fuses shall be assigned the same tag number.
- d. Plastic marking tabs shall be provided to label each terminal block. These marking tabs shall have a unique number/letter for each terminal which is identical to the "elementary" and "loop" diagram wire designation. Numbers on these marking strip shall be machine printed and 1/8 inch high minimum.
- e. Terminal blocks shall be physically separated into groups by the level of signal and voltage served. Power and control wiring above 100 volts shall have a separate group of terminal blocks from terminal blocks for wiring below 100 volts, intermixing of these two types of wiring on the same group of terminal blocks is not allowed.
- f. Provide a ground terminal or connection point for each grounding conductor.
- g. Provide a separate common or neutral terminal for every two (maximum) inputs and/or outputs.

G. MOTOR STARTERS:

- 1. Motor starters (M) shall be magnetically operated, electrically held, full voltage, non-reversing except as shown on the Drawings. NEMA sizes shall be as required for the horsepower of the supplied equipment. Contactors shall be UL rated and listed. Motor starters shall be Allen-Bradley Bulletin 509 or approved equal.
- 2. Each motor starter shall have a 120 volt operating coil rated for continuous operation.
- 3. Auxiliary contacts shall be provided as shown on the Drawings or as required. Each motor starter shall be furnished with a minimum of two spare auxiliary contacts in excess from those shown to be used. Auxiliary contacts shall be convertible, in the field, from normally open to normally closed, or vice versa.
- 4. Starters shall have adjustable overload relays. Adjustable overload relays shall be adjustable for trip point and for automatic or manual reset. Overload shall feature interchangeable heater packs adjustable +/- 24% to match motor full load amps. Each overload shall be ambient compensated with a visible trip indicator. Each overload shall have selectable class 10 or 20 trip time and be provided with built-in load lugs. Each overload relay shall have a built-in test trip pushbutton and an adjustable calibrated trip with indicating dial. Three-phase starters shall have 3 overload relays. Each overload relay shall have an isolated normally open auxiliary contact. Motor overloads shall be Allen-Bradley or approved equal.

H. CONTROL POWER TRANSFORMER

1. Control power transformer shall be provided with a time-delay, slow-blow secondary fuse rated to protect the transformer and interrupt 10,000 amperes at 120VAC. Two primary fuses with KAIC interrupt rating of corresponding power connection shall be provided. Transformer size minimum ratings shall be as shown on Contract E-Series drawings.

2.04 CONTROL PANEL

- A. Control Panel shall consist of the PLC system, operator interface, power supply, enclosure, radios and other devices for a complete and operational system.
 1. Micro Logic Controller (mLC) to be Allen-Bradley MicroLogix 1400 series, or approved equal provided with:
 - a. Processor 1766-L32AWAA with battery, built-in Ethernet port, 20 discrete inputs, 12 discrete relay outputs, 4 analog voltage inputs & 2 analog voltage outputs, and removable flash memory card loaded with PLC program at end of project as accepted.
 - b. Discrete Input cards: 8 channel 120 VAC discrete 120VAC input card 1762-IA8.
 - c. All wiring from the mLC I/O terminals shall be wired to interface terminal blocks, including all spares.
 2. Operator Interface:
 - a. Provide Operator Interface (OI) C-More Touchpanel system, or approved equal. OI to be panel mounted through cutout in Control Panel door. Provide all cables necessary for a complete and operable system.
 - b. Provide an operator interface that meets the following requirements:
 - 1) Touch screen operator interface with Ethernet Communication Port.
 - 2) Trending.
 - 3) Operator interface with 6" TFT color liquid crystal display with replaceable backlight and 320 x 240 touch area on the display.
 - 4) Operator terminal capable of setup using standard PC.
 - 5) Full programming software to be delivered to Owner.
 3. Devices:
 - a. Lights, switches, pushbuttons, terminal blocks etc. to match those specified under Devices subsection.
 - b. Connection between Ethernet Port and Ethernet hub shall be made with Cat 5 patch cable. Patch cable shall be 4 pair stranded PVC cable with HI-FLEX conductors. Length shall be 5 feet minimum. Color of cable shall be red.
 - c. Ethernet hub shall be N-Tron 900 Series compatible with Allen-Bradley Ethernet communications, or approved equal.
 - d. Receptacle to be duplex and rated 20 amps, 120 VAC, 2 pole, 3 wire grounding, NEMA 5-20R configuration, specification grade, and side wired to screw terminals.
 - e. DC power supply to be non-switching, VDC quantity and sizes per Contract drawings, Power One Linear series, Sola, or approved equal.

- f. RFI filter for radio interference protection shall be Corcom 15VK, or approved equal.
- g. Uninterruptible Power Supply:
 - 1) The Uninterruptible Power Supply (UPS) to provide VA shown on Contract drawings (minimum) backup power upon power failure to the 24 VDC power supply, Operator Interface (OI), 120VAC powered instruments & displays, radio, and the micro logic controller (mLC) and mLC I/O cards in the Control Panel for 2 hours (minimum).
 - 2) The UPS to have status "UPS ON BATTERY" and "UPS TROUBLE LOW BATTERY/FAIL" dry contacts for monitoring by mLC. Install relays in order to switch 120VAC control circuits.
 - 3) UPS to have temperature rating compatible with expected internal enclosure temperature. Provide enclosure with adequate ventilation fans or AC unit to keep enclosure internal temperature within UPS temperature rating.
 - 4) UPS to be an American Power Conversion Smart-UPS with SmartSlot Relay I/O module, battery connection cables and 24V battery packs, to match Owner's standard.
- h. Analog 4-20 mA signals on wiring to all field instruments shall have surge protection terminals installed at panel originating loop power. Surge protection terminal blocks shall be fused and limit maximum working voltage to 32 VDC and rated for 50 mA.
- i. Data wiring between mLC devices shall be protected on both ends by fused terminal surge protectors rated for use with data signal
- j. Isolator shall provide complete isolation of the 4-20 mA output signal from the input signal and isolator power supply. Each isolator shall have all solid state circuitry mounted in a plug-in module. The 4-20 mA output signal shall be capable of driving a 600 ohm load. Both accuracy and linearity shall be +/- 0.10% of span. The isolator shall be powered as shown on Contract Drawings. Each isolator shall have a seven year warranty. The isolators shall be as manufactured by AGM Electronics, Action Instruments, or approved equal.

B. PLC ladder logic applications program shall meet the intent of the P&IDs on I - Series Contract Drawings. The following additional program functions shall be provided (minimum):

- 1. Run times and number of pump starts for each pump operation.
Reset/Non-resettable, daily, previous 24 hours and today's.
- 2. Pump Operation:
 - a. Decant Pump Station:

- 1) Only one pump at a time will run when pumps are in auto.
- 2) Operator will select the Effluent Storage tank that the decant pump will fill. The Operator will manually adjust the valves.
- 3) Pump will start only when the "Auto Initiate" pushbutton for that pump has been pressed.
- 4) Pumps shall stop on level setpoints or low section flow. Each condition shall have a time delay before stopping the pump. Provide separate stop setpoints for each tank.
- b. Transfer / Spray Field Pump Station:
 - 1) Only one pump at a time will run when pumps are in auto.
 - 2) Operator will select pump operator – "Transfer" between tanks or "Spray Field" from the Control Panel selector switch. The Operator will manually adjust the valves.
 - 3) Pump will start only when the "Auto Initiate" pushbutton for that pump has been pressed.
 - 4) Transfer - Pumps shall stop on high target level setpoints or low source level setpoints. Each condition shall have a time delay before stopping the pump. Provide separate stop setpoints for each tank.
 - 5) Spray Field - Pumps shall stop on low level setpoints. Each tank shall have a time delay before stopping the pump. Provide separate stop setpoints for each tank.
3. Scaling to engineering values of all variables:
 - a. Level in 1/100s foot resolution.
4. High and low level alarms for all analog inputs.
5. Transducer fail alarms.
6. All setpoints and registers shall be adjustable.
 - a. Alarms:
 - 1) PLC-Fail
 - 2) High/Low Analog Values
 - 3) Pump Fail
 - 4) UPS Trouble
 - 5) UPS On
 - 6) High/Low Analog Level.
 - b. Trending:
 - 1) Tank Level, FT
- C. The Contractor shall include in his bid price an additional 40 hours of PLC/OI program and SCADA Operator Interface graphic changes to be designated during testing and start-up. Programming changes made during factory testing shall not be deducted from these hours unless agreed upon by Engineer. Field program changes shall be made by original programmer within two (2) working days after notification in writing by Engineer. Failure of programmer to respond and make requested program changes within these two (2) working days will result in Owner hiring another programmer and backcharging the Contractor \$150.00 for each hour of the other programmer's time, plus travel expenses. All programming configuration changes shall be performed by the original programmer and shall be made as directed by the Engineer in writing. A weekly report shall be prepared by System Supplier listing extra hours utilized, dates when work was done, description of work performed, and remaining number of extra hours. None of the hours shall be

used for documentation, paperwork, travel, overhead, construction management, etc. that are not related to programming changes, since this is included in the hourly rate, without written approval from Engineer. All hours used shall be allocated for additional PLC program changes, as directed by Owner, during the one-year warranty period.

- D. No passwords shall be enabled on PLC/OI/SCADA software or hardware developed for this project. All electronic disk copies provided to Owner shall not have any password protection enable on them or the software. Software submitted with password protection will be removed by Owner and the Contractor will be backcharged for the cost thereof.

2.05 ELECTRICAL ENCLOSURES AND BOXES

- A. Enclosures and boxes to be wall mounted, minimum 14 gauge, type 316 stainless steel with seams continuously welded & ground smooth, and fast access door latches. Outer door shall have provisions for locking enclosure with standard padlock. Provide white backpan in box. Provide accessories consisting of breaker to disconnect incoming power, heater, fan, louvers, and thermostats. Enclosure shall be Hoffman, Circle AW or approved equal.

2.06 FIELD DEVICES

- A. The temperature-type flow switch shall be based on thermal dispersion principle. Flow switch shall be stainless steel with 1"MNPT process connection. The flow switch shall be sized per the piping per manufacturer's recommendation. Provide remote electronics and sufficient manufacturer cable from flow element to remote electronics. The flow switch shall be DPDT 3 amp resistive. The flow switch shall be Ameritrol FX series or approved equal.

2.07 LIGHTING FIXTURES AND LAMPS

- A. Install lighting fixtures with lamps, frames, lenses, hangers, supports, etc., complete. Install lighting fixtures as shown on Contract E-Series drawings.
- B. Accessories such as straps, mounting plates, nipples or brackets shall be provide for proper installation.
- C. All unused opening on fixtures shall be plugged.
- D. Replace any burned out lamps or failed ballasts prior to close out of project.

2.08 WIRE

- A. This section applies to all wires or conductors used internal (non-field) for all electrical equipment or external for field wiring. Wire quantity and size shall be per "Conduit & Wire Routing Schedule."

- B. Material - Wire shall be new, plainly marked with UL label, gauge, voltage, type of insulation, and manufacturer's name. All wire shall conform to the following:
1. Conductors shall be copper, with a minimum of 98% conductivity.
 2. Wire shall be Class B stranded.
 3. Insulation of all conductors and cables shall be rated 600 volt.
 4. Insulation type for conductors smaller than #6 AWG shall be moisture and heat resistant thermoplastic NEC Type THHN/THWN, rated 90 °C in dry locations and 75 °C in wet locations, or approved equal. Conductors #6 AWG and larger shall be XHHW insulation rated 90 °C in dry locations and 75 °C in wet locations.
 5. Field wire minimum AWG sizes:
 - a. #12 for wires used for individual conductor circuits 100 volt and above, except for Control Wire which may be #14AWG when listed in the Conduit and Wire Routing Schedule.
 - b. #14 for wires used for individual conductor circuits below 100 volt.
 6. Nonfield or equipment wire minimum AWG sizes:
 - a. #16 for wires used for individual conductor circuits 100 volt and above.
 - b. #18 for wires used for individual conductor circuits below 100 volt.
 7. Instrument wiring:
 - a. Field: Instrument cables shall have 600V tray/UV rated cable rated insulation and 100% individual shielded twisted pair #16 AWG conductors with drain wire.
 - b. Non-Field (inside enclosures): Instrument cables shall have 600V rated insulation and 100% individual shielded twisted pair #18 AWG conductors with drain wire.
 - c. Single twisted shielded pair (T.S.P.R.) cables shall be Belden or approved equal.
 8. Special purpose wiring:
 - a. Manufacturer Supplied Cables (MNFR CBL): Cables and wiring for special systems shall be provided by the manufacturer with the equipment and installed per the manufacturer's recommendations.
 - b. CAT 5 Cable:
 - 1) CAT 5 communication cable in underground (UG) conduit shall meet the following requirements:
 - 2) TIA/EIA-568-A Category 5E Specifications.
 - a) #24 AWG solid bare copper conductor, 4 or 25 pair shielded twisted pair per "Conduit & Wire Routing Schedule."
 - b) Rated for direct burial application.
 - c) Insulation: Solid Polyolefin.
 - d) Filling compound: 80°C extended thermoplastic rubber.
 - e) Outer Jacket: Black, water and UV resistant polyethylene.
 - f) Electrically continuous aluminum shield.
 - g) Communication cable shall be Superior Essex OSP Broadband Category 5E Outside Plant Cable or approved equal.
 - 3) Indoor CAT 5 communication cable meet the following requirements:
 - a) TIA/EIA-568-A Category 5E specifications.
 - b) #24 AWG solid bare copper conductor, 4 twisted pairs.
 - c) Thermoplastic Dielectric type.
 - d) Shielded bulk cable.

- e) PVC jacket.
- f) UL listed.
- g) Non-plenum usage rated when routed in conduit.
- h) Plenum usage rated when routed in plenum spaces.

C. Color code - color code of all wire shall conform with the following table.

WIRES COLOR CODE TABLE

DESCRIPTION	PHASE/CODE LETTER	FIELD WIRE WIRE OR TAPE COLOR	NON-FIELD WIRE COLOR
480 V, 3 PHASE	A	BROWN	BROWN
	B	ORANGE	ORANGE
	C	YELLOW	YELLOW
240 V or 208 V, 3P	A	BLACK	-
	B	RED (ORANGE if high leg)	-
	C	BLUE	-
240 / 120 V, 1 P	L1	BLACK	BLACK
	L2	RED	-
24V POSITIVE	24P	PINK	PINK
24V NEGATIVE	24N	BLACK/WHITE STRIPE	BLACK/WHITE STRIPE
AC CONTROL (Not Neutral)		VIOLET	RED (YELLOW FOR FOREIGN CIRCUITS)
DC CONTROL		BLUE	BLUE
NEUTRAL	N	WHITE	WHITE
GROUND	G	GREEN	GREEN
SHIELDED PAIR	+	BLACK	BLACK
	-	WHITE/CLEAR	WHITE/CLEAR

1. High leg of open delta shall be colored orange per NEC 215-8.
2. All wires #8 and below shall have wire insulation the color specified. Wires #6 and larger may be black with color tape.
3. No other colors shall be used without prior approval of the Owner.
4. The same color shall be connected to the same phase throughout the panel.
5. All wires shall be properly fused or protected by a breaker at the amperage rating allowed by the NEC.
6. Neutral wires used for AC Control shall be White per NEC.

- D. Wire identification - all wires, field and interior (non-field) to equipment, shall be identified with machine permanent ink printed sleeve markers. Hand lettered wire labels are not acceptable and shall be replaced at the Contractor's expense. All wires that are electrically the same (connected to common termination points) and do not pass through a contact or other switching device shall have the same wire identification. The wire labeling code for each end of the same wire shall be identical. Tubing shall be sized for the wire and shrunk into place with the properly sized heat gun. The wire identification code for field and panel wiring shall be the number/letter designated on the approved "elementary," "loop" and "interconnection" diagrams.

2.09 CONDUIT, RACEWAYS, AND WIREWAYS

- A. GENERAL - Conduit, raceways, and wireways, wiring methods, materials, installation shall meet all requirements of the NEC, be UL labeled for the application, and meet the minimum following specifications.
1. All wiring shall be installed in conduits, raceways, or wireways when interconnecting equipment and devices.
 2. The Contractor shall use special conduit, raceways, wireways, construction methods, and materials as shown on the Contract drawings; which shall take precedence over any general methods and materials specified in this section.
 3. The minimum size conduit shall be 3/4-inch unless indicated otherwise on the Drawings or for special connections to equipment.
 4. Conduit stubs shall be capped with coupling, nipple, & cap and each end identified with conduit labels.
 5. CONDUIT MARKING
 - a. All conduits listed in the "Conduit and Wire Routing Schedule" shall have conduit tags at both terminations of each conduit.
 - b. Tag material shall be rigid laminated red phenolic with white lettering. The size of the tag shall be 2" diameter. No letters are allowed smaller than 7/16". Tags shall be heat and UV resistant, stainproof, electrically non-conductive and non corroding. Securely fasten tags in place using UV resistant, black plastic tie-wraps. Engrave the tags, on both sides, with the conduit number as listed in the Conduit and Wire Routing Schedule on the Contract "E" Series Drawings. Labeling shall be neatly installed for visibility and shall be clearly legible. Conduit tags shall be Brady Custom B-1 or approved equal.
- B. GALVANIZED RIGID STEEL CONDUIT – (GRS)
1. Standard weight, zinc coated on outside by hot-dipping or sherardizing process. Fabrication shall be hot-dip galvanized after fabrication, conforming to NEMA RN1.
 2. Provide galvanized rigid steel factory ells for 90 degree transitions.
 3. Fittings and couplings shall be hot dipped galvanized steel or galvanized cast ferrous metal. Provide threaded-type fittings, couplings, and connectors; set-screw type and compression-type are not acceptable.

4. All joints shall be treated with T & B type CP "Kopr-Shield," LPS No. 3 rust inhibitor, or approved equal.
5. All junction and metal pull boxes shall be galvanized.
6. Metal conduits entering enclosures shall be fitted with insulated grounding bushing; O-Z "HBLG," Appleton "GIB," or approved equal. All grounding bushings shall be tied to the grounding system with properly sized bonding conductors per the NEC code.

C. GALVANIZED RIGID STEEL CONDUIT - PVC COATED (GRS-PVC)

1. Standard weight, galvanized conduit with a 40-mil thick polyvinylchloride coating bonded to both the outside and urethane interior coating. Conduit shall be hot-dip galvanized conforming to NEMA RN 1. GRS-PVC conduit to be Robroy Plasti-bond Red or approved equal.
2. Provide PVC coated galvanized rigid steel factory ells for 90 degree transitions.
3. Fittings shall be hot dipped galvanized steel or galvanized cast ferrous metal with a PVC 40 mils thick coating. Provide threaded-type fittings, couplings, and connectors; set-screw type and compression-type are not acceptable.
4. All junction and metal pull boxes shall be galvanized with exterior surfaces PVC coated to 40 mils thickness.
5. Conduits entering enclosures shall be fitted with insulated grounding bushing; O-Z "HBLG," Appleton "GIB," or approved equal. All grounding bushings shall be tied to the grounding system with properly sized bonding conductors per the NEC code.
6. GRS-PVC conduits shall be used for underground conduits where listed in the "Conduit and Wire Routing Schedule."
7. GRS conduit is allowed only when specifically called out in the "Conduit and Wire Routing Schedule."

D. PVC CONDUIT, SCHEDULE 40 or 80 (PVC)

1. Shall be high impact schedule 40 or 80 polyvinylchloride suitable for use underground, direct burial and for use with 90 C wires, and shall conform to UL 651. Shall be UL listed and labeled for "direct" burial.
2. A copper bonding conductor shall be pulled in each raceway and bonded to equipment at each end with approved lugs.
3. Each underground run shall be placed in a trench with a five (5) inch sand bed evenly compacted on all sides, top and bottom.
4. Bends, elbows, and risers shall be made with PVC coated galvanized rigid steel (GRS-PVC) conduit using threaded adapters. Bond each metallic portion to each other and to equipment connected at each end of conduit run.
5. PVC fittings shall have solvent-weld-type conduit connections.
6. PVC conduit shall be stored on a flat surface and shielded from the sun.

E. LIQUID TIGHT FLEXIBLE METAL CONDUIT - (FLEX)

1. All flex conduits shall be metallic with water tight outer jackets.

2. Connectors:
 - a. NEMA 1 or 12: Metallic with insulated bushings.
 - b. Non-NEMA 1 or 12 Areas: PVC coated metallic with insulated bushings.
3. Final connections to vibrating equipment such as heaters and fans shall be made with flexible conduits.
4. Flexible conduit lengths shall not be greater than 36 inches.
5. Flexible metallic conduit shall not be considered as a ground conductor, install a separate wire for equipment bonding.
6. Flexible conduit shall only be installed in exposed or accessible locations.
7. Flex conduits shall be used for conduit coupling to all vibrating and shifting equipment.

2.10 DEVICES

A. BOXES

1. Concealed device boxes shall be of zinc-galvanized steel type with shape and size best suited for the particular application, rated for the location installed, and shall be supported directly to structure by means of screws, anchors, or bolts.
2. Exposed boxes located in outdoor or in moist locations shall be weatherproof (WP) PVC coated cast type with threaded hubs. Indoor exposed boxes not in moist locations can be non-coated cast type.
3. Box dimensions shall be in accordance with size, quantity of conductors, and conduit clearances per NEC articles 370 requirements.

B. SWITCHES

1. General purpose switches shall be manufactured in accordance with UL 20. Switches shall be one pole rated, 20 amps, at 277 VAC. Bodies shall be of ivory phenolic compound supported by mounting strap having plaster ears. Switches shall have copper alloy contact arm with silver cadmium oxide contacts. Switches shall have slotted terminal screws and a separate green grounding screw. Furnish Hubbell 1221, Leviton 1221, or approved equal.

C. RECEPTACLES

1. General purpose receptacles shall be duplex and rated 20 amps, 120 VAC, 2 pole, 3 wire grounding, NEMA 5-20R configuration, specification grade, and side wired to screw terminals. Face color shall be white or ivory. General purpose receptacles shall be Leviton 5362, Bryant, Hubbell, or approved equal.
2. GFI (ground fault circuit interrupting) receptacles shall be used in all boxes shown as weatherproof. GFI receptacles shall be duplex, 20A, 120V, with "test" and "reset" buttons with shallow design for mounting and standard screw terminals for direct wiring. Receptacles shall be designed, manufactured, and tested to prevent nuisance tripping from voltage spikes, RFI, EMI, or electronic component failures. Chaining multiple receptacles from one GFI unit is not acceptable. GFI receptacles shall be Leviton 6899, Arrow-Hart or approved equal.

D. DEVICE PLATES and COVERS

1. General purpose device plates and covers shall be stainless steel. Plates or covers shall be attached with stainless steel screws. Circuit breaker number and panelboard name shall be stamped on each cover.
2. PVC coated device boxes shall have PVC coated gasketed covers.
3. Weatherproof switch, outlet, and receptacle boxes shall be fitted with gasketed covers rated for wet locations in accordance with NEC 410-57.
4. Access cover for weatherproof receptacles shall have a cover to maintain the weatherproof integrity even when a plug is connected to the receptacle. Final decision of type of access cover for specific location shall be per ENGINEER. Screws and hinge springs shall be stainless steel. Weatherproof access covers shall be Hubbell, TayMac, Crouse-Hinds, or approved equal.
5. Receptacle and light switch plates shall be stamped or engraved as specified herein.

2.11 PANELBOARD TRANSFORMER

- A. The panelboard transformer shall be ventilated dry type. Voltage, phase and KVA ratings shall be as shown on the Contract One-line drawing. The transformer shall be as manufactured by G.E. Type QL, Westinghouse, Jefferson, or approved equal.
- B. The transformer shall have 115°C rise, insulation 220°C rise class H insulation system.
- C. Vibration isolators shall be installed between the transformer and its mounting surface to reduce case vibration and compensate for slight unevenness of the mount. They shall be sized for the appropriate loading at twice the fundamental frequency. The Transformer housing shall be securely fastened to the mounting surface to eliminate possible sound generation.
- D. The transformer shall be finished with two coats of heavy enamel to resist rust and corrosion.
- E. Transformers that require neutral grounding shall be grounded in accordance with Article 250-26 N.E.C. and any applicable local ordinances. Protection of the grounding attachments shall be per N.E.C. 250-117.

2.12 GROUNDING SYSTEM

- A. The panel ground bus shall be tied to a #2/0 Uffer ground grid supplemented by a ground rod. Bond grid to metal water pipe and building metal support frames when available.
- B. The main ground bonding wire from the UFFER shall extend up into the panel for the visible connection with a UL approved "ground clamp" attached to the ground bus. The main ground bonding wires shall be a bare copper as shown on Contract Drawings.

- C. Install #1/0 (minimum) bare copper ground bond wires to the various locations shown on the drawings.
- D. Ground clamps shall be bolt-on type as manufactured by ILSCO type AGC, O-Z Gedney type GRC, or approved equal.
- E. Grounding conductors shall be sized as shown on the Plans or in accordance with NEC table 250-95, whichever is larger.
- F. Grounding and bonding wires shall be installed in all conduits and raceways and connected to the grounding termination point in all equipment.
- G. The ground rod shall consist of not less than 10 continuous feet of 3/4 inch copper coated electroplated high grade carbon steel. The ground rod shall be a NEHRING type NCC, Weater 348 or approved equal.
- H. Each ground bus shall be copper. Screw type fasteners shall be provided on all ground busses for connection of grounding conductors. Ground bus shall be a Challenger GB series, ILSCO CAN series or approved equal.
- I. The system neutral conductor and all equipment and devices required to be grounded by the National Electrical Code shall be grounded in a manner that satisfies the requirements of the National Code.
- J. The system neutral (grounded conductor) shall be connected to the system's grounding conductor at only a single point in the system. This connection shall be made by a removable bonding jumper sized in accordance with the applicable provisions of the National Electrical Code if the size is not shown on the Drawings. The grounding of the system neutral shall be in the enclosure that houses the service entrance main overcurrent protection.
- K. One side of the secondary on all transformers and DC power supplies shall be grounded to the ground bus.
- L. All raceway systems, supports, enclosures, panels, motor frames, and equipment housings shall be permanently and effectively grounded.
- M. All receptacles shall have their grounding contact connected to a grounding conductor.
- N. Branch circuit grounding conductors for receptacles, or other electrical loads shall be arranged such that the removal of a lighting fixture, receptacle, or other load does not interrupt the ground continuity to any other part of the circuit.
- O. Attachment of the grounding conductor to equipment or enclosures shall be by connectors specifically provided for grounding. Mounting, support, or bracing bolts shall not be used as an attachment point for ground conductors.

PART 3 – EXECUTION

3.01 WORKMANSHIP

- A. All work in this Section shall conform to the codes and standards outlined herein.
- B. The Contractor shall employ personnel that are skilled and experienced in the installation and connection of all elements, equipment, devices, instruments, accessories, and assemblies. All installation labor shall be performed by qualified personnel who have had experience on similar projects. Provide first class workmanship for all installations.
- C. Ensure that all equipment and materials fit properly in their installations.
- D. Perform any required work to correct improper installations at no additional expense to the Owner.
- E. The Engineer reserves the right to halt any work that is found to be substandard or being installed by unqualified personnel.

3.02 CONSTRUCTION METHODS, GENERAL

- A. All field wires and panel wires shall have wire markers as specified in the "WIRE" subsection.
- B. No wires shall be spliced without prior approval by the Engineer.
- C. Where splices are allowed or approved by the Engineer they shall conform with the following:
 - 1. Wire splicing devices shall be sized according to manufacturer's recommendations.
 - 2. Splices of #10 and smaller, including fixture taps, shall be made with see-thru nylon self-insulated twist on wire joints; T & B "Piggys," Ideal "Wing-Nut" or approved equal.
 - 3. Splices of #8 and larger shall be hex key screw two way connectors, with built in lock washers; T & B "Locktite," O-Z type XW or approved equal, insulated with 3M Scotch Super #88, Plymouth or approved equal.
 - 4. Splices in underground pullboxes and exterior connection boxes shall be insulated and moisture sealed with 3M "Scotchlok" cast resin splice kits. Do not use splice kits with a date marking for shelf life that has expired.

3.03 ELECTRICAL EQUIPMENT FABRICATION

- A. Electrical Equipment cutouts for devices (i.e. indicating lights, switches) shall be cut, punched, or drilled and smoothly finished with rounded edges. Exposed metal from cutouts that are made after the final paint finish has been applied shall be touched up with a matching paint prior to installing device. Do not paint nameplates, labels, tags, switches, receptacles, conductors, etc.

- B. All MCC doors shall be fully gasketed with nonshrinkable, water and flame resistant material.
- C. Bolts and screws for mounting devices on doors shall be as specified by the manufacturer, otherwise they shall have a flush head which blends into the device or door surface. No bolt or screw holding nuts shall be used on the external surface of the door.
- D. Each component within the MCC shall be securely mounted on an interior cubicle or backpan and arranged for easy servicing, such that all adjustments and component removal can be accomplished without removing or disturbing other components. Mounting bolts and screws shall be front located for easy access and removal without special tools. Access behind the sub panel or backpan shall not be required for removing any component.
- E. A ground bus shall be provided in each bussed MCC section. It shall have provisions for connecting a minimum of ten grounding conductors. Screw type lugs shall be provided for connection of grounding conductors. All grounding conductors shall be sized as shown on plans or in accordance with NEC Table 250-95, whichever is larger.
- F. Minimum wire bending space at terminals and minimum width of wiring gutters shall comply with NEC tables 373-6 (a) & (b).
- G. Future device and component mounting space shall be provided on the door, backpan, and subpanel where detailed on the Drawings. Where no detail is shown, provide a minimum of 15 percent usable future space. Also, add extra DIN rail to allow adding relays & terminal blocks in the future as called out on Contract drawings.
- H. Doors shall swing freely a minimum of 90° and close with proper alignment.
- I. HARNESS: Where space is available, all wiring shall be run in slotted plastic wire ways or channels with dust covers. If space is not available for wireways, then all wiring shall be neatly bundled and laced with plastic tie-wraps, anchored in place by screw attached retainer. Wire ways or channels shall be sized such that the wire fill does not exceed 60%. Tie-wraps shall be T&B TY-RAP or approved equal.
- J. HINGE LOOPS: Where wiring crosses hinged surfaces, provide a "U" shaped hinge loop protected by clear nylon spiral wrap. The hinge loop shall be of sufficient length to permit opening and closing the door without stressing any of the terminations or connections. Spiral wrap shall be Graybar T25N or approved equal.
- K. RETAINERS: Wire ways, retainers, and other devices shall be screw mounted with round-head 316 stainless steel screws or mechanically mounted by push-in or snap-in attachments. Glue or sticky back attachment of any type or style shall not be used. Retainers shall be T&B TC series or approved equal.

- L. ROUTING: Wires shall be routed in slotted plastic wire-ways with snap covers. Wires carrying 120 VAC shall be separated as much as possible from other low voltage wires and signal cables, and shall be routed only in ducts for 120 VAC. If the power wiring has to cross the signal wiring, the crossing shall be as close to a right angle as possible. Ducts for 24 VDC wiring shall be used for all other wires and cables. Routing of 120 VAC in combined ducts is not allowed without prior written approval of the Owner. Wires and cable shall be routed along the shortest route between termination points, excepting routes which would result in routing 120 VAC and other wires and cables in the same duct. Wires and cables shall have sufficient length to allow slack and to avoid any strain or tension in the wire or cable. Wires and cables shall be placed in the ducts in a straight, neat and organized fashion and shall not be kinked, tangled or twisted together. Additional wire ducting shall be provided for use by the electrical subcontractor for routing field wires to their landing points in the each electrical and instrumentation panel.
- M. Wiring not routed in duct work shall be neatly bundled, treed, and laced with plastic ties. Wiring across door hinges shall be carefully made up and supported to avoid straining and chafing of the conductors or from putting any strain on their terminals.
- N. TERMINATIONS: Single wire and cable conductors shall be terminated according to the requirements of the terminal device. All terminations must be made at terminals or terminal blocks. Use of spring or buttsplice connectors is not allowed.
1. Provide 3" minimum separation between wireway and terminal blocks. Installation of wireways too close to terminal blocks will be required to be completely reworked to the satisfaction of the Owner.
 2. For captive screw pressure plate type terminals, the insulation shall be removed from the last 0.25 inches of the conductor. The conductors shall be inserted under the pressure plate to full length of the bare portion of the conductor and the pressure plate tightened without excess force. No more than two conductors shall be installed in a single terminal. All strands of the conductor shall be captured under the pressure plate.
 3. For screw terminals, appropriately sized locking forked spade lugs shall be used. Lugs shall be crimp on type that form gas tight connections. All crimping shall be done using a calibrated crimping tool made specifically for the lug type and size being crimped.
 4. On shielded cables, the drain wire shall be covered with insulating tubing along its full bare length between the cable jacket and the terminal lug or terminal pressure plate.
 5. For screwless terminals, wire shall be stripped back and inserted per the manufacturer's instructions. When stripping insulation from conductors, do not score or otherwise damage conductor.
 6. Heat shrink shall be placed on ends of shielded cable to cover foil.
 7. Additional condulets with terminal blocks shall be supplied for wire termination to devices with leads instead of terminals. (i.e. solenoid valves, level probe, etc.)
- O. All devices and wiring shall be permanently labeled.

- P. All components associated with a particular compartment's or enclosure's function shall be mounted in that compartment or enclosure.
- Q. Spacing and clearance of components shall be in accordance with UL, JIC, and NEC standards.

3.04 DAMAGED PRODUCTS

- A. Damage products will not be accepted. All damaged products shall be replaced with new products at no additional cost to the Owner.

3.05 FASTENERS & LUGS

- A. Fasteners for securing equipment to walls, floors, and the like shall be stainless steel.
- B. Stainless steel anchor bolts, ½" minimum size, shall be installed for the Electrical Equipment in the front and back of each section at locations recommended by Electrical Equipment manufacturer.
- C. All wire & cable lugs shall be copper; aluminum or aluminum alloy lugs shall not be used. The Electrical Contractor shall supply all lugs to match the quantity & size of wire listed in the conduit & wire routing schedule.

3.06 INSTALLATION, GENERAL

- A. Install all products per manufacturer's recommendations and the Drawings.
 - 1. Contract Drawings are intended to show the basic functional requirements of the electrical and instrumentation system and do not relieve the Contractor from the responsibility to provide a complete and functioning system.
 - 2. Provide all necessary hardware, conduit, wiring, fittings, and devices to connect the electrical equipment provided under other Sections. The following shall be done by the Contractor at no additional cost to the Owner:
 - a. Provide additional devices, wiring, conduits, relays, signal converters, isolators to complete interfaces of the electrical and instrumentation system.
 - b. Changing normally open contacts to normally closed contacts or visa versa.
 - c. Adding additional relays to provide more contacts as necessary.
 - 3. All programmable devices shall be programmed, set-up and tested by the Contractor prior to startup. This includes all instruments, PLC, OI, UPS and radio. Programming and set-up parameters shall be adjusted or changed as directed by the Owner or Engineer during start-up and throughout the warranty period, at no additional cost to the Owner. Record of all programming parameters setup for this project shall be recorded by Contractor and included in the final O&M manuals.
 - 4. Coordinate with the Owner and setup all alarm, process, and operation setpoints.

B. PANELS AND ENCLOSURES

1. Install panels and enclosures at the location shown on the Plans or approved by the Engineer.
2. Install level and plumb.
3. Seal all enclosure openings to prevent entrance of insects and rodents.
4. All conduits entering outdoor panels and enclosures shall use watertight hubs. These hubs shall be located on sides or bottom only. Top entry of outdoor panels or enclosures is not allowed unless specifically shown on plans.
5. Clearance about electrical equipment shall meet the minimum requirements of NEC 110-26.

C. CONDUITS

1. Install conduit free from dents and bruises.
2. All conduits shall be labeled on all ends; at junction boxes, pull boxes, enclosures, stub-outs, or other terminations.
3. All conduit entering or leaving a Electrical Equipment shall be stubbed up into the bottom horizontal wireway directly below the vertical section in which the conductors are to be terminated.
4. A maximum of three equivalent 90 degree elbows are allowed in any continuous runs. Install pull boxes where required to limit bends in conduit runs to not more than 270 degrees or where pulling tension would exceed the maximum allowable for the cable.
5. Route all above grade conduits parallel or perpendicular to structure lines and/or piping. Conduits installed above grade shall be braced in place with stanchions. Expansion joints shall be installed every 100 feet.
6. In pullboxes and vaults separate power "L, & P" wiring to one side within and all other wiring "A, C, D & V" wiring to opposite side in bundles. In vault, these separate bundles are to be supported on plastic cable supports rated for the bundle loading.
7. Verify pullboxes are sized appropriately for conduit entry per Conduit and Wire Routing Schedule.

D. Wiring, grounding, and shielding: It is important to observe good grounding and shielding practices in the generally noisy environment in this application. The shield of shielded cables shall be terminated to ground at one end only, and covered with insulated heat shrink tubing. The shield at the other end shall be encased in an insulated material to isolate it from ground.

E. Provide the excavation for utility service, equipment foundations, and trenches for conduits or buried cables as necessary. Repave any area that was paved prior to excavation. Backfill and surface all areas as shown on the Drawings or where not shown to the original condition that was present prior to the excavation.

- F. Conduit entrances: Seal each conduit entrance from below grade into the panel and other electrical enclosures with plugging compound sealant to prevent the entrance of insects and rodents. Conduits between the enclosures shall be sealed with plugging compound sealant on each end. Plugging compound sealant shall be Courtaulds Aerospace (609 456-5700) Semco PR-868 or approved equal.

G. SEALS

1. Seal around all conduits, wires, and cables penetrating between walls, ceilings, and floors in all buildings with a fire stop material. Seal shall be made at both ends of the conduit with a fire stop putty. Seal shall have a minimum two hour rating. Fire stop sealing shall be International Protective Coatings Flamesafe, or approved equal.
2. Seal around conduits entering outside to inside structures and around bottom of free standing enclosures to maintain watertight integrity of structure.
3. Place conduit seal inside each underground conduit riser into panels and enclosures to prevent entrance of insects and rodents.

H. HOUSEKEEPING PADS

1. Concrete housekeeping pads are required for all free standing electrical equipment. Housekeeping pads shall be 3-1/2" inches above surrounding finished floor or grade unless otherwise shown and shall be 4 inches (minimum) larger in width on all sides of equipment. The depth of housekeeping pads shall be 18 inches (minimum).
2. Housekeeping pads shall be installed for future units as shown on the Contract Drawings.
3. Housekeeping pad shall be Class "A" concrete with rebar crossway network. The minimum size rebar allowed is #3. Concrete shall be precisely leveled so that equipment set in place will not require shimming.

I. CLEANING AND TOUCH UP

1. At the prior to startup and completion of the work prior to final acceptance, all parts of the installation, including all equipment, exposed conduit, devices, and fittings shall be cleaned and given touch up by Contractor as follows:
2. Remove all grease and metal cuttings.
3. Any discoloration or other damage to parts of the building, the finish, or the furnishings, shall be repaired.
4. Thoroughly clean any of his exposed work requiring same.
5. Vacuum and clean the inside of all MCC and electrical and instrumentation enclosures.
6. Clean all above and below ground pull boxes, junction boxes, and vaults from all foreign debris prior to final acceptance.
7. Paint all scratched or blemished surfaces with the necessary coats of quick drying paint to match adjacent color, texture, and thickness. This shall include all prime painted electrical equipment, including enclosures, panels, poles, boxes, devices, etc.

8. Repair damage to factory finishes with repair products recommended by Manufacturer.
9. Repair damage to PVC or paint finishes with matching touchup coating recommended by Manufacturer.

3.07 MAINTENANCE AND OPERATING INSTRUCTIONS

- A. Provide six (6) sets Operation and Maintenance manuals bound in three ring binders with one set made up completely with original manuals. O&M manuals shall provide at least the following, at a minimum:
 1. A comprehensive index.
 2. A complete "Record" set of favorably reviewed electrical submittals as provided under SUBMITTAL AND DRAWING REQUIREMENTS.
 3. As-built one-line, elevation, loop, elementary and interconnection drawings with all field changes included.
 4. A complete list of the equipment supplied, including serial numbers, ranges, catalog cuts, and pertinent data.
 5. Full specifications on each item.
 6. Detailed service, maintenance and operation instructions for each item supplied. Schematic diagrams of all electronic devices shall be included. A complete parts lists, including stock numbers, shall be provided on the components that make up the assembly.
 7. Safety precautions and procedures.
 8. Record of each breaker and overload heater element including Manufacturer, full part number, size, setting etc.
 9. Record of each motor nameplate data including manufacturer, full part number, size, etc.
 10. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.
 11. Spread sheet listing all setpoints and programmable parameters entered for this project for instruments, etc.
 12. All of these sets of O & M Manuals shall be made up of "original" (no copies, PDFs or reproductions) documents. No photo or fax copies are allowed of standard published manuals available from Manufacturers.
 13. Include all completed and signed test data and forms from factory and field testing.
 14. Warranty certificate with start dates, duration and contact information.
- B. At the end of the project these manuals shall be updated to show "as-built" conditions.
- C. Provide two (2) sets of CDs containing all drawings in AutoCAD format and PLC OI & SCADA OI software prepared for this project, updated to reflect as-built conditions. PLC disks shall contain the ladder program with comments in RS Logix 500, and C-More. SCADA OI software shall be the configured Wonderware graphics and all support files. These disks shall be the property of the Owner, for its use on this and future projects.

3.08 TESTING

A. GENERAL REQUIREMENTS

1. It is the intent of these tests to assure that all equipment is operational within industry and Manufacturer's tolerances and is installed in accordance with design plans and specifications
2. All equipment setup and assembled by the Contractor shall be in accordance with the design plans and Drawings and the Manufacturer's recommendations and instructions and shall operate to the Engineer's satisfaction. Follow all Manufacturer's instructions for handling, receiving, installation, and pre-check requirements prior to energization. After energization, follow Manufacturer's instructions for programming instrumentation, set-up and calibration of equipment. The Contractor shall be responsible for, and shall correct by repair or replacement, at his own expense, equipment which, in the opinion of the Engineer, has been caused by faulty mechanical or electrical assembly by the Contractor. Necessary tests to demonstrate that the electrical and mechanical operation of the equipment is satisfactory and meets the requirements of these Specifications shall be made by the Contractor at no additional cost to the Owner.
3. The testing shall not be started until the Manufacturer has completed fabrication, wiring, and setup, has performed satisfactory checks and adjustments and can demonstrate the system is complete and operational. Certification of completion of Contractor's in-house tests shall be submitted prior to scheduling of factory testing.
4. Factory tests shall not be scheduled until submittals associated with the equipment have been approved by the Engineer. If equipment is significantly different from submittal drawings, this shall be grounds for cancellation and rescheduling of factory tests at no additional costs to Owner or extension of Contract time.
5. The first Pre-Energization tests shall be performed to determine the suitability for energization and shall be completed with all power turned off and complete prior to the start of any of the Post-Energization tests. The Electrical Contractor shall have qualified personnel on the job site for all Pre-Energization and Post-Energization tests.
6. All tests shall be witnessed by the Engineer and/or Owner personnel. The test forms shall be completed by the testing person for field checkout, testing, and calibration of all equipment and instruments. All filled in test forms shall be given to the Engineer and/or Owner the day of the test. Fill in two sets of test forms if Contractor wants to keep a copy. All tests shall be documented in writing by the supplier and signed by the Engineer as satisfactory completed. The supplier shall keep a detailed log of all tests that failed or did not meet specifications, including date of occurrence and correction. Completed forms with proper signatures and dates shall be included and become a component of the Operations and Maintenance Manual for each of the respective systems.
7. Prior to any field testing, Interconnection Drawings and Operation & Maintenance Manuals shall have been submitted by the Contractor and approved by the Engineer.

8. The Contractor shall notify the Owner and the Engineer of the Supplier's readiness to begin all factory and field tests in writing (a minimum of ten working days prior to start), and shall schedule system checkout on dates agreed to by the Owner and the Engineer in order that the testing be scheduled and witnessed.
9. The Contractor shall fill in & submit for approval the "Scheduled Test Request Form" located in Appendix "A" for each requested inspection, factory and field test.
10. The supplier shall submit for approval, the proposed factory & field testing sheets at least 24 days prior to the start of the tests. Each testing sheet shall have a title giving the type of test and entry spaces for the name of the person who performed the test, name of the person who witnessed the test, and the date. Tests performed without approved forms shall be retested at no additional cost to Owner.
11. Separate test procedures in separate binders shall be submitted for approval for the Factory and Field Tests. Testing shall not commence until the test procedures have been reviewed and approved by the Owner.
12. If the results of any of tests are unacceptable to the Engineer, the Contractor shall make corrections and perform the tests again until they are acceptable to the Engineer; these additional tests shall be done at no additional cost to the Owner.

B. FAILURE TO MEET TEST

1. Any system material or workmanship which is found defective on the basis of acceptance tests shall be reported to the Engineer. The Contractor shall replace the defective material or equipment and have tests repeated until test proves satisfactory to the Engineer without additional cost to the Owner.

C. SAFETY

1. Testing shall conform to the respective manufacturer's recommendations. All manufacturer's safety precautions shall be followed.
2. The procedures stated herein are guidelines for the intended tests, the Contractor shall be responsible to modify these tests to fit the particular application and ensure personnel safety. Absolutely no tests shall be performed that endanger personal safety.
3. The Electrical Contractor shall have two or more Electricians present at all electrical field tests.
4. Two non-licensed portable radios are to be made available by the Contractor for the testing organization to conduct tests.
5. California Electrical Safety Orders (ESO) and Occupational Safety and Health Act (OSHA): The Contractor is cautioned that testing and equipment shall comply with ESO and OSHA as to safety, clearances, padlocks and barriers around electrical equipment energized during testing.
6. Field inspections and pre-energization tests shall be completed prior to applying power to equipment.

D. ELECTRICAL FACTORY TESTS

1. The system supplier shall conduct a thorough and complete factory test by qualified factory-trained personnel witnessed by Owner per the criteria specified herein. Factory test shall be held within 150 miles of project location.
2. All components of the system setup shall be completely assembled and thoroughly pre-tested by the supplier or Manufacturer before start of factory test.
3. Faulty and/or incorrect hardware operation of major portions of the system may, at the discretion of the Owner Engineer, be cause for suspension or restarting of the entire factory test, at no additional cost to the Owner or extension in contract time.
4. Factory test shall not be scheduled until submittals associated with the equipment have been approved by the Engineer. If factory equipment is found to be significantly different from submittal drawings this shall be grounds for cancellation and rescheduling of factory tests at no additional costs to Owner or extension of Contract time.
5. The testing personnel shall provide all material, equipment, labor and technical supervision to perform such tests and inspections.
6. The Contractor shall pay all expenses incurred by his personnel, including labor, material, transportation, lodging, daily subsistence, and other associated incidental costs during the factory testing.
7. Temporary wiring and equipment shall be setup during these tests to simulate the complete assembled system.
8. The tests, as a minimum, shall simulate all operating conditions including steady state, transients, upsets, startup, shutdown, power failure, and equipment failure conditions (for control logic).
9. The panel system set-up for factory testing consists of, but is not limited to, Motor Control Panel, control panels, pedestal, PLC, field control stations and any miscellaneous associated electrical equipment.
10. The length of the factory testing shall be a minimum of 8 hours all on one day. If in the opinion of the Owner or Engineer the factory testing is not completed at the end of the working day, the testing shall be extended, at no additional cost to the Owner or extension in Contract time. The Contractor shall agree that the sum set forth hereafter is a reasonable amount to be charged as liquidated damages; and it is therefore agreed that the Contractor will pay the Owner the sum of five hundred dollars (\$500.00) in liquidated damages for each and every calendar day beyond the time prescribed above for the completion of factory testing for the panel system. Liquidated damages will be assessed to the Contractor each and every day past the time allotted for factory testing.

11. All factory tests shall be conducted at the System Supplier's facility. All factory tests shall be completed prior to installation of any of the panel system at the jobsite. The panel system shall be fully assembled and connected as it will be installed in the final configuration. If the panel system is found to be not fully and completely ready for factory testing, the Contractor shall be responsible for paying for the Owner and Engineer to return for the factory testing. Factory testing is to ensure that there are no defects. The hardware shall be tested for compliance with the plans and Specifications included herein and for the ability to perform the control functions.
12. Provide a complete clean copy of System Supplier drawings for Owner and Engineer's use during Factory Test.
13. The associated factory tests for each of the factory testing sheets that are to be performed by the supplier and witnessed by the Owner Engineer shall include the following panel system as a minimum:
 - a. Inspections of the panel as follows:
 - 1) Visual and mechanical, for compliance with Contract and submittal drawings.
 - 2) Inspect for physical damage, proper support, and wiring.
 - 3) The Contractor shall fill in test form TF4 located in Appendix "A."
 - b. Testing of the panel as follows:
 - 1) All PLC/OI components of the system shall be completely assembled, programmed, and thoroughly pre-tested by the supplier or Manufacturer before start of factory test.
 - 2) I/O points shall be simulated for the complete checkout of PLC program and OI setup.
 - 3) The Contractor shall complete each test and fill in the I/O test form TF11 located in Appendix "A."
 - c. Each line of control logic on the elementary diagrams shall be checked. After a line of control logic is tested, the person performing test shall initial the corresponding line on the elementary diagram. When the complete elementary diagram has been checked, it shall be signed and dated by testing person and person witnessing test.
14. During the testing period, under the supervision of the supplier, the Engineer and other Owner personnel shall have unlimited and unrestricted access to the usage and testing of all hardware and software in the system.
15. Spare parts for the system shall also be tested during this test period. The supplier shall prove by temporarily connecting the spare hardware to the system that any or all of the spare parts function in a manner equivalent to the original equipment under test.
16. The factory test will be considered complete only when the integrated system has successfully passed all tests to the satisfaction of the Owner or Engineer. No electrical equipment shall be shipped to jobsite without authorization from the Owner or Engineer that the factory test has been completed.
17. Acceptance and witnessing of the factory tests does not relieve or exclude the Contractor from conforming to the requirements of the Contract Documents.

18. All modifications to documentation as a result of the factory tests shall be corrected and completed before the submittal and delivery of "operation and maintenance" manuals.
19. Copies of the completed and witnessed factory testing forms shall be placed in the Operation and Maintenance Manual.

E. ELECTRICAL FIELD TESTS

1. PRE-ENERGIZATION TESTS: These tests shall be completed prior to applying power to any equipment.
 - a. INSPECTIONS
 - 1) Visual and Mechanical
 - a) Inspect for physical damage, proper anchorage, and grounding.
 - b) Compare equipment nameplate data with design plans and starter schedule.
 - c) Compare overload setting with motor full load current for proper size.
 - 2) The Contractor shall compile, by visual inspection of equipment installed for each motor, the following data in neatly tabulated form:
 - a) Equipment driven
 - b) Motor horsepower
 - c) Nameplate amperes
 - d) Service factor
 - e) Temperature rating
 - f) Overload catalog number
 - g) Overload current range and setting
 - h) Circuit breaker rating
 - 3) Circuit breaker trip setting, for magnetic only circuit breakers
 - 4) The Contractor shall fill in, for each piece of equipment, Test Form TF4 located in Appendix "A."
 - b. TORQUE CONNECTIONS:
 - 1) All electrical, mechanical and structural threaded connections inside equipment shall be tightened in the field after all wiring connections have been completed. Every worker tightening screwed or bolted connections shall be required to have and utilize a torque screwdriver/wrench at all times. Torque connections to the value recommended by the equipment manufacturer. If they are not available, use NEC 2005 110-14 as guidelines.
 - c. WIRE INSULATION & CONTINUITY TESTS:
 - 1) All devices that are not rated to withstand the 500V megger potential shall be disconnected prior to the megger tests.
 - 2) Megger insulation resistances of all 600 volt insulated conductors using a 500 volt megger for five seconds. Make tests with circuits installed in conduit and isolated from source and load. Each conductor shall be meggered conductor to conductor and conductor to ground. These tests shall be made on cable after installation with all splices made up and terminators installed but not connected to the equipment.

- 3) Megger insulation resistances of all motor leads using a 500 volt megger for ten seconds. Make these tests with motors installed in place and not connected to any other wiring. Each motor lead shall be tested conductor to ground.
- 4) Each megger reading shall not be less than 100 Meg-ohms resistive. Corrective action shall be taken if values are recorded less than 100 Meg-ohms.
- 5) Continuity Tests: Each instrumentation conductor twisted shielded pair shall have the conductor and shield continuity measured with an ohmmeter. Conductors with high ohm values, that do not match similar lengths of conductors the same size, shall be replaced at no additional cost to the Owner.
- 6) The Contractor shall fill in test forms Power and Control Conductor Test Form TF1 and Instrumentation Conductor Test Form TF2 located in Appendix "A."
- 7) Values of different phases of conductors in the same conduit run showing substantially different Meg-ohm values, even if showing above 100 Meg-ohms shall be replaced

d. GROUNDING SYSTEM TESTS

1) VISUAL AND MECHANICAL INSPECTION

- a) Verify ground system is in compliance with drawings and specifications.

2) ELECTRICAL TESTS

- a) Before making connections to the ground electrodes, and before placement of sidewalks, landscape and paving, measure the resistance of each electrode to ground using a ground resistance tester. Perform the test not less than two days after the most recent rainfall and in the afternoon after any ground condensation (dew) has evaporated.
- b) After all individual ground electrode readings have been made, interconnect as required and measure the system's ground resistance.
- c) Perform point-to-point tests to determine the resistance between the main grounding system and all major electrical equipment frames, system neutral, and/or derived neutral points.
- d) The grounding test shall be in conformance with IEEE Standard 81.
- e) Plots of ground resistance shall be made and submitted to the Engineer for approval.
- f) The current reference rod shall be driven at least 100 feet from the system under test.
- g) Measurements shall be made at 10 feet intervals, beginning 25 feet from the test electrode and ending 75 feet from it in a direct line between the system being tested and the test electrode.

3) TEST VALUES

- a) The resistance between the main grounding electrode and ground shall be no greater than five ohms for commercial or industrial systems per IEEE Standard 142.
- b) Investigate point-to-point resistance values that exceed 0.5 ohms.

- c) The Contractor shall fill in Grounding System Test Form TF3 located in Appendix "A"
- e. **PANELBOARD TEST**
 - 1) Visual and Mechanical Inspection
 - a) Inspect for physical damage, proper anchorage and grounding.
 - b) Compare equipment nameplate data with design plans.
 - c) Compare breaker legend for accuracy.
 - d) Check torque of bolted connections.
 - 2) The Contractor shall fill in Panelboard Test Form TF5 located in Appendix "A."
- f. **BREAKER TEST**
 - 1) All breakers shall be checked for proper mounting, conductor size, and feeder designation. Operate circuit breaker to ensure smooth operation. Inspect case for cracks or other defects. Check tightness of connection with torque wrench in accordance with Manufacturer's recommendations.
 - 2) All breakers 100 amps and above shall be tested, including the generator breaker. Time current characteristic tests shall be performed bypassing three hundred percent (300%) rated current through each pole separately. Trip time shall be determined. Instantaneous pickup current shall be determined by run up or pulse method. Clearing times should be within four (4) cycles or less. All trip times shall fall within NETA Table values. Instantaneous pickup current levels should be within 20% of manufacturer's published values. Certification stickers, listing date and company who performed the tests, shall be attached to the inside of the breaker compartment door right after the breaker has passed all tests.
 - 3) Contact and Insulation Resistance: Contact resistance shall be measured and be compared to adjacent poles and similar breaker. Deviations of more than 50% shall be reported to Engineer. Insulation resistance shall be measured and shall not be less than 100 megohms.
 - 4) After the completion of all breaker tests, all TM & MCP breakers shall be set by Contractor to their proper settings to protect equipment.
 - 5) The Contractor shall fill in Breaker Test Form TF8 located in Appendix "A."
- 2. **POST ENERGIZATION TESTS**
 - a. **Panel Tests**
 - 1) During these tests, simulate all local and remote control operations.
 - b. **Electrical Tests**

- 1) Perform operational tests by initiating control devices to affect proper operation.
 - 2) The Contractor shall fill in Operational Device Checks and Tests Form TF6 and MCC Device Test Form TF7 located in Appendix "A."
- c. Phase Rotation Tests
- 1) Check connections to all equipment and motors for proper phase relationship. During this test, disconnect all devices which could be damaged by the application of voltage or reversed phase sequence. Three phase equipment shall be tested for the phase sequence "ABC" front to back, left to right, and top to bottom.
 - 2) The Contractor shall fill in Phase Rotation Test Form TF10 located in Appendix "A."
- d. Motor Testing
- 1) Record the amperage draw on all phases of each motor operating under full load. Ensure that these values do not exceed the motor nameplate full load amperage.
 - 2) Record the voltage between all phases of each motor operating under full load. If the voltage balance is not within plus or minus 5 percent of nominal, request the Utility power company or other responsible party to correct the problem.
 - 3) The Contractor shall compile, by visual inspection of equipment installed for each motor, the following data in neatly tabulated form and be placed in the O&M manual:
 - a) Equipment driven.
 - b) Motor horsepower.
 - c) Nameplate amperes.
 - d) Service factor.
 - e) Temperature rating.
 - f) Overload catalog number.
 - g) Overload current range and setting.
 - h) Circuit breaker rating.
 - i) Circuit breaker trip setting, for magnetic only circuit breakers.
 - 4) The Contractor shall fill in Motor Test Form TF9 located in Appendix "A."
- e. INSTRUMENTATION TESTS
- 1) Instrumentation tests shall be conducted per the following criteria:
 - a) As a minimum, all the tests indicated/specified on the Instrument Data Sheet and Calibration Record Form TF12 in appendix "A" shall be performed by the Contractor all instruments listed in Appendix B "Device Index."
 - 2) Test equipment used for testing shall be of suitable quality so as not to mask performance deficiencies. All test equipment shall be traceable to National Bureau of Standards and have been calibrated within six months of test date.
 - 3) Testing shall be accomplished using simulated inputs only with prior written approval of the Owner.
 - 4) The overall accuracy of each instrument loop shall be checked to ensure that it is within acceptable tolerance.
 - 5) All the I/O points for the PLC/OI shall be tested by Contractor for proper wiring. Where practical, the final element shall be used,

- i.e., trip the intrusion switch or change levels. During this task the Contractor shall have:
- a) Qualified field technician that has experience in the startup of similar systems to operate the field devices.
 - b) Test instruments as required.
 - c) A pair of radios for communication.
- 6) The Contractor shall fill in "I/O point Checkout Test Sheet" TF11.
- 7) Calibration stickers shall be installed on all instruments right after calibration has been successfully completed. Calibration stickers shall list the following information:
- a) Tag number.
 - b) Calibrated by whom (name), firm, city and telephone number.
 - c) Date calibrated.
 - d) Calibration range.
 - e) Comments.
- 8) The Contractor shall provide a minimum of one (1) hour of field acceptance testing for each instrument. If any instrument has not been fully tested during its allotted time, the Contractor shall provide additional hours for finishing testing of the instrument, to be paid by the Contractor.
- f. Control System Tests
- 1) All the I/O points for the PLC shall be tested by the system supplier in the field for proper operation of alarms, status, analog, control, and Human Machine Interface (HMI/OI) display functions. Where practical, the final element shall be used, i.e. trip the intrusion switch or change levels. Testing shall be accomplished using simulated inputs only when necessary.
 - 2) The overall accuracy of each instrument loop shall be checked to ensure that it is within acceptable tolerance.
 - 3) All the I/O points for the PLC/OI shall be tested by Contractor for proper wiring. Where practical, the final element shall be used, i.e., trip the intrusion switch or change levels. During this task the Contractor shall have:
 - a) Test instruments as required.
 - b) A pair of radios for communication.
 - c) Coordinated to have the PLC/SCADA provided field technician available so PLC/OI program changes can be made.
 - 4) During this task the System supplier shall have:
 - a) Qualified field technician with experience in the startup of similar systems with PLC controls, and other field devices.
 - b) Test instruments as required.
 - c) A pair of radios for communication.
 - 5) The Contractor shall fill in "I/O Point Checkout Test Sheet" TF11.

F. OPERATIONAL TESTING

1. After all the previous tests in this subsection are complete, the Contractor shall conduct operational testing.

2. For the operational testing the new equipment shall be activated to automatically run for 5 days, Monday through Friday 24 hours a day. During this five day period the Owner will run the different combinations of the pump control options. If equipment failure occurs during the 5 days of operational testing, the Contractor shall repair or replace the defective equipment and shall begin another 5 day operational test, Monday through Friday 24 hours a day. This shall be continued until the new equipment functions acceptably for 5 consecutive days.

3.09 TRAINING

- A. At time of completion, the Contractor shall provide a period of not less than 8 hours training for instruction of operation and maintenance personnel in the use of all control systems at the station site. Instruct all personnel in two four (4) hour sessions. Provide product literature and application guides for user's reference during instruction. Training shall include instruction on how to setup and operate soft starters and how to use the OI graphic interface.

3.10 SPARE PARTS

- A. The Contractor shall supply all spare parts prior to start of field tests. All parts shall be sealed in plastic bags and delivered to the site in a heavy duty plastic storage bag. Bag shall be clearly labeled with part name & number and the corresponding equipment tagname.
- B. The Contractor shall make available any replacement parts that are not manufacturer's normal stock items for immediate service and repair of all the electrical & instrumentation equipment throughout the warranty period.
- C. The following spare parts shall be provided to the Owner as part of this Contract:
 1. Ten (10) fuses for each type of fuse.
 2. Ten (10) lamps for each type of removable indicating light.
 3. One (1) relay for each type of control, intrinsic safe and time delay relays with bases.
 4. One spare PLC DI, DO & AI card of each type.

3.11 WARRANTY

- A. The Contractor shall have a staff of experienced personnel available to provide service on 2 working days notice during the warranty period. Such personnel shall be capable of fully testing and diagnosing the hardware, software and implementing corrective measures. If the Contractor "fails to respond" in 2 working days, the Owner at its option will proceed to have the warranty work completed by other resources; the total cost for these other resources shall be reimbursed in full by the Contractor. "Fail to respond" shall be defined as: The Contractor has not shown a good faith effort and has not expended adequate resources to correct the problem. The use of other resources, as stated above, shall not change or relieve the Contractor from fulfilling the remainder of the warranty requirements.

- B. The Contractor shall warrant all electrical and instrumentation equipment including video surveillance system, PLC, RTU & OI software programming for a period of one (1) year from date of final acceptance. Standard published warranties of equipment which exceed the preceding specified length of time shall be honored by the manufacturer or supplier.
- C. The Contractor shall provide all labor and material to troubleshoot, replace, or repair any hardware that fails or operates unpredictable and correct any software problems during the warranty period, at no additional cost to the Owner.
- D. Each time the Supplier's repair person responds to a system malfunction during the warranty period, he or she must contact the designated Owner maintenance supervisor for scheduling of the work, access to the jobsite, and permission to make repairs. Operation of facilities necessary to test equipment shall only be performed by or under the direction of the Owner Staff. The Owner reserves the right at its sole discretion to deny operations requested by the Supplier. A written description of all warranty work performed shall be documented on a field service report to be given to Owner prior to the repair person leaving job site each day. This field service report shall detail and clearly state problem, corrective actions taken, additional work that needs to be done, data, repair person name and company.
- E. Prior to "Final Acceptance," the Contractor shall furnish to the Owner a listing of warranty information for all manufacturers of materials, instruments, and equipment used on the project. The listing shall include the following:
 - 1. Manufacturer's name, service contact person, phone number and address.
 - 2. Material and equipment description, equipment number, part number, serial number, and model number.
 - 3. Manufacturer's warranty expiration date.
- F. Software support which shall be provided by the supplier:
 - 1. Free technical security system (software and hardware) and PLC/RTU/OI hardware configuration phone support for a period of one year. Security system and PLC/RTU/OI phone support shall be provided directly from the group that configured the security system and PLC/RTU/OI. Phone support shall be available between 8 a.m. and 4 p.m. Pacific Standard Time Monday through Friday.
 - 2. The supplier shall correct any security system and PLC/RTU/OI configuration error that is discovered within the warranty period, at no additional cost to Owner. Updated documentation for each "operation and maintenance" manual and new floppy disks of updated software shall be provided for each correction.
 - 3. Program changes made by Owner or under direction of Owner by others shall not relieve or void Contractor of warranty requirements for parts of software programmed under this Contract.

- G. The Contractor shall provide all labor and material to troubleshoot, program, replace, or repair any hardware or software that fails or operates unpredictably during the warranty period, at no additional cost to the Owner.

3.12 FINAL ACCEPTANCE

- A. Final acceptance will be given by the Owner after the equipment has passed the "final acceptance trial period," each deficiency has been corrected, final documentation has been provided, and all the requirements of design documents have been fulfilled.
- B. Upon completion of the project, prior to final acceptance, remove all temporary services, equipment, material, and wiring from the site.
- C. At the end of the project, following the completion of all of the field tests, and prior to final acceptance, the Supplier shall provide the following final documentation to the Owner:
 - 1. A listing of warranty information.
 - 2. Each "operation and maintenance" manual shall be modified or supplemented by the Supplier to reflect all field changes and as-built conditions.
 - 3. Two (2) disk copies of all final documentation to reflect as-built conditions.
- D. Prior to final acceptance submit each key with matching duplicate. Wire all keys for each lock securely together. Tag and plainly mark with lock number or equipment identification, and indicate physical location, such as panel or switch number.