

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT			1. CONTRACT ID CODE N/A	PAGE OF PAGES 1 142
2. AMENDMENT/MODIFICATION NO. 0012	3. EFFECTIVE DATE 6 JUN 03	4. REQUISITION/PURCHASE REQ. NO. N/A		5. PROJECT NO. (If applicable) SPEC. NO. 1296
6. ISSUED BY DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO 1325 J STREET SACRAMENTO, CALIFORNIA		7. ADMINISTERED BY (If other than Item 6) SEE ITEM 7		

8. NAME AND ADDRESS OF CONTRACTOR (No., street, county, State and ZIP Code)		(√)	9A. AMENDMENT OF SOLICITATION NO. DACW05-03-B-0007
		×	9B. DATED (SEE ITEM 11) 21 APR 2003
			10A. MODIFICATION OF CONTRACTS/ORDER NO. N/A
			10B. DATED (SEE ITEM 13) N/A
CODE	FACILITY CODE		

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offers is extended, is not extended.

Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended, by one of the following methods:

(a) By completing Items 8 and 15, and returning 1 copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12. ACCOUNTING AND APPROPRIATION DATA (If required)

13. THIS ITEM APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS, IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.

(√)	A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A.
	B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation date, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(b).
	C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF:
	D. OTHER (Specify type of modification and authority)

E. IMPORTANT: Contractor is not, is required to sign this document and return _____ copies to the issuing office.

14. DESCRIPTION OF AMENDMENT/MODIFICATION (Organized by UCF section headings, including solicitation/contract subject matter where feasible.)
SACRAMENTO RIVER FLOOD CONTROL SYSTEM PHASE 11 - MARYSVILLE/YUBA AREA SITE 7 EXTENSION
YUBA COUNTY, CALIFORNIA

- 2 ENCLS 1) PRICING SCHEDULE, 02525A, 16010, 16110, 16120, 16470, 16480, 16482, 16600, 16905, 16910, 16915 AND 16940.
2) DRAWINGS L-1, L-8, RW-1 AND RW-2.

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.

15A. NAME AND TITLE OF SIGNER (Type or print)		16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print)	
15B. CONTRACTOR/OFFEROR _____ (Signature of person authorized to sign)	15C. DATE SIGNED	16B. UNITED STATES OF AMERICA BY _____ (Signature of Contracting Officer)	16C. DATE SIGNED

0013	AGGGREGATE BASE (MAINTENACE ROAD)	470*	CY	\$ _____	\$ _____
0014	BARBED FENCE AND EROSION CONTROL SEEDING				
0014AA	BARBED FENCE	9,350*	LF	\$ _____	\$ _____
0014AB	EROSION CONTROL SEEDING	21	AC	\$ _____	\$ _____
0015	PIPE GATE	3	EA	\$ _____	\$ _____
0016	RELIEF WALLS				
0016AA	INSTALL AND TESTED	19	EA	\$ _____	\$ _____
0016AB	PRECAST MANHOLE	19	EA	\$ _____	\$ _____
	SUBTOTAL ESTIMATED PRICE				\$ _____
	(ITEMS 0001 THRU 0016)				
	<u>PUMP STATION, PUMP, MOTOR AND ELECTRICAL WORK</u>				
0017	MOBILIZATION/ DEMobilIZATION	1	LUMP SUM	LUMP SUM	\$ _____
0018	VERTICAL AXIAL- FLOW OR MIXED FLOW SINGLE STAGE IMPELLER-TYPE PUMP	2	EA	\$ _____	\$ _____
0019	PUMP CONTROL CENTER AND ELECTRICAL PANEL (INCLUDES CONDUIT, ALARMS, SENSORS, TELEMETRY, BOLLARDS, PG & E SERVICE, AND OTHER INCIDENTAL ELECTRICAL WORK	2	EA	\$ _____	\$ _____
0020	PUMP AND MOTER INSTALLATION (INCLUDES ALL WORK TO INSTALL AND SETUP THE PUMP AND MOTER INSIDE THE PUMP STRUCTURE, INCLUDING ALL TESTING AND QUALITY CONTROL WORK	2	EA	\$ _____	\$ _____
0021	PG & E POLE RELOCATION, TRANSFER WORK AND METER PANEL (INCLUDES ALL COORDINATION WORK WITH PG & E, ALL FEES TO BE PAID BY OTHERS)	1	LUMP SUM	LUMP SUM	\$ _____
0022	CAST-IN-PLACE CONCRETE (MOTOR CONTROL PAD)	1	LUMP SUM	LUMP SUM	\$ _____
0023	CAST-IN-PLACE CONCRETE (TRANSFORMER PAD)	1	LUMP SUM	LUMP SUM	\$ _____
0024	SECURITY LIGHTING	1	EA	\$ _____	\$ _____
0025	PUMP STATION STRUCTURE (COMPLETE)	1	LUMP SUM	LUMP SUM	\$ _____

1.3 APPLICABLE PUBLICATIONS

The following publications of the issue listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references there_to:

1.3.1 Department of the Army, Corps of Engineers, Engineer Manual

EM 1110?2?1906 Laboratory Soils Testing, 30 November 1970.

1.3.2 American Society for Testing and Materials (ASTM)

A 312/A312M-94 (REV B) Seamless and Welded Austenitic Stainless Steel Pipes

C117-95 Materials Finer Than 75-UM (No. 200) Sieve in Mineral Aggregates by Washing

C-136-95 Sieve analysis of Fine and Coarse Aggregates

F 480-94 Thermoplastic Well Casing Pipe and couplings Made in Standard Dimension Ratios (SDR) Schedule 40 and Schedule 80

1.3.3 The Aluminium Association (AA)

AA SAS-30 (1986) Aluminum Construction Manual Series - Secion 1 Specifications for Aluminum Structures

1.3.4 American Welding Society (AWS)

Structural Welding Code - Steel

1.4 MEASUREMENT AND PAYMENT

1.4.1 Relief Well.

Compensation for the relief well will be made at the contract unit price and shall include materials, equipment, and labor required to drill, develop, perform tests, and complete the relief well. Depth shall be measured as a total linear distance between the ground surface (top of berm) and 2--feet below the bottom of the tail pipe. If the total depth of the relief well is greater than that specified in the contract for Item "RELIEF WELLS INSTALLED AND TESTED", ~~the additional depth shall be paid for at the contract unit price for Item "ADDITIONAL RELIEF WELL DEPTH".~~ Any holes or wells ordered abandoned by the Contracting Officer due to no fault of the Contractor will be paid for under Item "ADDITIONAL RELIEF WELL DEPTH". No payment will be allowed for wells abandoned due to faulty construction practices or for the convenience of the Contractor. No separate payment will be made for relief wells screen, riser, check valves, gravel pack, development, or backfill.

PART 1: GENERAL

1.01 SCOPE OF WORK

- A. This division includes the provisions for all material, labor, tools, equipment, testing and services necessary to provide a complete and operable electrical system.
- B. The provisions of this section shall apply to all electrical items specified in the various sections of Division 16, Electrical, except where otherwise specified or shown in the Contract Documents. Detailed requirements for specific electrical items are specified in other sections but are subject to the general requirements of this section.
- C. The Contractor shall install, ready for use, the electrical system as specified herein and shown on the Contract drawings. 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 accompanying drawings, included in these Specifications, or necessary for fully operating facility. See Section 16940 for “Instrumentation Index” for this project.
- D. 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.
- E. Examine the specification 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.
- F. The major components in the scope of work shown on the Contract drawings which includes both the furnishing and installation are:
 - 1. Utility Metering with Main Disconnect.
 - 2. Motor Control Center (MCC):
 - a. Motor controls with solid state starters.
 - b. Control Panel.
 - c. Panelboard and transformer.
 - d. Miscellaneous equipment as shown on Contract Drawings.
 - 3. Instrumentation with coordinated mounting supports.

4. Programmable Logic Controller (PLC) and Operator Interface (OI) is used for controlling the pumps and other miscellaneous devices at the Station. The Contractor is to provide all configuration, programming and setup of the PLC and OI.
 5. Conduits, grounding system and the field interconnection wiring between the instruments, field devices, and electrical enclosures and mechanical equipment as required for a functional system.
 6. All necessary hardware, connectors, fittings, and devices to connect the designated equipment and wiring.
 7. All necessary instrument supports, piping and valves to complete installation of any of the instruments listed herein.
 8. All necessary miscellaneous shut off, sample and calibration valves to sensors.
 9. Trenching, backfilling, compaction and resurfacing for all new underground conduit routes, concrete pads, and pull boxes.
 10. Coordination and equipment for new utility power services per Utility engineered drawings.
 11. Site electrical devices, lights and receptacles.
- G. All electrical equipment and materials, including installation and testing, shall conform to the applicable codes and standards listed in this and other Sections. All electrical work shall conform to the National Electric Code (NEC) ~~1999~~ 2002 issue, Institute of Electrical and Electronic Engineers (IEEE), and Underwriters Laboratories Inc (UL). Nothing on the Drawings or in the Specifications shall be construed to permit methods or materials not conforming to these codes and standards.

1.02 RELATED WORK IN OTHER SECTIONS

- A. The following are covered in other sections in the Contract documents and are part of Division 16.
1. Section 16110 – Conduit, Devices, Boxes & Grounding.
 2. Section 16120 – Wire, Fuses & Terminal Blocks.
 3. Section 16470 – Panelboard and Power Transformer.
 4. Section 16480 – Motor Control Center.
 5. Section 16482 – Solid State Soft Starter.
 6. Section 16600 – Factory and Field Testing.
 7. Section 16905 – Control Panel.
 8. Section 16910 – PLC & OI Hardware.
 9. Section 16915 – PLC & OI Applications Programming.

10. Section 16940 – Instrumentation.
- B. Provide an electrical system that interfaces work performed under other Mechanical, Electrical and Equipment Sections of these Specifications.
- C. The contents of this section apply to all "electrical and instrumentation" equipment suppliers and manufacturers doing work listed in following sections:
 1. Division 11 - Equipment.
 2. Division 13 - Special Construction.
 3. Division 15 - Mechanical.

1.03 QUALIFICATIONS

- A. Electrical Contractor
 1. It is the intent of this Division that the complete responsibility for management and installation of the electrical and instrumentation required for this project be by the Electrical Contractor. This responsibility includes, but not limited to, supervision and coordination of work performed by all suppliers of Division 16.
 2. General Contractor shall disclose the proposed Electrical Contractor with bid documents that he intends to use on this project.
 3. If the Electrical Contractor, General Contractor ~~or~~ System supplier listed in bid documents are deemed not qualified by ~~Owner~~ *Government*, they will have their bid rejected at the ~~Owner~~ *Government's* sole discretion and the next qualified bidder selected.
 4. The Electrical Contractor shall meet the following minimum qualifications:
 - a. Has regularly engaged in similar electrical contracting for the Municipal Water and Wastewater Industry.
 - b. Has successfully performed work of similar or greater complexity on at least two previous projects under the present company name.
 - c. Has been actively engaged in the type of electrical and instrumentation work specified in this Division for a minimum of two years.
 - d. Has a current C-10 Electrical Contractor's License.
- B. System Supplier/Integrator
 1. It is the intent of the ~~Owner~~ *Government* to secure the highest quality of work for this project. The Suppliers listed below have been determined to meet minimum qualifications specified in this Division and are pre-qualified by the ~~Owner~~ *Government* for providing supplier bids as system suppliers on the project. Other suppliers may submit to ~~Owner~~

Government prior to bid opening a statement of qualification listing relevant experience on similar projects completed. The ~~Owner~~ *Government* will list additional prequalified suppliers in an addendum prior to bid opening.

- a. Tesco Controls, Inc. (916) 395-8800
- b. Krug-Bixby-Long Associates (KBL) (510) 887-1117
- c. Meyer Control Corporation (MCC), (707) 449-0341
- d. Control Manufacturing Company (CMC) (707) 258-8400

- 2. It is the intent of this specification that complete responsibility of the control system required for this project be supplied by a single System Supplier. This responsibility includes, but not limited to, all work necessary to select, furnish, construct, supervise installation, calibrate, test, and place into operation all transmitters, instruments, programmable controllers, motor controls, alarm equipment, communications, monitoring equipment, and accessories as specified herein.
- 3. The system supplier shall have an on staff a project engineer with prior experience on similar sized projects. This project shall coordinate the technical aspects of this project and prepare the submittals and drawings. The system supplier project engineer shall attend all coordination meetings when specifically requested by the ~~Engineer Contracting Officer~~ or ~~Owner~~ *Government*.
- 4. The system supplier shall meet the following minimum qualifications:
 - a. Has regularly engaged in similar systems for the Municipal Water and Wastewater Industry.
 - b. Has successfully performed work of similar or greater complexity on at least five previous projects under the present company name.
 - c. Has been actively engaged in the type of PLCs and instrumentation work specified in this Division for a minimum of five years.
 - d. Employs personnel on this project who have successfully completed ISA or equal training courses on general purpose instrumentation.
 - e. Has a permanent, fully staffed and equipped service facility within 150 miles of the project site for a minimum of 1 year prior to bid date with personnel and equipment required to maintain, repair and calibrate the instrumentation system.

1.04 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 omissions of detail in either shall not relieve the Contractor from the obligations thereunder to install in correct in detail any and all materials necessary for a complete operational system, at no additional cost.

- B. Contract drawings are diagrammatic and indicate general arrangement of systems and equipment, except when specifically dimensioned or detailed. Exact locations of electrical products shall be verified in the field with the ~~Engineer~~ *Contracting Officer*. Field measurements take precedence over dimensioned drawings. Intent is to show size, capacity, approximate location, direction and general relationship of equipment of area shown but not exact detail or arrangement. The requirements or descriptions in the drawings shall take precedence in the event of conflict.
- C. Location at facilities of equipment, inserts, motors, anchors, panels, pull boxes, manholes, conduits, stub-ups, lighting fixtures, power outlets and fittings for the electrical system are to be determined by the Contractor and ~~Engineer~~ *Contracting Officer* at time of installation. Contractor shall make minor adjustments to locations of electrical equipment as required by conditions or in coordination with other trades at no additional cost.
- D. The Contractor shall examine the architectural, mechanical, structural, and electrical and instrumentation equipment provided under other specifications sections 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 electrical terminals. If the Contractor installs equipment conflicting with the architectural, mechanical, structural, instrumentation or electrical equipment provided under this and other specifications sections, the Contractor shall replace without additional cost to the ~~Owner~~ *Government*.
- E. All equipment shall be installed and located so that it can be readily accessed for operation and maintenance. The ~~Engineer~~ *Contracting Officer* reserves the right to require minor changes in location of equipment, without incurring any additional costs.
- F. Where conduits are shown 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~~ *Contracting Officer*. Should there be a need to deviate from the Contract documents, submit written details and reasons for all changes to the ~~Engineer~~ *Contracting Officer* for favorable review.
- H. The resolution of conflicting interpretation of the Contract documents shall be as determined by the ~~Engineer~~ *Contracting Officer*.
- I. The Contractor shall maintain a neatly and accurately marked full size set of Contract Drawings recording the as built locations and layout of all electrical and

instrumentation equipment, routing of raceways, junction and pull boxes, and other diagram or drawing changes. Drawings shall be kept current weekly, with all "change orders", submittal modifications, and construction changes shown. Drawings shall be subject to the inspection by the ~~Engineer~~ *Contracting Officer* at all times, progress payments or portions thereof may be withheld if drawings are not accurate or current.

When documents are changed, they shall be marked with erasable colored pencils using the following coloring scheme:

Additions - red
Deletions - green
Comments - blue
Dimensions - black

Prior to acceptance of the work, the Contractor shall deliver to the ~~Engineer~~ *Contracting Officer* one set of record full size drawings neatly marked accurately showing the information required above.

1.05 COORDINATION

- A. The Contractor shall coordinate the electrical work with the other trades, code authorities, utilities, and the ~~Engineer~~ *Contracting Officer*; with due regard to their work, 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. Coordinate all work with the serving Power Utility, Pacific Gas & Electric (PG&E) for the work shown on Contract Drawings. The Contractor shall obtain the required inspections.
 - 1. Submit to the power Utility the proposed metering details. Provide a written statement from the Utility that shows approval of proposed metering.
 - 2. All work associated with material and installation for the Utility power service not paid by the Utility shall be borne by the Contractor. The Contractor shall provide and install all material, conduits, wiring, pull ropes, pole risers, transformer pads, bollards, etc. as shown on Utility engineered drawings or standards for new power service.
 - 3. All fees and charges of the Utility power for service hook-up will be paid by the ~~Owner~~ *Government*.

- D. Coordinate all work with the serving Telephone Utility for the new telephone service.
1. Provide all the equipment and materials not provided by the telephone Utility Company for permanent service at the locations shown on the Contract Drawings. All work shall meet the requirements of the serving telephone Utility Company.
 2. Coordinate all work with the serving telephone Utility, obtain the required inspections, and notify the respective Utility Company when service is required.
 3. All fees and charges associated with the new telephone service will be paid by the ~~Owner~~ *Government*.
- E. Following award of Contract, schedule all service installations and connections with utilities. Construction or start-up delays as a consequence to lack of documented effort by the Contractor which delay the project completion due to lack of Utility services will not be considered valid and Contract liquidated damages will be assessed.
- F. The Contractor shall cease work at any particular point and temporarily transfer his operations to other portions of work as directed by the ~~Owner~~ *Government*, when in the judgment of the ~~Owner~~ *Government* it is necessary to do so.
- G. Prior to commencing construction, the Electrical Contractor shall arrange a conference with the ~~Owner~~ *Government* as well as all equipment and system suppliers vital to the current phase of work. During the meeting, the equipment supplier shall verify types, sizes, locations, installation requirements, controls and diagrams of all equipment furnished. The equipment supplier shall inform the ~~Engineer Contracting Officer~~ in writing that all phases of coordination of this equipment have been covered. If there are any additional issues or coordination requiring ~~Engineer Contracting Officer~~ attention, they shall be identified within the letter at this time. If the supplier does not complete this coordination, then the equipment supplier and Contractor shall assume full responsibility for coordination and costs of equipment installation.
- H. Where connections must be made to existing or new operational facilities, the Contractor shall schedule all the required work with ~~Owner~~ *Government*, including the power shutdown period. Carry out each shutdown so as to cause the least disruption to the operation of the installation.
1. The Contractor shall limit all unscheduled shutdown periods to less than 15 minutes and only with prior approval of the Station operator.

2. Carry out shut downs of durations greater than 15 minutes only after the time and date schedule and sequence of work proposed to be accomplished during shutdown has been favorably reviewed by the ~~Owner~~ *Government*. Submit shutdown plans at least 2 days in advance of when the scheduled shutdown is to occur.
3. The ~~Owner~~ *Government* reserves the right to delay, change, or modify any scheduled shutdown at any time, at no additional cost to the ~~Owner~~ *Government*, when the risk of such a shutdown would jeopardize the operation of the water distribution system and/or water plant operation.

1.06 SUPERVISION

- A. 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.
- B. The Contractor shall supervise all work in this Section, including the electrical system general construction work, from the beginning to completion and final acceptance.
- C. The Contractor shall supervise and coordinate all work in this Section to insure each phase of the project, submittal, delivery, installation, and acceptance testing, etc. is completed within the allowable scheduled time frames.
- D. 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.

1.07 INSPECTIONS

- A. All work or materials covered by the Contract documents shall be subject to inspection at any and all times by the ~~Owner~~ *Government*. 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~~ *Government*, 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. The ~~Engineer~~ *Contracting Officer* may inspect and test the fabricated equipment at the factory before shipment to job site. See Section 16600 for requirements.
- C. Work shall not be closed in or covered over before inspection and approval by the ~~Engineer~~ *Contracting Officer*. All costs associated with uncovering and making repairs where non-inspected work has been performed shall be borne by the Contractor.

- D. The Contractor shall cooperate with the ~~Engineer~~ *Contracting Officer* and 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~~ *Contracting Officer*, will be necessary to determine the quality and adequacy of the work.

1.08 JOB CONDITIONS

A. Construction Power

1. 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.
2. When required, provide all equipment, materials and wiring in accordance with the applicable codes and regulations.
3. Upon completion of the project, remove all temporary services, equipment, material and wiring from the site as the property of the Contractor.

B. Equipment Storage

1. The Contractor shall provide adequate protection for all equipment and materials during shipment, storage and construction.
2. Equipment and materials shall be completely covered with two layers of plastic and set on a pallet above grade so that they are protected from weather, wind, dust, water, or construction operations.
3. Equipment shall not be stored outdoors without the approval of the ~~Engineer~~ *Contracting Officer*. 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.

- C. The project site is located in Northern California where outside temperatures vary between 10 deg F. to 110 deg F. Humidity in this area will range from 10% to 100%.

1.09 SUBMITTAL AND DRAWING REQUIREMENTS

- A. The Contractor shall ensure all equipment suppliers provide the submittal documentation required in this section. Submittals shall be complete, neat, orderly, and indexed. The Contractor shall check all submittals required under this Division for the correct number of copies, adequate identification, correctness, and compliance with the Contract Specifications and Drawings, and initial all copies certifying compliance.

- B. Identify all submittals by submittal number on letter of transmittal. Submittals shall be numbered consecutively and resubmittals shall have a letter suffix. For example:
1. 1st submittal: 1
 2. 1st resubmittal: 1A
 3. 2nd resubmittal: 1B, etc.
- C. Within calendar 45 days after contract award the Contractor shall furnish to the ~~Engineer~~ *Contracting Officer* six (6) sets of all submittals required for this Division except for training documents and test procedures.
- D. Normally, the ~~Engineer~~ *Contracting Officer* will review and return two (2) copies of the submittals within 14 calendar days after receipt, exclusive of any time awaiting clarification or further information.
- E. The reviewed submittals will be annotated "Make Corrections Noted", "No Exceptions Noted", "Revise and Resubmit Noted Items", or "Rejected without Review". The following actions shall then be taken by the Contractor:
1. "No Exceptions Noted" - The Contractor may proceed with the work covered in this submittal. No resubmission is necessary.
 2. "Make Corrections Noted" - The Contractor may proceed with the work covered in this submittal incorporating the changes noted. However, the Contractor shall revise the submittal in accord with the changes noted and resubmit six (6) copies of drawings, bill of materials, and catalog data denoting changes within 14 calendar days when requested by the ~~Engineer~~ *Contracting Officer* for record keeping purposes.
 3. "Revise and Resubmit Noted Items" - The Contractor shall not proceed with the work covered in this submittal. The Contractor shall revise and correct the submittal in accordance with the comments and resubmit six (6) copies within 14 calendar days for approval.
 4. "Rejected without Review" submittal - The Contractor shall not proceed with the work covered in this submittal. The Contractor shall revise and correct the submittal in accordance with the specifications, and resubmit six (6) copies within calendar ~~14 days~~ *30 Days* for approval.
- F. Resubmittals shall address all comments by the ~~Engineer~~ *Contracting Officer*. Partial resubmittals may be returned without review at the discretion of the ~~Engineer~~ *Contracting Officer*. The Contractor shall be responsible for the ~~Engineer~~ *Contracting Officer*'s review cost for each resubmittal in excess of the second resubmittal. These costs will be back-charged to the Contractor and will be deducted from his progress payments.

- G. The Contractor 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. Time extensions will be allowed because of failure to properly schedule submittals.
- H. No material or equipment shall be delivered to the job site until the submittal for such items has been reviewed by the ~~Engineer~~ *Contracting Officer* and marked "no exceptions noted" or "make corrections noted".
- I. The Contractor shall coordinate submittal with the work so that project will not be delayed. This coordination shall include scheduling the different categories of submittal, so that one will not be delayed for lack of coordination with another.
- J. The equipment specifications have been prepared on the basis of the equipment first named in the Specifications. The Contractor 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 to meet Specifications all at no additional cost to the ~~Owner~~ *Government*.
- K. The decision of the ~~Engineer~~ *Contracting Officer* governs what is acceptable as a substitution. If the ~~Engineer~~ *Contracting Officer* considers it necessary, tests to determine equality of the proposed substitution shall be made, at the Contractor's expense, by an unbiased laboratory that is satisfactory to the ~~Engineer~~ *Contracting Officer*.
- L. 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 subtab section. Also list the project name, contract number and equipments supplier's name, address, phone number, and contact person on the index page.
 3. Field equipment shop documents, panel equipment shop documents, drawings, and bill of materials shall be grouped under separate tabs. Shop documents shall be ordered in the same sequence as their corresponding Contract specification subsection.
 4. All spare parts shall be listed separately at the end of the Bill of Materials list.

5. Data summary sheets shall be provided to subtab all shop documents for each individual piece of instrumentation. Data summary sheets shall be bright yellow or blue for easy identification.

The data summary sheets shall have the following information preceding their corresponding shop documents:

- a. Instrumentation type and tag name as used on the Contract Drawings or schedules.
 - b. Location/description of assembly at which it is installed.
 - c. The manufacturer's model number, part number or other designation. This shall include the specific numbers of all proposed options.
 - d. Range, span, engineering units, input and output characteristics.
 - e. Description of component as it relates to the model number. For each portion of the model number the associated description shall be shown.
 - f. Contract specification subsection number.
6. Drawings may be bound in separate 11 x 17 binder or included with the 8.5 x 11 binder if folded such that the title block is visible with drawing folded. Drawings that are "C" or "D" size are not allowed.
- M. 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 (as a minimum):
1. Table of Contents
 2. Comment Letter: The Project ~~Engineer~~ *Contracting Officer* of the System Supplier shall note all deviations from Contract Documents and the reason(s) for the deviation. He may use this forum to inform the ~~Engineer~~ *Contracting Officer* or installing Contractor of important information related to the project. RFIs must be submitted separately.
 3. Bill of Materials: The Contractor and System supplier each shall provide Bill of Material for electrical components formatted as shown in Section 16600 Appendix "A". Generic names or part numbers as defined by a distributor or Integrator are not acceptable. Only the originating manufacturer's name and part number shall be listed.
 4. Shop Drawings:
 - a. Equipment elevations with enclosure details drawn to scale.
 - b. Electrical One-line and Elementary diagrams
 - c. Computer I/O diagrams.
 - d. Interconnection diagrams
 5. Catalog Data shall include the following:
 - a. Instrumentation data summary sheets (by Contractor)
 - b. Manufacturer's catalog ordering information

- c. Manufacturer's description or equipment features
 - d. Physical size and mounting details
 - e. Range and/or calibration
 - f. Input/output signal characteristics
 - g. Requirements for electric power, air, and/or water supply
 - h. Options selected and available
 - i. Materials of construction of components
6. Program Software Documentation
- a. Programming hardcopy
 - b. Programming disk copy
- N. Deviations from the Contract documents shall **not** be incorporated into the work without prior written approval of the ~~Engineer~~ *Contracting Officer*. A "Change Order" directive from the ~~Engineer~~ *Contracting Officer* is required prior to incorporating any deviation from the Contract documents that has costs associated. The cost differential associated with this change order must be negotiated with the ~~Engineer~~ *Contracting Officer* to amend the Contract to reflect the costs or savings.
- O. Exceptions to the Specifications or Drawings or equipment or procedures submitted as "equal" to specified equipment shall be clearly identified by the equipment supplier in a letter at the front of the submittal. Submittal data for "equal" equipment or procedures shall contain sufficient details so a proper evaluation may be made by the ~~Engineer~~ *Contracting Officer*. The Contractor is responsible for verifying proper application/operation of substituted equipment.
- P. All shop and interconnect drawings shall be generated with a computer utilizing the AutoCAD 14 or later drafting package. Standard preprinted drawings simply marked to indicate applicability to the Contract will not be acceptable. Drawings shall be prepared in a professional manner and shall have borders and a title block identifying the project, system, drawing number, AutoCAD file name, project engineer, date, revisions, and type of drawing. Drawings shall be no smaller than 11" x 17" and printed with a laser jet printer or plotted in ink white paper. The lettering shall be legible and no smaller than 0.075 inch in height.
- 1. The Contractor shall submit for approval the proposed drawing format for each type of drawing or diagram specified. The Contractor shall not go into production with the drawings or diagrams for this project until the ~~Engineer~~ *Contracting Officer* has given written approval of the submitted proposed drawing format submittal.
 - 2. Shop drawings shall be provided with minimum drafting details as illustrated on the Contract electrical drawings. Diagrams shall carry a uniform and coordinated set of wire colors, wire numbers, and terminal block numbers.

Q. Shop Drawings - Shop drawings shall be furnished for each electrical panel even if one was not shown explicitly on the Contract drawings. Each shop drawing shall include the following as a minimum:

1. Electrical one line diagrams detailing all devices associated with the power distribution system.
2. Detailed analog and digital I/O diagrams showing the wiring requirements for each instrument or device connection. Reference the Contract Drawings for an example of each I/O card drawing requirements. If one is not included in the Contract Drawings, then one may be obtained from the ~~Engineer~~ *Contracting Officer* upon request.
3. Elementary diagrams shall be provided for all relay logic, power supplies, and other wiring not shown on the loop diagrams. All elementary diagrams shall be drawn in JIC EMP/EGP format and standards. Show rung number, coil and contact cross references on all drawings.
4. Enclosure layout diagrams; show all front panel 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. Submit full size drawing of all nameplates and tags to be used on the project. The ~~Engineer~~ *Contracting Officer* has the right to adjust nameplate engraving titles during submittals at no additional cost to the ~~Owner~~ *Government*. 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.

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 questionable 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 provided they are favorably reviewed by the ~~Engineer~~ *Contracting Officer* 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~~ *Contracting Officer*, 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.

2.02 NAMEPLATES & TAGS

- A. Equipment exterior nameplates - Nameplate material shall be rigid laminated black plastic 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 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~~ *Contracting Officer* in the submittal.

1. For each major piece of electrical equipment provide a manufacturer's nameplate showing the Contract specified name and number designation, and pertinent ratings such as voltage, # of phases, ratings, 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.
 3. Where no inscription is indicated in the Contract documents, furnish nameplates with an appropriate inscription providing the name and number of device.
- B. Equipment Interior Nameplates - 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. The size of the nameplate tape shall be no smaller than 1/2" in height with 3/8" lettering unless otherwise approved by the ~~Engineer~~ *Contracting Officer*. Securely fasten nameplates in place on a clean surface using the adhesion of the tape. 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. Stamp the nameplates with the inscriptions as approved by the ~~Engineer~~ *Contracting Officer* in the submittal.
- C. Equipment Tags - When there is no space or it is impractical to attach an engraved plastic 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. 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~~ *Contracting Officer*. The tag shall be attached to the equipment with stainless steel wire of the type normally used for this purpose.

2.03 COMPONENTS

A. SWITCHES AND PUSHBUTTONS

1. Switches (HS) and pushbuttons (HC) for general purpose applications shall be water and oil tight as defined by NEMA 4X, corrosion resistant as defined by NEMA ICS 6-110.58, U.L. listed, standard 30 mm diameter, with plastic holding nut.
2. Switches and pushbuttons shall have contacts rated NEMA A600 or 10 amperes continuous and 600 VAC. Provide NO and NC contacts as required.
3. Engraved black legend plates shall be provided to define each switch and pushbutton function.

4. Selector switch handles and pushbutton caps shall be black unless otherwise noted on drawing. Lock-out stop caps shall be red.
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.
6. Pushbuttons and selector switches in hazardous locations shall have hermetically sealed contacts or explosion proof enclosures.
7. Lockout stop pushbuttons shall include padlocking attachment. Pushbutton type shall be coordinated with padlock attachment type.
8. Switches and pushbuttons shall be Allen-Bradley 800H, or approved equal.

B. INDICATING LIGHTS

1. Indicating Lights for general purpose applications shall be NEMA 4X, corrosion resistant as defined by NEMA ICS 6-110.58, U.L. listed, 30 mm diameter, with plastic lens, plastic holding nut, and miniature bayonet lamp base.
2. Lamp shall be full voltage 120 VAC with 28 chip (min) High Intensity LED.
3. Indicating lights shall have contacts rated NEMA A600 or 10 amperes continuous and 600 VAC. Provide NO and NC contacts as required.
4. Engraved black legend plates shall be provided to define each lights function.
5. Indicating light type and color of lens shall be as shown on the Drawings or specified in the Contract documents. Lamp color shall be as follows:
 - a. Open/On Green
 - b. Closed/Off Red
 - c. Alarm Amber
 - d. Power On White
6. Indicating lights designated "PTT" on wiring diagram or shown with push-to-test wiring shall be provided with a push-to-test switch and wiring.
7. Indication lights shall be Allen-Bradley 800H, or approved equal.

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 shown on the Contract drawings. Coil voltage shall be 120 VAC unless otherwise described or shown on the Contract drawings. Relays and timers shall be designed for continuous duty. All relays shall be U.L. listed. All relays and sockets shall be the product of a single manufacturer. 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. Sockets for plug-in relays and timers shall be standard industrial type din rail mount with barrier type pressure plate screw terminals. Sockets shall be rated 300 VAC, 10 amps minimum.
 - a. Blade 8 or 11 pin for coil voltage above 90 volts AC or DC.
 - b. Octal 8 or 11 pin for coil voltage below 90 volts AC or DC.
3. Control relays (CR) shall be plug-in type with neon indicating lights and clear see-through sealed housing to exclude dust. Provide IDEC Type RR, or approved equal. Two form-C contacts (minimum) shall be provided on each relay.
4. Time delay relays on energization (TR-TDOE) shall be solid state plug-in relays with adjustable timer ranges from 1 second to 10 hours selectable unless other ranges are shown. Provide LED timer energized indicator lamp. Time delay relays shall be IDEC RTE, or approved equal.
5. Time Delay Relays (TR-TDOD)
 - a. Time delay relays on de-energization (TR-TDOD) (continuous power control input) shall be solid state plug-in relays with a timer adjustable range from 1 second to 10 hours selectable unless other ranges are shown. Provide LED timer energized indicator lamp. Time delay relays shall be IDEC RTE, or approved equal.
 - b. Time delay relays on de-energization (TR-TDOD) (true off) shall be solid state plug-in relays with a timer adjustable range from 1 second to 10 minutes unless other ranges are shown. True off time delay relays shall be IDEC GT3F-2, or approved equal.

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 bolt-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 Cutler-Hammer, G.E., ITE, or approved equal.
2. Each 480 volt circuit breaker shall have a minimum interrupting capacity of 42,000 amperes. Each 120 or 208 or 240 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.

F. CONTROL POWER TRANSFORMER

1. Control power transformer shall be epoxy encapsulated for superior dust and moisture protection. The internal wiring shall be copper and have 105 deg. C insulation rating. The unit shall feature barriered screw terminals for connection to electrical circuits. Provide with time-delay, slow-blow secondary fuse rated to protect the transformer and interrupt 10,000 amperes at 120VAC. Two primary fuses rated to interrupt 42,000 amperes at 480 VAC shall be provided. Transformer minimum size and voltage ratings shall be as shown on Contract drawings. Control power transformer shall be Micron Impervitran or approved equal.

G. VOLTAGE MONITOR/RELAY (PFR)

1. The voltage monitor relay (PFR) shall continuously monitor the three phases for power loss, low voltage, phase loss, and phase reversal. The time/date function shall time stamp failures in the electrical system. The voltage monitor shall have a drop-out voltage adjustment and fault delay adjustment from 0.1 to 15 seconds and delay on make/break adjustment from 0.1 to 10 minutes. The unit shall have a status/fault indicating 2 line LCD alphanumeric text display. Voltage monitor/relay shall be 3 phase multiple function Watsco 8002 series Linebacker Phase Protector, or approved equal.

H. SURGE SUPPRESSOR

1. The surge suppressor shall be rated for use on a 480 VAC, 3 phase WYE system. The nominal line voltage of the surge suppressor shall be 277V L-N with a maximum continuous line voltage of 320V L-N. The surge suppressor shall dissipate a minimum of 80,000 amps single pulse surge current over a 8x20 usec period. The surge suppressor shall dissipate a minimum of 2560 joules transient energy per phase. Provide external fusing as required by the manufacturer for proper operation. The surge suppressor shall be Leviton 32277-DY3, or approved equal.

2.04 DEVICES

A. SWITCHES

1. General purpose specification grade switches shall be manufactured in accordance with UL 20. Switches shall be one pole rated, 20 amps, at 277 VAC, 1HP at 120 VAC, 2 HP at 240 VAC. Switches shall have copper alloy contact arm with silver cadmium oxide contacts. Switches shall have slotted terminal screws and a separate green grounding screw. Provide Leviton 1221, or approved equal.
2. Special purpose switches shall be provided with the amperage, voltage, and configuration as shown on the Drawings. Switches used as motor disconnects for single phase motors shall be horsepower rated.

B. 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 ivory. General purpose receptacles shall be specification grade Leviton 5362-I 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. "Daisy Chain" connecting multiple receptacles from one GFI unit is not acceptable. GFI receptacles shall be Leviton 6898, or approved equal.

2.05 UTILITY METERING SWITCHBOARD

A. Metering Panel

1. Provide front accessible, self contained meter/main power utility metering panel. Voltage, phase, AIC and continuous amperage rating shall be as shown on Contract Drawings. Panel will include meter socket, factory installed breaker(s) and test by-pass facility.
2. Design entrance features per NEC, local codes, and serving Utility requirements.
3. Metering enclosure shall be NEMA 3R construction for underground utility service. Enclosure shall be manufactured from galvanized 14 ga. (min) sheet steel. The cabinet shall be finished with ANSI 61 gray enamel paint. Provide pad mount, surface mount or flush mount cabinet per installation detail.
4. Utility metering switchboard shall be Cutler Hammer Pow-R-Line, Tesco Metering Switchboard or approved equal.

B. Switchboard

1. Switchboard shall be front accessible with group mounted, buss connected circuit protective devices. Where provisions for future circuit protective devices are required, space for the device, corresponding vertical buss, device connectors and the necessary mounting hardware shall be supplied.
2. Distribution section shall meet all requirements per NEC, local codes, and as defined in the drawings.
3. Power buss shall be copper, 3 phase, 4 wire, 480 volt, ~~42,000 AIC~~ 65,000 AIC minimum (or as shown otherwise in the drawings).
4. Ground buss shall be copper and rated per NEC relative to the power bus amperage rating.
5. Switchboard enclosure shall be NEMA rated as shown in the drawings.
6. Utility metering switchboard shall be Cutler Hammer Pow-R-Line, or approved equal.

2.06 RADIO SYSTEM

A. RADIO MODEM

1. Unlicensed 900 Mhz spread spectrum radio for continuous communications to multiple addresses. The radio system shall be addressable to minimize interference from adjacent systems with different system addresses. The radio shall utilize a DB-9 RS-232 port for communications input and SMA connector for antenna lead connection output. The radio shall operate on DC voltage as shown in contract drawings. The radio shall operate to full performance over a temperature range of -30 deg C to +60 deg C. The radio shall be Data Linc SRM-6000 with diagnostics, or approved equal.

B. ANTENNA

1. Each antenna system shall be furnished and installed complete and functional for the intended use. An antenna system shall include but not be limited to, antenna, antenna pole, mounting hardware, lightning arrestor, and coaxial cables with connectors.
2. Antenna system shall be meet the following specifications:
 - a. Antenna shall be installed and supported as shown on the Contract Drawings. Support members shall have sufficient strength to withstand local wind conditions and shall be protected from sun exposure and weather damage.
 - b. Support hardware such as clamps, orientation mounts, and offset brackets

shall be steel protected with a hot dip galvanized finish or stainless steel. Clamps and mounts shall be heavy duty in order to transfer the full antenna load to the support tower or mast. Bolts and screws shall be stainless steel.

- c. The radio antenna shall be 9 dB gain, welded construction, vertically polarized, directional type Yagi, VSWR 1.5:1, 50 ohm impedance, N-female connection, Maxrad Model BMOY 8905 or approved equal.

C. TRANSMISSION CABLE

1. Provide 50 Ohm, 1/2" weatherproof coaxial cable from lightning arrestor to antenna. The coax cable shall have a corrugated outer conductor of copper, copper-clad aluminum inner conductor with foam dielectric. The coax cable shall be jacketed for corrosive environment and ultra-violet exposure. The coax cable shall be capable of a minimum bending radius of 5 inches. The cable shall be installed as one continuous length from the antenna to the lightning arrestor. Antenna cable shall be Andrew LDF4-50A 1/2" coax cable or approved equal.
2. Pigtail connector. Provide low loss connection cable for connecting the Radio antenna connection to the lightning arrestor.
3. A flange mount antenna lighting "N" connector arrestor shall be furnished on the antenna coaxial transmission line. The lightning arrestor shall be grounded using to the radio enclosure itself and directly to the ground buss by a #8 AWG or larger bonding wire. The lightning arrestor shall be a PolyPhaser IS-50NX-C2 or equal with flange mount.
4. Provide miscellaneous hardware such as grounding kits, hanger kits, and feed through assemblies.
5. The cable shall be carefully installed to prevent damage to the jacket and routed with a minimum bending radius of 8 inches.
6. Provide connector weatherproofing kits for outdoor exposed connectors and grounding strap attachments. All mating connectors that are exposed to weather shall be wrapped with a sealing material designed to protect against water and dirt entry into the connectors.

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~~ *Government*.
- E. The ~~Engineer~~ *Contracting Officer* reserves the right to halt any work that is found to be substandard or being installed by unqualified personnel.
- F. Keep the premises free from accumulation of waste material or rubbish on a daily basis. Upon completion of work, remove materials, scraps, and debris from the premises and from the interior and exterior of all devices and equipment. Refinish damaged surfaces to new condition using skilled craftsmen of the trades involved at no additional cost to the ~~Owner~~ *Government*.
- G. All equipment installed by the Contractor shall be in accordance with the Drawings and the manufacturer's recommendations & instructions and shall operate to the ~~Engineer~~ *Contracting Officer*'s satisfaction. Follow all manufacturers' instructions for handling, receiving, installation, and pre-check requirements prior to energization. After energization, follow manufacturer's instructions for programming, set-up and calibration of equipment. The Contractor shall be responsible for, and shall correct by repair or replacement, at his own expense, equipment that, in the opinion of the ~~Engineer~~ *Contracting Officer* 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~~ *Government*.

3.02 CONSTRUCTION METHODS, GENERAL

- A. All field wires and panel wires shall be per specification Section 16120 - Wire, Fuses & Terminal Blocks.
- B. Equipment shall be wired and piped by the manufacturer or supplier. Major field modifications or changes are not allowed without the written "change order"

authority by the Engineer. When field changes are made, the components, materials, wiring, labeling, and construction methods shall be identical to that of the original supplied equipment. Contractor's cost to replace or rework the equipment to match original manufacturer or supplier methods shall be done at no additional cost to the ~~Owner~~ Government.

- C. Mating fittings, bulkhead fittings, plugs, connectors, etc. required to field interface to the equipment and panels shall be provided by the supplier when the equipment is delivered.
- D. All electrical and instrumentation drawings associated with the equipment shall be provided with the equipment when it is delivered to the job site. Drawings for each piece of equipment shall be placed in clear plastic packets of sufficient strength that will not tear or stretch from drawing removal and insertion.

3.03 EQUIPMENT FABRICATION, GENERAL

- A. Panel 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.
- B. All 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. No fastening devices shall project through the outer surfaces of equipment.
- E. Each component within the equipment shall be securely mounted on an interior subpanel 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.
- F. A ground bus shall be provided in each enclosure or cabinet. 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.
- G. Minimum wire bending space at terminals and minimum width of wiring gutters shall comply with NEC tables 373-6 (a) & (b).

- H. 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.
- I. Doors shall swing freely and close with proper alignment.

3.04 EQUIPMENT SHIPMENT AND STORAGE

- A. Shipment -- Any equipment whose destination (jobsite) is more than 25 miles from the factory shall be carefully protected for shipping. All openings shall be protected by plywood securely fastened to the framework of the equipment. Equipment shall be adequately covered during local delivery.
- B. Storage -- From the time of receipt until the equipment is installed and energized, the equipment shall be considered in storage. While in storage, a 120V, 1 phase source of power shall be made available and connected to space heaters in all items of equipment so equipped. Equipment not provided with space heaters shall be provided with a light bulb or electric heater while in storage to prevent moisture condensation. Unless stored indoors, it shall be a least 1 foot above grade covered with at least 2 layers of heavy polyethylene plastic sheets and anchored to prevent damage by high winds. All equipment shall be protected from dust and moisture prior to and during construction.

3.05 DAMAGED PRODUCTS

- A. Damaged products will not be accepted. All damaged products that cannot be repaired to the satisfaction of the ~~Owner~~ *Government* shall be replaced with new products at no additional cost to the ~~Owner~~ *Government*.
- B. Minor cosmetic damage shall be repaired by spray painting, after properly preparing the surface, all scratches or defects in the finish of the equipment. Only identical paint furnished by the equipment manufacturer shall be used for such purposes.

3.06 FASTENERS

- A. Fasteners for securing equipment to walls, floors, and the like shall be stainless steel. The minimum size fastener shall be 3/8 inch diameter.
- B. Concrete pad with stainless steel anchor bolts shall be provided for the MCC.

3.07 INSTALLATION, GENERAL

- A. Install all products per manufacturer's recommendations and the Drawings.
 - 1. 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~~ *Government*:

2. Provide additional devices, wiring, conduits, relays, signal converters, isolators to complete interfaces of the electrical and instrumentation system.
3. Changing normally open contacts to normally closed contacts or visa versa
4. Adding additional relays to provide more contacts as necessary.
5. All programmable devices shall be programmed, set-up and tested by the Contractor prior to startup. Programming and set-up parameters shall be adjusted or changed as directed by the ~~Owner~~ *Government* or ~~Engineer~~ *Contracting Officer* during start-up and throughout the warranty period, at no additional cost to the ~~Owner~~ *Government*.
6. Coordinate with the ~~Owner~~ *Government* and setup all alarm, process, and operation setpoints.
7. Keep a copy of the manufacturer's installation instructions on the jobsite available for review at all times prior to and during the installation of the associated equipment.

B. Panels and enclosures:

1. Install panels and enclosures at the location shown on the Plans or approved by the ~~Engineer~~ *Contracting Officer*.
2. Install level and plumb.
3. Seal all enclosure openings to prevent entrance of insects and rodents.
4. Clearance about electrical equipment shall meet the minimum requirements of ~~1999~~ *2002* NEC 110.26

C. Conduits and Ducts:

1. Install all conduits and ducts per 16110 - Conduit, Devices, Boxes & Grounding System.

D. Wiring, Grounding, and Shielding:

1. Observe proper grounding and shielding practices as this application environment generally noisy. The shield of shielded cables shall be terminated to ground at one end only, the origination end. The shield at the other end shall be encased in an insulated material to isolate it from ground.

E. Cutting and Patching:

1. The Contractor shall do all cutting and patching required installing his work. Any cutting which may impair the structure shall require prior approval by

the ~~Engineer~~ *Contracting Officer*. Cutting and patching shall be done only by skilled labor of the respective trades. All surfaces shall be restored to their original condition after cutting and patching.

F. Cleaning and Touch up:

1. At the completion of the work, all parts of the installation, including all equipment, exposed conduit, and fittings, shall be thoroughly cleaned of grease and metal cuttings. Any discoloration or other damage to parts of the building, the finish, or the furnishings, due to the Contractor's failure to properly clean the system, shall be repaired by the Contractor without cost to the ~~Owner~~ *Government*.
2. The Contractor shall thoroughly clean any of his exposed work requiring same.
3. Vacuum and clean the inside of all electrical and instrumentation enclosures prior to applying power.
4. The Contractor shall paint scratched or blemished surfaces with the necessary coats of quick drying paint to match existing color, texture and thickness. This shall include all prime painted electrical equipment including but not limited to enclosures, poles, boxes, devices etc.

3.08 OPERATING AND MAINTENANCE INSTRUCTIONS

- A. At time of completion, the Contractor shall provide a period of not less than 6 hours training for instruction of operation and maintenance personnel in the use of systems. Instruct all personnel at one time in one session. Make necessary arrangements with manufacturer's representative. Provide product literature and application guides for user's reference during instruction.
- B. Provide six (6) Operation and maintenance manuals bound in a three ring binder and shall provide at least the following as a minimum.
 1. A comprehensive index.
 2. A complete "Record" set of favorably reviewed electrical submittals as provided under subsection SUBMITTAL AND DRAWING REQUIREMENTS illustrating all components, piping, and electrical connections.
 3. A complete list of the equipment supplied, including serial numbers, ranges, catalog cuts, and pertinent data.
 4. Full specifications on each item.

5. Detailed service, maintenance and operation instructions for each item supplied. Schematic diagrams of all electronic devices shall be included. A complete parts list with stock numbers shall be provided for the components that make up the assembly. All of these shall be originals, no copies.
 6. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.
 7. Complete listing of as-built OI and PLC setup and programming listings.
- C. At the end of the project these manuals and drawings shall be updated to show "as-built" conditions.
- D. Provide two (2) sets of compact disk (CD) containing all drawings prepared for this project in AutoCAD format, updated to reflect as-built conditions.

3.09 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 instrumentation equipment throughout the warranty period.
- C. The following spare parts shall be provided to the ~~Owner~~ *Government* as part of this Contract:
1. Ten (10) fuses for each type of fuse.
 2. Ten (10) lamps for each type of light.
 3. Two (2) relays for each type of control, and time delay relay.
 4. One (1) power fail relay.

3.10 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~~ *Government* 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 & software 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. Prior to "final acceptance", the Contractor shall furnish to the ~~Engineer~~ *Contracting Officer* a listing of warranty information for all manufacturers of materials and equipment used on the project. The listing shall include the following:
1. Manufacturer's name, Material and equipment description, equipment number, part number, serial number, and model number.
 2. Manufacturers service contact person, phone number, and address.
 3. Warranty expiration date.
- D. Software support which shall be provided by the supplier:
1. Free technical PLC / OI software and hardware configuration phone support for a period of one year. PLC / OI phone support shall be provided directly from the person(s) that configured the PLC / 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 PLC / OI software configuration error that is discovered within the warranty period, at no additional cost to ~~Owner~~ *Government*. Updated documentation for each "operation and maintenance" manual and new floppy disks of updated software shall be provided for each correction.
- E. The Contractor shall provide all labor and material to troubleshoot, replace, or repair any hardware or software that fails or operates unpredictable during the warranty period, at no additional cost to the ~~Owner~~ *Government*.

- F. Each time the Supplier's repair person responds to a system malfunction during the warranty period, he or she must contact the designated ~~Owner~~ *Government* 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~~ *Government* Staff. The ~~Owner~~ *Government* reserves the right at its sole discretion to deny operations requested by the Supplier.
- G. The Contractor shall provide to the ~~Owner~~ *Government* the names, addresses and phone numbers of service personnel.

3.11 FINAL ACCEPTANCE

- A. Final acceptance will be given by the ~~Engineer~~ *Contracting Officer* 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. At the end of the project, following the completion of the field tests, and prior to final acceptance, the Supplier shall provide the following to the ~~Owner~~ *Government*:
 - 1. Each "operation and maintenance" manual shall be modified or supplemented by the Supplier to reflect all field changes and as-built conditions.
 - 2. Two (2) disk copies of all final documentation to reflect as-built conditions.
- C. Keys: Submit two sets of all keys for locks supplied on this project. 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.

END OF SECTION

PART 1: GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall install, ready for use, the conduit, devices, boxes, & grounding system as specified herein. 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 required 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 conduit, devices, boxes, & grounding system as shown on the Drawings, included in these Specifications, or required for fully operating facilities.
- C. Work includes that specified in Section 16010 - Electrical.
- D. The conduit, devices, boxes, & grounding system scope of work includes:
 - 1. Provide and install miscellaneous trenching, conduits, junction boxes, field interconnection wiring, and associated hardware.
 - 2. Provide all necessary hardware, conduit, wiring, fittings, and devices to connect the electrical equipment provided under other Sections.
 - 3. Provide disconnect switches at all control panels and motors to disconnect all sources of power.

1.02 SUBMITTALS AND DRAWINGS

- A. Provide submittals and drawings as specified in Section 16010 - Electrical, SUBMITTAL AND DRAWING REQUIREMENTS.

PART 2: PRODUCTS

2.01 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 for future use shall be capped with coupling and plug. Identify each end with conduit labels.
 5. Conduits to be abandoned that protrude above graded shall be cut flush and filled with grout.
 6. Conduit Tags
 - a. All conduits listed in the "Conduit and Wire Routing Schedule" shall have conduit tags at both ends of each conduit run. This shall include ends within underground pull boxes.
 - b. All conduits shall have temporary tags during construction. Temporary tags may be made from duct tape with hand written ink marking or suitable equivalent. Temporary tags shall be removed by Contractor at time of installation of permanent tags.
 - c. Tag material shall be rigid laminated red plastic with white lettering. The size of the tag shall be 1" diameter. No letters are allowed smaller than 1/4". 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. Labeling shall be neatly installed for visibility and shall be clearly legible. Conduit tags shall be Brady Custom B-1 or approved equal.
 7. Mounting and Support Channels
 - a. Channels shall be cold formed from prime pickled and oiled mild strip steel. Cross section of a single channel shall be 1-5/8" x 1-5/8"

and cross-section of a double channel shall be 1-5/8" x 3-1/4". The channel wall thickness shall be 12 gage.

- b. Channel material and finish shall be per the following table unless otherwise noted in the drawings. Brackets, fittings and hardware shall be of the same material and finish.

Location	Material
Indoors NEMA 12	Hot dipped galvanized
Outdoors NEMA 4	Stainless Steel
Corossive areas NEMA4X	PVC bonded, 40 mil, factory applied

- c. Channels shall be used for mounting equipment to walls and for supporting conduit runs. Double channel type shall be used for fabricating equipment mounting rack as required and as detailed on the drawings. All field cut surfaces of the channels shall be covered with matching zinc paint and PVC.

B. GALVANIZED RIGID STEEL CONDUIT - (GRS)

1. Manufactured from high-strength steel and hot dipped zinc galvanized inside and out. Conduit shall meet UL standards for Rigid , UL 6 and conform to NEMA RN 1. Conduit shall be capable of being used as an equipment grounding conductor per NEC 250-91b
2. Provide galvanized rigid steel factory sweeps and elbows for 90 degree transitions.
3. Cast fittings and device boxes shall be malleable iron or aluminum. Appleton type FS/FD or approved equal.
4. All fittings, hubs, couplings, pulling elbows and connectors shall be threaded-type; set-screw type and compression-type are not acceptable.
5. Pipe threads shall be treated with T & B "Kopr-Shield".
6. 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. Galvanized Rigid Steel conduit with a 40-mil thick polyvinylchloride exterior coating and a urethane interior coating. The bond of the PVC to the substrate must be stronger than the tensile strength of the PVC.
2. Provide PVC coated galvanized rigid steel factory sweeps and elbows for

90 degree transitions.

3. Cast fittings and device boxes shall be malleable iron or aluminum with a 40 mils thick PVC coating. Robroy type FS/FD or approved equal.
4. Provide PVC coated threaded-type fittings, hubs, pulling elbows, couplings, and connectors; set-screw type and compression-type are not acceptable. Form 8 conduit fittings, 1/2" through 2", must have a tongue-in-groove gasket to effectively seal out the corrosive elements.
5. Pipe threads shall be treated with conduit interior urethane touch up compound.
6. All junction and metal pull boxes shall be galvanized with exterior surfaces PVC coated to 40 mils thickness.
7. Unistrut, strut clamps, pipe straps, and clamp back spacers, shall have 40 mil thick PVC coating. All mounting anchors shall be stainless steel.
8. Conduits entering enclosures shall be fitted with insulated grounding bushing; OZ/Gedney "HBLG " or approved equal. All grounding bushings shall be tied to the grounding system with properly sized bonding conductors per the NEC code.
9. GRS-PVC conduit to be Robroy Plasti-bond Redhot or approved equal.

D. EMT CONDUIT, ELECTRICAL METALLIC TUBING

1. Shall be thinwall electroplated galvanized steel suitable for indoor and outdoor use with 90 C wires, and shall conform to UL 797.
2. Where exposed and below 8 feet from floor fittings and device boxes shall be malleable cast iron or aluminum. Appleton type FS/FD or approved equal. Where concealed in walls or ceilings or above 8 feet from floor, device boxes may be stamped steel.
3. All fittings, hubs, couplings, pulling elbows and connectors shall be compression-type, set screw type are not acceptable.

E. PVC CONDUIT, SCHEDULE 40 or 80 (PVC-40, PVC-80)

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 unless otherwise noted.
4. Elbows, and risers shall be per exposed conduit transition detail. PVC conduit is not allowed above ground except where specifically called out on the drawings.
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.

F. LIQUID TIGHT FLEXIBLE METAL CONDUIT - (FLEX)

1. Flexible metal conduit shall be liquid –tight, shall have moisture- and oil-proof PVC jacket extruded over a galvanized, flexible steel conduit, and shall conform to UL 360.
2. Connectors:
 - a. Outdoors when extension of GRS-PVC: PVC coated galvanized steel with insulated bushings.
 - b. Outdoors when extension of GRS or PVC: Galvanized steel with insulated bushings
 - c. Indoors: Galvanized steel with insulated bushings.
3. Final connections to vibrating equipment such as motors, heaters and fans shall be made with liquid tight flexible conduit.
4. Flexible conduit lengths shall not be greater than 36 inches for sizes up to 2 ½” and 48 inches for 3” and larger conduit.
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.

2.02 DEVICE BOXES

A. BOXES

1. Device boxes shall be of zinc-galvanized malleable iron or cast aluminum 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. Box dimensions shall be in accordance with size, quantity of conductors, and conduit clearances per NEC articles 370 requirements.

3. Boxes exposed to the weather or in moist locations shall be weatherproof (WP) by means of gasketing under a weatherproof cover.
4. Boxes connected to GRS-PVC conduit runs shall be PVC coated with 40 mil coating.

B. DEVICE PLATES and COVERS

1. Indoor general purpose device plates and covers shall be stainless steel. Plates or covers shall be attached with stainless steel screws. An engraved plastic label denoting circuit breaker number and panelboard name shall be affixed to each cover with #4 screws.
2. Weatherproof switch, outlet, and receptacle boxes shall be fitted with gasketed covers rated for wet locations in accordance with NEC 408-8. Each access cover shall have a padlockable cover to maintain security and weatherproof integrity even when a plug is connected to the receptacle. Screws and hinge springs shall be stainless steel. Weatherproof access covers shall be Leviton 5977-CL, Cooper 4966, or approved equal.

2.03 PULL BOXES

A. JUNCTION BOXES

1. Where required for best installation or where specifically called out in the drawings, junction boxes shall have JIC type construction with hinged door, NEMA 4X rating, manufactured of type 304 stainless steel. Door shall be fastened with stainless steel screws. No devices, screws, rivets, or bolts shall protrude through the exterior surface unless specifically shown on the drawings. Boxes shall be Circle AW, or approved equal.

B. UNDERGROUND BOXES

1. Underground pull boxes, where shown or required by length of conduit runs, shall be prefabricated concrete type with "Christy Box" size equivalent or dimensions shown on the Drawings or larger to allow for adequate pull area. Extension sections shall be provided as necessary to reach the depth of underground conduits. All boxes shall have galvanized steel hold down bolts and hardware. Boxes located in paved areas or other areas which vehicles may travel shall be H/20 loading rated and have traffic covers. Steel covers or lids shall be galvanized. Pull box covers shall be labeled power, signal, utility, and telephone, whichever applies. Pull boxes shall be Christy Concrete Products, Brooks or approved equal.

2.04 GROUNDING SYSTEM

- A. The utility service ground shall be tied to a building ground grid consisting of a

"UFFER" and/or ground rod type grounding system.

- B. The UFFER shall consist of bare copper wire laid in the building foundation as detailed on the Contract Drawings.
- C. 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. The ground rod shall extend up for visible connection of a UL approved "ground clamp" to the ground conductors.
- D. The main ground bonding wire from the ground rod shall extend up into the utility service panel with readily visible UL approved "ground clamp" attached to the ground bus
- E. Install bare copper ground bond wires from the UFFER ground to the various locations shown on the drawings.
- F. Ground rod clamps shall be bolt-on type as manufactured by O-Z Gedney type GRC, or approved equal.
- G. Grounding conductors shall be sized as shown on the Plans or in accordance with NEC table 250, whichever is larger.
- H. Grounding and bonding wires shall be installed in all PVC conduits and nonmetallic raceways and connected to the ground bus and all equipment.
- I. Each electrical enclosure shall have a copper ground bus. 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.
- J. 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.
- K. 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.
- L. The secondary on all transformers shall be grounded.
- M. All raceway systems, supports, enclosures, panels, motor frames, and equipment housings shall be permanently and effectively grounded.
- N. All receptacles shall have their grounding contact connected to a grounding

conductor.

- O. 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.
- P. 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.

2.05 PAINTING

- A. Raceway System: Paint all exposed conduit, boxes and fittings to match the color of the surface to which they are affixed. Paint finishes shall include proper surface preparation, prime coat and final finish coat.
 - 1. Indoors: Use paint type and color specified for walls and ceilings. Do not paint conduit where paint is not required for surface behind conduit.
 - 2. Outdoors: Paint conduit with outdoor enamel paint with color to match the surface behind conduit or per installation specific detail.

PART 3: EXECUTION

3.01 WORKMANSHIP

- A. All work in this Section shall conform to the codes and standards specified in Section 16010 - Electrical.
- B. All installation labor shall be performed by qualified personnel who have had experience on similar projects. The Supplier shall employ personnel that are skilled and experienced in the installation of conduits, devices, boxes, grounding system, accessories, and assemblies. 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~~ *Government*.
- E. The ~~Engineer~~ *Contracting Officer* reserves the right to halt any work that is found to be substandard or being installed by unqualified personnel.

3.02 INSTALLATION

- A. System:
 - 1. Install all products per 16010 - Electrical, INSTALLATION, GENERAL.
- B. Conduits and Ducts:
 - 1. Exposed conduits shall be neatly arranged with runs perpendicular or level and parallel to walls. Bends shall be concentric.
 - 2. Except as expressly indicated or approved, all conduits shall be surface mount on block walls, concealed behind gypsum walls, and buried to required depth below floor slabs.
 - 3. Installation of the GRS-PVC conduits must be in accordance with the manufacturer's installation recommendations. To ensure compliance, the installer(s) must be "manufacturer certified" before installation can proceed. Certification available by contacting manufacturer's representative and attending a brief instructional course. Rob-Roy representative for Northern California is Sierra Sales Engineering, www.sierrasales.net. Certification shall be available for review by the ~~Engineer~~ *Contracting Officer* or ~~Owner~~ *Government* upon request.
 - 4. A maximum of three equivalent 90 degree elbows are allowed in any continuous run. 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. Bends shall be concentric.
6. Care shall be exercised to avoid interference with the work of other trades. This work shall be planned and coordinated with the other trades to prevent such interference. Process Pipe, mechanical and HVAC shall have precedence over conduits for routing and space requirements.
7. Seal each bottom entrance conduit into the MCC and other electrical enclosures with plugging compound sealant to prevent the entrance of gasses, insects and rodents. Plugging compound sealant shall be Gardner Bender Duct Seal or approved equal.
8. Exposed conduit stubs for future use shall be capped with coupling and plugged. Drill hole in plug for pull rope as necessary.
9. All spare conduits shall have 3/8" nylon pull ropes installed.

C. Excavation and Back Filling:

1. Trenches for conduit below floor slabs and other underground electrical conduit shall be excavated to the required depths per utility requirements or specific detail. Conduits under floor slabs shall have minimum trench depth to contain bends without any portion of the radius visible at finished grade.
2. Underground conduits outside of structures, excluding utility conduits, shall have a minimum cover of 18 inches except under roadways where minimum cover shall be 24 inches or when concrete encased. Back filling shall be done only after conduits have been inspected. Excavation and back fill of conduits shall conform to the requirements of other applicable Specifications sections unless modified on plans, and to other entities (Utilities, etc.) as required.
3. At all times during the installation of the electrical system, the Contractor shall provide barricades, fences, guard rails, etc., to safeguard all personnel, including small children, from excavated trenches.

D. Device Mounting Heights:

1. Mounting heights of fixtures and devices shall be as follows unless otherwise indicated or when height has to be adjusted to be over or under counter tops.

Wall switches	=>	48 inches
Convenience outlets	=>	18 inches
Telephone outlets	=>	54 inches
Bracket fixtures	=>	7 feet 6 inches

E. Cutting and Patching:

1. The Contractor shall do all cutting and patching required to install his work. Any cutting which may impair the structure will require prior approval by the ~~Engineer~~ *Contracting Officer*. Cutting and patching shall be done only by skilled labor of the respective trades. All surfaces shall be restored to their original condition after cutting and patching.

3.03 WARRANTY

- A. Provide warranty as specified in Section 16010- Electrical, WARRANTY.

END OF SECTION

PART 1: GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall assemble, ready for use, the electrical and instrumentation system with wires, fuses and terminal blocks as specified herein.
- B. Furnish all required labor, materials, tools, test equipment, incidentals, and services to provide a complete and operational electrical and instrumentation system with wire and electrical devices as shown on the Drawings, included in these Specifications, or required for fully operating facilities.
- C. Work includes that specified in Section 16010 - Electrical.

1.02 SUBMITTALS AND DRAWINGS

- A. Provide submittals and drawings as specified in Section 16010 - Electrical, SUBMITTAL AND DRAWING REQUIREMENTS.

PART 2: PRODUCTS

2.01 WIRING AND ELECTRICAL DEVICES

A. GENERAL

1. General

- a. The electrical and instrumentation system supplier shall provide the wiring and electrical devices specified herein and install field and internal panel wiring as shown on the Contract Drawings. This section applies to all wires or conductors used internal (non-field) to electrical equipment or external for field wiring. Wire quantity and size shall be per "Wire Routing and Conduit Schedule".

2. Power Distribution

- a. All electrical and instrumentation panels shall be equipped with a 120 VAC main power disconnect circuit breaker and power distribution circuit breakers. The main power disconnect breaker shall be a one pole breaker rated at 15 amperes. Distribution circuit breakers shall be single pole. The circuit breakers shall be mounted on a standard DIN rail, and shall be Allen - Bradley Channel Mounting Type, Cutler Hammer type BAB with finger safe cover, or equal.
- b. For each power distribution circuit breaker, a neutral return terminal block shall be installed at the bottom of the breaker rail. The neutral return terminal block shall be standard DIN rail mounted, and shall be rated to carry up to 15 amperes and accept up to two 12 AWG wires.
- c. A spare duplex outlet wired to a separate circuit shall be provided in each control and instrumentation panel. This outlet shall remain available for future use, shall be labeled "CONVENIENCE RECEPTACLE" and shall not be used to power any equipment installed by the Control and Instrumentation panel vendor.

3. Analog Signals

- a. Analog signal transmission between electric or electronic instruments shall be 4-20 milliamperes and shall operate at 24 volts DC unless otherwise specified. Milliampere signals shall be current regulated and shall not be affected by changes in load resistance within the unit's rating. Provide powered current isolators wherever the loops' load resistance exceeds the originating current signal transmitter's rating. Associated shunt resistors shall be located on rail-mounted terminal blocks. Exposed resistor leads shall be insulated with heat-shrink tubing.

B. LOW VOLTAGE WIRE AND CABLE (through 600V except instrument signals)

1. General: Low voltage conductors shall be used for power, control, lighting and miscellaneous circuits. This Section applies to all wires or conductors used internal for all electrical equipment or external for field wiring. Wire shall be new, plainly marked with UL label, gauge, voltage, type of insulation, and manufacturer's name.
2. Control and Power Wiring:
 - a. Conductors shall be copper with a minimum of 98% conductivity.
 - b. Class C stranding. Solid conductors may be used for lighting and receptacle circuits.
 - c. Insulation of all conductors and cables shall be rated 600 volt (min).
 - d. Insulation type shall be moisture and heat resistant thermoplastic NEC Type THHN /THWN, rated 90 °C in dry locations and 75 °C in wet locations, for #8 AWG or smaller. Conductors #6 AWG and larger shall be XHHW insulation.
 - e. Field wire minimum AWG sizes:
 - 1) #12 for wires used for individual conductor circuits 100 volt and above, except for PLC I/O which may be #14 AWG unless otherwise noted.
 - 2) #14 for wires used for individual conductor circuits below 100 volt.
 - f. Nonfield or equipment wire minimum AWG sizes:
 - 1) #16 for wires used for individual conductor circuits 100 volt and above.
 - 2) #18 for wires used for individual conductor circuits below 100 volt.
3. Instrument wiring:
 - a. Field: Instrument cables shall have 600V tray cable rated insulation and 100% individual shielded twisted pair #16 conductors with drain wire. Single twisted shielded pair (T.S.PR.) cables shall be Belden 9342, or approved equal.
 - b. Non-Field: Instrument cables shall have 300V rated insulation and 100% individual shielded twisted pair #18 conductors with drain wire. Single twisted shielded pair (T.S.PR.) cables shall be Belden 8760, or approved equal.
4. Manufacturer Supplied Cables
 - a. Cables and wiring for special systems provided by the manufacturer with the equipment shall be installed per the manufacturer's recommendations.

C. COLOR CODE

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

WIRES COLOR CODE TABLE

Description	Phase/Code Letter	Field wire or tape color	Non-Field Wire Color
480V, 3 Ph	A	Brown	Brown
	B	Orange	Orange
	C	Yellow	Yellow
240V or 208V, 3 Ph	A	Black	-
	B	Red (Orange if high leg)	-
	C	Blue	-
240 / 120 V, 1 Ph	L1	Black	Black
	L2	Red	-
24V Positive	24P	Pink	Pink
24V Negative	24N	Black	Black
AC Control		Violet	Red (Yellow for foreign circuits)
DC Control		Blue	Blue
Neutral	N	White	White
Ground	G	Green	Green
Shielded Pair	+	Clear (White)	Clear (White)
	-	Black	Black

2. All wires #8 and below shall have wire insulation the color specified. Wires #6 and larger may be black with color electrical tape at termination points.
3. No other colors shall be used without prior approval of the ~~Owner~~ *Government*.
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.

D. WIRE MARKING

1. All panel, enclosure and field wiring shall have wire labels on both ends of each wire. Labeling shall be neatly installed for visibility and shall be clearly legible. Each conductor of instrument shielded signal wiring shall be labeled. Wire labels

shall be machine printed with on white heat shrinkable tubing. Each label shall fit a minimum 23 characters, 3/16" in height before shrink. Tubing shall be sized for the wire and shrunk into place using an electric heat gun. Hand lettered wire labels are not acceptable and shall be replaced at the Contractor's expense. Provide Brady "Bradysleeve" or approved equal.

2. **Node Style Wire Identification** - 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.
 - a. The wire identification code for **internal panel** wiring shall be the number/letter as designated on the Contract elementary and/or approved shop drawings.
 - b. Wire labeling for **field** wiring shall contain the panel/equipment name as a prefix and the termination point name. (I.E. PLC50-A103 or P10-124). The hierarchy of label names is 1) PLC panel name, 2) MCC equipment name, and 3) Equipment name. Therefore, wires from PLC50 to the MCC50 P10 cubicle will be labeled PLC50-XXX. Wires from MCC50 P10 to field pressure switch PSH10 will be labeled P10-XXX.
 - c. Wire labels shall be exactly per interconnection submittal -- abbreviations determined in the field are not allowed. Abbreviations may be used in the wire label as submitted and approved in the interconnection drawings submittal.
 - d. Wire labels for lighting and receptacle circuits shall consist of the panel board and circuit number and a unique node number. (I.E. LP#3-A, LP#3-B, LP#3-N)
 - e. Wire labels may be omitted on "neutral jumpers" less than 8" in length.

E. FUSES AND FUSE HOLDER

1. Fuses used in circuits 200 VAC and above shall be time- delay, 13/32" x 1-1/2", and have an interrupting rating of 10,000 AIC at 500 VAC. Fuses shall be Bussman type FNQ or approved equal. Fuse holders shall be of the barrier type with fuse puller and rated 30A at 600 VAC. Fuse holders shall be Connectron NDNF1 with PF1 fuse puller or equal.
2. Fuses used in 120 VAC shall be time-delay, 1/4" x 1-1/4", and have a rating of 250 VAC. Fuses shall be Bussman type MDA or approved equal. Fuse-holders shall be of the same manufacturer, series and color as the adjacent terminal blocks and have blown fuse neon indicators. Fuse holders

shall be Entrelec ML 10/13.SFL, Allen Bradley 1492-W4 or approved equal.

3. Fuses used in signal and 24 VDC circuits shall be fast acting, 5mm x 20mm, and have a rating of 250 VAC. Fuses shall be Bussman type GMA or approved equal Fuse-holders shall be of the same manufacturer, series and color as the adjacent terminal blocks. Fuse holders shall be Entrelec M 4/8.SF, Allen Bradley or approved equal.
4. Fuses shall be sized in conformance with the NEC.

F. TERMINAL AND FUSE 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. DIN rail shall be same type as used for the relays. Install an extra DIN rail on each type of terminal strip with 20% spare terminals for future additions.
- b. Provide terminal blocks with "follower" plates that compress the wires and have wire guide tangs for ease of maintenance. Terminal blocks that 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.). 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.
- h. COLOR CODING: Color coding of terminal blocks with colored tabs or terminal labels shall be:

- | | | |
|----|-----------------|--------|
| 1) | Digital Inputs | Red |
| 2) | Digital Outputs | Yellow |
| 3) | Analog Inputs | Blue |
| 4) | Communications | Orange |
| 5) | Power | Black |
- i. Terminal blocks shall be Entrelec M4/6, Allen Bradley 1492-W4 or approved equal.
2. MCC – Motor Starter Cubicle Terminal Blocks
 - a. MCC cubicle terminal blocks shall be pull apart as supplied standard by MCC manufacturer.
 3. Power – Power terminal Blocks
 - a. Backpan mounted termination blocks shall be rated for 600V (min). The power termination blocks shall be rated to accept Copper or Aluminum cable and rated as shown on Contract one-line diagrams. Each termination block shall be provided with quantity of primary and secondary cable connections as required per installation. The power termination blocks shall be Connectron Square D or approved equal.
 - b. Unmounted termination blocks shall be constructed of aluminum and suitable for use with Aluminum and copper wire. Size and quantity of cable connections shall be as required for installation. Termination blocks shall be insulated with molded high-dielectric strength plastic covering and eliminate the need for tape insulation of electric connection. The termination block shall have removable access plugs over the wire entry and hex screw ports. Provide NSI Polaris IPL or IPLD Series terminal blocks or approved equal.

G. PANEL GROUND

1. Each electrical, control and instrumentation panel shall be provided with a 1 inch x 0.25 inch x 8 inch (minimum size) solid copper grounding bus bar, mounted on the inside of the enclosure. The grounding bar shall be mounted on insulated standoffs so that no electrical connection is made between the ground bar and the cabinet through the mounting. The ground bar shall be drilled and tapped for a 0.25-20 screws at 0.5 inch interval along its entire length.
2. An un-insulated solid copper #8 AWG ground wire shall be attached between the ground bar and the panel enclosure, and between the ground bar and the mounting panels. The ground connection to the enclosure and panel shall be made by sanding the paint finish off a small area, drilling a hole for a 0.25 inch bolt and mounting a 0.25-20 bolt to the panel to serve as grounding stud.

The grounding stud shall be attached with a nut and flat washers on both sides of the enclosure/panel, and with an inside tooth star lock washer next to the panel surface. The star lock washer shall be on the inside surface of the enclosure, and the front surface of the mounting panel. The grounding wire shall be secured to the stud with a nut and inside tooth star lock washer. These grounding points shall be located within 12 inches of the bottom to the grounding bar. Each terminal strip rail shall be individually grounded by means of a #12 AWG wire to the ground bus. The PLC rack, power supply, lightning arrester shall be similarly grounded according to the manufacturer's recommendations.

PART 3: EXECUTION

3.01 WORKMANSHIP

- A. All work in this Section shall conform to the codes and standards specified in Section 16010 - Electrical.
- B. The Supplier shall employ personnel that are skilled and experienced in the installation of wire electrical devices, 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~~ Government.

3.02 INSTALLATION

- A. System:
 - 1. Install all products per 16010 - Electrical, INSTALLATION, GENERAL.
 - 2. The panels shall be completely factory wired and tested before shipment.
 - 3. All spare PLC input / output points shall be wired to terminal blocks.
 - 4. A minimum of 20% spare unwired terminals shall be provided in each panel.
- B. Wiring Methods:
 - 1. Wiring Separation: Wires carrying 100 volts and above shall be physically separated from lower voltage wiring by using separate bundles or wire ways with sufficient distance to minimize the introduction of noise, crossing only at 90 degree angles.
 - 2. Harness: All wiring shall be neatly bundled and laced with plastic tie-wraps, anchored in place by screw attached retainer. Where space is available, wiring shall be run in slotted plastic wireways with dust covers. Wireways shall be sized such that the wire fill does not exceed 60%. Tie-wraps shall be T&B TY-RAP or approved equal.
 - 3. Retainers: Wireways, 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.
 - 4. 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.

5. Routing: 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 or bundle. Wires and cables shall have sufficient length to allow slack and to avoid any strain or tension in the wire or cable.
 - a. Wires shall be routed in slotted plastic wireways with snap covers. Wires carrying 120 VAC shall be separated as much as possible from other 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. Wireways for 24 VDC wiring shall be used for all other wires and cables. Routing of 120 VAC in combined wireways shall be minimized. Wires and cables shall be placed in the wireways 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.
 - b. Provide 2” minimum separation between wireway and terminal blocks.
 - c. Wiring not routed in wireways work shall be neatly bundled, treed, and laced with plastic ties

C. Wire terminations

1. Single wire and cable conductors shall be terminated according to the requirements of the terminal device as follows:
 - a. Crimp-on terminals: shall be UL listed, self-insulating sleeve type, with ring or rectangular type tongue, suitable for the size and material of the wire to be terminated, and for use with either solid or stranded conductors.
 - b. Terminal Blocks: Remove the last +/- 0.25 inches insulation from of the conductor and insert it under the pressure plate to full length of the bare portion of the conductor. Tighten the screw to close the pressure plate onto the conductor. No more than two conductors shall be installed in a single terminal. All strands of the conductor shall be captured under the pressure plate.
 - c. Screw-less terminals: wire shall be stripped back and inserted per the terminal manufacturer's instructions.
 - d. Motors with pigtail leads: Install unmounted power terminal blocks on the motor pigtails and the cable(s) to be connected. Terminals

shall be non-insulated set screw type applied with an allen wrench. Only one wire allowed per terminal. Install plugs in unused terminal spaces.

2. When stripping insulation from conductors, do not score or damage conductor.
3. The drain wire of shielded cables shall be covered with insulating tubing along its full bare length between the cable jacket and the terminal lug or terminal pressure plate.
4. Heat shrink shall be placed on ends of shielded cable to cover foil.
5. Condulets with wire nut connections shall be supplied for wire termination to devices with leads instead of terminals. (i.e. solenoid valves, level probe, etc.)

D. Wire Splicing

1. No wires shall be spliced without prior approval by the ~~Engineer~~ *Contracting Officer*.
2. Where splices are allowed or approved by the ~~Engineer~~ *Contracting Officer* they shall conform to the following:
 - a. Wire splicing devices shall be sized according to manufacturer's recommendations.
 - b. Splices of #10 and smaller, including fixture taps, shall be made with nylon self-insulated twist on wire nuts; T & B "Piggys", Ideal "Wing-Nut" or approved equal.
 - c. Splices of #8 and larger shall be hex key screw, two way connectors, insulated with molded high-dielectric strength plastic; NSI Polaris IPL or IPLD Series terminal blocks or approved equal.
 - d. Splices in underground pullboxes shall be insulated and moisture sealed with 3M "Scotchcast" cast resin splice kits or approved equal and shall have a date marking for shelf life.

E. Wire Installation

1. Exercise care in pulling wires and cables into conduit or wireways so as to avoid kinking, stressing the cables, or damaging the insulation. Use a UL listed pulling compound for lubrication within conduits as necessary. The raceway construction shall be complete and protected from weather before cable is pulled in. Swab conduits before installing cables and exercise care in pulling, to avoid damage to the insulation or conductors.
2. Install all cables in one continuous length unless splices are submitted and

favorably reviewed.

3. Bundle incoming wire and cables in panels. Zip-tie at intervals of 2" and neatly spread into trees and connect to their respective terminals. Allow sufficient slack in cables for alterations in terminal connections. Do not bundle, tape or tie wires within conduits.

3.03 WARRANTY

- A. Provide warranty as specified in Section 16010- Electrical, WARRANTY.

***** END OF SECTION *****

PART 1: GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall supply panelboards and power transformers as specified herein. This document describes the materials and intended operation, but does not necessarily describe all devices necessary for a functional system. All components and devices shall be furnished and installed as required to provide a complete, operable and reliable system for accomplishing the functions and meeting the performance set forth hereinafter.
- B. The Contractor shall perform complete startup and testing services for the panelboard and power transformer per section 16600-TESTING.
- C. Furnish all required labor, materials, safety equipment, transportation, test equipment, incidentals and services to provide complete and operational panelboard and power transformers as described in these Specifications, or required for fully operating facility.
- D. Work includes that specified in Section 16010 - Electrical.
- E. The panelboard and power transformer scope of work includes:
 - 1. Furnishing and installation of panelboard and power transformer.
- F. Reference drawings for panelboard and transformer location – MCC or stand-alone. If within MCC, the Contractor shall supply the MCC section with factory installed panelboard and transformer. If stand-alone, the Contractor shall install individual components with enclosures as specified herein.
 - 1. The quantity of breakers with size and number of poles as shown on panelboard schedules.
 - 2. Submittal data and drawings.
 - 3. Startup assistance.
 - 4. Panelboard testing.
 - 5. Operation and maintenance manuals.
 - 6. Warranty of all components of the panelboard and power transformer.

1.02 SUBMITTALS AND DRAWINGS

- A. Provide submittals and drawings as specified in Section 16010- Electrical, SUBMITTAL AND DRAWING REQUIREMENTS.

- B. Provide ratings and characteristics including voltage, temperature rise, KVA, efficiency, materials of construction, NEMA enclosure rating, voltage taps, and impedance.
- C. Provide catalog cuts for circuit breakers and devices.
- D. Submit panelboard schedule for approval.

1.03 OPERATING INSTRUCTIONS

- A. Provide operating instructions as specified in Section 16010- Electrical, OPERATING INSTRUCTION.

PART 2: PRODUCTS

2.01 PANELBOARDS

A. General

1. The Contractor shall furnish panelboards of a type indicated on the one-line Contract drawings and specified herein.
2. Panelboards shall comply with the applicable sections of UL, NEC, and NEMA and shall be as manufactured by Cutler Hammer, Square D, ITT or approved equal.
3. A machine-typed circuit directory with clear plastic cover shall be supplied mounted on the inside of door in a frame when equipment is shipped. Circuit directory shall be as approved in the Submittal.

B. Interiors

1. Interiors shall be completely factory assembled with bolt-on devices.
2. Full size insulated neutral bars shall be included. Neutral busing shall have a suitable lug for each outgoing feeder requiring a neutral connection.
3. Main bus bars shall be plated copper sized in accordance with UL standards to limit temperature rise on any current carrying part to a maximum of 50 degrees C above an ambient 40 degrees C maximum.
4. A copper ground and neutral bus shall be included in all panelboards with terminal screws.

C. Boxes

1. Provide minimum gutter space in accordance with the National Electric Code. Where feeder cables supplying the mains of a panel are carried through its box to supply other electrical equipment, the box shall be sized to include the additional required wiring space. At least four interior mounting studs with adjustable nuts shall be provided.

D. Trims

1. Provide a hinged door over all circuit breaker handles. Doors in panelboard trims shall not uncover any live parts. Doors shall have a catch, lock and trim.
2. Surfaces of the trim assembly shall be properly cleaned, primed and a finish coat of gray ANSI 61 or 49 or to match MCC if contained within.

3. Surface trims shall be same height and width as box for surface mount, and $\frac{3}{4}$ " (min) beyond box on all sides for flush mount.

E. Panelboard Ratings

1. Panelboards shall have voltage, phase and short circuit (AIC) ratings as shown on the drawings.
2. Breakers shall be a minimum of 100 ampere frame. Breakers 15 through 100 amperes trip size shall take up the same pole spacing.
3. Panelboards shall be labeled with a UL short circuit rating. When series ratings are applied with integral or remote upstream devices, a label shall be provided. Series ratings shall cover all trip ratings of installed frames. It shall state the conditions of the UL series ratings including:
 - a. Size and type of upstream device
 - b. Branch devices that can be used
 - c. UL series short circuit rating

2.02 POWER TRANSFORMER

- A. The power transformer shall be ventilated dry type. Voltage and KVA ratings shall be as shown on the Contract Drawings. The transformer shall be as manufactured by Cutler Hammer, Jefferson, ACME, Square D, G.E., or approved equal.
- B. Coils shall be manufactured of electrical grade copper aluminum and shall be adequately braced for short circuit ratings as defined in ANSI and NEMA standards.
- C. Transformer shall be NEMA TP-1 and EPA “Energy Star compliant” meeting all locally recognized energy efficiency requirements.
- D. Transformers rated 31KVA and above shall have two 2-1/2 percent taps above and below normal full capacity (ANFC and BNFC).
- E. The transformer shall carry full load continuously at rated voltage and frequency without exceeding the average temperature rise of 115 °C above an ambient temperature of 40 °C. Insulation shall be rated for 220 °C (UL class 220°C). Transformer shall be designed, manufactured, and tested in accordance with the applicable ANSI, NEMA and IEEE standards.
- F. For transformers installed within electrical enclosures, vibration isolators shall be installed between the transformer and its mounting surface to reduce case vibration noise. Provide adequate ventilation for heat removal per manufacturer recommendations.
- G. For stand alone transformers, the transformer housing shall be securely fastened to the mounting surface with bolted connections sized appropriately to withstand seismic zone 4 forces. Provide vibration isolators shall between housing and core.
- H. The transformer shall be finished in UL approved light gray (ANSI 61) power coat paint resistant to rust and corrosion. Provide weather shield if shown to be located outdoors.
- I. Transformer neutral shall be grounded in accordance with Article 250-26 and 450-10 of NEC and any applicable local ordinances. Installation and protection of the transformer grounding conductors and attachments shall be per NEC 250-24.

PART 3: EXECUTION

3.01 WORKMANSHIP

- A. All work in this Section shall conform to the codes and standards specified in Section 16010 - Electrical.
- B. The Supplier shall employ personnel that are skilled and experienced in the startup and testing 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. Section 16010 - Electrical, GENERAL CONSTRUCTION METHODS and GENERAL EQUIPMENT FABRICATION apply to the construction and assembly of panelboards and power transformers.
- E. Perform any required work to correct improper installations at no additional expense to the ~~Owner~~ Government.

3.02 INSTALLATION

- A. Provide installation as specified in Section 16010 - Electrical, INSTALLATION.

3.03 FIELD ASSISTANCE

- A. Provide testing as specified in Section 16600 – FACTORY AND FIELD TESTING.

3.04 WARRANTY

- A. Provide warranty as specified in Section 16010- Electrical, WARRANTY.

***** END OF SECTION*****

PART 1: GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall supply motor control centers (MCC) as specified herein. This document describes the materials and intended operation, but does not necessarily describe all devices necessary for a functional system. All components and devices shall be furnished and installed as required to provide a complete, operable and reliable system for accomplishing the functions and meeting the performance set forth hereinafter.
- B. The Contractor shall perform complete startup and testing services for the motor control center per section 16600-TESTING
- C. Furnish all required labor, materials, safety equipment, transportation, test equipment, incidentals and services to provide a complete and operational MCC as described in these Specifications, or required for fully operating facility.
- D. Work includes that specified in Section 16010 - Electrical.
- E. The MCC scope of work includes:
 - 1. Providing MCC structure and all internal components.
 - 2. Installation of the complete MCC and concrete pad per details.
 - 3. Submittal data and drawings.
 - 4. Manufacturer's representative startup assistance.
 - 5. Factory and field testing.
 - 6. Operation and maintenance manuals.
 - 7. Warranty of all components of the MCC.
- F. All wiring, wire color codes, wire labeling and terminal blocks within MCC shall be as specified in Section 16120 - Wire, Fuses and Terminal Blocks.

1.02 SUBMITTALS AND DRAWINGS

- A. Provide submittals and drawings as specified in Section 16010- Electrical, SUBMITTAL AND DRAWING REQUIREMENTS.
- B. Submit floor plan of MCC showing conduit entry areas.

1.03 RELATED SECTIONS

- A. Section 16010 – Electrical
- B. Section 16120 – Wire, Fuses and Terminal Blocks
- C. Section 16250 – Automatic Transfer Switch
- D. Section 16470 – Panelboard and Power Transformer

E. Section 16482 – Solid State Soft Starter

1.04 OPERATING INSTRUCTIONS

A. Provide operating instructions as specified in Section 16010- Electrical,
OPERATING INSTRUCTION.

PART 2: PRODUCTS

2.01 MOTOR CONTROL CENTER

A. GENERAL

1. The motor control center (MCC) shall be built and tested in accordance with:
 - a. NEMA Standards
 - b. ANSI
 - c. Underwriters Laboratories, Inc.
2. The MCC shall comply with all provisions of UL 845, and bear a separate U.L. label on each individual MCC section. All wiring, devices, and components contained within the MCC shall be individually U.L. listed. An overall UL approval and labels shall be provided for the individual MCC sections prior to delivery from the factory, field UL labeling will not be allowed.
3. The MCC shall be 600 volt rated and built to operate from incoming voltage as shown on the electrical one-line drawings.
4. The MCC fabrication shall be NEMA class II with NEMA type B wiring.
5. The MCC shall be provided with the type, capacity, and ratings of components shown on the Drawings or otherwise specified. The breakers shall be rated to withstand the fault current of 42,000 RMS symmetrical amperes or as otherwise shown in the drawings.
6. MCP breakers shall be selected to have trip and breaker size based on the service factor amperage to meet NEC ~~1999~~ 2002. When the MCP breaker size changes due to a different motor size and amperage than that shown on the Contract Drawings, the Contractor shall provide the properly sized MCP breaker at no additional cost to ~~Owner~~ *Government*.
7. All breakers shall be provided with handle padlock provisions or thru-door operators with padlock provisions.
8. The motor control center (MCC) shall be Allen Bradley Centerline, Cutler Hammer Freedom, Square D Model 6 or approved equal.

B. QUALIFICATIONS

1. MCC structures shall provide for all equipment detailed on the single line Drawings including all spares and spaces. Where possible the MCC shall be built in strict accordance with overall sizing and component layouts as detailed on the Drawings and no deviations will be allowed without prior approval of the ~~Owner~~ *Government*.

2. When physical size requirements for individual components are different than that detailed on the MCC elevation Drawings, the single line drawing shall supersede the elevation drawing and the Contractor shall furnish additional vertical and/or horizontal sections as needed to fit the electrical equipment as shown in the one-line diagram. Deviations with sufficient evidence for the change shall be submitted for approval. The Contractor is required to provide for all equipment including spares and spaces as shown on the one-line diagram.
3. All devices and component of a similar type of function (i.e., circuit breakers, contactors, control relays, timers, etc.), shall be the product of one manufacturer.
4. All starters and contactors shall be rated and designated in accordance with NEMA standards. Starters and contactors rated in amperes without manufactures published data indicating the corresponding NEMA sizes are not acceptable. Submittals shall provide cross reference data which includes details of the manufacturer compliance with NEMA standards and tests.

C. CONSTRUCTION

1. MCC section construction shall consist of a NEMA 1A enclosure fabricated from 12 ga. formed steel channels. The subframes shall be welded and bolted to longitudinal members to form the complete rigid self supporting frame. Side, back and roof covers of 14 ga. steel shall be mounted with screw fasteners for quick and easy removal. All cubicle and wireway doors shall be hinged and made of 14 ga. steel with a ½” flange to provide rigidity.
2. The MCC shall consist of standard metal-enclosed, freestanding, dead-front and dead-back vertical sections, not more than 90 inches in height and not less than 20 inches deep. The composite MCC shall consist of vertical sections that are of equal height.
3. Provide MCC with NEMA 3R weather wrap where shown on Contract Drawings.
4. Usable space for control equipment excluding the upper and lower wireways of MCC shall be 72 inches. Compartments shall be spaced in increments of six inches. Minimum compartment height shall be six inches.
5. Each section shall be provided with a horizontal top and bottom wireways. Wireways shall be readily accessible and isolated from all busing by grounded steel barriers. The bottom wireways shall have adequate conduit entrance area and shall not be obstructed by transformers, capacitors or other devices. The wireways in each section shall line up horizontally with wireways in the adjacent sections. The side panels shall be eliminated

between adjacent sections so that wires may be pulled through wireways the entire MCC length.

6. Where shown on the Drawings, isolated (4" minimum width) vertical wireways shall be provided in each section with a dedicated door(s). Vertical wireways shall connect the top and bottom horizontal wireways for cable routing. Vertical wireways shall have wire hangers for wire tie-down spaced throughout the complete vertical trough. Vertical wireway doors shall be latched by quarter turn indicating type fasteners.
7. The MCC shall be designed for front access maintenance. All wiring, bus joints, and other mechanical parts requiring tightening or other maintenance shall be accessible from the front. Rear or side access shall not be necessary for inspection or maintenance.
8. All steel work shall be immersion cleaned and phosphated to inhibit rust prior to painting. A 2 mil thick (minimum) electrostatic powder paint coat shall be applied to all surfaces and baked to thermoset. MCC compartment interior color shall be white. All other interior MCC structure surfaces shall be finished in ANSI 61 light gray color. MCC painting process shall meet UL 1332 for electrical equipment steel enclosures. No field painting will be allowed except for "touching up" of damaged areas.
9. A manufacturer's nameplate shall be attached to the MCC giving the model number, serial number, bus amps, voltage, and other manufacturer's information pertaining to the MCC construction.
10. The MCC shall be furnished completely factory assembled and shipped to the jobsite in with multiple MCC sections bolted together, maximum 100 inch wide pieces. Removable lifting angles or eyes shall be provided on the top of each MCC shipping section. Quick disconnecting terminal blocks shall facilitate field re-assembly of multiple shipping sections.
11. The MCC shall be factory inspected and witness tested by the ~~Owner~~ *Government* prior to it being shipped to the jobsite. If the MCC is shipped to the jobsite without factory inspection and testing by the ~~Owner~~ *Government*, then the Contractor shall remove the MCC from the jobsite, and return it to the factory for factory inspection and witness testing, all at the expense of the Contractor.

D. BUSS SYSTEM

1. All vertical and horizontal buss material shall be tin plated copper. Aluminum bus will not be considered equal to copper bus. All buses, except ground buses, shall be completely isolated from front compartments by steel plates or insulating material.

2. A continuous horizontal bus shall be furnished and rated as shown on the Drawings.
3. A full length vertical buss shall be furnished in each section and rated as shown on the Drawings. Current rating shall apply to the full length of the vertical bus, tapered bus shall not be allowed. Vertical busses shall be insulated and isolated with glass polyester or equivalent continuous barriers. Cutouts in the insulation covering the bus shall be provided for plug-in connections. Unused plug-in openings shall be covered with removable insulating material. Lower ends of vertical busses shall be insulated from wireway access.
4. Buses shall be sized and braced to withstand a fault of 42,000 RMS symmetrical amperes. The MCC, breakers and other components all shall be individually and as a group, rated to isolate a fault current of this magnitude.
5. A ground buss shall be provided in the bottom horizontal wireway of each section. The ground buss shall be rated as shown on the Drawings. It shall be electrically continuous the entire width of the MCC. Provide cable lugs on each end of the ground buss.

E. COMPARTMENTS

1. Compartments shall be isolated from each other by horizontal steel plates without openings that are a part of the structure itself. Draw-out units shall totally isolate enclosed equipment. All unused openings to the adjacent vertical wiring space shall be plugged. All openings used for wiring shall have insulating grommets.
2. Doors for each compartment shall be fabricated from formed sheet steel of not less than 14 gauge thickness. The door opening shall be of sufficient size to permit ready removal of any of the devices in the compartment. Doors shall be mounted on adjustable and removable pin type concealed hinges so arranged that compartment doors may be removed without disturbing compartment doors above or below. Door latches shall be quarter turn indicating type fasteners. Overload relays shall be reset from outside the enclosure by means of an insulated button mounted on the door.
3. An operator mechanism mounted on the draw-out unit shall provide the means for operating the compartment breaker or disconnect switch. The operator shall extend through an opening in the compartment door and shall clearly indicate whether the disconnect is "on", "off", or "tripped". This indication shall function whether the door is open or closed. The operating mechanism shall not be attached to the compartment door.
4. Each compartment for combination starters, breakers, and disconnect switches shall be draw-out construction, containing individual units.

Draw-out provisions shall include a positive guide rail system and stab shrouds to absolutely ensure alignment of stabs with the vertical bus. The stabs shall be tin plated copper alloy and shall provide a self aligning pressure connection. The stab design shall assure a consistent low-resistance contact with the vertical bus even after repeated insertions and removals. Power wiring to stabs shall be contained within the draw-out unit; no wire shall extend behind the unit.

5. All similar compartments shall have the same structural features and the units shall be interchangeable.
6. A mechanical interlock shall prevent opening of the door when the disconnect is in the "on" position,. This interlock shall be provided with a defeater so that authorized personnel may gain access to the compartment without interrupting service. This interlock shall also prevent unintentional closing of the disconnect when the compartment door is open. A second mechanical interlock shall prevent any possibility of removing or reinserting the draw-out unit while the disconnect is in the "on" position.
7. The operator handle mechanism shall allow padlocking of the disconnect in the "off" position with up to three padlocks.
8. Compartment interconnect wiring shall be to unit mounted, class B, pull apart terminal blocks located on the right side of the cubicle between the cubicle and the wireway.
9. Pushbuttons, selector switches, and indicating lights shall mount on a removable device panel which is part of the draw-out unit unless otherwise shown in the drawings. The device panel shall not be part of the door.
10. Compartments containing panelboards shall have a card holder on the inside of the door.
11. Compartments containing motor starters shall each have an overload heater selection table posted inside the door.
12. MCC compartments labeled as space shall have a blank hinged door and drawout relay panel installed, occupying the full space area.

PART 3- EXECUTION

3.01 WORKMANSHIP

- A. All work in this Section shall conform to the codes and standards specified in Section 16010 - Electrical.
- B. Wire, terminal blocks and wire labeling shall conform to section 16120 – Wire, Fuses and Terminal Blocks.
- C. The Supplier shall employ personnel that are skilled and experienced in the startup and testing 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.
- D. Ensure that all equipment and materials fit properly in their installations.
- E. Perform any required work to correct improper installations at no additional expense to the ~~Owner~~ *Government*.

3.02 INSTALLATION

- A. Vertical sections shall be mounted on steel channel sills continuous on two sides. The steel channel sills shall be heavy duty to meet the specific seismic requirements of this project location. These sills shall be mounted in the concrete pad to be installed per the Contract Drawings.
- B. In general, all conduit entering or leaving a MCC shall be stubbed up 1" into the bottom horizontal wireway directly below the vertical section in which the conductors are to be terminated.
- C. All motor starters that utilize changeable overload heater elements shall be furnished to the job site with the elements shipped loose. The Electrical Contractor shall check the nameplates for the full load amperage (FLA) rating of all mechanical equipment and select the appropriate overload element to be installed.
- D. Field interconnect wiring to the MCC shall be neatly grouped by compartment and bound by plastic tie wraps. All wiring shall be supported so that circuit terminations are not stressed.
- E. Provide extension handles for breakers with center of the grip of the operating handle, when in its highest position, is above 78" from floor in order to conform with NEC article 380-8.
- F. The as-built electrical drawings shall be placed in a water tight plastic wrap and shipped with the MCC to the jobsite.

- G. Provide ¼ cup of each color used for exterior paint finish of MCC to ~~Owner~~ *Government* for its use.
- H. MCC supplier to provide all necessary lugs for connection of power cables to MCC bus, breakers and motors.
- I. Base of MCC shall be adequately grouted, caulked or sealed to prevent the entry of insects and rodents.

3.03 FIELD ASSISTANCE

- A. Provide field testing as specified in Section 16010 - Electrical, TESTING.

3.04 WARRANTY

- A. Provide warranty as specified in Section 16010- Electrical, WARRANTY.

***** END OF SECTION*****

PART 1: GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall supply along with complete startup and testing services for the solid state soft starter (SSS) as specified herein. 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 required to provide a complete operable and reliable system for accomplishing the functions and meeting the performance set forth hereinafter at no additional cost to the ~~Owner~~ Government.
- B. Furnish all required labor, materials, safety equipment, transportation, test equipment, incidentals and services to provide a complete and operational SSS system as described in these Specifications, or required for fully operating facility.
- C. Work includes that specified in Division 16.
- D. The SSS system scope of work includes:
 - 1. Providing each modular solid state soft starter as shown on Contract Elementary Drawings. Solid State Soft Starter shall be provided with full speed bypass where shown on Contract Drawings. All SSSs shall be of the same manufacturer.
 - 2. Providing cooling system, mounting hardware, associated miscellaneous devices, and field control stations.
 - 3. Installation of the complete SSS system with components as specified in Section 16010 - ELECTRICAL.
 - 4. Submittal data and Drawings.
 - 5. Startup assistance.
 - 6. Field and factory testing.
 - 7. Operation and maintenance manuals.
 - 8. Warranty of all components of the SSS system.

1.02 JOB CONDITIONS

- A. Rate the equipment to meet the job conditions listed in Section 16010 – Electrical.
- B. All the SSSs shall be rated for continuous full load operation at the amperage shown in the Contract one-line diagrams.

1.03 SUBMITTALS AND DRAWINGS

- A. Provide Submittals and Drawings as specified in Section 16010.

- B. Include a record of each SSS parameter available to be changed by the user. The list shall include factory defaults and space for entered values.

1.04 OPERATING AND MAINTENANCE INFORMATION

- A. Provide operating instructions as specified in Section 16010.
- B. Include a record of each SSS parameter setup during startup and testing and place a copy of setting in each O & M manual.

PART 2: MATERIALS

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 questionable durability shall not be used.
- C. Products that are specified by manufacturer, trade name, or catalog number establish a standard of quality and do not prohibit the use of equal products of other manufacturers provided they are favorably reviewed by the ~~Owner~~ *Government* and/or ~~Engineer~~ *Contracting Officer* prior to installation.
- D. Underwriter's Laboratories (UL) listing is required for all substituted equipment when such a listing is available for the first named equipment.

2.02 SOLID STATE SOFT STARTER

- A. General:
 - 1. Each solid state soft starter (SSS) shall be provided as a standalone system as an integral unit. The SSS shall be of the latest technology used exclusively for starting motors of the voltage and horsepower shown in the drawings by limiting the voltage and/or current provided to the motor. The SSS shall be available from a single manufacturer in the horsepower range of 1 to 500. The SSS shall be microprocessor controlled and use high efficiency gated power Silicon Controlled Rectifiers (SCRs). The SSS shall be an Allen-Bradley SMC Dialog Plus with pump control option or approved equal.

2. The SSS shall feature the following selectable motor starting/stopping modes:
 - a. Soft Start – The motor shall be raised to an initial torque value that is programmable from 0-90% of locked rotor torque. The motor voltage is gradually increased during the acceleration ramp time, which is adjustable from 0-30 seconds.
 - b. Soft Start with Selectable Kickstart – The kickstart, or voltage boost, is in addition to the normal soft start as described above. The soft starter shall provide a 0-2 second (selectable) current pulse equal to 550% of the motors full load current.
 - c. Current Limit Start – This starting mode will limit the maximum starting current supplied to the motor during starting. The user shall be able to adjust the current limit from 50% to 600% of full load current.
 - d. Full voltage Start- This mode will provide full voltage and current to the motor with a ¼ second ramp.
 - e. Soft Stop – This feature will linearly ramp down the voltage over a time interval of 0-60 seconds (selectable)
 - f. Pump Control – This optional mode (required as specified herein) provides non-linear voltage ramp starting and stopping to smoothly accelerate and decelerate the motor. The starting time shall be programmable from 0-30 seconds and the stopping time programmable from 0-120 seconds.
- B. Load - The SSS shall be designed to continuously operate the following motor/pump load:
 1. Motor, squirrel-cage induction.
 2. Pump, per Mechanical Division Specification.
 3. Horsepower, at Full speed R.P.M. of supplied motor.
 4. Voltage, 460 VAC, three phase, 60 cycle.
 5. Service factor, 1.15 S.F.
- C. Input Power - The SSS shall be rated to continuously operate under the following input power conditions:
 1. Voltage, VAC as shown in Contract one-line diagram, +10%, -10%.
 2. Frequency, 60 Hz.
 3. Three phase.

- D. Output Power - The SSS shall be rated to continuously operate while providing the following output power conditions:
1. Voltage, 0 to 460 VAC.
 2. Frequency, 60 Hz.
 3. SSS amp size (minimum) as shown on Contract one-line drawing.
 4. Continuous motor horsepower.
 5. Continuous current, 125% of rated motor nameplate Amps.
- E. Environmental - The SSS shall be rated to continuously operate under the following environmental conditions:
1. Ambient temperature, 32°F to 122°F (0°C to 50°C).
 2. Altitude, no derating below 3,300 ft.
 3. Relative humidity, 95% non-condensing.
- F. Digital programmer/controller –The SSS shall be provided with a door mounted alpha-numeric human interface module (HIM) digital display with keypad to view and adjust the following diagnostic and status registers:
1. Volts AC per phase.
 2. Current per phase.
 3. Watts.
 4. KWH.
 5. Power Factor.
- G. Adjustments - The following setting ranges shall be provided and made independently accessible for operator adjustment:
1. Overvoltage level/delay.
 2. Undervoltage level/delay.
 3. Current unbalance level/delay.
 4. Underload level/delay
 5. Phase reversal
 6. Jam level/delay.
 7. Starts per hour.
 8. Ramp times (start and/or stop).
 9. Motor code letter
 10. Overload class
 11. Motor FLA
 12. Motor Service Factor.
- H. Input and Output Terminations - The SSS assembly shall have terminals for input and output cabling as defined in the Conduit and Wire Schedule as shown on the Contract Electrical Drawings.

- I. Features - The SSS assembly shall have the following features:
1. Bypass Contactor Control - The SSS shall be capable of controlling a bypass motor contactor to allow motor current to flow around the soft starter, through the contactor, and to the motor. Once the motor is up to speed, the contactor shall be closed and held until a fault or stop command. In this mode, no current will flow through the soft starter power terminals but shall remain in the "on" state. An external current sensing module shall monitor the motor current to maintain the diagnostic, fault and control functions. Upon shutdown, the bypass contactor shall open and allow the soft starter to ramp down the motor. Provide sensing module as required per one-line or elementary diagram.
 2. Connection of the three incoming line leads and three-motor leads shall be the only connections necessary for manual operation of the SSS unit. All other wiring shall be prewired at the factory and self-contained within the SSS unit. A 120 VAC control power transformer and other auxiliary power supplies shall be provided with the SSS assembly for power to pilot lights, meters, relays, and miscellaneous devices specified to be supplied with the SSS. Lugs shall be provided for connection of all power leads; terminal blocks shall be provided for all other wiring.
 3. The SSS shall be protected by a circuit breaker disconnect. The disconnect shall be externally operated and shall have an operator mechanism that is an integral part of the enclosure. An operator mechanism shall be provided to allow padlocking the disconnect in the "off" position with up to two padlocks.
 4. AC input fuses shall be provided on the line and/or load side of the SSS (if required by the manufacturer) to isolate the SSS power circuitry upon a fault condition.
 5. Transient and surge voltage power line input protection shall be provided for the SSS through use of metal oxide varistors (MOVs), surge protective module, or other approved equal methods. Transient protection integral to the SSS shall be provided to a minimum of 1,600 volts, 220 joules without failure. The transient protection shall meet or exceed ANSI C7, 90-1971 and IEEE 472-1974 Standards without failure. Failure is defined as loss of components in the SSS including power SCRs and fuses. The SSS shall be protected from the following, as a minimum, power line transients and recover to automatically restart and resume normal operation without posting a fault:
 - a. Switching the primary of a power transformer.
 - b. Switching power factor correction capacitors "ON" and "OFF" line.

- c. De-energization or energization of contactors, relays, and other power equipment from the power line.
 - d. Starting and stopping of other motors when powered from Utility.
 6. Opening of the SSS's input switches, or breakers while the SSS is operating under load shall not result in damage to the SSS power or control circuit components.
 7. The SSS shall be capable of starting and operating without a motor load connected.
 8. Phase loss, reversal, undervoltage, overvoltage, and unbalance motor protection shall be provided built in to the SSS.
 9. External motor overload protection shall be required per drawings. External overload shall use bimetallic heating strips and provide +/-15% adjustment for full load amperage. Provide Cutler Hammer Freedom or approved equal.
 10. Any configuration of adjustments or controls not set by a switch or potentiometer shall be stored in nonvolatile memory. No configuration information shall be lost due to power failures of any duration.
 11. The SSS shall be capable of starting into a rotating motor without tripping out on a fault.
 12. Digital Programmer/Controller (HIM) shall be provided and remote door mounted. Remote serial interface shall be suitable for communication via Allen-Bradley standard protocol. Cable for remote digital programmer/controller shall be supplied. The remote controller shall be mounted and housed to maintain the NEMA 12 door rating.
- J. Enclosure - All components shall be accessible from the front of the enclosure. Rear or side access shall not be required in order to remove or service any component. The enclosure shall include the following in its construction:
1. The SSS shall incorporate fans for cooling. The air flow through the SSS compartment shall provide proper cooling of the operating SSS at an ambient temperature of 104° F. The thermostat shall be monitor and regulate air temperature in the SSS enclosure. Thermostat shall have bimetallic adjustable set point range of 30 to 140° F. Thermostat shall have a switching capacity of 10A at 120 VAC. Provide Hoffman A-TEMNO temperature switch or approved equal to operate fans.
 2. The complete SSS unit, including the enclosure assembly, shall be UL listed for a minimum of 42,000 RMS symmetrical ampere fault withstand

capability. SSS assemblies consisting of the SSS, enclosure and all accessories that are not UL listed will not be approved.

PART 3: EXECUTION

3.01 WORKMANSHIP

- A. All work in this Section shall conform to the codes and standards specified in Section 16010 - Electrical.
- B. The Supplier shall employ personnel that are skilled and experienced in the startup and testing 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. Electrical Section 16010 – GENERAL CONSTRUCTION METHODS and GENERAL EQUIPMENT FABRICATION apply to the construction and assembly of SSS's.
- E. Perform any required work to correct improper installations at no additional expense to the ~~Owner~~ *Government*.
- F. All equipment installed by the Contractor shall be in accordance with the Drawings and the manufacturer's recommendations and instructions. Follow manufacturer's instructions for handling, receiving, installation, and pre-check requirements prior to energization. After energization, follow manufacturer's instructions for programming, set-up and calibration of equipment. The Contractor shall be responsible for, and shall correct by repair or replacement, at his own expense, equipment that, in the opinion of the ~~Engineer~~ *Contracting Officer* 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~~ *Government*.

3.02 QUALITY CONTROL

- A. The quality assurance and testing program shall at a minimum consist of the following:
 - 1. The SSS manufacturer certified ISO-9001 per standards from the International Standards Organization.

3.03 FIELD ASSISTANCE

- A. Testing, checkout and start-up of the solid state starter equipment shall be performed under the technical direction of a factory trained authorized representative. Under no circumstances are any portions of the starter circuit to be energized without authorization from the manufacturer's factory service engineer.
 - 1. The setup and programming of the SSS shall be provided by a factory-trained representative who is authorized by the SSS manufacturer to perform the startup. This setup and programming shall be done prior to and during the first application of power to the pump motor. The SSS electronic motor overload protection shall be set to meet the NEC Code requirements.
 - 2. Provide testing as specified in Section 16600, FACTORY AND FIELD TESTING.
- B. Provide 1 hour of "SSS Setup" Training on operating and maintenance procedures.

3.04 WARRANTY

- A. Provide warranty as specified in Electrical Section 16010 – WARRANTY.

END OF SECTION

PART 1: GENERAL

1.01 SCOPE OF WORK

- A. This division defines factory and field testing requirements of electrical and instrumentation equipment and as specified in this section and in each section of division 16. All equipment provided under division 16 and electrical equipment provided under other sections shall be tested as specified herein.
- B. The ~~Electrical Contractor~~ *Contractor* shall coordinate and pay for the services of an approved qualified third party independent testing company for the purpose of performing specific tests as outlined in EXECUTION, Field Test of this section.
- C. The System ~~Supplier~~ *Contractor*, Testing Company and/or ~~Electrical Contractor~~ *Contractor* shall provide all labor, tools, material, power, and technical supervision to perform the specified tests and inspections.
- D. The ~~Electrical Contractor~~ *Contractor* shall be present during field testing and assist the System ~~Supplier~~ *Contractor* and/or Testing Company in testing all equipment. The ~~Electrical Contractor~~ *Contractor* shall be ready to correct any wiring problems found during testing.
- E. It is the intent of these tests to ensure that all equipment is operational within industry and manufacturer's tolerances and is assembled in accordance with design plans and Specifications.
- F. All tests shall be documented in writing by the person performing the test on the test forms submitted and similar to those shown in Appendix "A", and signed by the ~~Engineer~~ *Contracting Officer* as satisfactorily completed. The Testing Company, ~~Electrical Contractor~~ *Contractor* or System ~~Supplier~~ *Contractor* performing tests shall keep a detailed log of all tests that failed or did not meet Specifications, including date of occurrence and correction.

1.02 RELATED WORK IN OTHER SECTIONS

- A. Additional testing may be specified in Division 16 sections.

1.03 FACTORY AND FIELD GENERAL REQUIREMENTS

A. Testing General

- 1. The first set of tests to be performed shall determine the suitability for energization and shall be completed with all power turned off.

2. Prior to any field testing Operation & Maintenance Manuals shall have been submitted by the Contractor and approved by the ~~Engineer~~ *Contracting Officer*.
3. The test forms shall be completed by the testing person for field checkout, testing and calibration of all equipment. All tests shall be witnessed by the ~~Engineer~~ *Contracting Officer*. Completed test forms shall be given to the ~~Engineer~~ *Contracting Officer* the day of the test. Complete two sets of test forms if Contractor wants to keep a copy.
4. The Contractor shall give the ~~Engineer~~ *Contracting Officer* 10 working days notice of the dates and time for inspections and testing using the "Scheduled Test Date Request Form."
5. Include test results in the Maintenance and Operational Manual.
6. As a minimum, all the tests indicated/specified on the test forms in Appendix "A" shall be performed and test forms filled out by the Contractor.
7. Prepare and submit formal test procedures and forms to the ~~Owner~~ *Government* at least ~~two weeks~~ *30 Days* prior to the start of factory testing. Testing shall not commence until the test procedures have been reviewed and approved by the ~~Owner~~ *Government*. Submit a combined test procedure submittal with separate sections for factory and field tests.
8. If the results of any of tests are unacceptable to the ~~Engineer~~ *Contracting Officer*, the Contractor shall make corrections and perform the tests again until they are acceptable to the ~~Engineer~~ *Contracting Officer*; these tests shall be done at no additional cost to the ~~Owner~~ *Government*.

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~~ *Contracting Officer* immediately following the test. The Contractor shall replace the defective material or equipment and have tests repeated until test proves acceptable to the ~~Engineer~~ *Contracting Officer* without additional cost to the ~~Owner~~ *Government*.

C. Safety

1. Testing shall conform to the respective manufacturer's recommendations. All manufacturers' 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 Contractor shall have two or more personnel present at all tests.
4. Two non-licensed portable radios are to be made available by the Contractor for the Contractor 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 field installation tests shall be completed prior to applying power to MCC.

1.04 QUALIFICATIONS

A. Testing Company

1. Testing company shall have been actively engaged in the type of electrical testing specified in this Division for the past three years (minimum). The Testing Company representative shall have two years experience in field testing of equipment working for the Testing Company or equivalent. The following Electrical Testing Companies are pre-approved.
 - a. EETS (916) 965-1312
 - b. Industrial Test (916) 859-5959
 - c. Electro-Test (916) 652-8520
 - d. Apparatus Testing and Engineering (916) 835-6280
 - e. Power Systems Testing (916) 969 9177
2. Testing Companies not listed are required to submit company and individual representative resumes for review and approval by the ~~Engineer~~ *Contracting Officer*.

B. System ~~Supplier~~ *Contractor* Representative

1. The system ~~Supplier~~ *Contractor* representative shall have 1 year experience in field testing of equipment working for the system ~~Supplier~~ *Contractor* or equivalent. If the ~~Engineer~~ *Contracting Officer* deems that the representative does not demonstrate necessary experience or competence during testing or start-up, the System ~~Supplier~~ *Contractor* shall provide a representative meeting the required competence and experience.

C. ~~Electrical Contractor~~ *Contractor* Representative

1. The Electrician shall have 5 years minimum experience working with industrial control systems and have a Journeyman level experience rating.

1.05 SUBMITTAL REQUIREMENTS

- A. The Contractor shall ensure that the Testing Company and all equipment suppliers provide the submittal documentation required in this section. Submittals shall be complete, neat, orderly, and indexed. The Contractor shall check all submittals required under this Division for the correct number of copies, adequate identification, correctness, and compliance with the Contract Specifications and Drawings, and initial all copies certifying compliance.
- B. The System ~~Supplier~~ Contractor shall submit for approval complete testing procedures and forms at least ~~two weeks~~ 30 Days prior to the start of the factory tests. Contractor is responsible for compiling testing procedures and forms from multiple sub-contractors as required.
 1. Proposed procedure for each test whether it is performed in the factory or field. Procedure shall include method, materials and equipment necessary to conduct test regardless of who performs test.
 2. Proposed testing sheets (for all tests, factory and field, and regardless of who performs tests). Testing sheets shall be electronically completed prior to submittal with entry spaces filled. The only remaining data that shall require completion during the test is the test data itself. Testing sheets shall be provided as illustrated in Appendix "A".
- C. The approved shop one-line, elementary diagrams and PLC I/O shall be photocopied and included within the submittal for testing confirmation purposes.
- D. The control strategies shall be photocopied at 75% reduction and included within the submittal for testing confirmation purposes.

PART 2: PRODUCTS

2.01 TEST EQUIPMENT

- A. Test instruments shall be calibrated to references traceable to the National Bureau of Standards.
- B. All test equipment to be used as part of the testing shall be listed in the submitted testing sheets.
- C. The overall accuracy of each input and output loop shall be checked to ensure that it is within manufacturer's Specification tolerances. In no case shall the error exceed 0.5% or 0.08 mA.

PART 3: EXECUTION

3.01 FACTORY TESTING

A. General Requirements

1. The System ~~Supplier~~ *Contractor* shall conduct a thorough and complete factory test witnessed by ~~Owner~~ *Government* per the criteria specified herein. Factory test shall be held within 150 miles of project location.
2. Temporary wiring and equipment shall be provided and connected during these tests to simulate the complete assembled system.
3. The testing shall not be started until the manufacturer has completed fabrication, wiring, setup, and programming; performed satisfactory checks and adjustments; and can demonstrate the system is complete and operational.
4. The equipment required for factory testing shall consist of, but is not limited to, control panels, MCCs, and/or miscellaneous electrical panels as provided under this contract.
5. Two digital multimeters/signal generators (minimum +/- 0.2% accuracy) with clip-on leads shall be supplied and utilized during testing for measurement of digital and analog outputs.
6. The length of the factory testing shall be a minimum of one (1) working day(s) (8 hours per day).
7. The Contractor will have the sum of five hundred dollars (\$500.00) in liquidated damages deducted from his contract with the ~~Owner~~ *Government* for each and every calendar day beyond the time prescribed for the completion of factory testing for the Control System.
8. If the equipment is found to be not completely ready for factory testing, the Contractor shall be responsible for paying liquidated damages for the ~~Owner~~ *Government* and ~~Engineer~~ *Contracting Officer* to return for the factory testing.
9. All factory tests shall be conducted at the ~~Supplier~~ *Contractor*'s facility. All factory tests shall be completed prior to shipment of any equipment to the jobsite. The equipment shall be fully assembled, connected and programmed as it will be installed in the final configuration.
10. The PLC programmer shall be present during the testing to fix programming errors and make program modifications as requested by the ~~Engineer~~ *Contracting Officer*.

11. During the testing period, under the supervision of the System ~~Supplier Contractor~~, the ~~Owner Government~~ and/or ~~Engineer Contracting Officer~~ shall have unlimited and unrestricted access to the usage and testing of all hardware and software in the system.
12. The System ~~Supplier 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.
13. Faulty and/or incorrect hardware or software operation of major portions of the system may, at the discretion of the ~~Owner Government~~, be cause for suspension or restarting of the entire factory test, at no additional cost to the ~~Owner Government~~ or extension in Contract time.
14. The factory test will be considered complete only when the integrated system has successfully passed all tests to the satisfaction of the ~~Engineer Contracting Officer~~. No electrical equipment shall be shipped to jobsite without authorization from the ~~Engineer Contracting Officer~~ that the factory test has been completed.
15. Acceptance and witnessing of the factory tests does not relieve or exclude the Contractor from conforming to the requirements of the Contract Documents.
16. 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.
17. Copies of the completed and witnessed factory testing forms shall be placed in the Operation and Maintenance Manual.

B. Factory Tests

1. Structured Factory Tests: The associated factory tests are to be performed by the System ~~Supplier Contractor~~ and witnessed by the ~~Engineer Contracting Officer~~. The associated factory testing sheets shall be completed during each stage of the test.
 - a. Visual and mechanical
 - 1) Inspect for physical damage, proper assembly, and grounding.
 - 2) Compare equipment nameplate data with design one-line diagrams.
 - 3) The ~~Supplier Contractor~~ shall complete "MCC or Pump Control Cabinet Visual and Mechanical Inspection Form" and "Control Panel Visual and Mechanical Inspection Form" for all electrical components formatted as shown in Appendix "A".

- b. MCC and Control Panel Checkout
 - 1) Verify that equipment powers up and operates correctly in hand.
 - 2) Perform trip functions and verify that equipment returns to normal operation with only necessary operator intervention.
 - 3) The ~~Supplier~~ *Contractor* shall complete “MCC Operational Test Form” and “Control Panel Operational Test Form” for MCC and Control Panel formatted as shown in Appendix "A".

- c. Logic Controller I/O Point Checkout Test Sheet
 - 1) Connect signal generator to each PLC I/O point and complete testing form.
 - 2) The ~~Supplier~~ *Contractor* shall complete “Logic Controller I/O Point-To-Point Test Form” for Logic Controller I/O formatted as shown in Appendix "A".

- d. Wiring Tests
 - 1) Contractor shall confirm correct panel wiring per System ~~Supplier~~ *Contractor* panel shop drawings. Panel shop drawings shall be compared with Contract P&IDs to verify all hardwire logic is accounted for. Panel drawings used in factory tests shall be redlined and inserted into Factory Testing Results submittal.

- e. Control Tests
 - 1) Simulate the digital and/or analog signals at the field terminals to verify that each control system is functional and properly configured. When the complete elementary or loop diagram has been checked, the diagram shall be signed and dated by testing person and person witnessing test.
 - 2) Each line of control logic in the Control Strategies section shall be checked. When the complete control strategy has been checked, it shall be signed and dated by testing person and person witnessing test.
 - 3) Verify that all parameters (i.e., setpoints, runtimers, totalization, etc.) operate according to the Specifications.

- f. Alarm Tests

- 1) Simulate the digital and/or analog signals at the terminals to verify that each PLC I/O point is functional and properly programmed. Verify that all parameters (i.e., setpoints, enable/disable toggle bits, timers, etc.) for the alarms operate according to the Specifications. Multiple alarm states (i.e., LO, LO-LO, HI, HI-HI, etc.) shall be checked.
2. Unstructured Factory Tests: The various unstructured tests shall include, but are not limited to, the following.
 - a. Simulate the equipment failure and power fail/restart of PLC. Check the effects of each failure on maintaining operations with the remaining equipment.
 - b. The factory tests, as a minimum, shall simulate all normal and abnormal operating conditions including steady state, change of state, variable changes, fluctuations, transients, upsets, start-up, shutdown, power failure, and equipment failure conditions.
 - c. Simulation of PLC communication error. Demonstrate error detection, alarming, and recovery.
 - d. Measure and test all power supplies for correct voltage. Operate UPS under its own power to test UPS run duration and alarms.

3.02 FIELD TESTING

A. General Requirements

1. The ~~Electrical Contractor~~ *Contractor*, ~~System Supplier~~ *Contractor* and Testing Company shall divide the testing services as listed below in paragraph B.
2. The following field tests shall be performed by:
 - a. ~~Electrical Contractor~~ *Contractor*:
 - 1) Equipment Data.
 - 2) Torque Connections.
 - 3) Wire Insulation and Continuity Tests.
 - 4) Panelboard Tests
 - 5) Phase Rotation Tests.
 - 6) Motor Tests.
 - 7) Start-up and Operational Tests.
 - 8) Final Acceptance Trial.
 - b. ~~System Supplier~~ *Contractor*:

- 1) Equipment Data.
- 2) PLC Control System Tests.
- 3) Instrumentation Tests.
- 4) Operational Tests.
- 5) Final Acceptance Trial

c. Testing Company

- 1) Grounding System Tests
- 2) Breaker Tests

B. Electrical Field Tests

1. Pre-Energization Inspections and Tests:

a. Visual and Mechanical:

- 1) Inspect for physical damage, proper anchorage, and grounding.
- 2) The ~~Supplier~~ *Contractor* shall complete “MCC or Pump Control Cabinet Visual and Mechanical Inspection Form” and “Control Panel Visual and Mechanical Inspection Form” for all electrical components formatted as shown in Appendix "A".

b. Motor Data: The Contractor shall compile, by visual inspection of equipment installed for each motor, the following data in neatly tabulated form:

- 1) The ~~Supplier~~ *Contractor* shall fill in all nameplate data into the “Motor Test Form,” formatted as shown in Appendix "A".

c. 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 ~~1999~~ *2002* 110-14 as guidelines.

d. Wire Insulation and 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 ten 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 thirty 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 10 Meg-ohms resistive. Corrective action shall be taken if values are recorded less than 10 Meg-ohms. 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~~ *Government*.
- 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~~ *Government*.
- 6) Values of different phases of conductors in the same conduit run showing substantially different Meg-ohm values, even if showing above 10 Meg-ohms shall be replaced
- 7) The Contractor shall complete "Power Conductor Test Form", "Control Conductor Test Form", and "Instrumentation Conductor Test Form," for all conductors as shown in the Wire and Conduit Schedule. Forms shall be formatted as shown in Appendix "A".

e. 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~~ *Contracting Officer* 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 foot 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.
- h) The resistance between the main grounding electrode and ground shall be no greater than five ohms for commercial or industrial systems for generating or transmission station grounds per IEEE Standard 142.

3) Test Values

- a) Investigate point-to-point resistance values that exceed 0.5 ohms.
- 4) The Contractor shall complete "Grounding System Test Form" formatted as shown in Appendix "A".

f. Panelboard Tests:

- 1) Inspect for physical damage, proper anchorage and grounding.
- 2) Check torque of bolted connections.
- 3) Verify that panelboard and components are installed correctly.
- 4) Verify Circuit Breaker legend is correct per the Contract Documents .
- 5) The ~~Supplier~~ *Contractor* shall complete "Panelboard Test Form" for Panelboard formatted as shown in Appendix "A".

g. Breaker Tests:

- 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) Thermal magnetic breakers, 100 amps and above, shall be tested. 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. At end of test the thermal breakers shall be set by Contractor.
- 3) Magnetic breakers (MCP), regardless of amperage rating, shall be tested. Instantaneous pickup current shall be determined by run up or pulse method. Clearing times should be within four (4) cycles or less. At end of test the breaker trip setting shall be set by Contractor based on the motor locked rotor current.
- 4) 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~~ *Contracting Officer*. Insulation resistance shall be measured and shall not be less than 50 megohms. All trip times shall fall within NETA Table values. Instantaneous pickup current levels should be within 20% of manufacturer's published values.

- 5) The ~~Supplier~~ *Contractor* shall complete “MCC Breaker Device Test Form” and “Breaker Device Test Form” formatted as shown in Appendix "A".
2. Post Energization Tests:
- a. MCC and Control Panel Tests:
 - 1) Perform operational tests by initiating control devices to affect proper operation.
 - 2) The ~~Supplier~~ *Contractor* shall complete “MCC Operational Test Form” and “Control Panel Operational Test Form” formatted as shown in Appendix "A".
 - b. Phase Rotation Tests
 - 1) Check connections to all equipment 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) All three phase motors shall be tested for proper phase rotation. Revise wire color codes to indicate correct phase color if wires are swapped.
 - 3) The ~~Supplier~~ *Contractor* shall complete “Three Phase Equipment Rotation Test Form” formatted as shown in Appendix "A".
 - c. 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 complete “Motor Test Form,” formatted as shown in Appendix "A".

d. Instrumentation Tests

- 1) The Contractor shall complete "Instrumentation Calibration and/or Component Operational Tests Form," formatted as shown in Appendix "A". for each of the instruments listed in Section 16940 Appendix "A" Instrument Index.
- 2) All the I/O points for the PLC shall be tested by the ~~Engineer~~ *Contracting Officer* with assistance from Contractor to verify accuracy. Where practical, the final element shall be used, i.e., trip the intrusion switch or change levels.
- 3) The Contractor shall complete "Logic Controller I/O Point-To-Point Test Form," formatted as shown in Appendix "A".

C. Operational Testing:

1. After all the previous tests in this subsection are complete, the Contractor shall conduct operational testing.
 - a. Representatives from the General Contractor, ~~Electrical Contractor~~ *Contractor*, System Integrator, and ~~Owner~~ *Government's* Representative shall be present during testing.
 - b. Final testing shall be completed in the presence of the ~~Owner~~ *Government*.
2. During operational testing the Contractor shall avoid surging the discharge piping.
3. For the operational testing the new equipment shall be activated to automatically run for 5 days, 24 hours per day Monday through Friday. During the five day period the ~~Owner~~ *Government* will look for malfunctions. 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. This shall be continued until the new equipment functions acceptably for 5 consecutive days.

D. Final Acceptance Trial Period:

1. The system shall not be "final" accepted unless the system functions without hardware failures or software problems during a 30 day trial period, to the satisfaction of the ~~Engineer~~ *Contracting Officer*. The 30 day trial period will automatically restart when a major hardware failure has occurred or a software problem has been identified. The 30 day trial period is completed when no failures have been identified within the trial period.

- E. The completion of the above tests does not relieve the Contractor from warranties specified in Division 16.

SECTION 16600

APPENDIX "A"

TEST FORMS

Index of Forms:

BOM	Bill of Materials
STR	Scheduled Test Date Request Form
PC	Power Conductor Test Form
CC	Control Conductor Test Form
IC	Instrumentation Conductor Test Form
GS	Grounding System Test Form
MCCVM	MCC or Pump Control Cabinet Visual and Mechanical Inspection Form
CPVM	Control Panel Visual and Mechanical Inspection Form
PB	Panelboard Test Form
MCCO	MCC Operational Test Form
CPO	Control Panel Operational Test Form
BD	Breaker Device Test Form
MCCBD	MCC Breaker Device Test Form
MOTOR	Motor Test Form
PR	Three Phase Equipment Rotation Test Form
IOP	Programmable Logic Controller I/O Point-to-Point Test Form
IDC	Instrument Calibration and/or Component Operational Test Form

END OF SECTION

PART 1: GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall install, ready for use, the control panel as specified herein. 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 required 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 control panel as shown on the Drawings, included in these Specifications, or required for fully operating facilities.
- C. The Control Panel scope of work includes:
 - 1. Provide and install Control Panel on concrete pad per drawings.
 - 2. Provide complete wired, programmed panel with all devices installed per the contract drawings and as stated herein.
 - 3. Provide all necessary hardware, conduit, wiring, fittings, and devices to connect the control panel to equipment provided under other Sections.

1.02 RELATED SECTIONS

- A. Section 16010 – Electrical.
- B. Section 16120 – Wire, Fuses and Terminal Blocks
- C. Section 16910 – PLC & OI Hardware and Firmware
- D. Section 16915 – PLC & OI Application Programming
- E. Section 16940 – Instrumentation

1.03 SUBMITTALS AND DRAWINGS

- A. Provide submittals and drawings as specified in Section 16010 - Electrical, SUBMITTAL AND DRAWING REQUIREMENTS.
- B. Submit shop construction drawings for the Control Panel. The following drawings shall be provided as a minimum:

1. Scaled drawings of the Control panel elevation, baseplan. The dimensions and locations of the cutouts shall be dimensioned from the bottom left corner of the door(s).
2. Scaled drawings of the backpan including all mounted components and wireways.
3. Wiring diagrams for AC and DC power distribution, I/O for each card in the PLC and communications block diagrams.
4. Interconnection diagrams per section 16010.

PART 2: PRODUCTS

2.01 ENCLOSURE

- A. The enclosure for the control panel shall be a relay section of the same make and model of the adjacent MCC sections.
- B. Doors shall be hinged on one side and have multiple ¼ turn latches to secure door closed.
- C. The enclosure for the control panel shall be (at minimum) sized as shown in the Contract Drawings. Control panel construction shall consist of a NEMA 1A enclosure fabricated from 12 ga. galvanized steel. Door(s) shall be fully gasketed with non-shrinkable rubberized foam gasketing.
- D. Mount all equipment on 12 ga. painted white backpan(s) that is bolted to rear of the enclosure. Provide extra mounting bolts through the rear of the structure if equipment weight exceeds OEM mounting stud capacity.
- E. Provide door latch and accessories as detailed in the Contract Drawings.
- F. When physical size requirements for individual components are different than that detailed on the Control Panel backpan drawing, the wiring diagrams and specifications herein shall supersede the elevation drawing and the Contractor shall furnish additional panel width as needed to fit the electrical equipment. Deviations with sufficient evidence for the change shall be submitted for approval. The Contractor is required to provide for all equipment including spares and spaces as shown in the wiring diagrams.
- G. Enclosure shall be Hoffman Freestanding Type 12 Enclosure A-903624FS with L36 handle and mounting panels or approved equal.

2.02 POWER SUPPLIES

- A. Uninterruptible Power Supply (UPS)
 - 1. The UPS shall be installed within the control panel and power all process related 120 VAC devices and DC power supplies.
 - 2. The UPS capacity/size shall be as shown in the contract drawings.
 - 3. The UPS shall provide surge protection and filtering: 0.3% IEEE surge let-through, zero clamping response time to meet UL 1449.
 - 4. The power supply shall be wired into the control panel power circuit per the contract drawings.

5. The UPS operating ambient temperature range shall be 32 deg F to 104 deg F minimum.
6. When the Utility power voltage is outside of a preset range (approx. $<100 < V < 130$ VAC) then the UPS shall power the load from storage batteries and a solid state inverter.
7. The inverter shall be continuously on-line regardless of the Utility power existence. Utility power shall enable the rectifier/charger to maintain charge on the batteries.
8. The UPS shall have status "UPS ON-LINE" and "UPS LOW BATTERY" dry contacts for monitoring by PLC. Provide isolation relays and UPS accessory card as necessary to interface to the PLC.
9. The inverter shall provide true sine wave output.
10. The UPS shall be of a readily available commercial manufacturer. Provide American Power Conversion Smart UPS, MGE Pulsar Evolution or approved equal.

B. DC Power Supply (PS)

1. The DC power supply shall utilize a linear rectifier and voltage regulator. Switching power supplies are not acceptable.
2. The power supply shall operate on 120V AC and provide DC voltage and current as shown in the Contract drawings.
3. The power supply shall be wired and fused per manufacturer instructions and Contract drawings.
4. The power supply shall provide 0.05% voltage regulation for a change of 10% load to 100% full load.
5. The DC power supply shall be Power-One Linear Series or approved equal.

2.03 MISCELLANEOUS COMPONENTS

- A. Circuit Breaker: The disconnecting circuit breaker shall be din rail mounted with finger safe pressure plate terminals. Provide Allen Bradley 1492-CB or approved equal.
- B. Fluorescent Light: The fluorescent light shall be an "under cabinet" style with a single bulb and acrylic diffuser. Lamp shall be switched on/off with an integral door activated pin switch. Fluorescent Light shall be Hoffman A-LF series of length shown on Contract drawings, or approved equal.

- C. Circulation Fans: The control panel temperature shall be maintained 10 deg. F below lowest internal device's temperature rating. The fans shall be 6" (min), 240 CFM, unless otherwise noted on Contract drawings. The Contractor shall calculate the heat generation of all internal components and determine if the fans submitted will meet the cooling requirements of the internal components. Circulation fans shall be Dayton (Grainger #4C720) with wire guard, or approved equal.
- D. Heater: The control panel temperature shall be kept above 50 deg. F through the use of a resistive forced air heater when the panel is located outdoors. The heater shall contain a fan, heating elements, and thermostat within a single self contained unit. The wattage of the heater shall be as calculated by the supplier using the manufacturers sizing method to meet the temperature requirements. The heater shall be Hoffman D-AH series or approved equal.
- E. Thermostats: The air circulation fans shall be controlled by adjustable thermostat. The thermostat shall be mounted near the top of the panel and easily accessible by a technician. The thermostat shall be capable of control of a heater or cooling fan(s) by selecting the proper contact logic. The thermostat range shall be adjustable from 30 to 140 deg F. Thermostat shall be Hoffman A-TEMNO or A-TEMNC as required for application or approved equal.
- F. RFI Line Filter: The RFI line filter shall be a general purpose common-mode and differential-mode filter to control line-to-line and line-to-ground RFI interference. Filter shall provide minimum 20 dB insertion loss (line to ground) for frequencies above 1 MHz. Operating voltage and current shall be as shown in the contract drawings. Line filter shall be Corcom K Series or approved equal.

PART 3: EXECUTION

3.01 WORKMANSHIP

- A. All work in this Section shall conform to the codes and standards specified in Section 16010 - Electrical.
- B. All installation labor shall be performed by qualified personnel who have had experience on similar projects. The Supplier shall employ personnel that are skilled and experienced in the installation of conduits, devices, boxes, grounding system, accessories, and assemblies. Provide first class workmanship for all installations.
- C. Ensure that all components fit within the panel, on the backpan or door, with proper clearances per manufacturer's instructions.
- D. Perform any required work to troubleshoot and correct improper installations at no additional expense to the ~~Owner~~ *Government*.
- E. The ~~Engineer~~ *Contracting Officer* reserves the right to halt any work that is found to be substandard or being installed by unqualified personnel.

3.02 INSTALLATION

- A. Equipment Mounting:
 - 1. Mount all equipment using manufacturers mounting tabs/holes where possible. Where not possible, construct custom brackets to panel mount or backpan mount components as shown in the Contract drawings.
 - 2. Equipment or laptop shelves shall be provided where shown on the Contract drawings. Equipment shown on shelves shall not be placed on the bottom of the panel after field installation.
 - 3. All nuts, bolts, screws, washers and hinges used in the panel shall be stainless steel. All components shall be mounted using bolts or screw fasteners only which are drilled and tapped into the backpan. Pop rivets shall not be allowed within panel except for enclosure support arms.
- B. Wiring:
 - 1. Install all products per 16010 - Electrical, INSTALLATION, GENERAL.
 - 2. All field wires and panel wires shall be per section 160120 – Wire, Fuses & Terminal Blocks.
 - 3. Panel Wiring: All wiring shall be installed in wireways between terminal blocks, PLC and devices. Reference Contract drawings for Control panel power distribution diagram and control panel elementary diagrams.

4. Field Wiring: Wireways shall be provided for field wiring. Reference Contract drawings for Control panel power distribution diagram and control panel elementary diagrams

C. Cleaning:

1. The Contractor shall clean the inside of the control panel of any dust or debris remaining at the completion of installation and testing. The Contractor shall exercise care when using a vacuum cleaner or compressed air such as not to permanently damage any component within the panel.

3.03 OPERATING INSTRUCTIONS

- A. Provide operating instructions as specified in Section 16010 - Electrical, OPERATING INSTRUCTIONS.

3.04 FIELD ASSISTANCE

- A. Provide testing as specified in Section 16600 – FACTORY AND FIELD TESTING.

3.05 WARRANTY

- A. Provide warranty as specified in Section 16010- Electrical, WARRANTY.

***** END OF SECTION *****

PART 1: GENERAL

1.01 SECTION INCLUDES

- A. Providing and installing Programmable Logic Controller (PLC) and Operator Interface Hardware and all supporting hardware, wiring and devices as specified in division 16.

1.02 RELATED SECTIONS

- A. Section 16010 – Electrical
- B. Section 16120 – Wire, Fuses and Terminal Blocks
- C. Section 16915 – PLC and OI Application Programming

1.03 PROJECT SUBMITTALS

- A. Provide submittals per Section 16010.
- B. Submit documentation showing the number and type of I/O modules required for the initial point count as specified herein plus ultimate I/O point count. Include complete manufacturer's part and model numbers.
- C. Submit calculations showing that the power supply meets the specified requirements and the requirements of the devices powered.
- D. Include calculations of heating and cooling loads for the control panel cabinets showing that equipment will operate within its specified performance and accuracy range per Section 16010, JOB CONDITIONS.
- E. Submit shop drawings showing physical backpan layout of equipment in Control Panel.
- F. Submit PLC communications block diagram showing I/O module order and slot location.

1.04 OPERATION AND MAINTENANCE DATA

- A. Submit hardware Operations and Maintenance Manual per Section 16010.
- B. Submit original Operations and Maintenance Manuals for PLC hardware, no copies.

1.05 CONTRACT CLOSEOUT SUBMITTALS

- A. Provide manufacturer's warranty certificates for items supplied.
- B. Submit original manufacturer's operations and maintenance manuals, no copies.
- C. Provide training and manuals per section 16010 OPERATING AND MAINTENANCE INSTRUCTIONS.

1.06 PROJECT/SITE CONDITIONS

- A. Project / site conditions are as specified in Section 16010 Electrical, JOB CONDITIONS.

1.07 DEFINITIONS

- A. Initial Point Count: The PLC initial I/O points are determined by the Contract P&ID drawings. The Contractor shall count and total the PLC I/O points per PLC controller and per type of I/O required based on the P&ID diagrams. The initial point count shall be per I/O type.
- B. Ultimate Point Count: 125% of the initial point count per I/O type.

PART 2: PRODUCTS

2.01 GENERAL

- A. Provide a PLC-505 based system as manufactured by Allen-Bradley (AB) or approved equal. Allen-Bradley (A-B) PLC-505 & 1746 I/O modules & Panelview 600. or approved equal.
- B. Provide PLC modules from a single family of products, using the same software and interchangeable I/O cards, that can be configured for a range of applications from small, uncomplicated sites to large, complex sites with a variety of equipment.
- C. Provide a PLC that can be expanded in the field by the addition of the following types of plug-in modules or cards and interface cables without rendering the originally furnished PLC components obsolete.
 - 1. Digital Inputs
 - 2. Digital Output
 - 3. Analog Input
 - 4. Analog Output with PID control
- D. Size the PLC enclosure such that local I/O modules and supporting hardware required to meet the ultimate point count, as specified herein, will fit into the space of a single enclosure.
- E. Provide a PLC that will meet the following requirements:
 - 1. Size and provide a CPU and power supply to accommodate the Ultimate Point Count, as specified herein.
 - 2. Provide inputs and outputs (communication line(s), digital inputs, analog inputs, digital outputs, analog outputs, power, etc.) meeting ANSI C37.90.1 without damage or false operation.
 - 3. Provide addressing system allowing up to 256 PLCs to share a single RS-232 communications channel.

2.02 MECHANICAL

- A. Provide modular PLC consisting of I/O slot card cage, and plug-in processor, power supply, and I/O modules.
- B. Provide I/O modules with removable terminal strips so that I/O modules can be removed without disconnecting field wiring.
- C. Permanently mark each assembly, sub-assembly, circuit board and module with module function (Digital Input, Digital Output, etc.), part number, product manufacturing date code, and UL certification for traceability.

- D. Provide modules that can be keyed mechanically to prevent a module from being installed in the wrong slot.

2.03 CENTRAL PROCESSING UNIT

- A. Provide an AB PLC-505 or approved equal PLC with Central Processing Unit that meet the following specifications:
 - 1. 12-bit plus sign CMOS processor, minimum.
 - 2. Floating point coprocessor or emulation providing integer and floating point multiply and divide
 - 3. Hardware or software real time clock with 100 ms resolution and leap year compensation.
 - 4. Operational and Fail indicators
 - 5. Watchdog timer to trap failed processor
 - 6. Scan time: 6 ms per 1024 instruction words, maximum.
- B. CPU shall have the following minimum memory configuration.
 - 1. Application Program Memory: 32K words, minimum
 - 2. Registers and Data: 2048 registers, minimum
 - 3. Global References: 1024 minimum
 - 4. Control Relays: 128 minimum
- C. Processor shall utilize nonvolatile memory module for storage of register values and application programs.
 - 1. Nonvolatile storage shall maintain contents for 1 year, minimum, without maintenance or external power.
- D. I/O Bits: Provide sufficient data table memory to accommodate the number of I/O bits indicated by the Ultimate Point Count and the application program.
- E. CPU shall have the following communications interfaces (minimum).
 - 1. Provide one communication RS-232 port reserved for radio data communication.
 - 2. Provide one Ethernet communication port capable of data communication to the operator interface.
- F. CPU shall have the following programming manufacturer's standard firmware and instruction set (minimum).
 - 1. Provide CPUs capable of executing an application program whose source format is relay ladder diagram.

2. Provide relay ladder logic supporting relays, timers, counters, arithmetic, relational bit operations, data move, conversion, and control functions.
 3. Provide relay ladder logic allowing any number of references to a single contact within an application program.
 4. Provide relay ladder logic in which a single rung may energize more than one coil.
 5. Provide the following contact and coil operations:
 - a. Normally Open Contact
 - b. Normally Closed Contact
 - c. Coil
 - d. Negated Coil
 - e. Positive Transition Coil (leading edge one-shot)
 - f. Negative Transition Coil (trailing edge one-shot)
 - g. Set Coil (Latch)
 - h. Reset Coil (Unlatch)
- G. Provide the following timer and counter functions:
- a. Retentive On-Delay Timer - increments time when enabled and holds timed value until receiving power to reset input.
 - b. Simple On-Delay Timer - increments time when enabled and reset when not enabled.
 - c. Up Counter
 - d. Down Counter
 - e. 512 timers or counters in any combination in an application program, minimum.
 - f. Timer preset, value, and control words accessible via register reference.
- H. Provide the following arithmetic operations in both 16-bit signed integer and 32-bit double precision integer data types:
- a. Addition
 - b. Subtraction
 - c. Multiplication
 - d. Division (quotient)
 - e. Modulo (remainder)
 - f. Square Root
- I. Provide arithmetic function blocks with an enable input and overflow output.
- J. Provide the following relational functions:

- a. Equal to
 - b. Not Equal to
 - c. Greater than
 - d. Greater than or equal to
 - e. Less than
 - f. Less than or equal to
- K. Provide conversion functions to convert between 4-bit BCD and 16-bit signed integer formats.
- L. Provide the following program control functions to alter program execution:
- a. Subroutine
 - b. Event Alarm and Record
- M. Provide the following service request functions whose output is in BCD or Packed ASCII format and written to a generic serial link.
- a. Change/read checksum task state and logical number of words to checksum.
 - b. Change/read time of day clock
 - c. Clear fault tables
 - d. Read last fault table entry
 - e. Read elapsed time clock
 - f. Read I/O override status
- N. Provide the following PID (Proportional/ Integral/ Derivative) control algorithms and features.
- a. ISA standard PID algorithm which applies the proportional gain to each of the proportional, derivative, and integral terms.
 - b. Independent algorithm that applies the proportional gain only to the proportional gain term.
 - c. Program PID blocks using a fill in the blank approach without requiring special user programming.
- O. Provide program modules stored in ROM.
- P. Initialization
- a. Provide an initialization module which will, upon power up, reset, or initialization request from the PLC, initialize the PLC to a known state with current field status, load PLC database and generate a database directory of its complement of I/O cards.
- Q. Sequencing

- a. Provide sequencing module to allocate available CPU resources to each of the major program modules.
 - b. Provide sequencing module to time tag changes of state to the nearest 0.005 seconds for reporting to the master station.
 - c. Program sequencing module to accept a synchronization command from the PLC and synchronize the OI clock to the PLC real-time clock.
- R. Scanning
- a. Provide a scanning module to accept interrupts from the I/O cards and the communications interface card.
 - b. Program scanning module to determine the interrupt type and call the appropriate interrupt service module.
- S. Communications Handling
- a. Provide a communications handler module to transmit and receive messages between PLCs.
 - b. Program communications handler module to perform the following functions in receive mode:
 - 1) Perform error checking and correcting on received messages.
 - 2) Decode and check remote station address.
 - 3) If error checking and correcting yields a valid message and the station address corresponds to the PLC address, initiate appropriate response.
 - c. Program communications handler module to perform the following function in transmit mode:
 - 1) Collect and format messages for output.
 - 2) Initiate transmission and continue until output message is complete.
- T. Data Processing
- a. Provide data processing module to perform such functions as deadbanding, status/alarm processing, accumulator processing, and select before operate procedures.
 - b. Program Digital Input Cards to provide an interrupt when a state change occurs.
 - c. Program data processing module to save data in the PLC database until requested by the PLC.

- d. Program the data processing PLC to require the persistence of an alarm condition for an operator selectable time of 0 seconds to 60 minutes setpoint adjustable before reporting the alarm condition to the PLC.
- e. When a change of state is recorded in the PLC database, set change flags in the PLC database to indicate a change is to be reported to the PLC. Clear change flags when the PLC has acknowledged receipt of change.

U. Application Program Checksum

- a. Program CPU to calculate the application program checksum at the end of every sweep.
- b. Compare the calculated checksum to a reference checksum. If the checksums do not match, stop the processor.

2.04 INPUT/OUTPUT CARDS

- A. Provide a PLC that can be configured for specific types of inputs and outputs by the addition of Input/Output Cards without changing the Central Processing Unit or other modules.
- B. Provide AB 1746-IA16 Digital Input Cards or approved equal meeting the following specifications:
 - 1. 16 point input monitoring: Normally open and normally closed on/off contacts.
 - 2. Signal voltage: 85 ~ 132 VAC on state.
 - 3. Signal current: 2 mA, maximum off state.
 - 4. Change detection time: on=35 ms, off=40 ms, maximum.
 - 5. Electrical isolation from external signals: Opto-isolation
 - 6. Filter inputs for contact bounce and electrical noise isolation.
 - 7. Provide input to accept pulses from Form C and Form A contacts.
 - a. Counts per contact cycle: 1
 - b. Pulse rate: 10 counts per second, minimum
 - c. Provide filters to remove contact bounce (if needed).
- C. Provide AB 1746-OW16 or approved equal Digital Output Cards meeting the following specifications:
 - 1. 16 Normally open contact outputs rated at 120 VAC, 2 Amp continuous, 10 Amp make/break, minimum.
 - 2. Provide Digital Output Card designed to provide the following control output security:

- a. Ensure that false operations do not occur during power up.
 - b. Ensure that false operations do not result from inserting cards in incorrect slots.
 - c. Provide watchdog timer to trap a "runaway" processor and ensure it cannot execute control outputs.
- 3. Provide isolation relays when driving a foreign voltage (voltage sourced other than from the PLC D.O. card) or where shown on the contract drawings, or when the load driven exceeds the capabilities of the card.
- D. Provide AB 1746-NI4 or approved equal Analog Input Cards meeting the following specifications:
 - 1. 4 channel, differential input, 4-20 mA / 1-5 VDC analog input card field convertible.
 - 2. Inputs shall convert a current/voltage signal to digital value corresponding to magnitude and polarity.
 - 3. Maximum input current range: 0 - 24 mA
 - 4. Nominal input signal: +/- 20 mA DC or +/- 10 V DC maximum.
 - 5. Input signal burden: 250 Ohm, nominal (current mode), 10K Ohm (voltage mode)
 - 6. Conversion resolution with sign: 11 bits plus sign, minimum
 - 7. Error: $\pm 1.0\%$, maximum over range 0°C to 60°C
 - 8. Temperature error: $\pm 0.005\%/^{\circ}\text{F}$, maximum
 - 9. Common-mode rejection: 60 dB minimum
 - 10. Normal-mode rejection: 60 dB minimum at 60 HZ
- E. Provide AB 1746-N2 or approved equal Blank Card Slot fillers for unused positions in I/O card cage.

2.05 PLC POWER SUPPLY

- A. Provide AB 1746-P3 PLC power supply or approved equal.
- B. 120VAC power supply to be powered from UPS.
- C. Contractor shall verify that the power supply is sized correctly to power all I/O cards included in PLC card rack.

2.06 OPERATOR INTERFACE (OI)

- A. Provide an operator terminal Panelview 600 system as manufactured by Allen-Bradley (AB), or approved equal to meet the following requirements:

1. Provide operator terminal with keypad/ touch screen terminal with Ethernet Communication Port connected to PLC Ethernet port.
2. Provide operator terminal with color liquid crystal display with replaceable backlight and 128 touch cells (minimum) on the display.
3. Provide operator terminal with 240K application memory.
4. Provide one PCMCIA (ATA) memory card.
5. Provide operator terminal with the following pushbuttons and selector switches:
 - a. Momentary NO, NC
 - b. Maintained
 - c. Latched
 - d. Multistate
 - e. List Selector
6. Provide operator terminal with the following diagnostic displays:
 - a. Bar Graph
 - b. Message Display
 - c. Multistate Indicator
 - d. Numeric Data Display
7. Provide a list of value added services, features, and options that might benefit the ~~Owner~~ *Government* and provide these values configured at no added cost.
8. Provide the operator terminal capable of operating the following environmental conditions:
 - a. Operating Temperature: 32 to 131 degrees F
 - b. Storage Temperature: -4 to 140 degrees F
 - c. Humidity Rating: 5 to 95%, non-condensing at 9° F to 86° F.
 - d. Rating: NEMA 12, 13, 4X (indoor only)
 - e. Power: 85 to 264 VAC, 47 to 63 Hz.

PART 3: EXECUTION

3.01 FABRICATION

- A. Install PLC and Operator Interface loaded with manufacturer's standard Firmware.
- B. Mount, wire and Ground PLC and OI per manufacturer's recommendations.
- C. Organize equipment on control panel backpan per Backpan Layout detail in Contract drawings.
- D. Locate and install PLC(s) and OI(s) per Contract drawings.

3.02 WIRING

- A. Terminate status, control and analog wiring on terminal blocks.
- B. Label and wire PLC to terminal blocks per Section 16020-Wire, Fuses & Terminal Blocks and Example I/O Wiring Diagram in the Contract drawings.
- C. All spare I/O points shall be wired to terminal blocks.
- D. Install communication cable between Operator Interface and PLC.
- E. Bundle and tie down wires in a neat and orderly manner.
- F. Terminate drain wire of shielded cables at backpan terminal block only.

3.03 WARRANTY

- A. Provide warranty per Section 16010.
- B. Perform the following services during the warranty period:
 - 1. Repair or replace damaged modules returned for service within 24 hours.
 - 2. Determine and report the cause of failure of modules returned for service.
 - 3. Resolve design or implementation problems discovered.

3.04 MAINTENANCE

- A. Provide the following spare parts
 - 1. EE-PROM or other off line memory module containing PLC as-built program.
 - 2. One PLC processor loaded with final as-completed program
 - 3. One 7 slot PLC rack
 - 4. One I/O card of each type used.
- B. Provide special tools, cabling and equipment necessary for normal operation, maintenance and calibration.

3.05 ACCEPTANCE

- A. Final acceptance will be given by the ~~Owner~~ *Government* after the equipment has been "field" tested satisfactorily, each deficiency has been corrected, documentation has been provided, and all the requirements of design documents have been fulfilled.
- B. At the end of the project, following the completion of the field tests, and prior to final acceptance, the Supplier shall provide the following to ~~City~~ *Government*:
 - 1. Each "operation and maintenance" manual shall be modified or supplemented by the Supplier to reflect all field changes and as-built conditions.

3.06 TRAINING

- A. *The PLC System Supplier (Contractor) shall provide a minimum of 8 hours of training for 4 to 6 of the Government's engineering, operations, and maintenance personnel. The training shall consist of the following minimum sessions:*
 - 1. *4 hours – Station Operation through the use of the Operator interface: Describe and show all pump station modes of operation and alarm conditions. Simulate alarms and fault conditions and corrective actions. Show and describe emergency and manual modes of operation.*
 - 2. *4 hours - PLC Maintenance and Troubleshooting Course shall include:*
 - a. *Copying, restoring and saving programs.*
 - b. *Searching and replacing program elements.*
 - c. *Modifying ladder programs and data table information.*
 - d. *Isolating and safely correcting the most common problems in PLC system.*
- B. *Training shall be administered by manufacturer trained personnel in a classroom type setting at the Station.*

***** END OF SECTION*****

PART 1: GENERAL

1.01 SECTION INCLUDES

- A. Applications Programming for Programmable Logic Controller (PLC) and Operator Interface (OI).
- B. Related work as specified in Section 16010 - Electrical.

1.02 SUBMITTALS

- A. Provide submittals per Section 16010-Electrical, SUBMITTAL AND DRAWING REQUIREMENTS.
- B. Submit software operations manual including the following as a minimum.
 - 1. Program Code
 - a. Incorporate tag references into each program register. Tag references shall be shown in program code with program registers.
 - b. Comment for each block of code explaining purpose of program block.
 - c. Comment each program rung for purpose within block.
 - 2. Register cross reference listing
 - a. The listing shall be in table format and include all program constants and variable registers with their functions.
 - b. The listing shall show (block and rung number) where the register is used within the program code.
 - 3. Configuration and Set-up
 - a. The configuration of the processor and hardware selections shall be summarized.
 - b. The configuration of the communication ports shall be shown.
 - 4. Data Tables
 - a. Print data tables with initial register values shown.
 - 5. Special files
 - a. Include any special files that are particular to the manufacturer. All files pertinent to programming or configuration shall be submitted.

- C. Submit software documentation demonstrating understanding of control software requirements and compliance with Portability and Maintainability requirements specified in this Section.
1. Submit OI graphic layout and PLC program listing with cross-references for approval 4 weeks prior to factory test.
 2. Provide two (2) sets of OI graphic screens and PLC applications programs on 3.5" floppy diskettes or compact disks, Windows operating system with each software submittal and at the end of the project for as-programmed final documentation for O & M manuals. Each disk shall have a typed label clearly stating the contents, date, filenames, and submittal (i.e., initial or as-programmed final).
 3. A hard copy listings of OI graphic screens and PLC applications programs (with comments) shall be printed with standard laser print 8½" x 11" paper and supplied with the initial submittal and for as-programmed final documentation for O&M manuals. Copy and binding method shall not cut off any parts of ladder logic and comments. Print shall be sized so that the complete ladder logic run fits on one sheet, rungs extending to multiple sheets will not be accepted and will be returned without review.

1.03 PORTABILITY

- A. Program Code shall be modular in design with program blocks and data tables maintained as unique entities, each easily expanded or modified.
- B. Design and code programs to operate the facility as intended regardless of the size of the system database. Changes to the system database shall do not require changes in program logic.

1.04 MAINTAINABILITY

- A. Design and code programs to allow ~~Owner~~ *Government* to maintain software over the life of the system. This includes the following requirement:
1. Clearly comment each run of ladder logic code. Include module headers detailing the purpose of the module, programmer name, date of last revision, revision history, and description of sequence of events.
 2. Code shall use the P&ID ISA I/O point designations as labels or nicknames throughout the ladder logic.
 3. Code shall use the P&ID I/O point designations as labels or nicknames where possible, in comment areas at minimum.
- B. All software, including diagnostic, configuration and applications programming software shall be licensed directly to and become the sole property of the ~~Owner~~

Government for their use on this and future ~~Owner~~ *Government* projects.

- C. No software or documentation shall be labeled proprietary.
- D. Provide complete hardware and original manufacturer software manuals describing how to use the configuration software.
- E. Provide two (2) disks copies and two (2) hard copies of all as-installed programs at the end of the project.

1.05 APPLICATIONS PROGRAMMER

- A. All programming shall be performed by an application programmer with prior experience on similar PLC & OI projects. The ~~Owner~~ *Government* reserves the right to judge if the application programmer assigned to this project is adequate for the task. If the programming performed is deemed inadequate by ~~Owner~~ *Government*, then the system supplier shall provide a qualified application programmer to meet these requirements.

PART 2: PRODUCTS

2.01 APPLICATIONS PROGRAMMING SOFTWARE

- A. The Contractor's is responsible for obtaining correct revision of PLC & OI configuration software, manuals and licensing necessary to program and configure the PLC & OI. Contractor shall confirm proper version of software prior to the start of PLC programming.

2.02 APPLICATIONS PROGRAM CODE

- A. Provide applications programs in the PLC to execute the control strategies as described herein. The Contractor shall provide application program code that performs to the intent of the descriptions and any additional supporting program code for a fully operational processor and system.
- B. The Contractor shall provide the PLC & OI completely configured and programmed for the monitoring and control of the facility. The PLC & OI shall be setup as defined herein, and as shown on the Contract drawings.
- C. The control strategies for the PLC & OI are intended as guidelines for the supplier to use to program the PLC. The descriptions are intended to be general in nature and do not contain all details to program a fully functional and robust PLC logic program. Many details concerning programming methods and procedures are the responsibility of the Contractor to design and implement. The descriptions are written for best transference of intent may not be the best way to code the program. Errors and omissions in details shall be the supplier's responsibility to correct, at no additional cost to ~~Owner~~ *Government*. The supplier shall meet the intent of the strategies specified, making modifications as necessary to provide an operational system.
- D. The program code shall be written without any "hard-coded" constants that would effectively require a program change to modify the value. All function blocks shall contain variable registers only.

2.03 CONTROL STRATEGIES

A. GENERAL REQUIREMENTS

- 1. The following requirements (General and Specific) are intended to be used as a guideline for application programming of the PLC. They are the major functions and are not intended to be completely comprehensive of all requirements of the station operation and do not attempt to cover all necessary program routines for an operational system. Additional features and functions and registers will be required for an operational system.
- 2. The following general program functions shall be provided:
 - a. Enable/disable toggle bits and variable time delays for all alarms.

- b. Resettable and non-resettable operation hour meters for equipment.
- c. Scaling to engineering values of all variables.
 - 1) Level in 1/10th FEET.
- d. Transducer out of range alarms. If the scaled value of the analog input exceeds 21 mA or falls below 3.5 mA, an out of range alarm shall be triggered for that input.
- e. All setpoints registers, enable/disable toggle bits and settable variable time delays shall be adjustable from the OI direct to program data table.
- f. If a pump is called to start and the associated run status does not confirm start after a time delay then a pump fail alarm shall be triggered.
- g. A power fail shall reset all routines.
- h. Pumps or equipment shall have sequential start routines after power fails.
- i. If a device is called to start or move and the associated run status does not confirm start or move after a time delay then post a device fail alarm.
- j. Program the activation of digital alarm outputs to support the autodialer.
- k. Programming code shall have automatic error checking and proper initialization to prevent illegal operations such as negative values being placed in timer presets or mathematical out of range functions which could cause a processor fault.
- l. *PLC shall be programmed so that, in the event of a power interruption, the equipment controlled shall resume normal operation without requiring a manual reset unless otherwise shown.*

B. SPECIFIC REQUIREMENTS

1. ALARMS GENERAL

a. Inputs/Outputs

Inputs	Description	Latch	Units
LA52HH	Sump High High Level		
LA52H	Sump High Level		
LA52LL	Sump Low Low Level	Latch	
L51	Sump Level		FT
EA96L	UPS Low Battery		
UA96	120 V AC power fail		

EA99L	480 V AC power fail
UA10F	Pump #1 SSS Fail
UA10L	Pump #1 Motor Overload
UA20F	Pump #2 SSS Fail
UA20L	Pump #2 Motor Overload
UA30F	Pump #3 SSS Fail
UA30L	Pump #3 Motor Overload
UA40F	Pump #4 SSS Fail
UA40L	Pump #4 Motor Overload

Outputs	Description
X100	Station Alarm Light

b. Setpoints/Timers/Alarms

Setpoints	Description	Units
SPL51H	Sump Level High	FT
SPL51L	Sump Level Low	FT
SPL51HH	Sump Level High High	FT
SPL51LL	Sump Level Low Low	FT
SPT51H	Sump Level High delay	Seconds
SPT51L	Sump Level Low delay	Seconds
SPT51HH	Sump Level high high delay	Seconds
SPT51LL	Sump Level low low delay	Seconds
SPT96	120 V AC power fail delay	Seconds
SPT99L	480 V AC power fail delay	Seconds
SPT52HH	Sump High High Level delay	Seconds
SPT52H	Sump High Level delay	Seconds
SPT52LL	Sump Low Low Level delay	Seconds
SPT96L	UPS Low Battery delay	Seconds
SPT10F	Pump #1 SSS Fail delay	Seconds
SPT10L	Pump #1 Motor Overload delay	Seconds
SPT10SF	Pump #1 Start Fail delay	Latch Seconds
SPT20F	Pump #2 SSS Fail delay	Seconds
SPT20L	Pump #2 Motor Overload delay	Seconds
SPT20SF	Pump #2 Start Fail delay	Latch Seconds
SPT30F	Pump #3 SSS Fail delay	Seconds
SPT30L	Pump #3 Motor Overload delay	Seconds
SPT30SF	Pump #3 Start Fail delay	Latch Seconds
SPT40F	Pump #4 SSS Fail delay	Seconds
SPT40L	Pump #4 Motor Overload delay	Seconds
SPT40SF	Pump #4 Start Fail delay	Latch Seconds
Timers	Description	Units
K51H	Sump Level High delay	Seconds

K51L	Sump Level Low delay	Seconds
K51HH	Sump Level high high delay	Seconds
K51LL	Sump Level low low delay	Seconds
K96	120 V AC power fail delay	Seconds
K99L	480 V AC power fail delay	Seconds
K52HH	Sump High High Level	Seconds
K52H	Sump High Level	Seconds
K52LL	Sump Low Low Level	Seconds
K96L	UPS Low Battery	Seconds
K10F	Pump #1 SSS Fail	Seconds
K10L	Pump #1 Motor Overload	Seconds
K10SF	Pump #1 Start Fail	Seconds
K20F	Pump #2 SSS Fail	Seconds
K20L	Pump #2 Motor Overload	Seconds
K20SF	Pump #2 Start Fail	Seconds
K30F	Pump #3 SSS Fail	Seconds
K30L	Pump #3 Motor Overload	Seconds
K30SF	Pump #3 Start Fail	Seconds
K40F	Pump #4 SSS Fail	Seconds
K40L	Pump #4 Motor Overload	Seconds
K40SF	Pump #4 Start Fail	Seconds

c. Analog Alarms

- 1) If an analog value is above/below the associated setpoint, and the associated time delay has exceeded the time setpoint, then the alarm shall be generated/annunciated.
- 2) Transducer fails as described in CONTROL STRATEGIES, GENERAL REQUIREMENTS.
- 3) The alarm shall automatically reset unless it is designated as “latch”. A latching alarm requires manual reset

d. Digital Alarms

- 1) If the digital input state is true and the associated time delay has exceeded the time setpoint, then the alarm shall be generated/annunciated.
- 2) The alarm shall automatically reset unless it is designated as “latch”. A latching alarm requires manual reset.

2. TOTALIZATION

a. Inputs/Outputs

Inputs	Description	Units
N10R	Pump 1 run	Run/off
N20R	Pump 2 run	Run/off
N30R	Pump 3 run	Run/off
N40R	Pump 4 run	Run/off

Outputs	Description
	None

b. Timers/Totalizers

Timers	Description	Units
K10	Pump 1 running hours	Hours
K20	Pump 2 running hours	Hours
K30	Pump 3 running hours	Hours
K40	Pump 4 running hours	Hours

Totalizers	Description	Units
	None	

c. Hour Meters

- 1) If Pump 1 running (N10) is set, then start hour timer K10.
- 2) Similar for Pump 2.

3. PUMP START CONTROL

a. Inputs/Outputs

Inputs	Description	Units
Y10A	Pump 1 in auto	Auto/Null
N10R	Pump 1 in run	Run/Off
Y20A	Pump 2 in auto	Auto/Null
N20R	Pump 2 in run	Run/Off
Y30A	Pump 3 in auto	Auto/Null
N30R	Pump 3 in run	Run/Off
Y40A	Pump 4 in auto	Auto/Null
N40R	Pump 4 in run	Run/Off
L51	Sump Level	FT

Outputs	Description	Units
X10	Pump 1 start	Start/Stop
X20	Pump 2 start	Start/Stop
X30	Pump 3 start	Start/Stop
X40	Pump 4 start	Start/Stop

b. Setpoints/Timers/Alarms

Setpoints	Description	Units
SPL60A	Lead pump start level	FT
SPT60A	Lead pump start delay	Seconds
SPL60B	Lag pump start level	FT
SPT60B	Lag pump start delay	Seconds
SPL60C	Lag 2 pump start level	FT
SPT60C	Lag 2 pump start delay	Seconds
SPL60D	Lag 3 pump start level	FT
SPT60D	Lag 3 pump start delay	Seconds
SPL60E	Lead pump stop level	FT
SPT60E	Lead pump stop delay	Seconds
SPL60F	Lag pump stop level	FT
SPT60F	Lag pump stop delay	Seconds
SPL60G	Lag 2 pump stop level	FT
SPT60G	Lag 2 pump stop delay	Seconds
SPL60H	Lag 3 pump stop level	FT
SPT60H	Lag 3 pump stop delay	Seconds

SPR60	Pump Rotation	0, auto XXXX, named
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Timers	Description	Units
K60A	Lead pump start delay	Seconds
K60B	Lag pump start delay	Seconds
K60C	Lag 2 pump start delay	Seconds
K60D	Lag 3 pump start delay	Seconds
K60E	Lead pump stop delay	Seconds
K60F	Lag pump stop delay	Seconds
K60G	Lag 2 pump stop delay	Seconds
K60H	Lag 3 pump stop delay	Seconds

Alarms	Description	Units
	None	

c. Pump Start/Stop

- 1) If the Sump level (L51) rises above lead pump start setpoint (SPL60A) for a lead pump start delay setpoint (SPT60A) amount of time then, then start lead pump.
- 2) If the Sump level (L51) rises above lag pump start setpoint (SPL60B) for a lag pump start delay setpoint (SPT60B) amount of time then, then start lag pump.

- 3) Similar for lag 2 and lag 3 pumps.
 - 4) If the Sump level (L51) falls below lag pump stop setpoint (SPL60E) for a lag pump stop delay setpoint (SPT60E) amount of time then, then stop lag pump.
 - 5) If the Sump level (L51) falls below lead pump stop setpoint (SPL60F) for a lead pump stop delay setpoint (SPT60F) amount of time then, then stop lead pump.
 - 6) Similar for lag 2 and lag 3 pumps
- d. Pumps available
- 1) If a pump is in auto (YX0) and not failed (UAX0) and power failure is not received (EAL99) then the pump is available to be put into the rotation.
- e. Pump rotation
- 1) If the pump rotation order setpoint (SPR60) = 0 the pumps shall rotate after each pump cycle. Pump.
 - 2) If Pump rotation setpoint (SPR60) = 1 then Pump 1 shall be called first and stopped last.
 - 3) If Pump rotation setpoint (SPR60) = 2 then Pump 2 shall be called first and stopped last.
 - 4) Similar for pumps 3 and 4
- f. Pump Failure
- 1) If a pump is called to start, and the corresponding running feedback signal is not received by the PLC within (SPTX0SF) seconds, then post a pump failure.
 - 2) If a pump has failed, then another pump shall be called automatically in its place.

2.04 OPERATOR INTERFACE (OI)

- A. The following general information shall be provided on the OI display for all ladder logic program control strategies:
1. Display all analog values on the OI graphics with bargraph and analog readout along with its associated alarm setpoints arranged next to bargraph in

ascending order (i.e. low alarm setpoints at bottom and high alarm setpoints near the top).

2. Graphic screen(s) shall display station main parameters in process flow format similar to that shown on the P&ID diagrams.
3. OI shall display all station parameters, setpoints, statuses and outputs, regardless if the registers are linked to physical I/O or not.
4. Setup control parameter screen listing all setpoint registers. All settable values shall be changeable from the OI screens.
5. Alarm summary screens listing all alarms.
6. Flashing Alarm Indication
7. Acknowledge button to acknowledge alarms displayed on OI.
8. All values shall be displayed with engineering units.
9. Analog values shall be displayed with the resolution as described above.
10. Display indicating a new alarm regardless of the screen currently displayed.
11. Menu screen with jump buttons to all screens.
12. Jump button displayed on all screens to go to a menu screen.
13. Jump button displayed on all screens to go to the last screen.
14. Text accompanying any changes in color display (i.e., green – “RUN”, red – “OFF”, etc.).
15. Setup color convention to be used:
 - a. Background colors:
 - 1) Window - Black.
 - 2) Changeable variable points - Pale Yellow.
 - 3) Non-Changeable variable points - Light Blue.
 - b. Control Switch Colors
 - 1) Hand - Red.
 - 2) Off - Grey.
 - 3) Auto - Green.
 - c. Pump and Equipment Colors
 - 1) Run - Green.
 - 2) Off - Red.

- 3) Fail - Gold.
- 4) Ready/Available - White.
- d. Water Valve Colors
 - 1) Closed – Red
 - 2) Modulating – Purple
 - 3) Open – Green
 - 4) Undetermined – Grey
- e. Circuit Breaker Colors
 - 1) Closed – Green
 - 2) Open – Red
- f. Relay Logic Colors
 - 1) Closed Relay Contact - Green
 - 2) Open Relay Contact - Red.

PART 3: EXECUTION

3.01 SOFTWARE DEVELOPMENT

- A. The programming, setup and configuration of the PLC & OI shall be done by the PLC & OI supplier.
- B. The PLC & OI shall be ready to be placed in operation at the time of start-up.
- C. Additional Programmer Labor Hours
 - 1. The Contractor shall include in his bid price an additional 32 hours of PLC/OI program configuration changes to be designated by the ~~Engineer Contracting Officer~~ or ~~Owner Government~~ during testing and start-up.
 - 2. All programming configuration changes shall be performed by the original programmer and shall be made in the presence of the ~~Engineer Contracting Officer~~ in the field. None of the hours shall be used for travel costs, overhead, etc., that are not related to programming changes since this is included in the hourly rate without written approval from ~~Engineer Contracting Officer~~.
- D. Do not enable or set any passwords on the PLC software or hardware for this project.

3.02 MEDIUM

- A. Provide PLC & OI applications programs on CD recordable disk media with each submittal . Clearly label CD with station name and contents. CD disk shall contain the following:
 - 1. Application program, configuration and data tables.
 - 2. OI software with graphics and all support files.
 - 3. These disks shall become the property of the ~~Owner Government~~, for its use on this and future projects.
- B. In addition, one (1) set of 3.5" floppy diskettes of the application PLC & OI programs shall remain on site. All programs on the disks shall be updated each time the Contractor is called out to modify the programs.
- C. Provide two (2) copies of as-installed applications programs printed with standard laser print 8 1/2" x 11" paper at end of project. Insert new print-outs into the Operations and Maintenance manuals. Provide number of copies as specified in 16010 Operations and Maintenance Instructions.

3.03 FIELD ASSISTANCE

- A. Provide testing as specified in Section 16600 – FACTORY AND FIELD TESTING.

3.04 WARRANTY

A. Hardware support:

1. Provide warranty as specified in Section 16010 - Electrical, WARRANTY.

***** END OF SECTION*****

PART 1: GENERAL

1.01 SCOPE OF WORK

- A. Provide all devices, valves, tubing, fittings, wiring, terminal blocks, accessories, and enclosures as specified herein and as shown on Contract Drawings for the instrumentation system. The Contract Documents are intended as an outline for the work and are descriptive of the type of hardware and software configuration to be provided. Any error or omission of detail shall not relieve the Contractor from the obligations thereunder to provide and install any and all additional materials necessary for a complete operational instrumentation system per instrument manufacturer's requirements, at no additional cost to the ~~Owner~~ *Government*.
- B. The major components in the instrumentation scope of work are:
1. Provide/install instrumentation as listed in the instrument schedule "Appendix A" at the end of this section. This includes all necessary piping and valves, flanges, bracket supports, and anchors to complete installation. Provide all miscellaneous devices such as isolators and relays to complete wiring interface.
- C. The contract documents are not intended to cover every detail of materials, software, hardware, configuration, or construction. The Contractor shall furnish all tools, temporary utilities, materials, setup, parts, labor, and other incidentals necessary to fully complete the entire work, whether or not details are shown or specified, all at no additional cost to the ~~City~~ *Government*.
- D. Selection of instrumentation shall be per manufacturer's recommendation for the application and per specifications. If a manufacturer's recommendation or installation instructions differ from the Contract installation details and specifications for the application, then the Contractor shall inform the ~~Engineer~~ *Contracting Officer* of the discrepancy in writing within the submittal comment letter. Installation of properly applied instrumentation is the responsibility of the supplier.

1.02 RELATED WORK

- A. Installations of primary elements which require placement into or taps off of a process flow line are included under Division 15000 Mechanical. Electrical conduit and wire for instrumentation is covered in Section 16010 Electrical.

1.03 RELATED SECTIONS

- A. Section 16010 – Electrical

B. Section 16110 Conduit, Devices, Boxes and Grounding

C. Section 16120 Wire, Fuses and Terminal Blocks

1.04 SUBMITTALS AND DRAWINGS

A. Submit shop documents and drawings for approval in accordance with this subsection and as specified in Electrical Section 16010 - SUBMITTAL AND DRAWING REQUIREMENTS.

1.05 OPERATING INSTRUCTIONS

A. Provide operating instructions as specified in Section 16010 - Electrical, OPERATING INSTRUCTIONS.

PART 2: PRODUCTS

2.01 QUALITY

- A. Quality included that specified in Section 16010 - Electrical.
- B. 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 requiring a manual reset.
- C. Signal transmission from remote or field electric and electronic devices shall be 4-20 mA, sourced by a 24 VDC supply internal to the instrument or from a 24 VDC power supply located within 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.
- D. Transmitters or devices located in Class 1, Division 1 hazardous areas shall be rated for hazardous location installations per NEC and UL. Explosion proof enclosures and raceways or current/spark limiting devices located outside of the classified area shall be included at no additional cost to the ~~Owner~~ *Government*.
- E. Outputs of equipment that are not of the standard signals as outlined, shall have the output immediately converted to 4-20 mA signals for remote transmission.

2.02 LEVEL COMPONENTS

A. ULTRASONIC LEVEL TRANSMITTER

- 1. The ultrasonic level transmitter shall utilize non-contacting ultrasonic signal reflection technology to provide level monitoring for up to 50 ft range.
- 2. The transmitter shall feature advanced echo processing algorithms that can be configured to ignore selected echos.
- 3. The transmitter shall be capable of controlling two pumps in a lead/lag configuration or using outputs for high and low level alarm outputs.
- 4. The transducer level element (LE) shall have the following features:
 - a. Corrosion resistant plastic body, completely submergence rated.
 - b. Rated for Class 1, Div. 2 hazardous atmospheres.
 - c. Operating temperature of -40 to 200 deg F.
- 5. The level indicating transmitter shall have the following features:
 - a. NEMA 4X / IP65 enclosure.
 - b. Ground isolated 4-20 mA output, max load of 750 ohm.
 - c. Two 5 amp at 120V AC, SPDT relays.

- d. Integral 4 button keypad for configuring parameters.
 - e. Integral 1.5" x 4" (min) backlit LCD display.
 - f. Operating temperature range from -40 to 140 deg. F.
6. The calibration of the level transmitter and cable length shall be as shown in the instrument index located in Appendix "A" at the end of this section.
7. The ultrasonic level transmitter shall be Milltronics MiniRanger Plus, or approved equal.

B. CONDUCTANCE LEVEL RELAY

1. Probe Relay
- a. Probe relay relay shall be 120 VAC powered and have four 8 amp SPDT relay outputs, one assigned to each input channel. The relay shall be wired to use 5 probe devices for directing acting service. Provide UL listed Warrick Series 63 or approved equal.
2. Probes
- a. The probes shall be wire suspended type consisting of metallic bars within a protective plastic shield. The probes shall be suspended above or within the fluid via PVC insulated wires. Probe length to be shipped at 35' (min) length to be cut in field to achieve levels defined by Civil plans.
 - b. The probe holder shall be constructed of die cast aluminum housing with epoxy coated finish. The housing shall be mounted via a male threaded fitting. The probe holder shall be capable of holding 1 to 7 probes.

2.03 INSTRUMENTATION INDEX

- A. The Instrumentation Index spreadsheet in Appendix "A" is intended to be a summary of instrumentation equipment required for this project. Not all instrumentation details are shown on index. Some requirements may be shown in the instrumentation index such as enclosure rating and instrument span that are not described in the specifications. Both are required for a complete specification.
- B. If an instrument is shown in the P&IDs or on the site plan, then the device shall be provided whether or not it is shown on the instrumentation index.

PART 3: EXECUTION

3.01 WORKMANSHIP

- A. All instrumentation work in this contract shall conform to the codes and standards specified in Section 16010 - Electrical.
- B. The Contractor shall employ personnel who are skilled and experienced in the installation and connection of equipment defined in this section. All installation labor shall be performed by qualified personnel who have experience on similar projects. Provide first class workmanship for all installations.
- C. Verify that all equipment and materials fit properly.
- D. All instrumentation configuration, programming and calibration shall be completed prior to the start of field tests.
- E. The ~~Owner~~ *Government* reserves the right to halt any work that is found to be substandard or being installed by unqualified personnel.
- F. Rejected equipment or equipment without approved submittals shall be immediately removed from the job site by the Contractor.
- G. All equipment shall be properly stored indoors while awaiting installation. Protect installed equipment from construction debris or mishaps. The Contractor will replace any equipment that is not in new condition at the time of installation and/or start-up.
- H. Perform any required work to correct improper installations at no additional expense to the ~~Owner~~ *Government*.

3.02 INSTALLATION

- A. Install and supply all products necessary to provide an operational instrumentation system. This shall include the following:
 - 1. Contract Drawings are intended to show the basic functional requirements of the instrumentation system. Insufficient detail does not relieve the Contractor from the responsibility to provide a complete and functioning system. If additional detail or clarification is required, the Contractor shall request such information from the ~~Engineer~~ *Contracting Officer* prior to installation.
 - 2. Provide relays, signal converters, isolators, boosters, power conditioners, circuit cards, and other miscellaneous devices as required for the compatible and functional interface.
 - 3. Provide analog loop isolators where required to eliminate "ground loops."

4. The instrumentation and accessory equipment shall be installed in accordance with the manufacturer's instructions and located as shown on the Drawings or as approved by the ~~Engineer~~ *Contracting Officer*. When manufacturer's installation literature specifies a particular location or orientation in a process line due to measurement accuracy considerations, the installation shall be in conformance with the manufacturer's instructions.

B. Instrument installation methods.

1. Install instruments at the location shown on the Plans or approved by the ~~Engineer~~ *Contracting Officer*. Instruments enclosures shall be NEMA rated for the installed location.
2. Install level and plumb.
3. All instruments shall be provided with floor stands or wall brackets as shown in installation details or as required for functional installation.
4. Mounting stands shall be custom manufactured of aluminum channel with base plate unless otherwise noted in installation detail.
5. Mounting channels (unistrut), and spacers shall be galvanized steel above ground outdoors and stainless steel below ground (wetwell), unless otherwise noted in installation details.
6. All screws, bolts and anchors shall be stainless steel.

C. Wiring and raceway installation methods.

1. Terminal blocks shall be provided at all instrument cable junctions and all wires shall be identified at such junctions.
2. Instrumentation wiring shall be run without splices between instruments, terminal boxes, or panels.

D. Wiring, grounding, and shielding methods.

E. The following practices shall be observed unless modified by manufacturer's standards:

1. Each electronic equipment chassis shall be grounded to power ground.
2. Shielded twisted pair, shielded triad, or manufacturer supplied cables only shall be used for analog signals and communications signals.
3. Drain wire of shielded cables used for analog inputs to the PLC shall be connected at the PLC unit only. Shield shall be isolated from ground at all other termination points including transmitters.

4. Drain wire of shielded cables used for analog outputs from the PLC shall be connected at signal receiving device only. Shield shall be isolated from ground at all other termination points.
5. If electrical interference noise is imposed on DC status and alarm signals, then they shall be re-routed or wire changed to shielded twisted pair cables.
6. Each shield drain wire which is not connected to ground shall be cut off covered with a heat shrink insulating boot at cable jacket end. Shields shall be connected together at each transition from one cable to another for an effectively continuous shield circuit.

3.03 SUPPLIER SERVICES

- A. The Contractor shall be responsible for each supplier of equipment to provide the following minimum services for each type of instrument supplied. Each supplier shall provide a qualified instrumentation field technician to perform services listed herein.
 1. Advise and instruct Contractor on proper installation requirements.
 2. Inspect, calibrate, test, and place equipment in operation.
 3. All programmable devices shall be programmed and tested prior to startup. Programming shall be adjusted or changed as directed by the ~~Owner~~ *Government* or ~~Engineer~~ *Contracting Officer*, at no additional cost.
 4. Coordinate with the ~~Owner~~ *Government* and setup all alarm, process, and operation setpoints.
 5. Perform all witnessed testing.
 6. Visit the project site as often as required and spend as much time as necessary to ensure an operational instrumentation system.
 7. Provide telephone assistance to answer all questions on equipment supplied.
 8. Provide training as specified in TRAINING.
- B. The Contractor shall coordinate with each supplier of instrumentation to confirm that primary elements are provided in a timely manner, meeting critical path scheduling. The Contractor shall coordinate process connection size, equipment size, and material type when applicable and oversee the installation, calibration, and acceptance testing.

3.04 TRAINING

- A. The instrument supplier shall provide a minimum of one (1) hour of field training to instruct ~~Owner~~ *Government* personnel in the use, operation, calibration, programming, and maintenance on each type of "field" instrument listed in Instrumentation Index.

3.05 SPARE PARTS

- A. Provide spare parts as described in each section of PRODUCTS herein and specified in Section 16010 - Electrical, SPARE PARTS.

3.06 WARRANTY

- A. Provide warranty as specified in Section 16010 - Electrical, WARRANTY.
- B. Each time the Supplier's repair person responds to a system malfunction during the warranty period, he or she must contact the designated ~~Owner~~ *Government's* 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 direct supervision of ~~Owner~~ *Government* staff. The ~~Owner~~ *Government* reserves the right at its sole discretion to deny operational requests of the Supplier or require additional procedures or bypassing equipment if those operations may interfere with critical facility operations.

3.07 FINAL ACCEPTANCE

- A. Provide final acceptance as specified in Section 16010 - Electrical, FINAL ACCEPTANCE.
- B. At the end of the project, following the completion of the field tests, and prior to final acceptance, the Supplier shall provide the following to the ~~City~~ *Government*:
 - 1. Each "operation and maintenance" manual shall be modified or supplemented by the Supplier to reflect all field changes and as-built conditions.

***** END OF SECTION *****