Wastewater Treatment

Taking the waste out of water

Contract Documents for the Construction of

Sacramento Regional Wastewater Treatment Plant

REGIONALSAN
Sacramento Regional County Sanitation District

ARDEN PUMP STATION N19 PUMP 3 IMPROVEMENTS PROJECT RFB 8296

VOLUME 1 OF 2

SPECIFICATIONS
Electrical

July 2018

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HEALTH AND SAFETY REQUIREMENTS

1.01 GENERAL

A. All operations shall conform to applicable occupational safety and health standards, rules, regulations and orders which include, but are not limited to: Title 29 of the Code of Federal Regulations and the Electrical, Construction, Tunnel and General Industry Safety Orders issued by the Division of Industrial Safety (Cal/OSHA) of the State of California. In the event of a conflict between the requirements in the referenced standards, the most stringent standard shall prevail.

B. The Contractor shall submit their Injury and Illness Prevention Program (IIPP) for review.

C. All contractors, vendors and visitors will wear hardhats and safety vests at all times while in construction areas. In addition, if necessary, but not limited to: appropriate foot, eye and ear protection shall be worn.

D. Contractor shall have a Site Specific Safety Plan that has been specifically prepared for the contemplated work. Site Specific Safety Plan shall comply with section 3203 of Cal/OSHA and shall be applicable to all individuals engaged in the Work, including the Contractor's subcontractors, suppliers and others.

E. An Emergency Action Plan and a Fire Prevention Plan in accordance with sections 3220 and 3221 respectively of Cal/OSHA shall be included in Site Specific Safety Plan.

F. The responsibility for safety rests with the Contractor who must provide a safe work site for workers and other individuals entering the area.

G. District reserves the right to stop any work activity that creates a serious safety violation as defined by Cal/OSHA,

H. In accordance with OSHA's National Emphasis Program (NEP), any contractor or subcontractor working on or adjacent to digester gas systems during a Process Safety Management (PSM) inspection will also be inspected by OSHA per CPL 02-09-06.

1.02 PROJECT SPECIFIC SAFETY PROGRAM

A. Project Specific Safety Program shall include:

1. Designation of Safety Manager. A resume shall be provided.

2. Detailed description of Site Specific Safety Plan.

3. Policies and procedures to ensure compliance with regulations.

4. Staffing plan and organization chart for implementation of the safety program.

5. Training program including new employee orientation.

6. List of equipment, supplies, materials and personal protective devices that will be available and utilized.

7. Description of accountability for foreman and supervisors.

8. Site Specific Emergency Response Plan for accidents/incidents and injuries.

9. Description of accident investigation and reporting procedures.

10. Description and frequency of tailgate and regular safety meetings.

11. Participation of subcontractors, suppliers and others in Project Safety Program.

12. Method of identifying, correcting, or remedying situations that are unsafe or not in compliance with Project Safety Program.

13. Plans and procedures for confined space entries.

14. Provisions for excavation safety.

15. Procedure for preparation of Work Permits.

16. Method to remedy nonconforming situations.

B. Project Specific Safety Program and revisions shall be reviewed by full time Safety Professional. The full time Safety Professional shall state that the Site Specific Project Safety Program is adequate and complies with the regulations applicable to the Work. The Project Specific Safety Program shall be submitted to the District Representative, for review, prior to commencement of work and shall remain in effect until the Work has been completed. Site Specific Safety Plan shall be reviewed, updated, and changes submitted as they occur.

1.03 SAFETY MANAGER

A. A Safety Manager shall be designated who has responsibility for safety of the Work and who has the duty to implement and secure compliance with the Site Specific Safety Plan. This individual shall be independent from the construction work force and shall have the authority to act and affect all aspects of the Project Safety Program. Safety Manager shall have the authority to remedy or correct any unsafe or noncompliance situations or problems.

B. Safety Manager or designated alternate individual shall be on site when Work is being pursued. Contractor will be permitted to designate an alternate individual to act on behalf of Safety Manager when Safety Manager is absent from the work site.

C. Safety Manager shall have 5 years of industrial and heavy construction experience on projects similar to the Work. Three years of this experience shall involve full-time, construction site safety responsibilities. Safety Manager shall be knowledgeable of occupational health and safety rules and regulations.

D. Safety Manager shall prepare Work Permits for each confined space entry and shall organize and observe each entry.

E. Safety Manager and a District Representative shall tour the site on a weekly basis to observe the Work.

1.04 PROTECTION OF WORKERS

A. The SRWTP receives sewage and industrial wastes. There is a possibility that solvents, fuels and hazardous material may be in the wastewater. The wastewater and the associated facilities should be considered contaminated. Individuals who contact wastewater, debris or existing facilities should take appropriate safety and health precautions such as personal protective equipment and inoculations for disease.

B. Safety equipment and precautions shall be utilized to protect workers, District personnel, and the general public during the work.

1.05 WORK PERMITS

A. There are areas and operations at the SRWTP which are potentially hazardous or dangerous if the appropriate precautions are not taken. The Work Permit process is utilized to review proposed work activities and to ensure good work practices and appropriate safety measures are followed. Contractor is required to prepare Work Permits and comply with the stipulated conditions. A Work Permit shall provide a detailed description of the proposed activities and sequencing.

B. Examples of activities which require a Work Permit are:

1. Operations that have open flames, the potential for sparks or activities that may result in high temperatures. Examples include welding, cutting, grinding and electrical work.

2. The use of tools or electrical equipment in classified areas.

3. Work on equipment or piping which contains, or has contained, a flammable or hazardous material, chemical or gas. Work on or in proximity to chemical or gas storage facilities.

4. The use of hazardous materials.

5. Activities which involve electricity at greater than 500 volts.

6. Activities that involve pressures greater than 150 psi.

7. Activities that involve work in a confined space including the opening of vaults and manholes.

8. Activities that involve special precautions required by Cal/OSHA.

1.06 REPORTING

A. Monthly, Safety Manager shall prepare and submit a narrative report describing actions, incidents, near-misses and topics related to safety. The report shall indicate past events and proposed future activities. A summary of events of weekly job site tours shall be included.

B. All incidents that are reportable on OSHA Form 300 or that result in property damage in excess of $1,000 shall be promptly reported to District. A detailed description of the incident including names and statements of witnesses shall be provided within 5 days of the occurrence.

C. Contractor shall inform the District within 5 days of any claims, suits, or citations of violations that may arise from an incident or injury.

1.07 NON COMPLIANCE

A. When a serious hazard is identified, the Contractor will receive a verbal notification of the problem and a request to rectify the situation. If the situation is not corrected in the allotted time or reoccurs, a written notification will be issued to the Contractor that will clearly describe the condition, date Contractor initially was notified, the recommended action and the expected date of compliance. If the situation is not corrected, the Contractor's worker's compensation insurance carrier will be notified.

****END OF SECTION****

SECTION 26 05 00

ELECTRICAL GENERAL

PART 1: GENERAL

1.01 SCOPE OF WORK

A. The following list of components and areas of work is a summary of the work required in the drawings and specifications. The list is not comprehensive of the total work required nor is it in any specific order. It is merely being provided as an aid to the bidder. Work not listed herein, but described in the plans or specifications, is also part of the overall scope of work.

1. Coordinate and install Owner furnished Medium Voltage VFD for Pump 3. Footprint from VFD (per submittal from Allen Bradley) is shown on drawings.

a. VFD specification is provided herein for reference. Contractor must install per requirements defined in the specificaitons and per manufacturer instructions.

b. The VFD submittal and associated drawings will be provided to the Contractor upon request.

2. Pump 3 Local Control Panel.

3. Placeholder blank control panel (to hold up upper junction box)

4. PLC and SCADA.

a. Connect I/O to existing PLC control panel per drawings. I/O terminal points are listed in the drawings

b. Hardware, Software, Configuration and Programming of the PLC and SCADA System is by Application Programmer – a person or entity further defined in this section.

5. Instrumentation

a. Re-installation and testing of existing motor instrumentation.

b. Contractor shall calibrate, configure and test all instrumentation and document results.

6. Interconnection Diagrams.

7. Conduit – support systems, wire, and grounding system, for equipment interconnection, and operation.

8. Installation of Owner furnished VFD, connection newly rewound motor, and connection of all control accessories.

9. Coordination and equipment for connection of power utility and telephone services per utility drawings and standards.

10. Site electrical devices, lights and receptacles.

11. Seismic Anchorage Design Calculations and conforming installation.

12. System startup, calibration, testing and documentation.

    a. The Application Programmer (defined in Electrical Specifications [Electrical General].) and/or Construction Manager will be actively engaged in Operational Testing and Commissioning. These efforts shall be combined efforts of the Application-Programmer/Construction-Manager/Engineer and Contractor.

    b. The Contractor shall facilitate test as outlined herein such that hardware, software and application programming are tested completely and all applicable test documentation is completed.

    c. The Contractor shall assume that a minimum of 24 hours will be required to assist in this task.

    d. Sufficient time shall be allocated in the construction schedule for troubleshooting, testing, startup, and verification of application programming in front of associated construction milestones. For instance, if a pump station is required to be operational prior to a date certain, then the schedule shall allocate time for these activities. The time necessary depends on the system to be started and shall be coordinated with the Owner Representative or Application Programmer during construction scheduling early in the project.

13. Electrical Safety Training.

    a. Train operations and maintenance personnel in the proper methods to adhere to Electrical safety principals.

    b. Obtain existing Arc-Flash hazard information prior to training and use this information to tailor the training for the new equipment and its hazard level.

B. Electro-mechanical equipment to be installed in this project may be specified in

other divisions but will interface to equipment provided under Electrical Specifications. Obtain submittals for those devices, review, coordinate and provide all interfacing equipment, software, communications, I/O, and testing to integrate the equipment to the extent possible and as intended.

C. Install electrical and control portion of electro-mechanical equipment specified in other sections. Reference those specifications, pertinent details, and follow all manufacturer instructions to erect, install and commission equipment. Furnish all electrical equipment, interconnecting wire, and make connections to place equipment in operation.

D. All electrical equipment and materials, and methods - including installation, calibration, and testing - shall conform to the applicable codes and standards listed in this and other Sections. All electrical materials and work shall conform to published standards of the National Electric Code (NEC) current issue, Institute of Electrical and Electronic Engineers (IEEE), and Underwriters Laboratories Inc (UL).

1.02 RELATED SPECIFICATIONS

A. The following specification sections are part of the [Electrical Specifications].

Section	Description
26 05 13	Medium Voltage Wire
26 05 19	Low Voltage Wire and Communications Cable
26 05 26	Grounding
26 05 33	Conduit and Boxes
26 05 19	Low Voltage Wire and Data Cable
26 05 70	Factory and Field Testing
26 09 05	Control Panels
26 13 27	Medium Voltage Variable Frequency Drive

B. Owner, Engineer, Construction Manager, Application Programmer, and City are used within Electrical Specifications and are interchangeable. They are all representatives of the Owner, in this case, the Sacramento County Regional Sanitation.

1.03 QUALIFICATIONS AND REQUIRED WORK SCOPE

A. Electrical Contractor

1. Management and installation of the entire electrical and control system required for this project shall be by an Electrical Contractor meeting qualifications as defined herein.

a. Contractor shall be capable of looking at electrical equipment submittals, prior to installation, comparing hookup requirements to the drawings, and noting any deficiencies.

2. Electrical Contractor shall select, furnish, and install all commodity electrical materials (conduit, wire, supports, fittings, ductbanks, etc) that are generally not "custom" or uniquely manufactured for this project. Custom electrical panels, controls, and instrumentation shall be furnished by Systems Integrator.

3. Shall be competent in and familiar with management and subcontracting of specialty electrical and instrumentation supply and engineering work as requires of a Systems Integrator as described herein.

4. Electrical Contractor must be competent in performance, supervision and coordination of work required and performed by equipment suppliers and Systems Integrator (Subcontractors).

5. The Electrical Contractor (EC) shall meet the following minimum qualifications:

   a. Has a current C10 Electrical Contractor's License issued by the State of California Department of Consumer Affairs.
   b. EC shall be regularly engaged in similar industrial power and controls electrical contracting for the Water and Wastewater Industry.
   c. EC shall have successfully performed work of similar or greater complexity (as measured in contract value on industrial power and controls projects) on at least three (3) previous projects.
   d. EC shall carry all insurances as defined and required by the special provisions and as required by law.
   e. EC shall be competent in methods and materials execution and selection associated in the type of electrical and instrumentation work specified in this Division.
      1) EC shall be familiar with and understand codes and requirements from NFPA70, NFPA110, and all other governing national or local codes as required for work scope as described in the drawings and specifications.
      2) EC shall know and understand common terms and abbreviations used in this Industry. Not all terms and abbreviations will be defined in the drawings and specifications.

B. System Integrator

1. Systems Integrator shall be a supplier to the Electrical Contractor and must be competent in performance, supervision and coordination of work

required in this contract.

2. This includes, but is not limited to, all work necessary to select, furnish, construct, supervise installation, configure, calibrate, test, and place into operation all transmitters, instruments, programmable controllers, control panels, motor controls, alarm equipment, communications, monitoring equipment, and accessories.

3. The System Integrator shall have on staff a Project Engineer with three years prior experience on similar sized projects. This Project Engineer shall coordinate the technical aspects of this project and prepare the submittals and drawings. The Project Engineer shall attend all coordination meetings when specifically requested by the Engineer.

4. The System Integrator (SI) shall meet the following minimum qualifications:

   a. SI shall be regularly engaged providing electrical and control systems for the Municipal Water and Wastewater Industry.
   b. SI shall be capable of labeling all electrical panels as manufactured or customized by the System Integrator with appropriate UL label prior to factory testing or shipment to project site.
   c. SI shall have successfully completed work of similar or greater complexity and on similar facilities on at least ten previous projects under the present company name.
   d. SI shall be actively engaged in the following disciplines for the last 5 consecutive years.
      1) Design and manufacturing of custom Control Panels, Motor Controls Centers, and associated devices and equipment as specified in this division.
      2) Programming and commissioning of SCADA, PLC and Operator Interface hardware.
      3) Instrumentation - selection, purchase, calibration, start-up and commissioning.
      4) Testing, calibration, start-up, and commissioning of control systems as applied to the Water and Wastewater industry.
   e. SI shall employ personnel on this project who have successfully completed ISA or equal training courses on general purpose instrumentation.
   f. SI shall have a permanent, fully staffed and equipped service facility within 200 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.

C. Application Programmer

1. The Applications Programmer will be a part of the construction

management team and their work is not in contract.

2. The Application Programmer work is limited to programming and configuration, and associated startup and testing services of the PLC, Operator Interface, and SCADA. All other work is by Contractor.

3. The application programmer will define the station control description.

4. The Application Programmer will attend coordination meetings when specifically requested by the Construction Manager.

1.04 CONTRACT DOCUMENTS

A. The resolution of conflicting information within the contract electrical documents shall put precedence on electrical drawings over that of electrical specifications.

B. The Drawings and specifications are intended to be descriptive of the type of electrical system to be provided with sufficient detail to construct. Minor omission of detail shall not relieve a qualified contractor from the obligation to provide a complete operational system if it can be determined that the particular detail is usual and customary for similar systems.

C. The following specifications may incorporate specific equipment or materials that do not have equal equipment listed. These items are standards because of their familiarity, serviceability, and/or spare parts inventory. However, equal alternate equipment or materials (noted in the submittal cover letter) will be considered for use on this project if submitted. The Engineer may reject said equipment for the purpose of adherence to standards.

D. Contract drawings are diagrammatic and indicate general arrangement of systems and equipment, except when specifically dimensioned or detailed. Exact locations and layouts of electrical products shall be defined during submittal, assembly, or field fit during construction. Field measurements take precedence over dimensioned drawings. Drawing intent is to show initial size, capacity, approximate location, orientation, and general relationship of equipment in area shown but not exact detail or arrangement. The requirements or descriptions in the drawings shall take precedence in the event of conflict.

E. The Contractor shall examine the architectural, mechanical, structural, and electrical and instrumentation submittals and equipment furnished under other specifications divisions in order to determine conduit routing, stub-up locations, and final terminations for all conduits and cables. Conduits shall be stubbed up as near as possible to equipment electrical terminals. 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. 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.

F. All equipment shall be installed and located so that it can be readily accessed for operation and maintenance. If accessibility appears to be compromised, the location of equipment or stub ups shall be modified to the extent possible.

G. Where conduits are shown on the 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.

H. No changes from the Drawings or specifications shall be made without written approval of the Engineer. Should there be a need to deviate from the Contract documents, submit written details and reasons for all changes to the Engineer for review.

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 at all times, progress payments or portions thereof may be withheld if drawings are not accurate or current.

J. 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

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

1.05 PROJECT COORDINATION

A. Prior to submittal, the Electrical Contractor shall coordinate with equipment suppliers to verify sizes, mounting, connections, storage, and delivery of equipment. If there are any issues whereby the solution will be in conflict with plans and specifications, or that are undefined and need direction, they shall be brought to the attention of the Engineer or Construction Manager via the RFI process.

B. Where connections must be made to existing or new operational facilities, the Contractor shall schedule all the required work with Owner, 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 Engineer. Submit shutdown plans at least 2 days in advance of when the scheduled shutdown is to occur.

3. The Owner will activate any shutdown and deactivate any system needed for installation of the work. The Owner must be present for activation and deactivation of systems.

4. The Engineer reserves the right to delay, change, or modify any scheduled shutdown at any time, at no additional cost to the Engineer, 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. The Contractor shall coordinate and confirm that the project schedule is being adhered to and all work is being completed within the scheduled time frames.

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 coordinate, obtain, prepare, and/or complete the documentation required within this division. All documentation shall be complete and delivered prior to final acceptance.

1.07 INSPECTIONS

A. General

1. Contract work or materials shall be subject to inspection at any time by the Engineer. If equipment, material, or installation method does not conform to the Contract documents, or does not have a favorably reviewed submittal status and has been determined to be unsatisfactory by the Engineer, then the Contractor shall 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.

2. The Engineer may inspect and test the fabricated equipment at the factory

before shipment to job site. See Electrical Specifications [Factory and Field Testing] for requirements.

3. Work shall not be closed in or covered over before inspection and approval by the Engineer. All costs associated with uncovering and making repairs where non-inspected work has been performed shall be borne by the Contractor.

4. The Contractor shall cooperate with the Engineer 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, will be necessary to determine the quality of the work.

B. Milestones requiring inspection and signoff.

1. Factory testing. Coordinate test date with Engineer 2 weeks prior to test scheduled date.

2. Installation of electrical equipment. Equipment is anchored in place, conduit connections are complete, no wire is yet pulled into conduit. Permanent conduit tags must be in place per Electrical Specifications [Conduit and Boxes] and [Grounding].

3. Wire termination complete. Do not energize equipment. All wire tags must be installed and wires terminated per Electrical Wire Specifications. Pre-energization testing to commence after inspection.

4. Testing per Electrical Specifications [Factory and Field Testing]. All testing per Electrical Specifications [Factory and Field Testing] shall be witnessed unless specifically declined by the Engineer. Schedule tests with Engineer 2 weeks prior to test date.

5. Start-up per Electrical Specifications [Factory and Field Testing]. Schedule tests with Engineer 2 weeks prior to test date.

6. Punch list – final inspection. Schedule final walkthrough with Engineer one week prior to intended project completion date. All items on punchlist must be complete prior to scheduling walk-through.

1.08 JOB CONDITIONS

A. 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 and sufficiently sealed and

covered 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. Where equipment is stored or installed in an area with susceptibility to moisture, such as unheated buildings, untested piping, etc., provide an acceptable means to prevent moisture damage, such as plastic cover and a uniformly distributed heat source to prevent condensation.

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

1.09 AREA CLASSIFICATIONS

A. Area classifications are shown on the site electrical plans. The area enclosed by walls or the entire drawing area shall be classified as shown unless otherwise described in notes.

B. All electrical equipment, enclosures, conduit, and supports shall be formally rated for or, at minimum, meet the intent of the rating as interpreted by Engineer.

C. If no area classification rating is shown on the drawings, classification shall default to a NEMA 12 rating for indoors, and NEMA 4 rating for outdoors (non corrosive) and NEMA 4X for corrosive areas both indoors and outdoors.

1.10 SUBMITTAL REQUIREMENTS

A. General

1. Requirements described herein are specific to electrical submittals and are secondary to those described in other general specifications sections. Any additional requirements described here that are beyond those described in those sections shall be provided as described. Conflicts shall be resolved by giving priority to general specifications.

2. The Contractor shall ensure that the System Integrator and/or equipment suppliers provide the submittal documentation required in this section. Submittals shall be neat, orderly, complete (without un-needed parsing), and indexed.

3. 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 not be allowed due to failure to properly schedule submittals.

4. No material or equipment shall be delivered to the job site until the submittal for such items has been reviewed by the Engineer and marked

"no exceptions noted" or "make corrections noted".

5. 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 or functional installation.

6. Exceptions to the Specifications or Drawings or equipment or procedures submitted as “equal” to specified equipment shall be clearly identified 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. The Contractor is responsible for verifying proper application/operation of substituted equipment.

7. The opinion of the Engineer will be the final determination whether a substitution request meets the design intent.

8. Deviations from the Contract documents shall **not** be incorporated into the work without prior written approval of the Engineer. A "Change Order" directive from the Engineer 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 to amend the Contract to reflect the costs or savings.

B. Submittal Procedures

1. A unique number, sequentially assigned, shall be noted on the transmittal form accompanying each item submitted. Original submittal numbers shall have the following format: “XXX-0”; where “XXX” is the sequential number assigned by the Contractor. Resubmittals shall have the following format: “XXX-Y”; where “XXX” is the originally assigned submittal number and “Y” is a sequential number assigned for resubmittals, i.e., 1, 2, or 3 being the 1st, 2nd, and 3rd resubmittals, respectively. Submittal 25-0, for example, is the first submittal of Submittal 25, and Submittal 25-2 is the second resubmittal of Submittal 25.

2. Identify all submittals by submittal number on letter of transmittal. Submittals shall be numbered consecutively and resubmittals shall have a letter suffix. For example:

   a. 1st submittal: 1
   b. 1st resubmittal: 1A
   c. 2nd resubmittal: 1B, etc.

3. Shop documents and drawings shall be submitted for all devices and components in the electrical system. The Contractor is notified that this is a “Fast Track” project and all electrical & instrumentation drawings shall

be submitted in a timely manner as not to delay completion of the project.

4. Within 30 calendar days after contract award, the Contractor shall furnish to the Engineer all submittals (electronic) required for this Division. Interconnection drawings, training documents test procedures, and O&M Manuals as applicable shall be submitted timely as to not delay the project.

    a. Submittals shall be delivered entirely electronically via email (no hard copy required). However, General Contractor supervision must not be circumvented by sending submittals direct to Engineer.

    b. Electronic Submittals shall be viewable using a PDF reader.

    c. Electronic (PDF) submittals must follow all applicable requirements for indexing, bookmarks, highlighting, selection indicators (box, highlight) etc. Use of native PDF files (not scans) are required if one exists on the World Wide Web (WWW).

5. Submittal Preparation

    a. Electronic submittals shall be assembled in accordance with the specifications with table of contents, bookmarks, tabs, subtabs, etc. utilizing the electronic bookmarks feature available in the PDF assembler. Only one PDF file is allowed for each submittal. Multiple (.PDF) files will not be acceptable.

    b. Use of native PDF files (not scans) are required if one exists on the www. Ignoring this requirement is cause for submittal rejection.

    c. Submittal shall be appropriately labeled with the project name, contract number, equipment supplier's name, specification section(s), and major material contained therein.

    d. An index shall be provided. This index shall itemize the contents of each tab and subtab section.

    e. 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.

    f. All spare parts shall be listed separately at the end of the Bill of Materials list.

    g. Data summary sheets shall be provided for each individual piece of instrumentation. The data summary sheets shall have the following information preceding their corresponding catalog data:

1) Instrumentation type and tag name.
2) Location/description.
3) The manufacturer's model and part number with all options.
4) Range, span, units, input and output signals.
5) Description of component.
6) Contract specification subsection number reference.

6. 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:

   a. "No Exceptions Noted" - The Contractor may proceed with the work covered in this submittal. No resubmission is necessary.

   b. “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 for record keeping purposes.

   c. "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.

   d. "Rejected without Review" submittal - The Contractor shall not proceed with the work covered in this submittal. The submittal did not address the work scope as defined by the submittal’s title or the previous submittal comments have not been addressed in full. The Contractor shall revise and correct the submittal in accordance with the specifications, and resubmit six (6) copies within calendar 14 days for approval.

7. Resubmittals shall address all comments by the Engineer. A submittal response letter shall be submitted that addresses each comment by the Engineer with a standardized response of “revised” or with a written explanation. Partial re-submittals (that do not address all comments) may be returned without review at the discretion of the Engineer.

8. The Contractor shall be responsible for the Engineer'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.

C. Electrical Equipment -- Submittal data shall be grouped by equipment type. Each

submittal shall be as complete as possible covering the entire project and scope of supply. Drawings or equipment submitted individually that are not on the critical path will not be accepted for individual review. The electrical submittals shall include (as a minimum):

1. Table of Contents

2. Comment Letter: The Project Engineer of the System Integrator shall note all deviations from Contract Documents and the reason(s) for the deviation. They may use this forum to inform the Engineer or installing Contractor of important information related to the project. RFIs must be submitted separately. Re-submittals shall include written responses to every comment provided by the engineer during the previous review.

3. Bill of Materials: The Contractor and System Integrator each shall provide Bill of Material for electrical components formatted as shown below. 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. Provide separate bill of materials for each panel, MCC, instrument list, etc.

Bill of Material

Item #	Qty	Tag#	Description	Manufacturer	Part #

4. Shop Drawings:

   a. Equipment elevations with enclosure details drawn to scale or dimensioned with relative scale.
   b. Electrical One-line, Elementary, and wiring diagrams
   c. PLC I/O wiring diagrams
   d. Interconnection diagrams

5. Catalog Data shall include the following: (features and options shall be highlighted, circled, or "arrowed.")

   a. Instrumentation data summary sheets (by Contractor)
   b. Manufacturer's technical information brochure
   c. Physical size and mounting details and illustrations
   d. Calibration Range
   e. Input/output signals
   f. Electric power, air, and/or water supply requirements.
   g. Options selected and available (Cross out items not included)
   h. Materials of construction of components

D. Shop Drawings - Shop drawings shall be furnished for each electrical panel even

if one was not shown explicitly on the Drawings. Shop drawings shall be numbered in sequence. Blank drawings or drawings that contain no specific project data will not be accepted for review.

All drawings shall be generated with a computer utilizing AutoCAD or similar drafting program. Drawings shall be no smaller than 11" x 17". The lettering shall be legible and no smaller than 0.75 inch in height.

Drawings shall be custom prepared for this project and shall have borders and a title block identifying the project, manufacturer, system or location, drawing number, drawing title, AutoCAD file name, project engineer, date, revisions, and type of drawing. Diagrams shall carry a uniform and coordinated set of wire colors, wire numbers, and terminal block numbers. The shop drawings shall include the following as a minimum:

1. Electrical one-line diagrams detailing all devices associated with the power distribution system. The following applicable information or data shall be shown on the one- or three- line diagram: location, size and amperage rating of bus; size and amperage rating of wire or cable; breaker ratings, number of poles, and frame sizes; power fail and other protective devices; fuse size and type.

2. Detailed analog and digital I/O diagrams showing the wiring requirements for each instrument or device connection. Reference the Drawings for an example of each I/O card drawing requirements. If one is not included in the Drawings, then one may be obtained from the Engineer upon request.

3. Elementary (wiring) diagrams shall be provided for all relay logic, programmable logic controls, motor controls, power supplies, and other wiring. All elementary (wiring) diagrams shall be drawn in JIC EMP/EGP format and standards showing ladder rung numbers and coil and contact cross referencing numbers.

4. Equipment exterior and interior scaled drawings of front, side, elevation, deadfront, front panel devices, and backpan components. Show fabrication methods and details; including material of construction, paint color, door latch and lock, and ventilation system. Show shipping split locations and offloading information. Submit base plan showing allowed conduit entrance areas and bolt hole locations.

5. Drawings shall show UL required information as needed to UL label the equipment in accordance with UL procedures for label applied.

6. Submit full size drawing of all nameplates and tags, as specified herein, to be used on project. 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 nameplates on each, panel and enclosure.

E. Interconnection Diagrams - Interconnection diagrams shall be furnished for each electrical and instrumentation system, even if one was not shown explicitly on the Drawings. Reference the Drawings for an example of interconnection drawing requirements. If one is not included in the Drawings, then one may be obtained from the Engineer upon request. Each interconnection diagram shall include the following as a minimum:

1. The diagrams shall show connection point descriptions and field routing only. This includes, but is not limited to, terminal blocks, field wiring with numbers, junction boxes, conduit material with sizes, and conduit numbers.

2. Each conduit in the Conduit and Wire Schedule shall be shown on at least one interconnection diagram. Multiple conduits may be shown on a single interconnect and a conduit may appear on multiple interconnects.

3. Interconnect diagrams shall be based on connected equipment, ie. Interconnection diagram for Pump 1. All components connected to the MCC cubicle for Pump 1 shall be shown on a single interconnect.

4. All terminations points on the diagram shall be shown with the actual equipment identification terminal number or letter.

5. Interconnections between equipment shall be shown terminal to terminal with conduit lines in between. Wires within the same conduit shall be bundled and shown as a single line and labeled with the conduit name and wire fill. If not all wires within a conduit are used on a particular interconnection diagram, then the fill shall be noted as XX of XXX wires.

6. Conduit shall be shown as routed through junction boxes and pull boxes. Wire fill leading into a pull box shall be equal to the combined outgoing conduit wire fill.

7. Each wire and color code shall be shown connected to a terminal block. Spare wires may be shown as a list of wire numbers located near the end point of the wire.

8. Schematic symbols shall be used for field devices showing electrical contacts. Circuit polarities shall be shown where applicable.

9. The diagrams shall show all other Contract and shop drawing numbers, for reference, that are associated with each device that is interconnected.

Attached with each interconnect, a copy of all the support documents used in preparing interconnects. This includes current issues of panel schematics, connection diagrams, terminal block diagrams, submittals, contract drawings, vendor drawings and all other data used to develop the interconnection diagram as noted in the "Reference Documents" corner of interconnect drawings.

10. Provide a notes section on each interconnect drawing. In the note section list any variances from the Contract conduit schedule necessary for completing the interconnections. Change orders regarding wire fill, conduit schedule and errors in plans regarding conduits and wires may not be processed until interconnect drawings have been received for such work.

11. The interconnection drawings shall be As-Built by the Contractor after start-up and prior to project completion. All deletions and additions of equipment, wire and cables shall be clearly shown. Interconnects shall include list of all applicable field instructions and change orders.

12. The diagrams shall be utilized by the electrician during all phases installation and connection of all conductors to ensure coordination of equipment interconnect.

13. Field wiring shall not start before the interconnection drawing have been submitted by the Contractor and approved by the Engineer.

14. The Contractor shall not pull in any wires into conduits that do not have approved interconnects. If the Contractor pulls and/or terminates wire without approved interconnect drawings, the Contractor will not be reimbursed for labor for re-pulling/replacing wires even if there was an error in wire fill or sizing in the "Wire and Conduit Schedule". If the Contractor pulls and/or terminates wire without approved associated interconnect drawings, then all progress payments for that particular area of work will be withheld until approved interconnect drawings are in use.

F. Seismic Anchor Design Calculations

1. All switchgear, motor controls centers, transformers, cabinets, raceways, supports, and electrical materials shall be so installed as to remain in a secure and captive position when subjected to a horizontal force in accordance with the current, applicable, and more stringent of California Building Code (CBC) or International Building Code (IBC) requirements. Method of securing shall constrain equipment against both vertical and horizontal forces and overturning forces.

2. Calculations as prepared by a structural engineer registered in the State of California shall be submitted in accordance with code requirements for earthquakes forces on all specified equipment. Calculations shall include

wind loading forces for equipment installed outdoors.

1.11 OPERATING AND MAINTENANCE INFORMATION

A. Operational Training

1. 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. Operations and Maintenance Manuals

1. Provide Operation and Maintenance manuals per specifications as described in “Submittal Requirements” in this section with the following additional requirements:

   a. A comprehensive index.

   b. A complete "Record" set of favorably reviewed electrical submittals as provided under subsection “Submittal Requirements” illustrating all components, piping, and electrical connections.

   c. A complete list of the equipment supplied, including serial numbers, ranges, catalog cuts, and pertinent data.

   d. Full specifications on each item.

   e. 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.

   f. Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.

2. Submit electronic readable PDF file format (CD disk copies (2) or email with attachments or download links) of the proposed O&M manuals for review by the Engineer. Submittals shall be delivered timely to the Engineer to allow for review period, corrections, and re-submissions as necessary.

   a. General Contractor supervision must not be circumvented by sending submittals direct to Engineer.

   b. O&M Submittals shall be published 1st electronically and 2nd on hard copy paper stock.

c. Electronic Submittals shall be transmitted with the hard copy submittals and be viewable using a PDF reader.

d. Electronic submittals shall be assembled in accordance with the specifications for hard copy submittals with table of contents, bookmarks, tabs, subtabs, etc. utilizing the electronic bookmarks feature available in the PDF assembler.

e. Electronic (PDF) submittals must follow all applicable requirements for hard copy submittals including indexing, item selection indication, bookmarks, etc.

3. Provide four (4) hard copy O&M manuals per specifications as described in SUBMITTALS REQUIREMENTS in this section.

a. Deliver approved hard-copy O&M manuals to the project site and Owner prior to pre-operational testing or equipment start-up.

C. At the end of the project hard copy and soft copy electronic PDF files, shall be updated to "as-built" conditions.

D. Provide two (2) sets of compact disk (CD) containing all shop drawings, application programs, configurations, calculations, documents or other computer electronic files prepared for this project in native file format and updated to reflect as-built conditions.

PART 2: PRODUCTS

2.01 QUALITY

A. All equipment and materials shall be new, in current production, 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. Products specified that have become obsolete (out of current manufacturing, or have been superseded by another product) shall be cross-referenced to a replacement product(s) and provided in lieu of the specified product(s) for no additional cost. Under no conditions, shall products be submitted or furnished that are known (on manufacturer's list of obsolescence) and expected to be removed from current production within 12 months after project submittal. Products found to have been furnished this way will be removed and replaced at Contractor's expense.

C. 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 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.

D. The Contractor should expect that there will be occasional freezing conditions at the project site in outdoor locations. Instrument valves, tubing, instrumentation, and other components, etc. which are outdoors and susceptible to damage if frozen, must be provided with internal or external protection. Freeze protection can consist of internal or external active heaters with thermostats and/or passive insulation systems. Active systems can be powered from a nearby receptacle or via the conduit intended for the device.

E. Products that are specified and include a manufacturer, trade name or catalog number are intended to establish a standard of quality, performance, warranty and service. Products that are specified "or equal," do not prohibit the use of equal products of other manufacturers provided they are submitted, identified and promoted as equal, and favorably reviewed by the Engineer prior to procurement and installation.

F. Products submitted as "equal" to the named products will be reviewed for conformance with the specifications and in comparison with the first named product. If the equal product meets specifications, but does not have a feature or performance characteristic that is available with the first named product, and that feature or performance is required for this project, then the submitted equal product may be rejected on those grounds.

G. In the event that some claims of the manufacturer of submitted "equal" product are called into question by the Engineer, the Contractor, may be required to prove those claims either prior to installation or during startup of product. If the product does not meet the claims made or specifications, the product may be rejected by the Engineer and a replacement product must be submitted by the Contractor in its place. All cost for the rejected product, installation, testing, and removal will be the responsibility of the Contractor.

H. Underwriters Laboratories (UL) listing is required for all substituted equipment when such a listing is available for the first named equipment. Extra parts, labor, panel space, power supplies, GFIC devices shall be provided as necessary for incorporation of specified non-UL components.

I. When required herein or requested by the Engineer, the Contractor shall submit equipment or material samples for test or evaluation. The samples shall be furnished with information as to their source and prepared in such quantities and sizes as may be required for proper examination and tests, with all freight and charges prepaid. All samples shall be submitted before shipment of the equipment or material to the job site and in ample time to permit the making of proper tests,

analyses, examinations, rejections, and resubmissions before incorporated into the work.

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 type, 316L, if the nameplate is not an integral part of the device. Epoxy cement or glued on nameplates will not be acceptable. Engrave the nameplates with the inscriptions as approved by the Engineer in the submittal.

1. For each major piece of electrical equipment provide a manufacturer's nameplate showing the Contract specified name and number designation, 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 on the Drawings and described herein.

3. Where no inscription is indicated on the Drawings or described herein, furnish nameplates with an appropriate inscription providing the name and number of device.

4. Install Safety Signs in accordance with the latest OSHA requirements.

a. Entrances to electrical rooms and stations: Danger Sign requirements, ELECTRICAL ROOM, HIGH VOLTAGE (define voltage, example 480 VAC) KEEP OUT, AUTHORIZED PERSONNEL ONLY.

b. Equipment enclosures, cable tray and wireway where 120 VAC or higher and 50 V DC and higher exist: Danger Sign requirements, HIGH VOLTAGE (define voltage, example 480 VAC) AUTHORIZED PERSONNEL ONLY.

c. Equipment such as motor control centers, control panels, etc., where more than one source may be present in an enclosure or cubicle: Danger Sign requirements, VOLTAGE (define voltage, example 120 VAC control voltage or 480 VAC power) FROM MULTIPLE SOURCES IN THIS ENCLOSURE.

d. Equipment such as switchboards, switchgear, panelboards and motor control centers: Warning Sign requirements, WARNING,

SERVICE ENTRANCE DISCONNECT FOR 1 OF ___ (define quantity) SERVICES TO THIS BUILDING. OTHER SERVICE ENTRANCE DISCONNECTS ARE LOCATED AT (define locations).

5. Caution, warning and danger nameplates shall be red with white lettering

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. 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 on the Drawings and described herein. Where no inscription is indicated on the Drawings or described herein, 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 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. The tag shall be attached to the equipment with stainless steel wire of the type normally used for this purpose.

2.03 FASTENERS

A. Fasteners for securing equipment to walls, floors, or ceilings, shall be stainless steel. The minimum size fastener shall be 3/8 inch diameter.

2.04 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 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 as follows or as otherwise shown on the Drawings:

a.	Open/On	Green
b.	Closed/Off	Red
c.	Alarm	Amber or Blue
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 equal.

C. Relays and Timers

1. General: Relays and timers shall be provided with N.O. or N.C. contacts as shown on the 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 Drawings. Coil voltage shall be 120 VAC unless otherwise described or shown on the 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
PR – Power Relay

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 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 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 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 equal.

6. Power relays (PR) shall be plug-in type and clear see-through sealed housing to exclude dust. Provide Magnecraft Type 389FXCXC-120A, or equal. 3PDT contacts rated 20A or 1 HP at 240 VAC (minimum) shall be

provided on each relay. Furnish compatible blade type relay socket model 70-788EL11-1 or equal.

PART 3: EXECUTION

3.01 CONSTRUCTION METHODS

A. Equipment shall be assembled and wired by the manufacturer prior to shipment. Field modifications or changes are not allowed without a written "change order" to the Contract. Field changes, however large or small, shall be executed using the components, materials, wiring, labeling, and assembly methods identical to that of the original supplied equipment.

B. Electrical plugs, receptacles, cords, and connectors required to power or interface the equipment and panels shall be furnished and installed by the Contractor.

C. Factory as-built drawings for each custom manufactured control panel or MCC shall be shipped with the equipment and placed inside in waterproof envelopes.

3.02 EQUIPMENT FABRICATION

A. All electrical equipment, including custom manufactured equipment, shall meet the requirements of Underwriters Laboratories (UL) and bear the appropriate label. Panels shall be affixed with UL label prior to shipment and be built in accordance with the UL guidelines and procedure that corresponds to the UL label. Custom control equipment shall bear a UL-508 label, minimum, with additional UL labels as required per intended service.

B. 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.

C. Equipment doors shall swing freely and close and latch with proper alignment.

D. Component within the electrical equipment shall be securely mounted on an interior subpanel or backpan and arranged for easy servicing. Mounting bolts and screws shall be front mounted for device removal without special tools or removal of entire mounting panel.

E. 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.

F. Bolts and screws for mounting devices on doors shall have a flush head which blends into the device or door surface. No fastening devices shall project through

the outer surfaces of equipment.

3.03 WORKMANSHIP

A. All work in this division shall conform to the codes and standards outlined herein.

B. Installation shall be performed by qualified personnel providing first class workmanship per Electrical Specifications [Electrical General, Qualifications].

C. Maintain equipment installed (or to be installed) in new condition. Protect equipment from damage while in Contractor care from dust, water, or mishaps that are typical to construction sites

D. Confirm that equipment and materials are correct for their intended duty and will be installed per manufacturer guidelines. Equipment and components found to be installed inconsistent with manufacturer guidelines and/or these specifications will not be acceptable and subject to removal and replacement.

E. Upon completion of daily work, remove excess materials, scraps, and debris from the work area and from the inside of equipment.

F. Upon notification, stop work on any portion of the installation that is determined to be non-compliant with contract or being installed by unqualified personnel.

G. Perform all work to correct improper installations at no additional cost to the owner.

H. Equipment furnished under this contract or provided to Contractor for installation shall be installed in accordance with manufacturer's instructions, installation calculations, and contract documents.

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 that cannot be repaired to new condition shall be replaced with new products. All equipment and materials shall be in like-new condition at start-up and commissioning.

B. Any equipment furnished outside of contract to the Contractor shall be repaired or replaced if damaged while in the Contractor's care. The Contractor shall pay for the parts and/or services of the original equipment manufacturer (OEM) to troubleshoot, asses, and repair damaged equipment.

C. 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 INSTALLATION

A. General

1. Install all products per manufacturer's recommendations and the Drawings.

2. Provide all necessary hardware, conduit, wiring, fittings, and devices to connect the electrical equipment provided under other Sections.

3. Protect wiring insulation from wear by installing rubber cushions, bushings, or strip insulation, or by fastening the wiring to a rigid surface with zip ties and anchors.

4. Provide additional devices, wiring, conduits, relays, signal converters, isolators to complete interfaces of the electrical and instrumentation system.

5. Changing normally open contacts to normally closed contacts or vice versa

6. Adding additional relays to provide more contacts as necessary.

7. All programmable devices (not specifically excluded herein) 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 Engineer during start-up and throughout the warranty period.

8. Coordinate with the Engineer and setup all alarm, process, and operation setpoints.

9. 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.

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 NEC 110.26

C. Conduits and Ducts:

1. Install all conduits and ducts per Electrical Specifications [Conduit and Boxes] and [Grounding].

2. Minimum wire bending space at terminals and minimum width of wiring gutters shall comply with NEC tables 312-6 (a) & (b).

D. Wiring, Grounding, and Shielding:

1. Observe proper grounding and shielding practices as this application environment is 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 for installing his work. Any cutting which may impair the structure shall require prior approval by the Engineer. 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.

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.

3.07 APPLICATION OF POWER

A. The Engineer will direct the energization and de-energization of all existing and new equipment. The Contractor is not authorized to energize or de-energize any equipment unless they have been given written permission to do so or while in the presence of the Engineer.

1. Any equipment that is under repair, demolition or installation shall be locked off and tagged out of service with Contractor supplied padlocks and tags.

2. The Contractor is required to comply with NFPA 70E and specifically in regards to safety when working on live equipment. Obtain work permits when needed to do live work.

B. The Contractor is responsible for grounding of high and medium voltage cabling and/or bus during installation and removal of equipment. The contractor is responsible for complying with all California Electrical Safety Orders (ESO) and Occupational Safety and Health Act (OSHA) safety requirements and procedures while working in or near medium voltage equipment.

3.08 WARRANTY

A. The Contractor shall warrant all electrical and instrumentation equipment & software for a period of 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.

B. The Contractor shall have a staff of experienced personnel available to provide on-site warranty service on 2 working days notice during the warranty period. Such personnel shall be capable of fully testing and diagnosing hardware & software and implementing corrective measures.

3.09 FINAL ACCEPTANCE

A. Final acceptance will be given by the Engineer after the equipment testing is complete, each deficiency has been corrected, final documentation has been

provided, and all the requirements of Contract documents have been fulfilled.

B. At the end of the project, following the completion of the field tests, and prior to final acceptance, the Contractor shall provide the following:

1. Each "operation and maintenance" manual shall be modified or supplemented 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

SECTION 26 05 13

MEDIUM VOLTAGE WIRE

PART 1: GENERAL

1.01 SCOPE OF WORK

A. This section specifies wire (or cable) used in power distribution circuits 2500 to 15,000 volts.

B. The medium voltage wire scope of work includes:

1. Furnish and installation of medium voltage wire.
2. Submittal data and drawings.
3. Factory and field testing.
4. Start-up assistance
5. Operation and maintenance manuals.
6. Warranty of all components.

C. Factory and field testing per NETA standards and Electrical Specifications [Factory and Field Testing]. Furnish all required labor, materials, safety equipment, transportation, test equipment, incidentals and services to perform factory and/or field testing.

1.02 REFERENCES

A. This section contains references to the following documents. They are a part of this section. In case of conflict between the requirements of this section and those of the listed documents, the requirements of this section shall prevail.

1. Electrical Specifications [Electrical General]
2. Electrical Specifications [Conduit and Boxes]
3. Electrical Specifications [Factory and Field Testing]

B. Products and services shall conform to or exceed the applicable requirements of the following standards and codes and specifications:

1. IEEE 48 - Alternating-Current Cable Terminations 2.5kV through 756kV.

2. IEEE 383 - Type Test of Class IE Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations.

3. IEEE 386 - Separable Insulated Connector Systems for Power Distribution Systems above 600V.

4. IEEE 404 - Cable Joints for use with Extruded Dielectric Cable Rated

5000 - 138,000V and Cable Joints for use with Laminated Dielectric Cable Rated 2500 - 500,000V.

5. IEEE 510 - High-Voltage and High-Power Testing.

6. AEIC CS6 - Ethylene Propylene Rubber Insulated Shielded Power Cables Rated 5 Through 69 KV

7. ASTM B230 / B230M – 07 - Standard Specification for Aluminum 1350-H19 Wire for Electrical Purposes

8. ASTM B231 - Standard Specification for Concentric-Lay-Stranded Aluminum 1350 Conductors

9. ICEA S-68-516 - Ethylene-Propylene-Rubber-Insulated Wire

10. NEMA WC 7 - Cross-Linked Thermosetting Insulated Wire and Cable for the Transmission and Distribution of Electric Energy

11. NEMA/ICEA WC 74/S-93-639 - Shielded Power Cable 5-46kV.

12. NFPA 70-2005 - National Electric Code (NEC)

13. UL 486B - Wire Connectors for use with Aluminum Conductors.

14. UL 1072 - Medium-Voltage Power Cables

1.03 QUALIFICATIONS

A. Electrical Contractor

1. Cable Technician:

a. Minimum 5 similar installations performed within the last two years providing applicable experience in handling, installing, terminating and splicing medium voltage wire.

b. Specifically trained by a factory representative on the installation and terminations to be used on the project. If not trained on the specific products to be used, on-site training by the factory representative shall be preformed before any installation or terminations are performed.

2. Testing Company:

a. The testing company shall be independent of the installing electrical contractor and have been engaged in full practice in the final inspection, testing, calibration, and adjusting of electrical distribution systems, for a minimum of five years.

b. The testing company shall have a calibration program with accuracy traceable every six months in an unbroken chain, to the National Institute of Standards and Technology (NIST).

c. The testing company shall have a designated safety representative on the project. The standards followed shall include OSHA, NFPA 70E and IEEE 510.

d. Inspection, testing, and calibration shall be performed by an engineering technician, certified by a national organization, such as the National Electrical Testing Association (NETA) or the National Institute for Certification in Engineering Technologies, with a minimum of five years experience inspecting, testing, and calibrating medium voltage electrical systems. Information on the certified engineering technician shall be submitted for approval prior to the start of work.

e. The qualifications of the testing company shall be submitted to the Engineer for approval prior to the start of testing. Full membership to the National Electrical Testing Association constitutes proof of meeting all of the above requirements.

B. Manufacturer Qualifications: Minimum of 5 years experience in manufacturing medium voltage 5 to 15 kilovolt class power cables.

1.04 SUBMITTAL REQUIREMENTS

A. Submittals shall be provided in accordance with Section 16010 – Electrical General.

B. Submittals shall include the following information minimum:

1. Product data including catalog specifications of conductor and insulation.
2. Cable pulling data.
3. Termination equipment
4. Cable Technician required qualifications.
5. Independent testing company qualifications.
6. Install and termination technician's qualifications.

C. Cable test reports signed by the installing technician including the following information:

1. Summary of Project.
2. Description of equipment/components tested.
3. Visual inspection report.
4. Description of tests.
5. Test results including appropriate test forms.
6. Conclusions and recommendations.

7. Identification of test equipment used.

1.05 OPERATION AND MAINTENANCE INFORMATION

A. Submit hardware Operations and Maintenance Manual per Electrical Specifications [Electrical General].

PART 2: PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

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

1. Wire and Cable:

a. General Cable.
b. Houston Wire and Cable Company.
c. American Insulated Wire Corporation.
d. The Okonite Company.
e. Southwire Company.
f. Or equal

2. Lugs, Connectors and Terminations:

a. Minnesota Mining and Manufacturing Co.
b. Tyco.
c. Thomas & Betts.

2.02 RATINGS

A. Suitable for installation in wet or dry locations, indoors or outdoors (exposed to sunlight), in any raceway or underground duct, directly buried if installed in a system with a grounding conductor in close proximity that conforms with NEC Section 250.4(A)(5), or messenger supported in industrial establishments and electric utilities.

B. Newly manufactured (not more than 12 months old), with date of manufacture, size, grade of insulation, voltage, and manufacturer's name permanently marked on outer covering at not more than 2 feet 0 inch intervals. Identify and mark conductors in accordance with NEC Article 310. Cable shall meet requirements of ICEA, NEMA, and AEIC.

C. Ratings: Voltage class 5kv.

D. Standards:

1. NEMA WC 74/ICEA S-93-639.

2. AEIC CS8.
3. UL 1072.

E. Conductor Material:

1. Concentric class B stranded aluminum.

F. Insulation:

1. 133 percent insulation level.

2. Temperature rating: Type MV-105 per NFPA 70.

3. Layers over conductor

a. Strand Screen Extruded Semiconducting EPR
b. Ethylene propylene rubber (EPR)
c. Insulation Screen Extruded Semiconducting EPR
d. Shield
e. Outer Jacket

G. Shielding: 5 mil bare copper tape helically applied with 12.5% nominal overlap

H. Jackets shall be PVC rated for direct burial application.

I. Neutrals (if required per drawings):

1. Neutral conductors of grounded neutral systems shall be of the same insulation materials as the phase conductors, except with a 600 V insulation rating.

2. Cables with a concentric neutral shall have 1/3 concentric neutral.

2.03 CABLE ACCESSORIES

A. Lugs and Connectors:

1. Lugs:

a. Compression type.
b. Standard: UL 486B for aluminum and copper cables.
c. Voltage rating: Up to 35 kV.
d. Current rating: Continuous operation at the rating of the cable.
e. Material: Aluminum with bronze underplating, tin outerplating and aluminum anti-oxide paste.
f. Number of holes: Two, except one on motor leads.

2. Aerial Stem Connectors:

a. Same as lug type, except with a 6 IN copper stem.

3. Splice Connectors:

a. Standard: UL 486B for aluminum and copper cables.
b. Voltage rating: Up to 35kV.
c. Current rating: Continuous operation at the rating of the cable.
d. Material: Aluminum with bronze underplating, tin outerplating and aluminum anti-oxide paste.

B. Terminations:

1. End Caps:

a. Cold or hot shrink.
b. Used to environmentally seal and mechanically protect exposed cable ends.

2. Cold Shrink Kits:

a. Standard: IEEE 48, Class 1 termination.
b. Voltage rating: Same as the cable rating.
c. Current rating: Continuous operation at the rating of the cable.
d. One piece design, where high-dielectric constant stress control is integrated within a skirted insulator made of silicone rubber.
e. Suitable of contaminated indoor and outdoor locations.

3. Molded Rubber Kit:

a. Standard: IEEE 48.
b. Voltage rating: Same as the cable rating.
c. Current rating: Continuous operation at the rating of the cable.
d. One piece design or modular with stress cone and skirts, where high dielectric constant stress control is integrated within a skirted insulator made of EPDM rubber.
e. Suitable of contaminated indoor and outdoor locations.

4. Elbow Connectors:

a. Standard: IEEE 386.
b. Voltage rating: Same as the cable rating.
c. Current rating: 200A or 600A as required.
d. One piece design, comprised of an insulation shield, insulation layer and an outer shield constructed of EPDM rubber.
e. Dead-front, load-break type with hot stick pulling eye, grounding tab and test point.
f. Accessories to be constructed in a similar manner as the elbow connector:

1) Bushing inserts.
2) Bushing well plugs.
3) Feed thru inserts.
4) Protective caps.

C. Splices:

1. Cold Shrink Kits:

a. Standard: IEEE 404.
b. Voltage rating: Same as the cable rating.
c. Current rating: Continuous operation at the rating of the cable.
d. One piece design comprised of an insulation shield, insulation layer and a silicone rubber body.
e. Suitable for indoor, direct burial or submersible applications.

2. Molded Rubber Kit:

a. Standard: IEEE 386 or 404.
b. Voltage rating: Same as the cable rating.
c. Current rating: Continuous operation at the rating of the cable.
d. One or multi piece design, comprised of an insulation shield, insulation layer and an outer shield constructed of EPDM rubber.
e. Suitable for indoor, direct burial or submersible applications.

3. Modular Separable Molded Rubber:

a. Standard: IEEE 386.
b. Voltage rating: Same as the cable rating.
c. Current rating: 600A.
d. One piece design, comprised of an insulation shield, insulation layer and an outer shield constructed of EPDM rubber.
e. Dead-front, dead-break type.
f. Components: T-body, insulating plug with cap, insulating plug with cap and stud, and connecting plug.
g. Suitable for submersible applications.

4. Motor Lead Kits:

a. Voltage rating: Same as the cable rating.
b. Current rating: Continuous operation at the rating of the cable.
c. Material: EPDM rubber boot with nylon pin.
d. On shielded cables provide and additional EPDM rubber cold shrink sleeve.

PART 3: EXECUTION

3.01 WORKMANSHIP

A. All work in this Section shall conform to the codes and standards outlined herein.

B. Confirm that equipment and materials are correct for their intended duty and will be installed per manufacturer guidelines. Equipment and components found to be installed inconsistent with manufacturer guidelines and/or these specifications will not be acceptable and subject to removal and replacement.

C. Upon completion of daily work, remove excess materials, scraps, and debris from the work area and from the inside of equipment.

D. Equipment furnished under this contract or provided to Contractor for installation shall be installed in accordance with manufacturer's instructions, installation calculations, and Contract documents.

3.02 INSTALLATION

A. Cable Placement:

1. All cable shall be carefully checked as to condition, size, and length before being pulled into raceways. Cable pulled into the incorrect raceway or cut too short to rack, train, or splice as specified herein shall be removed and replaced by, and at no additional cost to the Owner.

2. Before unreeling, the outside of each cable reel shall be carefully inspected and protruding nails, fastenings, or other objects which might damage the cable shall be removed. A thorough visual inspection for flaws, breaks, or abrasions in the cable sheath shall be made as the cable leaves the reel, and the pulling speed shall be slow enough to permit this inspection. Damage to the sheath or finish of the cable shall be sufficient cause for rejecting the cable. Cable damaged in any way during installation shall be replaced by, and at no additional cost to the Owner.

B. Cable Pulling:

1. The pulling tension of the cable shall not exceed the maximum tension recommended by the cable manufacturer. Pulling mechanisms of both manual and power types used by the Contractor shall have the rated capacity (in pounds) clearly marked on the mechanism. A dynamometer shall be used to show the tension on the cable during all pulls and the indicator shall be constantly monitored. If any excessive strain develops, the pulling operation shall be stopped at once and the difficulty determined and corrected. Under no circumstances shall cable be pulled using equipment not monitored by a dynamometer. The use of motor

vehicles in pulling cable is prohibited. Any cable so pulled shall be removed, replaced, and the new cable installed at no additional cost to the Owner. The dynamometer shall have a maximum tension indicator to show the maximum tension developed during a pull. The maximum tension for each pull shall be recorded and submitted to the Construction Manager within 5 days after the pull was made. The information submitted to the Construction Manager shall include the dynamometer reading, the angle alpha, the lubricant used, the actual maximum tension of each pull measured while the cable is in motion, and the tension upon initial start of the pull just before the cable begins to move. The cable play-out reel shall be equipped with a suitable brake and shall be constantly manned during all pulls.

2. To avoid insulation damage from excessive sidewall pressure at bends in raceway runs, the pulling tension in pounds exiting a bend shall not exceed 200 times the radius of the bend in feet.

3. Extreme care shall be exercised during the placement of all cable to prevent tension and bending conditions in excess of the manufacturer's recommendations. The permanent radius of bend after cable installation shall be in accordance with the cable manufacturer's recommendations.

4. Do not install cable during wet conditions.

5. Prior to pulling cables, drain or pump out manholes and other low points if standing water is present.

6. Mandrel conduits to confirm no protrusions or foreign materials are present in conduit.

7. Install end caps immediately on all cut ends of cable prior to pulling, and maintain end caps while pulling in cable.

    a. Before and after pulling, the leading end seal of each length of cable shall be examined and replaced if necessary. All cut cable ends shall be promptly sealed after cutting except those to be spliced or terminated immediately.

    b. If end caps are damaged, remove and install new end caps.

    c. Do not remove end caps until ready to terminate or splice cable.

C. All raceway cleaning mandrels and cable pulling shall be done with Manila hemp line to prevent damage to the raceway. Nylon or stranded steel pulling lines shall not be used. "Fishing" may be done with CO2-propelled polyethylene cord.

D. A flexible feeding tube, with a removable nozzle sized to fit the raceway shall be used in pulling all cable. The feeding tube shall be long enough to extend from

the raceway entrance to the outside of the manhole and shall be so arranged that it will be impossible for the cable to drag across the edge of the manhole ring or any other damaging surface. Cable pulling into, through, or out of new manholes shall be done with the entire concrete manhole lid removed.

E. A cable lubricant shall be used on all conductors in all pulls, and shall be of the type, and applied in the quantity, recommended by the cable manufacturer. Only lubricants recommended by the cable manufacturer shall be used.

F. Factory-installed pulling eyes shall be used for pulling cable where they are available. Where pulling eyes are not available, woven wire cable grips shall be used to pull all single-conductor cable. When a cable grip or pulling eye is used for pulling, the area of the cable covered by the grip or seal, plus 6 inches, shall be cut off and discarded when the pull is completed. As soon as the cable is pulled into place, the pulling eyes on cable grips shall be removed and the cable shall be resealed.

G. A reliable, nonfreezing type of swivel, or swivel connection, shall be inserted between the pulling rope and the cable pulling eye, grip, or loop to prevent twisting under strain.

H. Where cable is to be pulled around sheaves, the sheave shall have a minimum radius of 12 times the cable diameter. The sheave radius shall be determined by measuring from the center axle hole to the inside of the flange where the cable makes contact with the sheave. Where multiple roller type sheaves are used, the radius around which the cable travels shall be a minimum of 18 times the cable diameter.

I. Arc-proof all cables in manholes.

1. Apply in spiral, half-overlap fashion to full exposed length of each cable in manhole.

2. Secure in place with glass cloth electrical tape.

a. Apply in reverse spiral to arc-proofing tape, at maximum interval of 9 inches and double wrapped at each end.

J. Do not install conductors when ambient temperature is near minimum as recommended by manufacturer for installation of the type of conductor insulation.

K. Supports:

1. All cable supports and securing devices shall have bearing surfaces oriented parallel to the surfaces of the cable sheath and shall be installed to provide adequate support without deformation of the cable jackets or insulation. Adequate cable end lengths shall be provided and properly placed in electrical equipment or manholes to avoid longitudinal strains

and distorting pressures on the cable at termination points and duct end bells. Final inspection shall be made after all cable is in place. Where supports, bushings, and end bells deform the cable jacket, additional supports shall be provided as directed by the Construction Manager.

2. Cable shall be supported at all times during handling, without short bends or sags, and shall not be permitted to lie on the handhole or manhole floor. Cable ends shall be sealed to prevent the entry of moisture or dirt. Cable racks or trays shall be provided for permanent support. Temporary support required during placement shall be with rope slings, timbers, or alternate method acceptable to the Construction Manager. Cable shall be neatly trained around the walls of handholes in a manner not blocking access to other conduits. Secure conductors to cable racks with a minimum of two nylon cable ties installed across each other. Cable ties shall be 0.3-inch wide minimum.

L. Splices:

1. Provide components in kit form, complete with instructions, supplied by a single approved manufacturer and suitable for the type of cable being used. Prepare cable ends, provide materials and follow all application steps in accordance with manufacturer's instructions.

    a. As a minimum requirement:

        1) The cable ends shall be cut squarely.
        2) The insulation shall be free from nicks or burrs after removal of jacket.
        3) The conductors shall be cleaned and an oxide inhibitor applied.
        4) For splices, connector indents shall be filled with insulating putty to eliminate voids.
        5) Attach grounding lead to system ground.

2. Splices are not allowed unless submitted and specifically allowed.

    a. Not more than one splice shall be permitted between termination points.
    b. No splices are permitted in runs less than 100 FT long under any circumstances.
    c. Splices will be made only at manholes or other accessible locations.
    d. Do not pull splices into ductbanks or conduits or leave them under tension.
    e. Splices shall not be made to utilize short lengths of cable, nor shall they be made to provide correct lengths on cable initially cut too short for a particular circuit.

M. Terminations

1. Cable shall be trained into place without bending the cable in a radius less than the manufacturer's recommended minimum bending radius. If the cable is bent at any time to a radius less than the minimum bending radius, the Contractor shall, at no additional cost to the Owner, re-terminate the cable at a point at least 6 inches below the bend. Where the shape and configuration of terminal fittings make workmanlike insulation of the bare connection impractical, the contours of the connection shall be smoothed by filling voids and molding over irregular surfaces with a moldable filler material as recommended by the terminator kit manufacturer before application of the recommended thickness of insulating material.

2. Terminations shall be in exact conformance with the written instructions accompanying the splicing or terminator kits. Special care shall be exercised by the Contractor to ensure that cable insulation is not damaged during stripping back of jacket, semiconductor layers, shields; or penciling operations. All stripping, back operations involving the cutting of nonmetallic layers of the cable shall be accomplished using a ringing tool. The usage of pocket or jack knives for stripping back or penciling operations is prohibited. Cable shields shall be grounded by connecting to the equipment ground bus in equipment or to the grounding electrode system in equipment without a ground bus. Shield grounds shall be connected to the grounding system with grounding braid or extra flexible #6 AWG copper conductors.

3. Provide voltage rated prefabricated terminations at each shielded cable termination.

   a. Select correct termination to match cable diameter and construction.

   b. Form and install terminations in strict accordance with instructions of cable manufacturer and termination manufacturer.

3.03 EQUIPMENT SHIPMENT AND STORAGE

A. Ship cable with removable watertight end seals, and store in dry place.

3.04 FIELD ASSISTANCE

A. Provide testing as specified in 16600 - Factory and Field Testing.

B. After all terminations and splices have been made, and prior to connections to equipment, provide the following acceptance tests:

1. Shield continuity test.
2. Additional tests per NETA Acceptance Testing Specifications.

C. The field tests shall be performed per NETA's Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.

D. The results from all testing shall be recorded and provided to the Construction Manager for review and record.

3.05 WARRANTY

A. Provide warranty as specified in Section 16010 – Electrical General.

3.06 FINAL ACCEPTANCE

A. After cables have been installed, test completed installation per ICEA/NEMA, including voltage tests, prior to energizing the circuits. No equipment shall be connected to the cables during tests. Repair and replace detected faulty terminations or cables, then retest at no additional cost to the Owner prior to acceptance.

END OF SECTION

SECTION 26 05 19

LOW VOLTAGE WIRE & DATA CABLE

PART 1: GENERAL

1.01 SCOPE OF WORK

A. Labor, materials, equipment, tools, safety gear, test equipment, incidentals, services, and transportation for a complete electro-mechanical installation as shown on the Drawings, included in these Specifications, or as can be reasonably implied from project descriptions.

B. The scope of work includes:

1. Furnish and install wire, splices, lugs, or other miscellaneous devices as defined in this specification.

2. Testing of conductors and completed wired systems.

3. Installations shall be designed and installed with components meeting the NEMA area designation.

C. Work includes that specified in Electrical Specifications [Electrical General].

1.02 REFERENCES

A. Electrical Specifications [Electrical General]
B. Electrical Specifications [Conduit and Boxes]
C. Electrical Specifications [Grounding]
D. Project Drawings

1.03 QUALIFICATIONS

A. Material furnished under this specification shall be installed by qualified installers meeting requirements specified in Electrical Specifications [Electrical General, Qualifications].

1.04 SUBMITTALS AND DRAWINGS

A. Provide submittals and drawings as specified in Electrical Specifications [Electrical General, Submittal Requirements].

PART 2: PRODUCTS

2.01 WIRING AND ELECTRICAL DEVICES

A. GENERAL

1. General

a. Provide wiring and electrical devices specified herein and install field and internal panel wiring as shown on the Contract Drawings.

b. This section applies to all wires or conductors used internal (non-field) to electrical equipment or external for field wiring.

c. Field wire quantity and size shall be per “Conduit and Wire Routing Schedule.”

2. 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.

b. 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.

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. Wire shall be rated 600 volt (min).

d. Size all conductors per NEC minimum or as shown on the drawings.

1) Minimum #12 AWG for wires used in power transmission circuits or as defined on the drawings.

2) Minimum #14 AWG for wires used in signal transmission circuits or as defined on the drawings.

2. Wire colors and sizes shall not change within the circuit.

3. Wire shall be properly fused or breaker protected at or below the maximum amperage rating allowed by the NEC.

4. Control and Power Wiring:

a. Field wire in conduit:

1) Type XHHW-2, XLPE insulation, rated 90 °C in wet or dry locations, oil resistant.

i Use for power circuits carrying voltages higher than 200 volts phase to ground.

2) Type THHN / THWN, PVC with nylon jacket insulation, rated 90 °C in dry locations and 75 °C in wet locations, oil resistant, UL83.

i Use for power circuits with voltages below 200 volts phase to ground, or control circuits.

3) Minimum #12 AWG for wires used in power transmission circuits or as defined on the drawings.

4) Minimum #14 AWG for wires used in signal transmission circuits or as defined on the drawings.

b. Field wire in tray (Tray Cable type TC):

1) Individual cables - Insulation type THHN/THWN, rated 90 °C in dry locations and 75 °C in wet locations, oil resistant, UL83.

2) Multi-conductor cables - Insulation type THHN/THWN (PVC/Nylon) conductors with an overall polyvinyl chloride (PVC) jacket, conforming to Article 318 “Cable Trays” and Article 340 “Power and Control Cable Type TC” of the National Electrical Code, and Standard 1277 of Underwriters Laboratories, Inc. Rated 600 volts, 90°C dry and 75°C wet, oil resistant, UL83.

3) 3 or more conductor plus ground wire in a single cable.

4) UL Listed as sunlight resistant, direct burial, and open wiring.

5) Conductor sizing per ICEA Publication P-54-440 for cable tray and ICEA P-46-426 for conduit

6) Minimum #12 AWG for wires used in power transmission circuits or as defined on the drawings.

7) Minimum #14 AWG for wires used in signal or conrol transmission circuits or as defined on the drawings.

c. Power cord

1) Flexible wire cord shall be type SOW, SOOW, or G and be provided in 2, 3, or 4 conductor plus ground as required for connected load.

2) EPR insulation, 90 deg C rating, oil and abrasion resistant., overall jacket plus individual conductor jackets. 600V rated

3) Conductors shall be stranded copper.

4) Cord shall be installed with cord grips on each end where it enters termination enclosures.

d. Nonfield control panel or factory installed equipment internal wiring:

1) Insulation - Type MTW, NFPA standard 79, UL 1063 with tinned copper.

2) Minimum #16 AWG for wires used for individual conductor circuits 100 volts and above.

3) Minimum #18 AWG for wires used for individual conductor circuits below 100 volts.

5. 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 (TSPR) cables shall be Belden 9342, or approved equal. Three wire twisted shielded cables (#18 TS3W) shall be Belden 1119A or

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 (TSPR.) cables shall be Belden 8760, or approved equal. Three wire shielded cable shall be Belden 8770 or equal.

c. Field multi-pair instrument cable as required per conduit schedule shall have 300V rated insulation and 100% individual shielded twisted pair #18 conductors with drain wire. Multiple twisted shielded pair (T.S.PR.) cables shall be Belden 9773 thru 9777, or equal.

d. Multi-pair cable is not allowed (unless specifically called out in conduit schedule or on plans) for use in field or non-field applications. One T.S.PR cable is required for each signal.

6. 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.

7. Data Cable

a. Data network category 6 cable (indoor) shall consist of 4 pair unshielded twisted pair #24 awg solid copper conductors. The cable shall be rated by IEEE for service intended – plenum and dry.

1) Cable: IEEE Category 6, various manufacturers.

2) Connectors: Standard RJ-45 with boot.

b. Data network cable (outdoor) shall consist of 4 pair foil and braid shielded twisted pair #24 awg solid copper conductors with anti-crosstalk divider, and drain wire. Rated Level 2 Category 5e Outdoor Carrier by IEEE for use in plenum, conduit, wet or dry.

1) Cable: IEEE Category 5e, Ubiquiti Tough Carrier, Belden, or equal

2) Connectors: Grounded RJ-45 with drain wire crimp.

C. COLOR CODE

1. 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.

2. No other colors shall be used without prior approval.

3. 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
	Neutral	Gray	Gray
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	24+	Pink	Pink
24V Negative	24-	Black	Black
12V Positive	12+	Pink	Pink/white
12V Negative	12-	Black	Black/white
AC Control		Red	Red (Yellow for foreign circuits)
DC Control		Blue	Blue
Neutral	N	White	White
Ground	G	Green	Green
Shielded Pair	+	Red, Clear, or White	Clear or White
	-	Black	Black

2.02 WIRE MARKING

A. 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 oversized for the wire and shrunk into place using an electric heat gun. The "shrunk" label shall have just enough give to allow the label to be rotated. Hand lettered wire labels are not acceptable and shall be replaced at the Contractor's expense. Provide Brady "PermaSleeve" or equal.

1. **Origin/Destination Wire Identification** - all wires, field and interior to equipment, shall be identified with wire labels.

   a. Wire labels shall be made up using "origination/destination" style numbering system. Consequently, each wire will have a unique set of wire labels that have their origin/destination numbers inverted on each end of wire.

   b. Wire labels shall be exactly per interconnection submittal and/or control panel drawings -- 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.

   c. Wire labels shall provide a complete description of the origination and destination panel/device and terminal number.

   d. Wire labels may be omitted on "neutral jumpers" less than 8" in length.

   e. 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) Wire labels for lighting and receptacle circuits are not origination/destination.

2.03 ELECTRICAL TAPE / SHRINKABLE INSULATORS

A. Vinyl tape shall be 7 mil, 600 volt rated, flame retardant, hot and cold weather resistant conforming to UL510. Provide 3M Scotch Super 33+ vinyl tape or equal

   1. Vinyl tape for color coding shall be 7 mil, ¾" width, vinyl tape conforming to UL 510. Provide 3M Scotch 35 vinyl tape or equal.

B. Rubber Tape: EPR rubber, 90 deg C continuous rated. Provide 3M 130C rubber tape or equal.

C. Varnished Cambric Tape: Adhesive backed, 7 mil, bias cut cotton tape, coated with yellow insulating varnish. Provide 3M Scotch 2510 or equal.

D. Shrinkable insulators shall be heat shrinkable, polyolefin thick wall sleeves, end caps and cable repair sleeves are designed for use in splicing, sealing and re-jacketing of direct bury secondary cables. The insulators shall comply with UL 486D and be rated up to 1000 Volts. They shall provide long-term reliable performance overhead, underground or submerged with mechanical and environmental protection. Shrinkable insulators shall be 3M ITCSN or 3M IMCSN per manufacturer instructions for the application or equal.

PART 3: EXECUTION

3.01 WORKMANSHIP

A. All work in this Section shall conform to the codes and standards specified in Electrical Specifications [Electrical General, Workmanship].

B. Perform work to remedy non-compliant installations after inspection.

C. Upon notification, stop work on any portion of the installation that is determined to be substandard or being installed by unqualified personnel.

3.02 FABRICATION AND INSTALLATION

A. System:

1. Install all products specified in Electrical Specifications [Electrical General, Installation].

2. 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 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 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 equal.

5. Routing: Wires and cable shall be routed such as to maintain separation between 100 Volt or higher from 100 volt or lower wiring being run 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 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 terminal connectors on the motor pigtails and the cable to be connected. Terminals shall be non-insulated crimp-on type applied with a rachet-type crimping tool.

The terminals shall be bolted together with a nut, bolt and lock washer combination. The connection shall be booted with 3/16" thick rubber boot. Boot kit shall include rubber boot for each motor connection, plastic locking pins, silicone grease, and mastic sealing strips, Boot kits shall be 3M Motor Lead Pigtail Splice #5302, #5303,or #5404 as applicable for wire size applied.

2. When stripping insulation from conductors, do not score or damage conductor.

3. The drain wire and stripped end of outer jacket of shielded cables shall be covered with heat shrink insulating tubing. The drain wire shall be covered along its full bare length between the cable jacket cover and the terminal lug and placed on end outer jacket to cover foil.

4. 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.

2. Where splices are allowed or approved 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 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 equal.

d. Non-Motor Splices #6 and smaller in underground pullboxes shall have wire-nut connections which are sealed with non-hardening silicone based sealant that protects the connection from moisture and corrosion. The wire nuts shall be factory filled with sealant and UL listed for waterproof connections. Provide Ideal Model 60 or equal.

e. Non-Motor Splices #4 and larger in underground pullboxes shall have double hex crimp barrel connections applied with adhesive/sealant filled heat shrinkable rubber insulation applied over the exposed connection. The cross-linked polyolefin shrink

tube shall extend 4” on each side of the exposed connection minimum. Heat shrink tubing shall be 3M ITCSN or equal.

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. All wire and cables (with the exception of coaxial antenna cable) shall be installed within UL listed raceways or enclosures. Install all wires and cables in one continuous length unless splices are per contract drawings, required to connect equipment or 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 Electrical Specifications [Electrical General, Warranty].

END OF SECTION

SECTION 26 05 26

GROUNDING

PART 1: GENERAL

1.01 SCOPE OF WORK

A. Labor, materials, equipment, tools, safety gear, test equipment, incidentals, services, and transportation for a complete electro-mechanical installation as shown on the Drawings, included in these Specifications, or as can be reasonably implied from project descriptions.

B. The scope of work includes:

1. Furnish and install grounding system required by drawings, or if not shown or defined, as required by Article 250 of the NEC. Ground conductors shall be sized for the protective device, minimum.

2. Furnish and install conduits, junction boxes, underground boxes, and associated hardware. Provide hardware, conduit, fittings, and other parts for a complete grounding installation.

3. Installations shall be designed and installed with components meeting the NEMA area designation.

C. Work includes that specified in Electrical Specifications [Electrical General].

1.02 REFERENCES

A. Electrical Specifications [Electrical General]
B. Electrical Specifications [Low Voltage Wire & Data Cable]
C. Electrical Specifications [Medium Voltage Wire]
D. Project Drawings

1.03 QUALIFICATIONS

A. Material furnished under this specification shall be installed by qualified installers meeting requirements specified in Electrical Specifications [Electrical General, Qualifications].

1.04 SUBMITTAL REQUIREMENTS

A. Provide submittals and drawings as specified in Electrical Specifications [Electrical General, Submittal Requirements].

B. Submit manufacturer's product information for connections, clamps, rods,

terminals, and grounding system components.

PART 2: PRODUCTS

2.01 GROUNDING SYSTEM

A. General

1. Grounding conductors shall be sized as shown on the drawings or in accordance with NEC table 250, whichever is larger.

2. Components of the grounding electrode system shall be manufactured in accordance with UL 467 - Standard for Safety Grounding and Bonding Equipment.

B. Raceway Grounds

1. Metallic conduits shall be assembled to provide a continuous ground path. Metallic conduits shall be bonded using insulated grounding bushings.

C. Equipment and Enclosure Grounds

1. Electrical and distribution equipment shall be connected to the grounding system. Cables shall be sized as specified.

D. Components

1. Provide ground well enclosures for all outdoor ground rods. Furnish Christy type F8 or equal unless otherwise shown on the drawings.

2. Ground rod clamps shall be bolt-on type as manufactured by O-Z Gedney type GRC, or equal.

3. Grounding and bonding wires shall be installed in all PVC conduits and nonmetallic raceways and connected to the ground bus and all equipment.

4. 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 equal.

PART 3: EXECUTION

3.01 WORKMANSHIP

A. All work in this Section shall conform to the codes and standards specified in specified in Electrical Specifications [Electrical General, Workmanship].

3.02 INSTALLATION

A. Grounding System:

1. Install all products per Electrical Specifications [Electrical General, Installation].

2. Each nonmetallic conduit shall contain a code sized grounding conductor.

3. 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.

4. 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.

5. Utilize mechanical connections in accessible locations and exothermic connections in non-accessible or buried locations.

6. The secondary on all transformers shall be grounded.

7. All raceway systems, supports, enclosures, panels, motor frames, and equipment housings shall be permanently and effectively grounded.

8. Install insulated grounding conductor with feeders and branch circuit conductors in conduits. Size grounding conductors in accordance with NEC. Install from grounding bus of serving panel to ground bus of served panel, grounding screw of receptacles, lighting fixture housing, light switch outlet boxes or metal enclosures of service equipment. Ground conduits by means of grounding bushings on terminations at panelboards and distribution panels with 12ga. conductor to grounding bus

9. All receptacles shall have their grounding contact connected to a grounding conductor.

10. 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.

11. 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.

12. Install grounding electrode conductor and connect to reinforcing steel in foundation footing. Electrically bond building steel to ground system. Bond metal siding not attached to grounded structure.

3.03 FIELD QUALITY CONTROL

A. Inspections:

1. Engineer shall inspect ground system prior to energization.

B. Testing:

1. Complete applicable test forms if provided in testing specifications [Factory and Field Testing]. If form is not provided, furnish results on a vendor standard form.

2. Test each grounding connection to determine the ground resistance. The grounding test shall be IEEE 81.2 and NETA 7.13. The current reference rod shall be driven at least 100 feet from the ground rod or grid under test. The measurements shall be made at 10-foot intervals beginning 20 feet from the test electrode and ending 80 feet from it, in direct line between the ground rod or center of grid and the current reference electrode.

END OF SECTION

SECTION 26 05 33

CONDUIT AND BOXES

PART 1: GENERAL

1.01 SCOPE OF WORK

A. Labor, materials, equipment, tools, safety gear, test equipment, incidentals, services, and transportation for a complete electro-mechanical installation as shown on the Drawings, included in these Specifications, or as can be reasonably implied from project descriptions.

B. The scope of work includes:

1. Furnish and install conduits, junction boxes, pull boxes, and associated hardware. Provide hardware, conduit, fittings, and other parts for a complete raceway installation.

2. Furnish and install grounding system required by drawings, or if not shown or defined, as required by Article 250 of the NEC.

3. Installations shall be designed and installed with components meeting the NEMA area designation.

C. Work includes that specified in Electrical Specifications [Electrical General].

1.02 REFERENCES

A. Electrical Specifications [Electrical General]
B. Electrical Specifications [Low Voltage Wire & Data Cable]
C. Electrical Specifications [Medium Voltage Wire]
D. Electrical Specifications [Grounding]
E. Project Drawings

1.03 QUALIFICATIONS

A. Material furnished under this specification shall be installed by qualified installers meeting requirements specified in Electrical Specifications [Electrical General, Qualifications].

1.04 SUBMITTAL REQUIREMENTS

A. Provide submittals and drawings as specified in Electrical Specifications [Electrical General, Submittal 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.

    a. The minimum size conduit shall be 3/4-inch unless indicated otherwise on the Drawings or for special connections to equipment.

    b. Provide cords and cord seals for devices or instrumentation requiring waterproof seal to maintain NEMA 4 or 4X ratings. Example devices include lighting and pipe mounted instruments that are located below grade.

2. Conduits may connect into junction boxes or wireways as shown in the drawings or as requested by Contractor and approved by Engineer. Junction boxes (circle with J in drawings) can be as simple as a condulet or JIC box, or larger box as determined by contractor and needed for the installation. Drawing may depict junction box requirements. Wireways or junction boxes shall be rated for area (as noted in the drawings), or furnish minimum NEMA 4 if not noted.

3. The Contractor shall use conduit material types (SPEC per conduit schedule) as defined below or as otherwise shown in the contract drawings or as specifically called out in the conduit schedule.

    a. Non-exposed underground portions of conduit run shall be PVC-40 for all signals and voltages unless otherwise shown in the conduit schedule.

b. Exposed conduit material (not underground and beyond transition) shall be per the following table unless specifically noted otherwise in the plan drawings. The conduit schedule denotes the conduit type for non-exposed (under-ground, in-concrete, etc.) and does not apply or coordinate with this table. Exposed condulets, elbows, fittings, device boxes, and hardware shall be of the same material and finish as the adjacent conduit.

Location	Material
NEMA 1 or 12	Galvanized rigid steel (GRS)
NEMA 3R	Galvanized rigid steel (GRS)
NEMA 4	PVC-Coated Steel (GRS-PVC)
NEMA4X	PVC-Coated Steel (GRS-PVC).
Class 1 Div 1 or 2 hazardous	PVC-Coated Steel (GRS-PVC)

4. Conduit stubs and transitions:

a. Conduit transitions shall be GRS-PVC for 6" on either side of the transition point (minimum) or as shown in drawing details. Conduit transition is defined as conduit sections emerging from or through concrete or earth or from below to above grade or through walls or vaults, non-exposed to exposed.

b. Beneath pad mounted electrical equipment, where not exposed, shall be installed or trimmed to 2" or less above slab and have bushing or end bell installed. Overall height of conduit entering into the base of equipment shall be enough for bushings/bells to be installed but be high enough for conduit tags to be installed.

c. Uniform in height for each panel or section. Conduits end bushings/bells shall not vary in height above slab more than ½" from lowest to highest.

d. Conduits shall be spaced apart such that bushings and end bells may be installed without interfering with the adjacent conduits.

e. Transitions to PVC shall include PVC coated locknuts to shield exposed steel pipe threads.

f. Through walls – shall protrude approximately 2" and include end bell or bushing. Pack space around conduit with non-shrink grout if the thru-hole was core drilled.

g. Conduits for future use shall be capped with coupling and plug. Identify each end with conduit labels.

h. Existing conduits that are no longer able to be used due to removal of a section or shown demolished and that protrude above graded shall be cut flush and filled with grout.

5. Conduit Tags

a. All conduits listed in the "Conduit and Wire Routing Schedule" (existing and new) shall have conduit tags at both ends of each conduit run with tag number from schedule identified. 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 ¼" thick by ¾" round or ¾" x 1" rectangle minimum.

d. Letter height shall be ¼" minimum. Engrave the tags with the conduit number or acronym. Labeling shall be neatly installed for visibility and shall be clearly legible. Securely fasten tags in place using 20ga stainless steel tie wire through a pilot hole on the tag.

e. Conduit tags shall be Custom manufactured per specification.

6. Supports

a. 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 gauge as applicable.

b. One-Hole clamps shall be intended for pipe mounting on support channels and equipped with clamp-backs. The clamps shall be Efcor, Thomas and Betts, Appleton or equal

c. Spacers, provided to support underground conduits in concrete encasements, shall be plastic. The spacers shall be Carlon, Johns-Manville, Underground Products or equal

d. Anchors shall be expansion type for securing equipment to concrete foundations, floors and walls. Anchors shall have length identification mark on the exposed end of the bolt. Provide Hilti Kwik Bolt 3, or equal.

e. Stanchions shall be provided as needed to mount equipment and electrical components. Stanchions shall be shop fabricated from

welded 4" c-channel, 12" x 12" x ¼" steel base plate, coated with a rust inhibiting primer and top coat of gray polyurethane gloss paint. Attach equipment to the stanchion direct or on a ¼" aluminum sheet sized for the equipment supported.

f. Conduit Hangers shall be trapeze construction, with double channel, 3/8-inch rods and nuts. Suspend from suitable structural support.

g. Support 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	Galvanized steel
Outdoors NEMA 3R	Galvanized steel
Outdoors NEMA 4	Stainless Steel type 316
Corrosive areas NEMA4X	PVC bonded, 40 mil, factory applied

h. Equipment mounting racks shall be designed by installer for rigid equipment and conduit mounting. Racks shall be bolted or welded construction and sized for equipment or as shown on the drawings.

i. Strut channels shall be used for mounting equipment to walls and for supporting conduit runs. Double strut channel type shall be used for fabricating equipment mounting racks as required and/or as detailed on the drawings. Add additional supports to rigid mounting locations as needed to prevent wobbling and to meet seismic requirements. All field cut surfaces of the strut channels shall be deburred and coated to prevent rust.

B. GALVANIZED RIGID STEEL CONDUIT - (GRS)

1. Manufactured from high-strength steel and hot dipped zinc galvanized inside and out. Conduit and fittings shall meet UL 514B, UL 6, and conform to NEMA RN 2. Conduit shall be capable of being used as an equipment grounding conductor per NEC 250.

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 equal.

4. In hazardous locations, fittings shall meet and be listed UL 886.

5. All fittings, hubs, couplings, pulling elbows and connectors shall be

threaded-type. Set-screw type and compression-type are not acceptable. All thread conduit is not allowed over 1/2" exposed length. Cover plates shall be cast iron with sealing gasket in NEMA 3R locations.

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.

7. Combination expansion-deflection fittings installed exposed shall be Type XD as manufactured by Crouse-Hinds Co.; Type DX as manufactured by O.Z. Gedney Co.; Type DF as manufactured by Appleton Electric Co., or equal

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

1. Galvanized Rigid Steel conduit with a 40-mil thick polyvinylchloride exterior coating and a 2-mil urethane interior coating meeting NEMA RN-1, UL-6 and ETL PVC-001. The bond of the PVC to the zinc coated pipe 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-mil thick PVC coating meeting the same

4. In hazardous locations, fittings shall meet and be listed UL 886.

5. 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, ½" through 4", must have a tongue-in-groove gasket to effectively seal out the corrosive elements. Covers shall be supplied with plastic encapsulated stainless steel cover screws. Form 8 fittings shall be UL and type 4X and IP69 listed.

6. A "PVC Coated Sealing Locknut" shall be used on all exposed male threads transitioning into female NPT threads which do not have sealing sleeves, including transitions from PVC couplings/female adapters to PVC Coated GRC elbows in direct burial applications. "PVC Coated Sealing Locknuts" are not to be used in place of a myers hub

7. A PVC sleeve extending one pipe diameter or two inches, whichever is less, shall be formed at every female fitting opening except unions. The inside sleeve diameter shall be matched to the outside diameter of the conduit.

8. All junction and metal pull boxes shall be galvanized with exterior

surfaces PVC coated to 40 mils thickness.

9. Unistrut, strut clamps, pipe straps, and clamp back spacers, shall have 40 mil thick PVC coating. All mounting anchors shall be stainless steel.

10. Conduits entering enclosures shall be fitted with insulated grounding bushing. All grounding bushings shall be tied to the grounding system with properly sized bonding conductors per the NEC code.

11. Installers of PVC Coated Conduit must be certified by the manufacturer and be able to present a valid, unexpired certified installer card.

12. GRS-PVC conduit to be Robroy Plasti-bond, Perma-Cote, KorKap, T&B OCAL or equal.

D. 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. Fittings and device boxes shall be PVC with factory fabricated conduit connections. Provide Carlon or equal.

6. Conduits entering enclosures shall be fitted with a glued male adapter, lock ring and bushing to prevent wire chafing. Conduits entering panels through concrete to an open bottom or entering a pull box shall have a glued end bell fitting.

7. PVC conduit shall be stored on a flat surface and shielded from the sun.

E. LIQUID TIGHT FLEXIBLE NON-METALLIC CONDUIT (up to 2”) - (FLEX)

1. Liquid tight flexible Nonmetallic Conduit shall be constructed of flexible PVC and have a smooth inner surface with integral crush resistant reinforcement within the conduit and be designated as a Type LFNC-B (for FNMC-B).

2. Liquid tight Flexible Nonmetallic Conduit shall be sunlight, oil, and flame resistant and approved for the installation of electrical conductors in indoor and outdoor applications.

3. Liquid tight Flexible Nonmetallic Conduit shall be listed to UL standard UL1660.

4. Liquid tight flexible non-metallic conduit shall be installed in accordance with Article 351, Part B of the National Electrical Code (NEC) and other applicable sections of the NEC and/or local electrical codes.

5. Liquid tight Fittings shall be listed for the use with Liquid tight Flexible Nonmetallic Conduit and shall be marked LFNC-B (FNMC-B).

6. Flexible Non-Metallic Conduit shall be Carlon Carflex or equal.

F. LIQUID TIGHT FLEXIBLE METAL CONDUIT (above 2-1/2") - (FLEX)

1. Liquid Tight Flexible Metal conduit shall be moisture and oil-proof with PVC jacket extruded over a galvanized flexible steel conduit.

2. Liquid tight Flexible Metallic Conduit shall be sunlight, oil, and flame resistant and approved for the installation of electrical conductors in indoor and outdoor applications.

3. Liquid tight Flexible Nonmetallic Conduit shall be listed to UL standard UL 360.

4. Liquid tight flexible metallic conduit shall be installed in accordance with Article 351, Part B of the National Electrical Code (NEC) and other applicable sections of the NEC and/or local electrical codes.

5. Liquid tight Fittings shall be listed for the use with Liquid tight Flexible Metallic Conduit and conform to UL514B.

   a. Outdoors when extension of GRS-PVC: PVC coated galvanized steel with insulated bushings.

   b. Outdoors when extension of GRS: Galvanized steel with insulated bushings.

   c. Indoors or outdoors when extension of stainless steel: 316 stainless steel with sealing ring and insulated bushing.

   d. Indoors: Galvanized steel with insulated bushings.

6. Flexible Metallic Conduit shall be Amer-Tite type GP or equal.

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 314 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 stainless steel screws.

2. Weatherproof switch, outlet, and receptacle boxes shall be fitted with gasketed covers rated for wet locations. 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 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 or as otherwise shown. Door shall be fastened with clamps and stainless steel screws. No devices, screws, rivets, or bolts shall protrude through the exterior surface unless specifically shown on the drawings. Boxes shall be Hoffman, Circle AW, or equal.

B. UNDERGROUND BOXES

1. Underground pull boxes shall be prefabricated “Christy Box” size and type as noted in the drawings or equal. Size shall be as shown or dimensioned on the Drawings. Provide larger boxes as needed to meet code or as determined in field to allow for adequate pull area at Contractor

discretion. Extension sections shall be provided as necessary to reach the depth of underground conduits with maximum depth of 48". All boxes shall have galvanized steel hold down bolts and hardware. Boxes shall be H/20 loading rated and have traffic rated covers. Steel covers or lids shall be galvanized and grounded with bonding jumper to the local grounding circuit per NEC. Pull box covers shall be labeled electrical, signal, utility, and telephone, whichever applies. Pull boxes shall be Christy Concrete Products, Brooks or equal.

C. PULL BOX AND VAULT IDENTIFICATION

1. Engrave or bead weld box covers with minimum thickness of ¼" x 1" lettering with pullbox name (i.e. PBX-XXX) and purpose (electrical, signal, fiber, telephone, etc.). Provide an additional identifier "high voltage" for boxes with 600 volts or higher.

2. Utility pull boxes shall be labeled per Utility Company standards.

PART 3: EXECUTION

3.01 WORKMANSHIP

A. All work in this Section shall conform to the codes and standards specified in specified in Electrical Specifications [Electrical General, Workmanship].

3.02 INSTALLATION

A. System:

1. Install all products per Electrical Specifications [Electrical General, Installation].

B. Rigid 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. Pipe threads shall be treated with conductive thread compound.

4. Installation of the GRS-PVC conduits must be in accordance with the manufacturer's installation procedures using recommended tools.

a. Apply touch up compound at each fitting sealing sleeve edge to improve watertight seal.

b. To ensure compliance, the installer(s) must be "manufacturer certified" before installation can proceed.

c. Certification available by contacting manufacturer's representative and attending a brief instructional course. Valid and unexpired certification card shall be available for review per installer.

5. Repair GRS-PVC coating utilizing a touch-up compound as provided by the manufacturer of the conduit of the same material as the coating. Overlap beyond the damaged area to cover the PVC coating. Contact from touchup compound to PVC is required to maintain integrity. The entire conduit shall be replaced if the repair exceeds 1" combined length.

6. 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.

7. 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.

   a. Combination expansion-deflection fittings installed exposed shall be Type XD as manufactured by Crouse-Hinds Co.; Type DX as manufactured by O.Z. Gedney Co.; Type DF as manufactured by Appleton Electric Co., or equal

8. 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.

9. 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 equal.

10. Exposed conduit stubs for future use shall be capped with coupling and plugged. Drill hole in plug for pull rope as necessary.

11. Explosion proof seal-off fittings shall be provided on all conduits that enter or leave hazardous areas per requirements of the National Electrical Code, Chapter 5 and UL 886. The seal-off fitting shall prevent hazardous gases and/or flames from passing from one type area to another through the conduit system. Ceramic or other non-asbestos fiber material and sealing compound shall be placed in the fitting to complete the seal.

12. Hazardous location conduit outlet boxes shall be used in hazardous locations for change in direction, access to conductors and as pull and splice boxes.

13. All spare conduits shall have 1/8" nylon pull ropes installed.

C. Flexible Conduit and Cords

1. Final connections to vibrating equipment such as motors, heaters and fans shall be made with liquid tight flexible conduit.

2. Flexible conduit lengths shall not be greater than 36 inches for sizes up to 2 ½" and 48 inches for 3" and larger conduit.

3. Flexible conduit shall include a ground conductor for equipment bonding in circuits over 30 VDC or as shown in the conduit schedule.

4. Flexible conduit shall only be installed in exposed or accessible locations.

5. Where equipment is cord connected, submersible rated, and conduit connections are not possible without modification, devices and equipment may be free-air cord connected in lieu of flexible conduit. Connection to adjacent rigid conduit shall be through liquid-tight cord connector fitting specifically designed for the purpose and sized appropriately for the cord. Cord connectors shall be rated similar to the adjacent conduit they are connected to: Stainless steel, galvanized or plastic.

D. 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 24 inches except under roadways where minimum cover shall be 30 inches or as otherwise shown in the Contract Drawings. 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. Install spacers to support underground conduits. Horizontal and vertical separation shall be maintained by plastic spacers set every four feet. Spacers shall be Carlon Snap-Loc or equal.

4. 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.

E. 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	=>	18 inches
Bracket fixtures	=>	7 feet 6 inches

F. Cutting, Coring, Patching and Repairing:

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. Cutting and patching shall be done only by skilled labor of the respective trades. Where it is becomes necessary to cut into existing work for the purpose of making electrical installations, locate existing post tension cables, rebar and electrical services prior to core drilling using ground penetrating radar or similar technologies. All surfaces shall be restored to their original condition after cutting and patching.

3.03 FIELD ASSISTANCE

A. General: Provide all equipment and supplies necessary to perform all testing. The Owner Representative shall have the option to witness and participate in the on-site tests performed by the installer.

B. Per Electrical Specifications [Factory and Field Testing].

3.04 WARRANTY

A. Provide warranty as specified in Electrical Specifications [Electrical General, Warranty].

END OF SECTION

SECTION 26 05 70

FACTORY AND FIELD TESTING

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 Electrical Specifications. All equipment provided under Electrical Specifications and electrical equipment provided under other sections shall be tested as specified herein.

B. The Electrical Contractor shall coordinate at no additional cost to the Owner, 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 Integrator, Testing Company and/or Electrical Contractor shall provide all labor, tools, material, power, and technical supervision to perform the specified tests and inspections.

D. The Electrical Contractor shall be present during field testing and assist the System Integrator and/or Testing Company in testing all equipment. The Electrical Contractor shall be ready to correct any wiring problems found during testing.

E. The Application Programmer (defined in Electrical Specifications [Electrical General].) and/or Construction Manager will be actively engaged in Operational Testing and Commissioning. These efforts shall be combined efforts of the Application-Programmer/Construction-Manager/Engineer and Contractor. The Contractor shall facilitate test as outlined herein such that hardware, software and application programming are tested completely and all applicable test documentation is completed.

1. Expect that field testing of SCADA and PLC checkout, is going to require 1 week after pre-operational tests are done. Contractor and System Integrator shall assist in this start-up. Coordinate with Owner Representative to schedule this start-up period.

F. 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.

G. The Owner and/or Construction Manager may witness testing in effort to insure quality and verify results. The Contractor is required to provide notification 2

weeks prior to any test that are intended to be documented and submitted for approval or are final tests. The Owner and Construction Manager must specifically decline witness of each test to be performed, and the test must be successful, and it must be documented on the day of test, in order for it to not have to be repeated in the presence of an authorized witness. Only the Owner or Construction Manager may assign an authorized witness.

H. All tests shall be documented in writing by the person performing the test on the test forms submitted (and similar to those shown at the end of this section) and signed by the Witness as satisfactorily completed. The Testing Company, Electrical Contractor or System Integrator performing tests shall keep a detailed log of all tests that failed or did not meet Specifications, including date of occurrence and correction.

I. The Contractor shall perform all applicable testing of Owner supplied or existing equipment as a unit and as part of a system. Testing shall include documentation and witness sign-off.

1.02 REFERENCES

A. Electrical Specifications [Electrical General]
B. Project Drawings
C. Additional testing may be specified in other Electrical Specifications.

1.03 FACTORY AND FIELD GENERAL REQUIREMENTS

A. Testing General

1. Prior to any field testing Operation & Maintenance Manuals shall have been submitted and approved.

2. The test forms shall be completed by the contractor during testing and calibration of all equipment. All tests shall be witnessed by the Owner's Representative. Completed test forms shall be given to the Owner's Representative the day of the test. Complete two sets of test forms if Contractor wants to keep a copy.

3. The Contractor shall give the Engineer 10 working days notice of the dates and time for inspections and testing using the "Scheduled Test Date Request Form."

4. Include test results in the Maintenance and Operational Manual.

5. As a minimum, all the tests indicated/specified on the test forms shall be performed and test forms filled out by the Contractor.

6. Prepare and submit formal test procedures and forms at least two weeks prior to the start of testing. Testing shall not commence until the test

procedures have been reviewed and approved. Submit a combined test procedure submittal with separate sections for factory and field tests.

7. If the results of any of tests are unacceptable, the Contractor shall make corrections and perform the tests again until they are acceptable; these tests shall be done at no additional cost.

B. Failure to Meet Test

1. Any system, material or workmanship which is found defective on the basis of these tests shall be reported immediately following the test. The Contractor shall replace the defective material or equipment and have tests repeated.

C. Safety

1. Testing shall conform to the respective manufacturer's recommendations. All manufacturers' safety precautions shall be followed.

2. Safety, as shown herein and in other divisions, shall be a combination of all methods and practices described. Safety practices may not be determined based on the least restrictive requirement, but instead, on the most restrictive requirement. Obtain clarification if there is any question prior to performing tests.

3. 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 in such a fashion that personnel safety is jeopardized.

4. The Contractor shall have two or more personnel present at all tests.

5. Two non-licensed portable radios shall be provided by the Contractor for use during testing.

6. Contractor shall comply with California Electrical Safety Orders (ESO) and Occupational Safety and Health Act (OSHA): All test and procedures shall comply with ESO and OSHA as to safety, protective clothing, clearances, padlocks and barriers around electrical equipment energized during testing.

7. The first set of tests to be performed (**pre-energization**) shall determine the suitability for energization and shall be completed with all power turned off.

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) 339-9691
    b. Industrial Test (888)-809-8550
    c. Emerson Electrical Reliability Services
    d. Apparatus Testing and Engineering (916) 853-6280
    e. Apparatus Testing and Engineering (925) 454-1363
    f. Power Systems Testing (925) 583-2361

2. Testing Companies not listed are required to submit company and individual representative resumes for review and approval.

B. System Integrator Representative

1. The system integrator representative shall have 1 year experience in field testing of equipment working for the System Integrator or equivalent. If the representative does not demonstrate necessary experience or competence during testing or start-up, the System Integrator shall provide a representative meeting the required competence and experience.

C. Electrical 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, System Integrator, 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 Integrator shall assemble and submit for approval complete testing procedures and forms at least two weeks prior to the start of testing. Contractor is responsible for compiling testing procedures and forms from multiple sub-contractors as required.

C. Test submittal shall include: (as applicable)

1. Proposed procedure for operational testing whether it is performed in the factory or field. Procedure shall include method, simulated I/O requirements, bypass piping, telemetry, and necessary materials and

equipment to conduct test.

2. Test forms (for all tests, factory and field, and regardless of who performs tests). Test forms shall be electronically completed prior to submittal with entry spaces filled to the extent possible. The only remaining data that shall require completion during the test is the test data itself. Test forms shall be provided as illustrated at the end of this section or equal.

3. Approved shop one-line, elementary diagrams and PLC I/O drawings.

PART 2: PRODUCTS

2.01 TEST EQUIPMENT

A. Test equipment required to perform testing and document results shall be provided by Contractor, Testing Company or System Integrator.

B. Test instruments shall be calibrated to references traceable to the National Institute of Standards and Technology. Instrument calibration shall be current to one year from date of start-up. Test equipment accuracy shall be at least twice the accuracy of instrument being calibrated. Test instrument certificates of calibration shall be on-hand and provided prior to testing.

C. All test equipment to be used as part of the testing shall be listed in the submitted testing sheets. Contractor supplying the component or system to be tested shall provide all necessary test equipment.

D. 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 0.25% or 0.04 mA.

PART 3: EXECUTION

3.01 FACTORY TESTING

A. Not required.

3.02 FIELD TESTING

A. General Requirements

1. Field testing is broken down into 4 components

a. Pre-Energization testing
b. Pre-Operational Testing
c. Operational Testing
d. Commissioning

2. Project wide, all Pre-Energization testing must be completed prior to Pre-

Operational testing, all Pre-Operational testing must be completed prior to Operational Testing, and all Operational Testing must be completed prior to Commissioning.

a. Any deviation of this order, whether on a component level or larger scale, must be approved.

b. Out of order testing, if allowed, will be evaluated on a case-by-case basis when brought to the attention of the Owner's Representative. The Owner's Representative may require that the entire system, or portions thereof, be retested once the missing component(s) are installed and functional.

3. All equipment supplied by the Contractor or others shall be tested by Contractor per these specifications.

4. Two digital multimeters/signal generators (minimum +/- 0.1% accuracy) , AC current meters, torque wrench, and other specialized test equipment shall be provided by the Contractor for use during testing.

5. If the equipment is determined not to be ready for testing, the test will be cancelled and rescheduled for a later date.

6. Faulty and/or incorrect hardware or software operation of major portions of the system may be cause for suspension, cancellation, or restarting of the area of testing, at no additional cost or extension in Contract time.

7. During the Operational testing period, under the supervision of the System Integrator, the Construction Manager and Application Programmer shall have unlimited and unrestricted access to the usage and testing of all hardware and software in the system.

8. The System Integrator shall pay all expenses incurred by his personnel including labor, material, transportation, lodging, daily subsistence, and other associated incidental costs during field testing.

9. Acceptance and witnessing of the tests does not relieve or exclude the Contractor from conforming to the requirements of the Contract Documents.

10. All modifications to documentation as a result of the tests shall be corrected and completed before the delivery of "as-built" documentation.

11. Copies of the completed and witnessed field testing forms shall be included in the Operation and Maintenance Manual.

12. The various contractors on this project (General Contractor, Electrical Contractor, Testing Company, and System Integrator) shall assume the

lead role in testing activities as listed below. The Contractor shall obtain assistance of suppliers and/or manufacturers representatives for any major equipment testing.

a. Electrical Contractor:

1) Pre Energization Tests
   a) Visual Mechanical Tests
   b) Wire Insulation and Continuity Tests.
   c) Panelboard Tests
   d) Breaker Tests
   e) Protective Relay Tests (Existing Relay at main breaker and Motor Protection Relay)

2) Commissioning.

b. System Integrator:

1) Pre-Operational Tests
   a) Visual Mechanical Tests
   b) Control panel pre-operational test
   c) MCC pre-operational test
   d) Motor Tests.
   e) PLC I/O point to point tests.
   f) Instrumentation switch tests
   g) Instrumentation transmitter tests.

2) Operational Tests.
3) Commissioning

c. Testing Company

1) Grounding System Tests
2) Breaker Device Tests
3) Protective Relay Tests

d. General Contractor

1) Test Scheduling
2) Operational Tests.
3) Commissioning.

e. Owner Representative (software systems)

1) Operational Tests.
2) Commissioning.

B. Electrical Field Tests – The following test shall be performed within each test category. Complete test forms for each electrical panel, instrument, and/or

device. Provide separate form for each component to be tested.

1. Pre-Energization Inspections and Tests:

    a. Visual and Mechanical Inspection Tests
    b. Wire Insulation and Continuity Tests
    c. Grounding System Tests
    d. Panelboard Tests
    e. Breaker Tests
    f. Protective Relay and Motor Protection Relay Tests
        1) Test form(s) to be provided by Testing Company.
        2) Test shall meet Utility and NETA test standards.
        3) Test each protective relay, each phase, each function utilized.
        4) Test other relays for their specific function.
        5) Test/prove relays in presence of Utility staff.

2. Pre-Operational Tests:

    a. MCC Pre-operational Tests:
    b. Control Panel Pre-operational Tests:
    c. Motor Testing:
    d. Harmonic Measurement: (Required for systems with VFDs)
    e. Instrumentation Switch Calibration Tests
    f. Instrument Transmitter Calibration Tests
    g. PLC I/O point tests.
    h. Communication Tests

        1) The Contractor shall verify that all communications via radio, telephone, wireline, fiber optic, or other are functional and ready for operational testing. Revise all configurable parameters without additional cost to the Owner as required for an optimally functional system.

        2) Verify that all components of the communication system operate together under all operating and power restart conditions. If faults occur, investigate source of problem and correct. Revise all configurable parameters without additional cost to the Owner.

        3) Change setpoints from SCADA and confirm that corresponding field setpoint changes correctly. Check every I/O point on every screen, trend, and database.

3. Operational Tests:

    a. After all the previous tests in this subsection are complete, the test forms are completed and signed-off, the Contractor shall conduct

operational testing.

b. Representatives from the General Contractor, Electrical Contractor, System Integrator, and Owner's Representative shall be present during testing. Operational testing shall be performed by Contractor in the presence of the Owner's Representative.

c. During operational testing the Contractor shall follow the instructions of the Owner. The Owner may place restrictions on operation that must be followed by the Contractor during testing. Any accidents or fines caused by actions of the Contractor where warnings or restrictions were placed, shall be remedied or paid by the Contractor.

d. Alarm Tests

1) Generate the digital and/or analog signals at the primary device 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.

e. Operational Control Tests (by Application Programmer with assistance of System Integrator and Contractor)

1) Generate the digital and/or analog signals at the primary device by raising or lowering the actual measured process. Inject signal into the terminals or utilize a "force" function within the device only as necessary. Verify that each control system is functional and properly configured and programmed.

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.

4) Verify that all data, setpoints, alarms are being received at SCADA correctly and that all I/O points on screen are true and accurate representations of field information.

f. Other Tests

1) Force a power failure and power fail/restart of PLC and all other systems. Check the effects of each failure on each piece of equipment and automatic recovery.

2) Force a PLC communication error. Demonstrate error detection, alarming, and recovery.

3) Perform additional operational testing that has not already been witnessed.

4) Perform any additional operational testing as necessary to confirm robust and error free operation under all operational conditions.

4. Trial Period

a. Station/Equipment shall be activated to automatically run for 5 days, 24 hours per day Monday through Friday.

b. During the trial period the Construction Manager will test all modes of operation and will look for errors and malfunctions. A punchlist will be generated to be completed by Contractor and re-tested prior to Commissioning.

c. If equipment failure occurs during the trial period, the Contractor shall repair or replace the defective equipment and shall begin another trial period, Monday through Friday.

d. This test shall be repeated until all new equipment functions acceptably and without failure for consecutive days.

C. Commissioning:

1. Commissioning shall not commence until Operational testing and System Training are complete with documentation submitted and with prior approval.

2. Commissioning period

a. The new equipment shall be activated by the Contractor to operate in full automatic for 10 consecutive days, 24 hours per day. Commissioning shall only start on Mondays or Tuesdays.

b. During Commissioning, the Owner will monitor and run the station in normal automatic mode. If equipment failure occurs during Commissioning, the Contractor shall repair or replace the defective equipment and shall begin another commissioning period after repairs are complete.

c. Parallel, existing and/or back-up systems shall remain in place and functional during commissioning period. Demolition of parallel, existing or back-up systems shall not begin until commissioning is completed.

d. This test shall be repeated until the new equipment functions acceptably for a consecutive commissioning period.

e. Warranty will begin at the start of a successful commissioning period. However, if major hardware failure occurs during commissioning, the warranty and commissioning will restart once the problem has been identified and repaired.

3.03 WARRANTY:

A. Provide warranty per Electrical Specifications [Electrical General, Warranty].

1. The completion of the above tests does not relieve the Contractor from any warranties specified in the Electrical Specifications or other sections.

2. Warranty shall begin on the start date of a successful Commissioning period.

3.04 FINAL ACCEPTANCE:

A. Final Acceptance per Electrical Specifications [Electrical General].

TEST FORMS

Index of Forms:

PC	Power Conductor Test Form
CC	Control Conductor Test Form
IC	Instrumentation Conductor Test Form
PR	Protective Relay Test Form (by Testing Company)
VM	Electrical Equipment Visual and Mechanical Inspection Form
MCO	MCC Operational Test Form
CPO	Control Panel Operational Test Form
MOTOR	Motor Test Form
HM	Harmonic Measurement Test Form
IOP	Programmable Logic Controller I/O Point-to-Point Test Form
ISC	Instrumentation Switch Calibration Test Form
ITC	Instrumentation Transmitter Calibration Test Form

END OF SECTION

POWER CONDUCTOR TEST FORM

PROJECT NAME: _____ DATE OF TEST: _____

TESTING COMPANY: _____ TEST LOCATION: _____

EQUIPMENT #: _____

INSULATION TESTS						
CONDUIT	PHASE TO GROUND			PHASE TO PHASE		
#	A	B	C	AB	BC	CA

NOTES:

1) Use single form for up to 25 power conduits. Use additional forms as necessary.

2) Disconnect both ends of wiring prior to megger tests.

3) Megger insulation resistances of all 600 volt insulated conductors using a 500 volt megger for 10 seconds (30 seconds for motor leads). 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 terminations installed but not connected to the equipment.

4) Each megger reading shall not be less than 22 Meg-ohms resistive. Corrective action shall be taken if values are recorded less than 10 Meg-ohms. Conductors with low ohm values, that do not match similar lengths of conductors the same size, shall be replaced at no additional cost to the Owner.

5) Values of different phases of conductors in the same conduit run showing substantially different Meg-ohm values, even if showing above 22 Meg-ohms shall be replaced.

CERTIFIED BY: _____ _____ _____

SIGNATURE COMPANY DATE

WITNESSED BY: _____ _____ _____

SIGNATURE COMPANY DATE

CONTROL CONDUCTOR TEST FORM

PROJECT NAME: _____ DATE OF TEST: _____

TESTING COMPANY: _____ TEST LOCATION: _____

INSULATION TESTS											
COND. # OF #	COND. TO GROUND	CONDUCTOR TO CONDUCTOR									
1		1 TO #	2 TO #	3 TO #	4 TO #	5 TO #	6 TO #	7 TO #	8 TO #	9 TO #	10 TO #
		X									
2		1 TO #	2 TO #	3 TO #	4 TO #	5 TO #	6 TO #	7 TO #	8 TO #	9 TO #	10 TO #
		X	X								
3		1 TO #	2 TO #	3 TO #	4 TO #	5 TO #	6 TO #	7 TO #	8 TO #	9 TO #	10 TO #
		X	X	X							
4		1 TO #	2 TO #	3 TO #	4 TO #	5 TO #	6 TO #	7 TO #	8 TO #	9 TO #	10 TO #
		X	X	X	X						
5		1 TO #	2 TO #	3 TO #	4 TO #	5 TO #	6 TO #	7 TO #	8 TO #	9 TO #	10 TO #
		X	X	X	X	X					
6		1 TO #	2 TO #	3 TO #	4 TO #	5 TO #	6 TO #	7 TO #	8 TO #	9 TO #	10 TO #
		X	X	X	X	X	X				
7		1 TO #	2 TO #	3 TO #	4 TO #	5 TO #	6 TO #	7 TO #	8 TO #	9 TO #	10 TO #
		X	X	X	X	X	X	X			
8		1 TO #	2 TO #	3 TO #	4 TO #	5 TO #	6 TO #	7 TO #	8 TO #	9 TO #	10 TO #
		X	X	X	X	X	X	X	X		
9		1 TO #	2 TO #	3 TO #	4 TO #	5 TO #	6 TO #	7 TO #	8 TO #	9 TO #	10 TO #
		X	X	X	X	X	X	X	X	X	
10		1 TO #	2 TO #	3 TO #	4 TO #	5 TO #	6 TO #	7 TO #	8 TO #	9 TO #	10 TO #
		X	X	X	X	X	X	X	X	X	X

NOTES:

1) Use single form for each conduit.

2) Disconnect both ends of wiring prior to megger tests.

3) Megger insulation resistances of all 600 volt insulated conductors using a 500 volt megger for 10 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 terminations installed but not connected to the equipment.

4) Each megger reading shall not be less than 22 Meg-ohms resistive. Corrective action shall be taken if values are recorded less than 10 Meg-ohms. Conductors with low ohm values, that do not match similar lengths of conductors the same size, shall be replaced at no additional cost to the Owner.

5) Values of different phases of conductors in the same conduit run showing substantially different Meg-ohm values, even if showing above 22 Meg-ohms shall be replaced.

CERTIFIED BY: _____ _____ _____

SIGNATURE COMPANY DATE

WITNESSED BY: _____ _____ _____

SIGNATURE COMPANY DATE

INSTRUMENTATION CONDUCTOR TEST FORM

PROJECT NAME: _____ DATE OF TEST: _____

TESTING COMPANY: _____ TEST LOCATION: _____

CONDUIT NUMBER: _____ EQUIPMENT #: _____

CONTINUITY TESTS			INSULATION TESTS	
CONDUCTOR PAIR # OF #	CONDUCTOR TO CONDUCTOR	CONDUCTOR TO SHIELD	CONDUCTOR TO CONDUCTOR	SHIELD TO GROUND

NOTES:

1) Disconnect both ends of wiring prior to 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) 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 low ohm values, that do not match similar lengths of conductors the same size, shall be replaced at no additional cost to the Owner.

4) 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.

CERTIFIED BY: _____ _____ _____

SIGNATURE COMPANY DATE

WITNESSED BY: _____ _____ _____

SIGNATURE COMPANY DATE

ELECTRICAL EQUIPMENT
VISUAL AND MECHANICAL INSPECTION FORM

PROJECT NAME: _____ DATE OF TEST: _____

TESTING COMPANY: _____ TEST LOCATION: _____

EQUIPMENT NAME: _____ EQUIPMENT #: _____

NAMEPLATE DATA (complete as applicable)

MANUFACTURER: _____ ENCLOSURE: _____

MODEL #: _____ U.L. #: _____

VOLTAGE: _____ PHASE: _____

BUS AMPERAGE: _____ SERVICE: _____

BUS TYPE: _____ BUS BRACING: _____

VERTICAL BUS: _____ HORIZONTAL BUS: _____

GROUND BUS: _____ NEUTRAL BUS: _____

SERIES #:

PHYSICAL INSPECTION CHECKLIST

ENTER A-ACCEPTABLE R-NEEDS REPAIR OR REPLACEMENT NA-NOT APPLICABLE

ITEM	CHECK	NOTES
CHECK NON-ELECTRICAL FASTENERS FOR TIGHTNESS		
TORQUE TEST ALL WIRING AND BUS CONNECTIONS		
VERIFY ANCHORAGE IS PER SPECS AND/OR CALCS		
CHECK BUS BRACING AND CLEARANCE		
CHECK MAIN GROUNDING CONNECTION AND SIZE		
VERIFY GROUND BUS BONDING		
VERIFY EQUIPMENT GROUNDS		
VERIFY CONDUIT GROUNDS AND BUSHINGS		
CHECK NEUTRAL BUS AND CONNECTIONS		
VERIFY ALL BREAKERS AND FUSES ARE RATED PROPERLY		
INSPECT FOR BROKEN OR DAMAGED EQUIPMENT		
INSPECT ALIGNMENT OF PANEL AND DOOR		
VERIFY REMOVAL OF ALL DEBRIS AND DUST		
VERIFY WIRE LABELS ARE INSTALLED		
VERIFY ALL WIRE TERMINATIONS		
CHECK FOR PROPER WIRE SIZES		
CHECK FOR PROPER WIRE COLOR CODES		
VERIFY ALL NAMEPLATES		
CHECK FOR PROPER CLEARANCES AND WORKING SPACE		
INSPECT ALL PAINT SURFACES		
CHECK HEATERS AND THERMOSTATS		
CHECK VENTILATION AND FILTERS		
CHECK IF DRAWINGS MATCH EQUIPMENT		
CHECK ACCURACY OF OPERATION & MAINTENANCE		

NOTES:

1) Complete checklist above. Note any items that were found out of compliance.

2) Torque all electrical connections to values defined by equipment manufacturer or per NEC 110-14.

CERTIFIED BY: _____ _____ _____

SIGNATURE COMPANY DATE

WITNESSED BY: _____ _____ _____

SIGNATURE COMPANY DATE

MOTOR CONTROL PRE-OPERATIONAL TEST FORM

PROJECT NAME: _____ DATE OF TEST: _____

TESTING COMPANY: _____ TEST LOCATION: _____

MCC NAME: _____ MCC MANUFACTURE _____

MCC TYPE: _____ MCC LOCATION: _____

EQUIPMENT NAME	EQUIPMENT TAG #	CUBICLE #	LOCAL DEVICE CHECKS AND TESTS						REMOTE DEVICE CHECKS AND TESTS		
			CONTROL SWITCH	TIME RELAY SETTINGS	METERING & INDICATIONS	OVERLOAD RESET	INTERLOCKS & CONTROL	ALARM & STATUS	CONTROL SWITCH	PUSHBUTTON LOCKOUT & STOP	METERING INDICATIONS

NOTES:

1) Verify equipment powers up and operates correctly in hand.

2) Perform trip functions and verify equipment returns to normal operation with only necessary operator intervention.

3) Enter data for each piece of equipment being served from MCC or Control Panel.

4) Enter NA - for non applicable entries.

CERTIFIED BY: _____ _____ _____

SIGNATURE COMPANY DATE

WITNESSED BY: _____ _____ _____

SIGNATURE COMPANY DATE

CONTROL PANEL PRE-OPERATIONAL TEST FORM

PROJECT NAME: _____ DATE OF TEST: _____

TESTING COMPANY: _____ TEST LOCATION: _____

CONTROL PANEL NAME: _____ CONTROL PANEL TAG #: _____

CONTROL PANEL MANUFACTURER: _____ CONTROL PANEL TYPE: _____

CATEGORY	EQUIPMENT TAG #	DEVICE CHECKS AND TEST								
		CONTROL SWITCHES	OPERATOR INTERFACE	PANEL METERS	PANEL LIGHTS	PANEL NAMEPLATES	PLC POWER SUPPLY	I/O CARDS		
Height										
Voltage										
Function										
CATEGORY	EQUIPMENT TAG #	POWER SUPPLY 1 (V)	POWER SUPPLY 2 (V)	POWER SUPPLY 3 (V)	UPS	PANEL LIGHTS				
Function										
Voltage										

NOTES:

1) Set configurable parameters and verify voltage input prior to applying power.

2) Verify equipment powers up and operates correctly.

3) Perform trip functions and verify equipment returns to normal operation with only necessary operator intervention.

4) Complete checklist above by entering a checkmark (CM) for acceptable, or R for needs repair or attention, or NA for not applicable

Attention Requied:

CERTIFIED BY: _____ _____ _____

SIGNATURE COMPANY DATE

WITNESSED BY: _____ _____ _____

SIGNATURE COMPANY DATE

MOTOR TEST FORM

PROJECT NAME: _____ DATE OF TEST: _____

TESTING COMPANY: _____ TEST LOCATION: _____

MOTOR NAME: _____ MOTOR TAG: _____

SERIAL #: _____

MOTOR NAMEPLATE DATA

MFG:		PHASE:		TYPE:		P.F:		S.F:		NEMA:	
VOLTS:		HP:		DUTY:		RPM:		CODE:		DESIGN:	
FREQ:		FLA:		MODEL:		FRAME #:		ROTATION (CW/CCW):			

INSULATION RESISTANCE TEST PHASE-TO-GROUND/PHASE-TO-PHASE

A: _____ / _____ B: _____ / _____ C: _____ / _____

CONTROL SETTINGS AND TESTS

MOTOR HEATER MEASURED AMPS:	_____ (AMPS)	MOTOR OVERLOAD SETTING:	_____ (AMPS)			
MOTOR THERMAL TRIP TEST:	_____	OVERLOAD RESET TEST:	_____ (YES/NO)			
MINIMUM SPEED (IF VFD):	_____ (HERTZ)	COIL RESISTANCE:	AB	BC	CA	

PHYSICAL MOTOR TESTS - ACTUAL MEASURED VALUES

VOLTAGE (VOLTS)		AMPERAGE (AMPS)		POWER	
AB:	_____ V	A:	_____ A	POWER FACTOR:	_____
BC:	_____ V	B:	_____ A	POWER DRAW:	_____ KW
CA:	_____ V	C:	_____ A	HORSEPOWER:	_____ HP
IMBALANCE:	_____ %	IMBALANCE:	_____ %		

NOTES:

1) Perform coil resistance measurements on motor leads with a low-resistance ohmmeter. Note measurements.

2) Perform insulation-resistance test utilizing 500 volt megger and/or accordance with manufacturer's published testing procedures. Motors 200 HP and more test duration 10 minutes, 200 HP and less test duration 1 minute.

3) Perform DC overpotential tests on motors rated 1000 HP and 4000 volts or greater in accordance with ANSI/IEEE Standard 95.

4) Verify that pump/shaft seals are lubricated and that automated lubrication systems are functional.

5) Verify that motor protection/monitoring circuits are installed and connected per contract drawings and manufacturer requirements.

6) Verify that the motor space heater is functional.

7) Perform a rotation test to insure correct shaft direction by "bumping" motor. Reverse as necessary in appropriate place. Phase taping must remain in order on terminals left-to-right once completed.

8) Measure running current and evaluate relative to load conditions and nameplate full-load amperes.

9) Record the voltage and current on all phases while operating under full-load. If voltage or current imbalance is above 2 percent, or if current is above nameplate FLA or expected level, investigate cause and report on findings. Calculate imbalance by dividing (high minus low measurement) by the average measurement of all 3 phases.

10) Vibration tests shall be conducted in cases of discernable abnormal vibration or when ordered by the Engineer (due to perceived excessive vibration). Vibration shall not exceed 0.1 in./sec as measured opposite driven end of motor. Make necessary corrections to reduce vibration below limit at all operational speeds and loads.

COMMENTS:

CERTIFIED BY: _____ _____ _____

SIGNATURE COMPANY DATE

WITNESSED BY: _____ _____ _____

SIGNATURE COMPANY DATE

HARMONIC MEASUREMENT TEST FORM

PROJECT NAME: _____ DATE OF TEST: _____

TESTING COMPANY: _____ TEST LOCATION: _____

TECHNICIAN _____ EQUIPMENT NAME: _____

POINT OF MEASUREMENT: _____

(If available, take measurements on primary side of main breaker, otherwise, on secondary side of main breaker.)

COMMENTS:

MEASURED HARMONIC VOLTAGE VALUES												
RUNNING CONDITION			TIME	VOLT	AMPS	THD(V)	THD(A)	5TH	7TH	11TH	13TH	15TH
PUMP 1 SPEED	PUMP 2 SPEED	PUMP 3 SPEED										
0	0	0										
70	0	0										
90	0	0										
100	0	0										
70	70	0										
90	90	0										
100	100	0										
70	70	70										
90	90	90										
100	100	100										

NOTES:

1) Measure the harmonics with a harmonic analyzer with each combination of pumps shown or as designated by Engineer at start-up in operation on the Utility source. Repeat test on generator (if applicable).

2) Use multiple forms and/or attach printouts of harmonic analyzer machine.

4) Expand this chart for pump stations/systems with more than 3 VFD pumps.

5) All harmonic conditioning equipment shall be on-line and operate other non-VFD loads as normal during test.

CERTIFIED BY: _____ _____ _____

SIGNATURE COMPANY DATE

WITNESSED BY: _____ _____ _____

SIGNATURE COMPANY DATE

PROGRAMMABLE LOGIC CONTROLLER I/O POINT-TO-POINT TEST FORM

PROJECT NAME: _____ DATE OF TEST: _____

TESTING CO: _____ TEST LOCATION: _____

PANEL NAME: _____ PANEL TAG #: _____

PLC NAME: _____ RACK # _____ SLOT # _____ I/O TYPE _____

I/O POINT				Scale					Digital	Operator	SCADA	Pass/Fail
I/O #	TYPE	TAG #	Description	@4mA	@8mA	@12mA	@16mA	@20mA	On/Off	Interface	Screen	CM or R
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												

NOTES:

1) Connect signal generator to each I/O point for factory testing.
2) Utilize actual instrument to generate signals for field pre-operational tests where possible.
3) Verify function and accuracy of loop by by switching the digital signal or modulating the analog signal from the connected device or instrument
4) Field verify all instruments and indicators within loop of signal.
4) Confirm polarity of signals and calibration ranges are equivalent for all components in loop.
5) Include significant digits past decimal in scale columns
6) Complete checklist above by entering a checkmark (CM) for acceptable, or R for needs repair or attention
7) Note items that need attention below

Attention Requied:

CERTIFIED BY: _____ _____ _____

SIGNATURE COMPANY DATE

WITNESSED BY: _____ _____ _____

SIGNATURE COMPANY DATE

INSTRUMENTATION SWITCH CALIBRATION TESTS FORM

PROJECT NAME: _____ DATE OF TEST: _____

TESTING COMPANY: _____ TEST LOCATION: _____

INSTRUMENT NAME: _____ INSTRUMENT TAG#: _____

INSTRUMENT UNITS: _____ NAME: _____

TYPE: _____ MODEL: _____

SERIAL #: _____

MANUFACTURER	INSTRUMENT
NAME: _____ TYPE: _____ MODEL: _____ SERIAL #: _____	UNITS: _____

PROCESS SETPOINT	INCREASING TRIP POINT	DECREASING TRIP POINT	DEADBAND	SETPOINT TIME DELAY	ACTUAL TIME DELAY

NOTES:

1) Field test instrumentation and associated control systems in accordance with the specifications and the manufacturer's instructions. Instrumenatation shall function as intended under actual process conditions or shall be repaired or replaced at Contractors expnse.

2) Complete a separate calibration form for each instrument provided.

3) Simulate process variable in field by applying known pressure, temperature, opening/closing measured device, raising/lowering actual level, etc. as required to confirm calibration. This step must be witnessed by inspector.

CERTIFIED BY:	_____	_____	_____
	SIGNATURE	COMPANY	DATE
WITNESSED BY:	_____	_____	_____
	SIGNATURE	COMPANY	DATE

INSTRUMENTATION TRANSMITTER CALIBRATION TEST FORM

PROJECT NAME: _____ DATE OF TEST: _____

TESTING COMPANY: _____ TEST LOCATION: _____

INSTRUMENT NAME: _____ INSTRUMENT TAG#: _____

MANUFACTURER	INSTRUMENT
NAME:	RANGE:
TYPE:	SCALE:
MODEL:	UNITS:
SERIAL #:	TRANSMITTER OUTPUT:
REMOTE SENSOR TYPE:	FACTORY SPECIFIED ACCURACY:
(If Applicable)	REMOTE SENSOR OUTPUT:
	(If Applicable)

DESIGNED VALUE				ACTUAL VALUE			
INPUT SIGNAL	OUTPUT	ENG VALUE	CALCULATED TOLERANCES	INSTRUMENT DISPLAY	INSTRUMENT OUTPUT SIGNAL	PROCESS INDICATOR	LOGIC VALUE

NOTES:

1) With this form, attach and submit factory calibration forms for flowmeters and transmitters that are available from factory.

2) Field test and calibrate instrumentation and associated control systems in accordance with the specifications and the manufacturer's instructions. Instrumenatation shall meet specified accuracy or shall be repaired or replace at Contractor's expense.

3) Complete a separate calibration form for each instrument provided.

4) Simulate process variable in field by applying known pressure, temperature, pH, etc. as required to confirm calibration. This step must be witnessed by inspector.

5) Provide parameter value for each parameter changed from factory default.

CERTIFIED BY: _____ _____ _____

SIGNATURE COMPANY DATE

WITNESSED BY: _____ _____ _____

SIGNATURE COMPANY DATE

SECTION 26 09 05

CONTROL PANELS

PART 1: GENERAL

1.01 SCOPE OF WORK

A. Provide and install Control Panels per Drawings.

B. Provide complete wired and tested panel with all devices installed per the contract Drawings and as stated herein.

C. Provide all necessary hardware, conduit, wiring, fittings, and devices to connect the control panel to equipment provided under other Sections.

1.02 REFERENCES

A. Electrical Specifications [Electrical General].

B. Electrical Specifications [Low Voltage Wire & Data Cable]

C. Electrical Specifications [Instrumentation]

1.03 SUBMITTAL REQUIREMENTS

A. Provide submittals and Drawings as specified in Electrical Specifications [Electrical General, Submittal 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.

C. Calculations for environmental controls. Environmental controls (including air conditioners, exhaust fans, heaters and circulation fans) shall maintain interior panels temperatures within ratings of all internal equipment given the intended installation location.

1. Design and install environmental control systems to meet requirements

herein and prevent premature failure of panel internal components.

2. Environmental controls may be shown in the Drawings and shall be considered the minimum level required. Additional components or systems shall be provided to meet internal temperature requirements.

3. Environmental control systems shall prevent and control intrusion of dust and bugs through the use of filtration systems.

4. Environmental control systems shall maintain humidity below that of the external ambient air and without condensation within panel.

1.04 OPERATING AND MAINTENANCE INSTRUCTIONS

A. Provide operating instructions as specified in Electrical Specifications [Electrical General].

PART 2: PRODUCTS

2.01 ENCLOSURE

B. The enclosure for the control panel shall be (at minimum) sized as shown in the Contract Drawings.

1. Arrangement: Where so indicated, the instruments mounted in the panels shall have the nominal size and general arrangement shown. Panel layouts and nameplates shall conform to the approved submittal.

2. Assembly: Mount all equipment on 12 ga. painted white backpan(s) that is bolted to rear (and sides) of the enclosure. Use drill and tap method for machine thread screws for all internal components on mounting panels. Provide extra mounting bolts through the rear of the structure if equipment weight exceeds backpanel mounting stud capacity.

3. Hardware: Provide door latch and accessories as detailed in the Contract Drawings or as required to meet NEMA area ratings.

a. Provide one or two single point latches for panels up to 36” height.

b. Provide 3 point latching mechanisms for panels over 36” height consisting of rotating handle with latch, extension bars with plastic wheels at ends and guide slots at top and bottom of door, or as otherwise shown on drawings.

c. Hinges, pins, bolts and screws shall be of 316 stainless steel only.

4. 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.

2.02 CONTROL PANEL CIRCUIT BREAKERS

A. Furnish circuit breakers and accessories as required per Drawings and application.

1. Copper busbar systems, up to 480VAC, 115A, 1, 2 or 3 phase as needed for application

2. Trip rating per Drawings or as needed for protected device. Trip curves as selected by System Integrator.

a. B curve magnetic trip point: 3 to 5 times the rated current, typically used for computers and electronic equipment with very low inrush loads (PLC wiring).

b. C curve magnetic trip point: 5 to 10 times the rated current, typically used for small transformers, pilot devices, etc.

c. D curve magnetic trip point: 10 to 20 times the rated current, typically used for transformers or loads with very high inductive loads.

3. Quantity of pins and feed in lugs as required.

4. Auxiliary contact, shunt trip as required in Drawings.

5. Din rail mounted, 18mm width per pole, finger safe pressure plate terminals.

B. Motor applications:

1. UL489 for branch circuit protection up to 40A, 1 to 3 pole.

2. 5 kAIC interrupting capacity @ 480 VAC

3. Alltech, Eaton FAZ, or equal.

C. Control circuit transformers and other Non-motor applications:

1. UL1077 supplementary protection up to 63 amps, 1 to 2 pole, AC or DC.

2. Used where a UL489 protective device is upstream powering the circuit (from a panelboard or other source).

3. Used within control circuits for power supplies, control power transformers, relays and PLC I/O points.

4. Used in place of fuses that are applied as supplementary protection.

5. Eaton FAZ, or equal.

2.03 FUSES AND FUSE HOLDER

A. Fuses shall not be used in branch or control circuits unless specifically shown in the drawings. Circuit breakers shall be furnished and utilized where possible.

B. 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 feature open fuse indication lights and shall be rated 30A at 600 VAC. Fuse holders shall be Bussman Optima Series OPM or equal.

C. 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-H4 or equal.

D. 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 and have blown fuse LED indicators. Fuse holders shall be Entrelec M 4/8.SFDT, Allen Bradley- 1492-H5 or equal

E. Fuses shall be sized in conformance with the NEC.

2.04 TERMINAL BLOCKS AND ACCESSORIES

A. General

1. Terminal blocks to be clamp type, 5 spacing, 300 volt, minimum rating of 20 amps, and mounted on DIN rail. DIN rail shall be same type as used for the relays. Install extra DIN rail on each type of terminal strip with 10% spare terminals for future additions.

a. Provide larger terminal as necessary based on gauge of connected wiring. Those terminals with 10 gauge larger gauge wiring or more than one 12 gauge wire should be evaluated and changed.

2. 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.

3. Provide end clamps, separators, din rails, and jumpers to complete terminal block system. See example PLC I/O drawing for additional information. Engineer can provide on request if not available in plans.

4. Terminal Tags and Markers: Each terminal strip shall have a unique identifying alphanumeric code at one end (i.e.: TB1, TB2, etc.) or as shown in drawings.

5. 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" high letters minimum.

6. Terminal blocks shall be physically separated into groups by the level of signal and voltage served an by PLC I/O card. 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.

7. Terminal blocks shall be gray in color unless otherwise shown on the drawings.

8. Provide a ground terminal or connection point for each grounding conductor.

9. Provide a separate signal, common, and/or neutral terminal for every wire and PLC or remote device connection at minimum.

B. CP – Control Panel Terminal Blocks

Description	**Model number, Allen Bradley or equal**
General Purpose Terminal Block, 20A	1492-W3
Disconnecting Terminal Block, 20A	1492-JKD3
Grounding Terminal Block	1492-JG4
PLC AI Sensor Block, 4 Level with GND	1492-WTS3
PLC Digital Output Relays, 120VAC, 6A, SPDT	700-HLT1U1

Note 1: General purpose relays are defined in ELECTRICAL – GENERAL

Note 2: Accessories are not listed such as end caps, anchors, jumpers, bridges, marking strips, or other items necessary to make up a complete terminal block layout. Furnish all parts necessary per manufacturer's intended solution.

C. MCC – Motor Starter Cubicle Terminal Blocks

1. MCC cubicle terminal blocks shall be pull apart as supplied standard by MCC manufacturer.

D. Power – Power terminal Blocks

1. 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. Termination blocks shall be insulated with molded plastic covering and finger safe cover. Each termination block shall be provided with quantity and size of primary and secondary cable connections as required per installation. The power termination blocks shall be Erico UD, UDJ, BD, TD, or SB series or equal.

E. METAL OXIDE VARISTOR (MOV)

1. MOVs shall be rated for 30 VDC MCOV. Provide Panasonic ERZ-V10-0470 or approved equal

F. PANEL GROUND

1. 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 equal.

2. A 12ga. copper 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.

3. Components within the panel shall be grounded according to the manufacturer's recommendations.

2.05 PANEL INDICATORS / MOTOR PROTECTION

A. Motor Protection Relay

1. GE Energy, Multilin 469 Motor Management Relay, no equal to match existing.

2. Hardware features (RTD inputs, CT inputs, trip outputs) as shown in the drawings.

B. Tachometer (speed meter)

1. Speed meter with RPM indication, LED 0.56" display, 0.1 sec update, 120VAC power.

2. Funish setpoint output card with two form C relays to close when speed reaches setpoint values. Furnish 4-20 mA analog output card for speed indication to PLC.

3. Magnetic pickup input shall have 200mV peak sensitivity, 100 mV hysteresis, and input impedance of 3.9K ohms at 60hz. Maximum output voltage is 40 V peak, 30 Vrms.

4. Furnish Red Lion PAX-I0020 with PAXCDS10 relay card, and PAXCDL10 analog card, or equal.

5. Magnetic pickup shall be compatible with speed meter and motor gear target. Furnish one magnetic pickup.

2.06 MISCELLANEOUS COMPONENTS

A. Wireway: Manufactured from light gray rigid PVC suitable for continuous use at temperatures up to 50 deg C. Wireway shall be 2" height, width as required with 0.5" slot spacing with removable covers. Provide Panduit type "F" or equal.

B. Intrusion Switch: The intrusion switch shall have a pin plunger that is depressed when the door is closed. The form C contacts shall be rated 2A at 120 VAC. Provide Hoffman A-LFSWD, Microswitch 1AC2 or equal.

C. LED Strip Light: The LED light shall be an "under cabinet" style with multiple LED lamps and acrylic diffuser. Lamp shall be switched on/off from integral switch or PIR motion sensor. Light housing shall be capable of magnet mount to top or side of enclosure or will include mounting tabs for mounting to brackets. Lamp shall be powered from 120VAC or from 24~48 VDC or shown in the contract drawings. LED Strip Light shall be Stego 02540, or equal.

D. Circulation Fans: The control panel temperature shall be maintained 10 deg. F below lowest internal device's temperature rating. The fans shall be 4" or 6" 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 include louver with filter and bug screen for outdoor installations.

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-TEMxx, or equal.

PART 3: EXECUTION

3.01 WORKMANSHIP

A. All work in this Section shall conform to the codes and standards specified in Electrical Specifications [Electrical General, Workmanship].

3.02 FABRICATION

A. Equipment Mounting:

1. Mount all equipment using manufacturers mounting tabs/holes or brackets 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. Environmental:

1. Control panel environmental accessories including fans, louvers, filters, bugscreens, air conditioners, etc. shall be provided as noted in the Drawings and as necessary for a complete environmental solution.

2. Panels environmental controls shall be designed during shop drawing submittal and fabricated to maintain temperatures 10 degrees F below lowest internal equipment maximum temperature rating.

3. Contractor shall provide [additional] fans, louvers, screens, sunshades, air conditioners, etc. as necessary to prevent equipment malfunction or premature failure. Provide associated wiring and thermostats as needed.

4. Environments:

a. NEMA 4X rated panels shall be cooled/heated with closed loop

type conditioning systems to include air conditioners, internal panel circulation fans and resistive heaters.

b. NEMA 3R rated outdoor panels shall be cooled/heated with open loop type conditioning systems to include air conditioners, exhaust fans and louvers, internal panel circulation fans and resistive heaters. All exhaust fans and louvers shall include filters and bugscreens.

c. NEMA 12 or 1 rated indoor panels shall be cooled/heated with open loop type conditioning systems to include air conditioners, exhaust fans and louvers, internal panel circulation fans and resistive heaters. All exhaust fans and louvers shall include filters and bugscreens.

C. Wiring:

1. 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.

3.03 INSTALLATION

A. Wiring:

1. Install all equipment per Electrical Specifications [Electrical General].

2. All internal and field wiring shall be per Electrical Specifications [Low Voltage Wire].

3. Panel Wiring: All wiring shall be installed in wireways between terminal blocks 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.

B. 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.

2. The Contractor shall exercise care when using a vacuum cleaner or compressed air such as not to damage any component within the panel.

3. Many electrical and computer components are open for ventilation. Falling debris can penetrate the openings and cause equipment failure.

Equipment with debris inside shall be removed, cleaned and/or replaced.

3.04 FIELD ASSISTANCE

A. Provide testing as specified in Electrical Specifications [Factory and Field Testing].

3.05 WARRANTY

A. Provide warranty as specified in Electrical Specifications [Electrical General, Warranty].

3.06 FINAL ACCEPTANCE

A. Final Acceptance per Electrical Specifications [Electrical General].

END OF SECTION

SECTION 26 13 27

MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE

This specification provided to determine necessary requirements for VFD drive installation and Contractor to use for in coordination with VFD manufacturer's scope of work.

PART 1: GENERAL

2.1 SCOPE OF WORK (VFD Furnished by Owner for Contractor installation)

A. Variable frequency drives (VFDs) for use with medium voltage motors.

1. One complete VFD system, clean power with 24 pulse transformer input, bypass contactor not required.
2. Pump application with expected speed range of 50% to 100% operating. Ramp from 0% on start and to 0% stop.
3. 800 HP, 585 RPM, 136 FLA, 1.15 SF newly rewound induction motor.
4. Input and output voltage: 4,160V, 3 phase, 3 wire.
5. Circuit protection from existing switchgear within view in same room.
    a. Eaton MV circuit breaker with ABB DPU 2000R relay.
    b. Settings to be revised by Owner for new VFD.
6. CTs for motor protection relay interface.
7. Kirk-key interlock - VFD door and existing circuit breaker. Therefore, in order to open the VFD medium voltage door, the circuit breaker must be off and key relocated to VFD door lock.
8. Compatible with overhead feed, underground motor load conduits.
9. Compatible with underground feed control conduits.

B. The VFD scope of work includes:

1. Providing enclosure and all internal components.
2. Suitable for installation on concrete pad per details.
3. Submittal data and drawings.
4. Factory tests.
5. Shipment to project site.
6. Configuration and Start-up.
7. Field verification testing.
8. Operation and maintenance manuals.
9. Warranty of all components.

2.2 REFERENCES

A. The VFD shall conform to or exceed the applicable requirements of the following standards and codes:

1. ANSI American National Standards Institute
2. CSA Canadian Standards Association
3. ETL ETL Testing Laboratories
4. IEEE Institute of Electrical and Electronic Engineers
    5. IEEE 399 Recommended Practice for Industrial and Commercial Power Systems Analysis
    6. IEEE519 Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
7. NEMA National Electrical Manufacturer's Association
    8. NEMA 250 Enclosures for Electrical Equipment (1,000 Volts Maximum) NEMA ICS 6 Industrial Control and Systems: Enclosures
9. NEMA MG 1 Motors and Generators
10. NFPA 70 National Electrical Code (NEC)
11. UL 508 Standards for Safety Industrial Control Equipment

2.3 DEFINITIONS

A. Variable Torque (VT):

1. Defines a load characteristic in which the torque delivered from the motor to the load is reduced as speed is reduced below full rated.
2. This type of load permits the VFD and the motor to operate at reduced output current at reduced speed.

B. Constant Torque (CT):

1. Defines a load characteristic in which the torque delivered from the motor to the load remains constant as speed is varied.
2. This type of load requires the VFD to be able to continuously deliver rated output current over the entire speed range.

C. Constant Horsepower:

1. Defines a load characteristic in which the torque delivered from the motor to the load is reduced as the speed is increased.
2. This characteristic is required for operation of the VFD and motor above rated frequency to maintain output current within the rated value.

D. Point of common coupling (PCC):

1. The point of common coupling for all harmonic calculations and field measurements for both voltage and current distortion shall be defined as the input terminals at each VFD.

2.4 QUALIFICATIONS

A. Manufacturer Qualifications: Minimum of 10 years experience in manufacturing medium voltage VFDs.

2.5 SUBMITTAL REQUIREMENTS

A. A copy of this specification section, with addenda updates, with each paragraph check marked to show specification compliance or marked to show deviations.

B. Product Data

1. Manufacturer of VFD.
2. Manufacturer of all component parts of VFD.
3. Enclosure dimensions, weight, and center of gravity.
4. Nameplate schedule.
5. Bill of material.
6. Optional features
7. Ratings:
    a. Voltage.
    b. Phase.
    c. Input current.
    d. Output current with overload rating.
    e. Interrupting rating.
    f. Momentary current rating.
8. List of recommended spare parts.
9. Manufacturer's service center with contact information.
10. Manufacturer's seismic certification with substantiating test data for enclosure size and weight submitted.

C. SHOP DRAWINGS:

1. VFD panel Shop Drawings
    a. Unit Description including amperage rating, frame sizes, trip settings, pilot devices, etc.
    b. Complete Schematic, wiring, and interconnection diagrams.
    c. Three (3) line diagrams showing AC schematic of VFD, input and output devices with device ratings.
    d. Field wiring diagrams showing locations and sizes of all electrical connections, ground terminations, and requirements for shielded wire usage or any other special installation considerations.
    e. Complete 1-line diagrams and 3-line diagrams for each VFD:
        1 Drawings shall indicate devices comprising the switchgear assembly including, but not limited to, disconnects, circuit breakers, control power and instrument transformers, meters, relays, control devices and monitoring devices.
    f. Clearly indicate device electrical ratings on Drawings.
    g. Design data:
        1 Block diagram showing the basic control and protection systems specifying the protection, control, trip and alarm functions at the different locations, the reference signals and commands and the auxiliary supplies (i.e. air, oil, cooling

water, electrical auxiliary supplies).

2 Electrical single line diagram showing main and auxiliary circuitry, including main power input, control power transformer, disconnects, VFD, system grounding, and auxiliary supplies - showing all CTs, PTs, relays, meters, etc., for the control, protection and operation of the drive system with electrical data (i.e. voltage, current, time ratings, impedances, tolerances).

3 Input power to output power efficiency.

4 Power factor over load range.

5 Harmonic distortion analysis.

2. Schedule of VFDs for the project listing for each VFD:

a. Equipment Tag Number.

1 Pump 3, tag M01106A

b. VFD Complete Catalog Number.

c. VFD Frame Size.

d. Variable or Constant Torque Rating Basis.

e. Rated Input Current.

f. Rated Continuous Output Current.

g. Rated Short Circuit Current.

h. VFD Maximum Motor Lead Length.

i. Motor Manufacturer.

j. Motor Frame Size.

k. Motor Full Load Amps.

l. Motor Service Factor.

m. Motor Lead Length as Determined by Contractor.

n. VFD options provided to meet harmonic or motor protection specifications.

3. Fully dimensioned and to scale equipment fabrication and/or layout drawings:

a. Structure Descriptions showing:

1 Shipping splits

2 Enclosure rating

3 Fault rating

b. Conduit entrance locations for power supply, motor, and controls connections clearly identified.

c. Elevation drawings showing dimensional information.

d. Top, front and side exterior views, with details showing maximum overall dimensions of enclosure, mounting provisions and conduit/cable entry provisions.

e. Identify minimum clearances from other VFDs or electrical equipment required

for proper cooling at top, bottom, sides, and back of enclosure.

f. Interior layout drawings showing location of all components within enclosure, field wiring terminal boards, and power and grounding connections.

g. Assembly drawings, cross-section as a minimum, for each VFD with major dimensions indicated.

4. Installation instructions:

a. Detail the complete installation of the equipment including rigging, moving, and setting into place.

b. For equipment installed in structures designated as seismic design category C, D, E, or F:

1 Provide project-specific installation instructions and anchoring details based on support conditions and requirements to resist seismic

2 Submit seismic anchoring drawings with supporting calculations.

3 Drawings and calculations shall be stamped by a professional engineer registered in the state where the Project is being constructed.

5. Calculations:

a. Harmonic study

1 A preliminary harmonic analysis shall be performed. A power system short circuit ratio of 10 shall be assumed, with all VFDs operating at maximum speed and maximum load. Short circuit current (ISC) utilized for harmonic analysis calculations is defined as: I_{SC} = 10 * (Sum of total full load amps of All VFD system).

2 The harmonic analysis must be submitted by the VFD system manufacturer with submittal, which includes all voltage and current harmonics up to the 99th. The harmonic analysis must be performed at the defined point of common coupling.

b. Drive parameter study based upon the actual system configuration, control I/O, and specific motor protection parameters.

c. Protective device settings to coordinate with upstream protective devices, protect the drive to the best extent possible, and to coordinate with the drive settings.

1 Existing relay is ABB DPU2000R.

2 Define major functions and settings for overcurrent curve, setting and time delay, short time, and instantaneous functions. Ground fault setting and time delay if needed.

6. Certification: Submit with Shop Drawings:

a. Letter from the VFD manufacturer stating that the specific application has been reviewed and that the VFD will satisfy the drive duties required with the actual motor furnished.

b. Efficiencies meet the requirements of this Section.

c. Certificate that the VFD system proposed has been in operation for a minimum of 5 years.

d. Provide a letter from the VFD manufacturer that lists each paragraph, subparagraph, etc. of this Section and state compliance/non-compliance with said paragraph. If non-compliance is indicated, provide an explanation for the deviation and alternative method to address the non-compliance.

e. Identification and location of closest authorized service organization.

f. Harmonic analysis required by PART 2 of this Specification Section.

g. Certified factory test reports confirming compliance with specified requirements.

h. Submit certified field service report(s) for each VFD after installation, configuration, startup, and testing showing:

1 Certification letter from manufacturer that VFD system has been inspected and is installed in accordance with the manufacturer's requirements.

2 VFD is operational.

3 VFD and its driven equipment motor are compatible.

4 VFD responds correctly to the input control signals.

5 Critical frequencies of the drive system and that the VFD has been set to lockout these frequencies.

7. Test forms and reports:

a. Submit complete factory acceptance test procedures and all forms used during the test.

b. Certified subassembly test results. Certified system level test results.

c. Harmonic compliance test results.

d. Manufacturer to furnish a certified report after the shop tests.

e. Manufacturer's startup representative to furnish a written report after the startup:

1 Report must state that the installation is complete and satisfactory, or list items requiring additional attention and proposal for the actions.

f. If any items require attention after the initial startup, a final report is required stating that the installation is complete and satisfactory.

2.6 OPERATION AND MAINTENANCE INFORMATION

A. OPERATION AND MAINTENANCE MANUALS:

1. Submit operating instructions and a maintenance manual presenting full details for care and maintenance of equipment of every nature furnished and/or installed under this Contract.

2. The operating instructions written descriptions must detail the operational functions of all normally used controls, which have been placed on the front panel of the VFD.

3. Furnish maintenance manuals with instructions covering all details pertaining to care and maintenance of all equipment as well as data identifying all parts. These manuals shall include but are not limited to the following:

   a. Initial test, adjustment and start-up procedures.

   b. Detailed control instructions, which outline the purpose and operation of every control device used in normal operation.

   c. All schematic, wiring and external diagrams furnished in reduced 11- by 17-inch format and shall be fully legible at the drawing size. Approved copy of VFD schedule.

4. Manufacturer's instruction manuals.

5. Troubleshooting procedures with a cross-reference between symptoms and corrective recommendations.

6. Connection data to permit removal and installation of recommended smallest field-replaceable parts.

7. The manufacturer's recommended spare parts and special tools lists. Commissioning sheets showing "as-left" values of all user-programmable or adjustable drive parameters.

B. Submit hardware Operations and Maintenance Manual per RFP No. 8293.

2.7 QUALITY ASSURANCE

A. The entire VFD System shall be factory assembled and tested with UL label by the VFD manufacturer.

B. Adjustable frequency drives shall be manufactured by the VFD manufacturer at its own facility, which shall have a quality assurance program that is certified in conformance with ISO Standard 9001.

C. Coordination:

1. VFD manufacturer shall verify with the driven equipment manufacturer that the VFD and the drive motor are compatible and that the VFD will operate the motor over its required operating range and will do so without exceeding the motor or 85% of VFD full load rating.

2. VFD shall be supplied complete with all required control components.

   a. VFD manufacturer shall review the application and provide, at no additional cost to the District, the hardware and software necessary to allow the VFD to control the driven equipment motor over its required operating range.

   1 These may include, but are not limited to, analog and digital interface modules, communication interface modules, switches, lights and other devices.

   b. Coordinate control devices with devices furnished with driven equipment such as vibration switches, thermal sensors, leak detectors, etc.

3. Verify plan dimensions with equipment space requirements as indicated on the Drawings.

   a. Equipment which exceeds the allotted maximum dimensions may not be acceptable.

b. Equipment which reduces clear work space below the minimums established by the NEC will not be acceptable.

D. QUALIFICATIONS:

1. It is the intention of this document to specify dependable and reliable equipment offering the best performance available from currently proven technology. All equipment furnished under this Contract must, therefore, have documentation showing proof of actual operation for a minimum of 3 years in similar service:

a. New components or design topologies that have less than 5 years of actual operating experience will not be acceptable.

2. VFD supplier shall have a minimum of 10 years' experience in medium voltage VFDs.

3. VFD supplier shall maintain an authorized service organization within 300 miles of the project site.

a. Measured harmonic levels as required by PART 2 of this Specification Section.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Packing, shipping, handling and unloading:

1. Offload drive from delivery vehicle and place inside power building for installation by others.

2. VFD system shall be delivered to the site pre-assembled and wired with all specified interconnecting wiring and cable:

a. Cabling for connection across shipping splits shall be neatly coiled and identified.

b. Exposed sections of equipment shall be fully protected from damage during shipment.

c. All necessary hardware for reconnecting shipping splits shall be provided

3. Complete instructions for handling and storage shall be provided before delivery of the equipment:

a. All equipment shall have adequate provisions for handling by overhead crane and forklift.

4. VFDs shall be shipped to the Site in dedicated air ride vans.

B. Acceptance at Site:

1. Upon arrival at the Site, the Contractor and the VFD manufacturer shall inspect the equipment and identify any shortcomings or damage.

2. Repair all damage and correct all shortcomings within 30 days of delivery at the Site.

1.09 PROJECT OR SITE CONDITIONS

A. Sacramento, California

B. Indoor location, conditioned space, 50°F to 95°F minimum to maximum ambient temperature

C. VFD system shall be capable of continuous operation of the rated load at its nameplate horsepower and amperage without de-ration under the installed conditions.

D. Motor lead length of 300 feet maximum.

1.10 WARRANTY

A. Extended warranty:

1. Provide an additional 5 years manufacturer's warranty for all equipment provided under this Section from date of delivery.

1.11 SYSTEM START-UP

A. The VFD system manufacturer shall be responsible for starting up the VFD in the presence of the driven equipment manufacturer, motor manufacturer, District Representative and District.

B. Any difficulties of problems that arise as a result of start-up shall be documented by the VFD manufacturer and shall be corrected within 5 working days at no cost to the District.

PART 2: PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS (VFD furnished by Owner for Contractor installation)

A. Siemens-Robicon – Sinamics Perfect Harmony Series;

B. Rockwell Automation Allen Bradley – Powerflex 7000;

C. NO EQUAL.

2.02 RATINGS

A. The overload capacity shall be:

1. Normal Duty/Variable Torque Load – 110% for 1 minute, every 10 minutes.

2. Heavy Duty/Constant Torque Load – 150% for 1 minute, every 10 minutes.

B. The VFD shall have an output frequency range of 0.2 to 75 Hz (0.2 to 85 Hz optional).

C. VFDs shall comply with the latest edition of IEEE 519 Harmonic Guidelines.

D. Voltage:

1. The VFD shall accept nominal plant power of 4,160V at 60Hz.

2. The supply input voltage tolerance shall be ± 10% of nominal line voltage with a potential imbalance of up to 2%.

3. Low voltage, auxiliary power to power the VFD cooling system and VFD control circuits will be provided by CPTs internal to VFD.

4. The VFD shall create its own control voltage of 120V, single-phase 50/60 Hz (20A) minimum.

E. Displacement power factor:

1. The VFD shall be capable of maintaining a minimum true power factor (Displacement P.F. x Distortion P.F.) of 0.98 from 60-100% load.

2. If the VFD vendor cannot meet the true power factor requirement, then a power factor correction unit shall be quoted as an option.

3. The true power factor that can be met (with and without power factor correction unit) shall be stated clearly in the proposal.

4. A Power Factor Compensation feature shall be available to control Power Factor – leading or lagging, (when enabled).

F. Efficiency:

1. VFD system efficiency shall be a minimum of 96% at 100% speed & 100% load. System efficiency shall include VFD, input transformer or line reactor, harmonic filter (if applicable) power factor correction unit (if applicable), and output filter (if applicable).

2. Control power supplies, control circuits, cooling fans or pumps, shall be included in all loss calculations.

G. Environmental Ratings:

1. Storage ambient temperature range: -40°C to 70°C.

2. Operating at ambient temperature range: 0°C to 40°C (32°F to 104°F) without de-rating.

3. The relative humidity range is 0% to 95% non-condensing.

4. Elevation – up to 1,000 m (3,300 ft).

H. Audible Noise Level:

1. The maximum audible noise from the variable frequency drive shall comply with OSHA standard 3074, Hearing Conservation, which limits noise level to 85 dB(A).

2. The variable frequency drive shall comply with the OSHA standard at a distance of one meter from the front of the equipment (with doors closed at any speed or load condition).

3. Variable frequency drives with audible noise in excess of this limit must be provided with sufficient noise abatement treatment to reduce the sound pressure level below 85 dB(A).

I. Motor Compatibility:

1. The variable frequency drive shall be capable of operating a standard AC squirrel cage induction motor (standard AC synchronous motor, standard AC wound rotor induction motor) of equivalent power and speed rating over the speed range specified. Drives which require motors with higher insulation values will not be acceptable.

2. The variable frequency drive shall provide near sinusoidal voltage and current waveforms to the motor at all speeds and loads. Output current THD shall be less than 5%. Standard induction or synchronous motors shall not require de-rating or upgraded turn-to-turn insulation and shall not require additional service factor.

3. The motor insulation system is susceptible to stress due to VFD output change in voltage over a very short change in time (dv/dt). dv/dt at the motor terminals (line-to-line) shall be limited to 10 volts per microsecond. If dv/dt at the motor terminals (line-to-line) exceeds 10 volts per microsecond, the manufacturer must state the actual value in the attached data sheets and include steps taken to guarantee the long term life of the motor insulation system.

4. The variable frequency drive shall provide stable operation of the motor without compromising the motor insulation system up to a cable distance of 15 km. The manufacturer shall clearly state the limitations in motor cable distance with the proposal. If an output filter is required to mitigate reflected waves, or to meet any special requirements of the application, it must be integral to the VFD controller and not effect the VFD detrimentally beyond required specification.

5. If output filters are used in the variable frequency drive, a Selective Harmonic Elimination (SHE) switching technique must be available to eliminate a potential harmonic resonance in the operating speed range.

    a. The output filter components shall be integral to the VFD system lineup:

1 If it is not possible to integrate the output filters into the VFD system enclosure, the cabling and connecting must be entirely supplied and/or contracted by the VFD system manufacturer, and approved by the District Representative.

    b. Any inductors used shall be iron-core with a maximum temperature rise of 115°C with minimum 220°C insulation and over-temperature protection:

        1) Reactors shall be designed to prevent saturation under maximum fault current conditions. Reactors shall be in accordance with IEEE C57.16.

6. Variable frequency drive induced torque pulsations to the output shaft of the mechanical system shall be less than 1% to minimize the possibility of exciting a resonance.

2.03 OPERATIONAL FEATURES

A. Drive Output:

1. Near sinusoidal voltage and current waveforms provided to the motor at all speeds and loads.

   a. Output current Total Harmonic Distortion (THD) shall be less than 5%.

   b. Motors shall not require de-rating or upgraded turn-to-turn insulation and shall not require additional service factor.

2. No compromising of the motor insulation thermally or due to dv/dt stress.

   a. Stable operation of the motor shall be provided with motor cable distances up to 15 km without the need for additional output filters.

   b. dv/dt at the motor terminals (line-to-line) shall comply with IEC Technical Specification 60034-17 – Rotating Electrical Machines Part 17, Cage Induction Motors When Fed from Converters.

3. VFD-induced torque pulsations to the output shaft of the mechanical system at less than 1%, to minimize the possibility of exciting a resonance.

4. Elimination of potential harmonic resonance in the operating speed range via selective harmonic elimination (SHE) switching technique.

B. The VFD shall be capable of producing a variable voltage and variable frequency output to provide continuous operation over the speed range specified.

1. The VFD shall be capable of operating with the output short circuited at full current.

2. The VFD system shall provide controlled speed over the range specified. Speed accuracy within this range, expressed as a percent of top speed, shall be within 0.1% of base speed without encoder or pulse tachometer feedback (0.01% with encoder or pulse tachometer feedback).

3. The VFD shall be capable of 100% breakaway torque without tachometer feedback.

C. The VFD shall have a “normal duty” rating of 100% continuous current with a short-time duty rating of 110% overload for one minute, once every 10 minutes (suitable for variable torque loads).

D. The VFD shall be capable of regenerative motor braking for high inertia loads.

2.04 DRIVE UNIT DESIGN

A. Hardware:

1. The VFD converter section shall be Active Front End with selective Harmonic Elimination OR shall be designed with a 24 pulse (or more) transformer to meet harmonic mitigation requirements. Harmonic shall be maintained with line voltage imbalance of up to 2% and from 60-100% load.

2. Input isolating switch:

   a. Provide an air gap type input isolation switch to isolate the entire VFD from the power source.

b. Input isolation switch may be:

1) Load break.

2) Non-load break if interlocked with the VFD control system so that the VFD is stopped before opening of the isolation switch.

3. Input contactor:

a. Medium voltage input contactor shall be a NEMA E2 type controller provided with fixed mounted 400A vacuum contactor.

4. The VFD shall have a minimum availability of 99.9% with a Mean Time Between Failures (MTBF) of 100,000 hours.

5. In order to optimize reliability and minimize complexity, inverter power switch component count shall be minimized by utilizing high Peak Inverse Voltage (PIV) rated devices.

6. Use a control power monitoring system that monitors all power supply voltages and signals.

7. Fiber optic interface boards to provide gating and diagnostic feedback signals for power semiconductor devices. The diagnostic feedback system shall allow constant control of the device as well as constant monitoring of device health and temperature feedback.

8. Power switch device diagnostics shall detect and protect against device short, over or under gate voltage, loss of gating, loss of diagnostic feedback, heat sink temperature feedback as well as overload monitoring and protection.

9. All internal firing signals, and other communications, which link operational controls with power components such as status and diagnostic signals, must meet noise immunity and safety requirements as defined by applicable EN Norms and IEEE Standards.

10. Failed switch bypass/ride-through capability:

a. The failure of any power switching device (SCR, GTO, diode, IGBT, IGCT, etc.) or switching device control shall not result in a process trip and shall allow for continued operation of the VFD system. In the event of a device or device control failure, the VFD shall annunciate and identify the specific location of the failed device and allow for continued operation, although at a reduced capacity, until such time as repairs can be scheduled.

11. Power bus and wiring:

a. Main power bus shall be high-conductivity copper and tin-plated for chemical and corrosion resistance and low losses:

1) Bus shall be appropriately sized for the VFD continuous current rating and braced to withstand the mechanical forces caused by a momentary short circuit current of a minimum of 40 kA or the actual calculated fault current level, whichever is greater, expected at the bus.

2) All connections shall be bolted or continuously welded.

3) Main grounding of the VFD system shall have a common loop consisting of 4/0 minimum copper cable placed in the enclosure base

4) This cable shall loop the perimeter of the base and shall be attached to stainless steel grounding pads welded to the base in 2 locations, one at each end of the enclosure.

b. All control wiring shall be physically separated from the power wiring:

1) Low and high voltage cables shall be physically isolated from each other.

2) The VFD system shall be pre-wired within the enclosure.

3) Only ring type connectors are allowed, spade type connectors are not acceptable.

4) No soldering shall be used in connection with any wiring.

5) Wiring shall be adequately supported to avoid tension on conductors and terminations.

6) All wiring shall be run in surface mounted conduit or wire-ways.

7) Any section of wiring outside of conduit or wire-way shall be securely tied with cable ties at intervals not exceeding 6 inches.

8) No cables shall be tied off to or in any way supported from power busses.

9) Wherever wiring passes metal edges or through holes, suitable guards or grommets shall be provided to prevent cutting or chafing of the insulation.

10) All terminal blocks shall have at least 20 percent spares:

11) No more than 2 wires shall be terminated on 1 terminal.

12) All wiring shall be tagged with permanent labels at each termination, junction box, and device.

13) Labels shall correspond to the schematic and wiring diagrams.

14) Ground connection.

15) Stainless steel grounding pads shall be provided in each power cubicle.

16) A tin-plated copper ground bus shall be provided for grounding of control circuits.

12. The VFD system shall be protected from damage due to the following, without requiring an output contactor:

a. Single-phase fault or 3-phase short circuit on VFD system output terminals.

b. Failure to commutate inverter thyristor due to severe overload or other conditions.

c. Loss of input power due to opening of VFD input disconnect device or utility power failure during VFD operation.

d. Loss of 1 phase of input power.

e. Motor regeneration due to backspin or loss of VFD input power.

13. The VFD shall be able to withstand the following fault conditions without damage to the power circuit components:

a. Failure to connect a motor to the VFD output.

b. VFD output open circuit that may occur during operation.

14. Data displays:

a. A door-mounted flat panel display shall be furnished, capable of displaying the VFD operational status and drive parameters:

1) The digital display must present all diagnostic message and parameter values in plain English, engineering units when accessed, without the use of codes.

b. As a minimum, the following door mounted digital indications shall be provided on the digital display:

1) Speed in percent.

2) Input current in amperes.

3) Output current in amperes.

4) Output frequency in Hertz.

5) Output voltage.

6) Total 3-phase kilowatt output.

7) Kilowatt hour meter.

8) Elapsed time running meter

15. User input/keypad:

a. A door-mounted keypad with integral digital flat panel display shall be furnished, capable of controlling the VFD and setting drive parameters:

1) The display must present all diagnostic message and parameter values in standard engineering units when accessed, without the use of codes.

2) The keypad shall allow the operator to enter exact numerical settings in standard engineering units.

3) An English language user menu, rather than codes, shall be provided in software as a guide to parameter setting.

b. Drive parameters shall be factory set in non-volatile EEPROM registers and re-settable in the field through the keypad:

1) Password security shall be available to protect drive parameters from unauthorized personnel.

2) The EEPROM stored drive variables must be able to be transferred for programming of new or spare boards.

c. The keypad module shall contain a "self-test" software program that can be activated to verify proper keypad operations.

d. The VFD system shall have the user selectable option of programming up to 3 speed avoidance bands.

16. Communications for configuration

a. VFD shall be capable of direct communication to an IBM or compatible computer for:

1) Serial link setup of parameters.

2) Fault diagnostics.

3) Trending.

4) Diagnostic log downloading.

b. An RS-232 port shall be door-mounted for computer or printer interface.

c. VFD parameters, fault log and diagnostic log shall be downloadable for hard copy printout via the RS-232 port and a standard serial printer.

d. The VFD shall be provided with single port digital communication capability to allow direct control and status communication with a PLC, SCADA or other control system:

e. An Ethernet communications port shall be provided.

17. Printed circuit boards:

a. All printed circuit boards shall be new.

b. They shall be conformably coated for moisture and chemical resistance, in addition to any dielectric coating properties.

18. Direct current link inductors:

a. Direct current link inductors, if required, shall be air core to prevent saturation.

b. Separate inductors, split dual winding type, shall be provided in the positive and negative leg of the direct current link to minimize stray magnetic fields.

c. Maximum temperature rise shall not exceed 115°C with minimum 220°C insulation and over-temperature protection.

d. The inductors shall be integral to the VFD system lineup.

e. If it is not possible to integrate the inductors into the VFD system enclosure, the cabling and connecting must be entirely supplied and/or contracted by the VFD system manufacturer, and approved by

the District Representative.

f. Inductors shall meet the requirements of ANSI C57.16 and shall be designed to prevent saturation under maximum fault current conditions.

19. Direct current link capacitors:

a. Capacitors (if used) in the converter direct current link shall be integral to the VFD system lineup.

b. Capacitors used in the converter direct current link shall contain discharge resistors and capable of reducing the residual charge to 50 volts or less within 5 minutes after the capacitor is disconnected from the source of supply.

B. Control Logic:

1. The control logic section shall be fully digital and not require analog adjustment pots or fixed selector resistors.

2. Fault log data storage memory shall be stored in non-volatile memory.

3. The VFD shall include a comprehensive microprocessor based digital diagnostic system which monitors its own control functions and displays faults and operating conditions.

4. A "Fault Log" shall record, store, display and print upon demand, the following 50 most recent events:

a. VFD mode (Auto/Manual).

b. Date and time of day.

c. Type of fault.

d. Reset mode (Auto/Manual).

5. A "Historical Log" shall record, store, display and print upon demand, the following control variables at an adjustable time interval for the 50 intervals immediately preceding a fault trip and 100 intervals following such trip:

a. VFD mode (Manual/Auto/Inhibited/Tripped/etc.).

b. Speed demand.

c. VFD output frequency.

d. Demand (output) amps.

e. Feedback (motor) amps.

f. VFD output volts.

g. Type of fault.

h. Drive inhibit (On/Off).

i. The fault log record shall be accessible via an Ethernet communication link, as well as line by line on the keypad display.

6. A "Windows-Based" graphical tool suite shall be supplied with the VFD:

a. This graphical PC tool shall be able to plot and display up to 8

different VFD parameters and have the ability to freeze plotting and print hard-copy versions of the plots.

b. It shall be capable of displaying at least 8 different VFD system parameters, all parameters displayed on the PC tool shall be synchronized with the standard keypad display.

7. Produce a variable voltage and variable frequency output to provide continuous operation over the application speed range.

8. Capable of operating with the output short circuited at full current.

9. The drive system shall provide controlled speed over the range specified. Speed accuracy within this range, expressed as a percent of top speed, shall be within 0.5% of base speed without encoder or pulse tachometer feedback (0.1% with encoder or pulse tachometer feedback).

10. A "normal duty" rating of 100% continuous current with a short-time duty rating of 110% overload for one minute, once every 10 minutes (suitable for variable torque loads).

11. Capable of 100% breakaway torque without tachometer feedback.

2.05 DRIVE UNIT FEATURES

A. Control Mode:

1. The variable frequency drive shall utilize sensor less direct vector control or full vector control, with pulse tachometer feedback, for optimum performance.

B. Auto Tuning:

1. The variable frequency drive shall have a programmable auto tuning function.

2. The function shall be capable of being disabled.

3. The function shall be programmable for the following tuning options.

a. Commutation inductance

b. DC link time constant

c. Motor stator resistance

d. Motor leakage

e. Inductance

f. Flux regulator

g. Total Inertia

C. Starting Mode:

1. The variable frequency drive shall offer two starting modes.

2. The S-Curve profile shall consist of both nonlinear and linear portions:

a. A parameter shall exist that specifies the duration that the drive is ramping in the non-linear portion.

b. A parameter shall define the total time to accelerate to rated speed in S- Curve.

3. The Ramp Mode shall be programmable with four ramp speed break points:

   a. The Ramp Mode shall have programmable acceleration and deceleration times.

   b. The Ramp Mode shall have a parameter for Ramp Start Delay that specifies the time the speed reference remains at zero after the drive is started.

4. The VFD shall include a customer selectable automatic restart feature:

   a. When enabled, the VFD shall automatically attempt to restart after a trip condition resulting from over-current, over-voltage, under-voltage, or over-temperature.

D. Stopping Mode:

1. The variable frequency drive shall have three stop modes.

2. The Ramp Mode shall be programmable with four deceleration times.

3. In the Coast Mode, a programmable parameter shall be set to specify the speed at which the drive shuts off and coasts when stopping.

E. Flying Re-Start:

1. Capable of restarting and taking control of a motor attached to a spinning load in the forward or reverse direction.

2. Appropriate safeguards must be included in this operation to prevent damaging torque(s), voltages, or currents from impacting any of the equipment.

3. The user shall have the option of employing this feature or disabling it.

F. Preset Speeds:

1. The variable frequency drive shall have three (3) preset speeds.

2. The preset speeds shall be programmable between 0.5 and 75.0 Hz.

G. Skip Speeds:

1. The variable frequency drive shall have three (3) skip speeds.

2. The skip speeds shall be programmable between 1.0 and 75.0 Hz.

3. The skip speeds shall have a programmable band width between 0.0 and 5.0 Hz.

H. Load Loss Detection:

1. The drive shall have a parameter to specify the response of the drive to a loss of load condition.

2. The parameter shall have the following configuration options: disabled, warning or fault.

I. Fault Configuration:

1. The variable frequency drive shall have fault classes that define the following:

   a. Class of drive input protection

   b. Class of rectifier magnetic protection

   c. Class of DC link protection

d. Class of motor protection

e. Class of isolation transformer protection

f. Auxiliary trip class

g. External fault class

2. Each fault class shall have the following configurations:

a. Disable the fault input

b. The drive will shut down immediately

c. The drive will perform a controlled shutdown

d. The drive will not shutdown but a warning will be displayed

3. The variable frequency drive shall have fault and warning masks.

J. Protection Features:

1. Power component protection:

a. VFD system shall include distribution class surge arrestors to protect the input transformer and VFD against voltage surges.

b. The VFD system shall include power fuses on the input to the converter rectifier devices to protect the secondary of the transformer from any potentially harmful fault currents.

2. Fault information shall be accessible through the Human Interface Module.

3. The variable frequency drive shall have the following minimum line side protective features.

a. Line current unbalance trip with programmable delay

b. Line overcurrent trip with programmable delay

c. Line overload warning and trip with programmable delay

d. Line overvoltage trip with programmable delay

e. Line undervoltage trip with programmable delay

f. Power loss protection

g. Line voltage unbalance trip with programmable delay

h. Ground fault overvoltage trip with programmable delay

i. Ground Fault overcurrent trip with programmable delay

4. The variable frequency drive shall have the following minimum system level protective features:

a. DC Overcurrent trip with programmable delay

b. DC overvoltage trip with programmable delay

c. Rectifier heatsink temperature warning and trip

d. Cabinet temperature warning and trip

e. Inverter heatsink temperature warning and trip

f. Control Power warning and fault

g. Adapter (communication port) loss warning and fault

h. XIO adapter loss

5. The variable frequency drive shall have the following minimum load side protective features:

a. Ground fault overvoltage trip with programmable delay

b. Ground fault overcurrent trip with programmable delay

c. Machine side dc link overvoltage trip with programmable delay

d. Motor overcurrent trip with programmable delay

e. Motor overload warning and trip with programmable delay

f. Motor overvoltage trip with programmable delay

g. Motor stall delay

h. Motor overspeed trip with programmable delay

i. Motor flux unbalance trip with programmable delay

j. Motor current unbalance trip with programmable delay

k. Load loss level, speed and programmable delay

K. Metering:

1. The variable frequency drive shall display metered parameters through the operator interface.

2. The variable frequency drive shall meter the following:

a. Input current, individual phase RMS values and average RMS value

b. RMS value of the motor current

c. Average RMS value of input voltage

d. RMS value of the motor terminal voltage

e. Motor output power in kilowatts, KVAR

f. Motor speed in percent.

g. Input frequency

h. Power factor

i. Input kilowatt hour

j. Input current Total Harmonic Distortion (THD), average of 3 phases

k. Single harmonic calculation in input voltage and current, phases A, B or C

l. Drive efficiency

m. Motor flux in percent

n. Motor torque in percent

o. Drive output power (kilowatt)

p. Output kilowatt hour

3. The metered values shall be capable of being assigned to an analog output to drive an optional output meter.

L. Input Contactor Configuration:

1. The variable frequency drive shall have parameters for configuring when the input contactor opens/closes.

2. The input contactor configuration parameter shall specify under what conditions the input contactor shall be commanded to open the line side of the drive. The parameter options shall be – open when not running, open for all faults or open for critical faults.

2.06 DRIVE SYSTEM

A. Enclosure:

1. Air-cooled VFD enclosures shall be NEMA 1G (IP42). Door vents shall consist of louver-panel assemblies that can be removed from the front in order to replace air filters. Safety screens shall be located behind each louver panel. Cabinets and doors shall be fabricated using minimum 12 gauge (2.64 mm thick) steel for sturdy construction. All doors shall be gasketed to provide environmental protection and secure fits.

2. Door latches shall be heavy-duty ¼-turn type units which are operated with an Allen wrench. The converter cabinet door and cabling cabinet door shall be interlocked with up-stream isolators or breakers with a key lock. Interlocking shall be fully coordinated to prevent access to all medium voltage compartments.

3. Front access to allow for installation with no rear access. Equipment that requires rear or side access shall not be accepted.

B. Ground fault withstand:

1. In the event of a ground fault, the VFD shall be capable of annunciating the ground fault condition, safely operating and, by user selection, either trip or continue operation.

2. As a result of a ground fault trip, the VFD shall be capable of being reset and operating normally.

3. There shall be no risk of fire or electric shock as a result of the ground fault.

C. Interlocks (Kirk-Key):

1. Mechanical key interlocks shall be provided on all doors.

2. Interlocking shall be fully coordinated to prevent access to all high voltage compartments, including transformer, filters, or any switchgear that is part of the supply, when line power is applied to the VFD system.

3. Interlocks must be mechanical to provide positive lock-out prevention and safety:

4. Electrical interlock switches alone are not acceptable.

D. Cooling System:

1. The VFD system shall be ambient indoor air-cooled.

2. Indoor air temperature is expected to range from 50°F to 95°F. The space is conditioned, however, in the event of conditioning failure, the drive needs to maintain operation.

3. Air-cooled VFDs shall be provided with a redundant, mixed flow cooling blower/fans, mounted integral to the VFD enclosure. The VFD shall include temperature detectors to monitor proper operation of the air cooling system. If a fan fails, the system must generate alarm indication of the fan failure. Vane type air flow switches are not acceptable.

E. Control Input and Output Terminations:

1. Sixteen (16) digital inputs, all independently programmable with at least twenty-five (25) input function selections. Inputs shall be designed for 24 VDC remote closed contact.

2. Eight (8) relay contact digital outputs, all independently programmable with at least thirty (30) output function selections. Relay contacts shall be rated to switch two (2) Amps continuous current 30VDC or 250VAC. Function selections shall include indications that the drive is ready (no faults and in remote), running, etc.

3. Two (2) analog inputs, each selectable for 0VAC - 10VAC or 4mA - 20mA, and independently programmable with at least ten (10) input function selections. Analog input signal processing functions shall include scaling adjustments, adjustable filtering and signal inversion. If the input reference (4-20mA or 0-10V) is lost, the VFD shall give the user the option of the following: (1) stopping and displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last good reference received, or (4) cause a warning to be issued, as selected by the user. The Drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus.

4. Two (2) analog outputs providing 0 (4mA) to 10V (20mA) signals. Outputs shall be independently programmable to provide signals proportional to at least twelve (12) output function selections including output speed, frequency, voltage, current and power.

5. Provide I/O input and relay output expansion card(s) as needed. The option card shall be integrally mounted to the drive.

F. Auxiliary Relays:

1. Provide relays for all digital outputs.

2. Relays to be form C contacts, 2 N.O. & 2 N.C. The relay contacts shall be rated for 115V AC/30V DC, 10 Amp.

G. Communications – The VFD shall include communications module for interface to the PLC. All settable parameters and instantaneous operational registers shall be accessible from the communications port.

1. Type

a. Modbus TCP (Schneider Automation Standard)

2. Command and Metering registers to include:

a. Digital input reads (giving status of inputs)

b. Digital output commands (to relay DOs)

c. 3 phase voltage and current

d. Power in KW, KWH and Power factor

e. Elapsed motor run time

f. Start/Stop

g. Running

h. Fault conditions

i. Heat Sink Temperature

j. Others as available

H. Motor Heater Control:

1. Provide drive control circuitry to interface with a remote 120VAC/2,700W power source to energize the motor heater whenever the motor is not running.

2. The heater shall be interlocked with the drive run relay and shall be energized whenever the motor is not running.

I. Pilot Devices:

1. None required. Pilot devices will be located on a remote panel.

2. Provide local start/stop and speed control via keypad mounted on the drive system enclosure door.

J. Monitoring and Editing Software:

1. Provide a Windows-based application software to monitor and edit drive parameters, upload and save parameters to a file, download parameters to the drive, print parameters, and view and clear faults/alarms in the drive.

K. Control Power Transformers (CPTs):

1. Control power transformer(s) (CPT(s)) shall be provided within the enclosure downstream of isolating switch and upstream of input contactor so that control power is available to VFD with input contractor open.

2. The CPTs shall internally derive all necessary control power for the VFD cooling system and VFD low voltage control circuits.

3. The kilovolt-ampere rating of the CPTs shall be determined by the manufacturer and shall have a minimum of 25% spare capacity.

4. The CPTs primary shall be fused with current limiting fuses with an interrupting rating no less than 100,000 amperes.

5. The CPTs secondary shall be fused and have one terminal grounded.

6. Provide multiple circuit breakers for controls, cooling, etc.

L. Integrated Drive Isolation Transformer:

1. If required for harmonic mitigation, a drive isolation transformer shall be integrated in the VFD enclosure to provide power conversion from the line voltage to the required VFD voltage and to isolate the line from harmonics and common mode voltages. The transformer shall conform to ANSI/IEEE C57 or to corresponding IEC standards. Active Front End drives will be designed as "Direct-to-Drive" so as to not require this transformer.

2. The transformer shall be designed to withstand a short circuit. It shall maintain electromagnetic symmetry when only one secondary winding is in short circuit in order to minimize the resulting short circuit forces. The transformer shall be capable of thermally withstanding a short circuit for 2 seconds.

3. Dry type transformers shall be provided rated for a maximum 130 degrees Celsius rise and minimum 220 degrees Celsius insulation with over- temperature protection:

   a. Transformers shall be OA rated and applied in a FA installation.

4. Transformers shall be of a high efficiency type with full load losses of no greater than 2%.

5. Transformer winding material shall be copper.

6. Suitable vibration dampers shall be provided with the transformer and its enclosure in order to attenuate mechanical resonance and to reduce the operational sound level.

7. The transformer shall include electrostatic shielding between the windings to carry high frequency capacitive currents to ground.

8. Transformer designs shall be open type with force ventilation and air-cooled.

9. Only rectifier grade with K-factor of 20 transformers shall be utilized, with K-Factor of 6 for diode rectifiers. VFD manufacturers providing SCR type rectifiers shall include K Factor of 12 transformers for variable torque applications and K Factor of 20 for constant torque applications.

M. Current Transformers

1. Furnish mounted (preferable) or unmounted current transformers based on space allocated and installation requirements. The current transformer shall have wire leads or binding posts and ratio of 200% of drive capacity. The accuracy shall be metering accuracy class 0.6 at a minimum burden at 60 hz shall be 2.5 VA and as required to meet specified accuracy of device(s) fed.

2. The current transformers will report to a GE Multilin 269 relay to be mounted in a drive control panel (by others).

3. CTs shall have 0-5A AC output with linear output according to the ratio.

2.07 HARMONIC PROTECTION REQUIREMENTS

A. All VFDs shall be capable of satisfactory operation from a source having voltage distortion and notch characteristics identified as acceptable for a "dedicated system" in IEEE 519, Table 10.2.

1. With all VFDs operating under worst-case harmonic current conditions, and the facility supplied from either or both the utility and generator sources, the VFDs

shall not produce harmonic effects in excess of the following limits at the 4.16 kV bus.

a. Voltage distortion and notch characteristics: IEEE 519, Table 10.2 for Special Applications.

b. Current Distortion: IEEE 519, Table 10.3 based on ISC/IL < 20.

2. VFD manufacturer shall determine, for their proposed equipment, uncorrected harmonic distortion levels and mitigation techniques required to meet the specified limits and shall furnish the VFD types and all accessory items and equipment necessary to do so, whether specified herein or not.

3. Following start-up, with facility at full load operation, provide measurement of harmonic voltage, current and notch characteristics at each PCC according to the requirements of IEEE 519, Section 9.

a. Values in excess of specified limits require correction by contractor and re- measurement.

b. Provide certification of compliant measurements as part of Field Service Engineer's final report.

2.08 SOURCE QUALITY CONTROL

A. Factory Tests:

1. Conduct all standard tests in accordance with NEMA and ANSI standards to ensure conformance to specification requirements.

2. Type tested at full load (not specific unit).

a. Temperature cycling test, 0 to 50°C for 50 HRS.

3. Prior to final assembly:

a. Incoming inspection of all components.

b. 100 percent test and inspection of all power devices and integrated circuits.

1) Functional tests.

4. Subsequent to final assembly:

a. Continuity and insulation test of 4,160 VAC circuits.

b. Use minimum test voltage of 10 kV DC.

c. Drive tests:

1) Line-to-line and line-to-ground fault tests with VFD at full load.

i Electronic fault protection circuitry shall initiate trip prior to any device failure.

2) Verify all auxiliary circuits operational.

3) After all testing is complete VFD shall undergo a 24 HRS burn-in test at 100 percent motor load without an unscheduled shutdown.

4) After burn-in cycle is complete, VFD shall undergo a 30-minute cycling motor load test.

d. Systems tests:

1) Provide inputs to field connections and simulate on-site operation.

2) Test all auxiliary equipment.

5. Efficiency evaluation:

a. Each VFD system shall be factory tested for efficiency using a dynamometer, or test with a calibrated resistive/inductive load.

b. The system will include all transformer losses, filters, and all other auxiliaries.

2.09 LABELING

A. Hazard-Alerting Signs

1. All external doors shall be provided with "Warning—Keep Out—Hazardous Voltage Inside—Can Shock, Burn, or Cause Death" signs.

2. The inside of each door shall be provided with a "Danger—Hazardous Voltage—Failure to Follow These Instructions Will Likely Cause Shock, Burns, or Death" sign. The text shall further indicate that operating personnel must know and obey the employer's work rules, know the hazards involved, and use proper protective equipment and tools to work on this equipment.

3. Interrupter switch compartments shall be provided with "Danger" signs indicating that "Switches May Be Energized by Backfeed."

4. Fuse compartments shall be provided with "Danger" signs indicating that "Fuses May Be Energized by Backfeed."

5. Barriers used to prevent access to energized live parts shall be provided with "Danger— Keep Away—Hazardous Voltage—Will Shock, Burn, or Cause Death" signs.

B. Rating Nameplates

1. The integrated switchgear assembly shall be provided with an external nameplate indicating the manufacturer's drawing number and the following: voltage ratings (kV, nominal; kV, maximum; kV, BIL); main bus continuous rating (amperes); short circuit ratings (amperes, RMS symmetrical and MVA three-phase symmetrical at rated nominal voltage); and the momentary and fault-closing ratings (amperes, RMS asymmetrical).

2. Each individual module shall bear a nameplate indicating the ratings of the interrupter switch (amperes, continuous, and interrupting); the maximum rating of the fuse in amperes; and the catalog number of the fuse units, refill units, interrupting module, or control module. The enclosure category shall also be specified.

PART 3: EXECUTION

3.01 INSTALLATION

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

B. Provide installation instructions and answer questions of installer.

C. Verify the installed motor nameplate electrical requirements do not exceed the VFD capacity under any operational condition.

3.02 MANUFACTUER SERVICES

A. Manufacturer's Field Service Engineer shall perform configuration and start- up services:

1. Verify installation per Manufacturer’s instructions.
2. Configure drive inputs, outputs, and parameters.
3. Make adjustments, calibrations, and check installation.
4. Simulate input signals to operate equipment.
5. Complete manufacturer’s start-up instructions to full operational status.
6. Provide start-up services report certified by manufacturer stating that drive is installed in accordance with manufacturer's instructions, has been fully tested, and is operating properly.

B. Field Service engineer to verify drive performance with drive in service under load for compliance with "Certifications" previously specified.

1. Provide certified test report.

3.03 TRAINING

A. Provide on-site instruction and training for District's personnel in drive theory, operation, maintenance and repair:

1. Allow a minimum of two (2) half days on-site for training.
2. Provide instruction manuals and training materials for a minimum of six (6) people.
3. Provide training personnel qualified by education, factory-training and field experience with the specific equipment furnished on this Project.

3.04 WARRANTY SERVICE

A. Equipment Warranty Duration:

1. Parts and labor, 5 years from equipment delivery.

B. Warranty Service:

1. Failures and malfunctions repaired free of additional charges.
2. Technical telephone support as needed to identify issues.
3. Non-field repairable issues shall result in a complete replacement product.
4. Manufacturer shall warrant that service and repair parts shall be available for a

minimum of 10 years from equipment order.

5. All components and parts supplied with the equipment shall be clearly labeled for ease of identification and to permit the shortest possible time to obtain and repair:

   a. Any parts that come from a sub-supplier shall be labeled with that manufacturer's name and part number.

6. Manufacturer shall state closest point where spare parts are stocked and where service can be obtained:

   a. Maximum response time for trouble calls shall be next business day.

   b. A qualified service technician shall be on site within 48 hours of a qualified request.

C. Maintenance service:

1. The VFD manufacturer shall provide maintenance service throughout the warranty period at no additional cost to the District:

2. Provide equipment maintenance yearly, 4 visits.

3. Clean filters, fans, inside and outside of equipment.

4. Check for loose connection and tighten.

5. Investigate and repair any faults.

6. Recalibrate inputs/outputs as needed.

7. Maximum response time to a maintenance call shall not exceed 2 weeks.

END OF SECTION