

DIVISION 1: GENERAL REQUIREMENTS

SECTION 01001 Basic Requirements

DIVISION 16: ELECTRICAL

SECTION 16010 Basic Electrical Requirements

SECTION 16060 Minor Electrical Demolition for Remodeling

SECTION 16111 Conduit

SECTION 16123 Building Wire and Cable

SECTION 16170 Grounding and Bonding

SECTION 16190 Supporting Devices

SECTION 16195 Electrical Identification

SECTION 16441 Enclosed Switches

SECTION 16470 Panelboards

SECTION 16496 Enclosed Transfer Switch

SECTION 16622 Emergency/Standby Power System – Generator Set

**SECTION 01001
BASIC REQUIREMENTS**

1.0 GENERAL

1.1 SECTION INCLUDES

SUMMARY OF WORK

- 1.2 Work by Owner
- 1.3 Contractor Use of Premises
- 1.4 Regulatory and Permit Requirements

CONTRACT CONSIDERATIONS

- 1.5 Cash Allowances – Not applicable
- 1.6 Contingency Allowance – Not applicable
- 1.7 Inspection and Testing Allowances
- 1.8 Schedule of Values
- 1.9 Application for Payment
- 1.10 Change Procedures
- 1.11 Alternates

COORDINATION AND MEETINGS

- 1.12 Coordination
- 1.13 Field Engineering
- 1.14 Cutting and Patching
- 1.15 Conferences
- 1.16 Progress Meetings

SUBMITTALS

- 1.17 Submittal Procedures
- 1.18 Construction Progress Schedules
- 1.19 Shop Drawings
- 1.20 Samples
- 1.21 Manufacturers' Certificates
- 1.22 Construction Photographs

QUALITY CONTROL

- 1.23 Quality Assurance/Control of Installation
- 1.24 References
- 1.25 Field Samples
- 1.26 Inspection and Testing Laboratory Services
- 1.27 Manufacturers' Field Services and Reports

CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

- 1.28 Temporary Utilities
- 1.29 Temporary Sanitary Facilities
- 1.30 Barriers and Fencing
- 1.31 Enclosures
- 1.32 Protection of Installed Work
- 1.33 Security
- 1.34 Access Roads and Parking
- 1.35 Progress Cleaning
- 1.36 Project Identification
- 1.37 Field Offices and Sheds
- 1.38 Removal of Utilities, Facilities and Controls

MATERIAL AND EQUIPMENT

- 1.39 Products
- 1.40 Transportation, Handling, Storage and Protection

1.41 Substitutions

STARTING OF SYSTEMS

- 1.42 Starting Systems
- 1.43 Demonstration and Instructions
- 1.44 Testing, Adjusting and Balancing

CONTRACT CLOSEOUT

- 1.45 Contract Closeout Procedures
- 1.46 Final Cleaning
- 1.47 Adjusting
- 1.48 Project Record Documents
- 1.49 Operation and Maintenance Data
- 1.50 Warranties
- 1.51 Spare Parts and Maintenance Materials

1.2 WORK BY OWNER:

- A. Unless specified on construction documents, Owner will be responsible for removal of all non-fixed materials.
- B. Owner will be responsible for notification of all tenants, and matters dealing with press/public relations.

1.3 CONTRACTOR USE OF PREMISES: All work requiring disruption of electrical power shall be performed according to the following:

- A. May be performed during the normal working hours of 8:00 A.M. to 5:00 P.M., Monday through Friday. Contractor shall schedule these outages with owner 14 days in advance. Length of power disruption shall be limited to 8 hours at a time.
- B. Work that does not require power disruption may be performed during normal working hours.
- C. Owner will arrange access to the facility, but will not provide keys.

1.4 REGULATORY AND PERMIT REQUIREMENTS:

- A. Regulatory and Permit Requirements: Contractor is responsible for obtaining all necessary permits required for construction as indicated on the drawings.

1.5 CASH ALLOWANCES – Not applicable

1.6 CONTINGENCY ALLOWANCE – Not applicable

1.7 INSPECTION AND TESTING ALLOWANCES - Not Applicable

1.8 SCHEDULE OF VALUES

- A. Submit Schedule of Values on EJCDC Form 1910-8-E or contractor's standard form is acceptable.
- B. Submit Schedule at time of First application for payment.

1.9 APPLICATION FOR PAYMENT

- A. Submit 3 Original documents at each application on AIA form or contractor's standard using the AIA format.
- B. Content and Format: Utilize the Schedule of Values for listing items in Application for Payment.
- C. Payment Period: Will be discussed at Pre-Construction Meeting.

1.10 CHANGE PROCEDURES

- A. Change Order Forms: as included in the project manual.

1.11 ALTERNATES

- A. Alternates quoted on Bid Forms will be reviewed and accepted or rejected at the Owner's option.

Alternates will be taken in sequential order as funds permit. Contractor must indicate on the Bid Form whether it is an additive or deductive alternate by crossing out the inapplicable item.

- B. Coordinate related Work and modify surrounding Work as required.
- C. Schedule of Alternates: See Scope of Work on the Drawings and the Bid Form

1.12 COORDINATION

- A. Due to the nature of activity at the building, the Contractor shall be required to carefully schedule work with the building occupants' representative. No work shall be performed without an approved schedule from the representative. The Owner will continue to occupy and use the buildings during the period of construction. Any work which will, in the Contractor's opinion, require coordination with Owner's staff and/or services shall be scheduled through the Owner's representative. This includes any shut down of power, utilities, heating, cooling, ventilation, etc. Contractor shall provide and employ protection for all areas and areas adjacent to that in which he is working.
- B. It shall be the responsibility of each trade to fully examine the documents and understand the full scope of work. The Prime contractor shall be responsible for coordinating all work by his own company and the subcontractors to provide a complete system. It shall further be the responsibility of each trade to coordinate his work with the work of other trades.
- C. Verify utility requirement characteristics of operating equipment are compatible with building utilities.
- D. Coordinate space requirements and installation of mechanical and electrical work which are indicated on Drawings. Follow routing shown for pipes, ducts, and conduit, as closely as practicable.
- E. In finished areas, conceal conduit, pipes, ducts and wiring within the construction.

1.13 FIELD ENGINEERING

- A. Immediately upon entering project site with the purpose of beginning work, the Contractor shall locate all general reference points and take such action necessary to prevent their destruction, lay out his own work and be responsible for all lines, elevations, and measurements of buildings, utilities and other work executed by him under this Contract. He must exercise proper precaution to verify all aspects of the drawings and specifications shown on the drawings before laying out work. He will be held responsible for any error resulting from his failure to exercise such precaution.

1.14 CUTTING AND PATCHING

- A. Employ a skilled and experienced installer to perform cutting and patching new Work; restore Work with new Products.
- B. Submit written request in advance of cutting or altering structural or building enclosure elements.

1.15 CONFERENCES

- A. The Engineer will schedule a pre-construction conference for all affected parties.
- B. When required in individual specification Section, convene a pre-installation conference at the project site prior to commencing Work of the Section.

1.16 PROGRESS MEETINGS

- A. The frequency of progress meetings will be determined at the pre-construction conference.

1.17 SUBMITTAL PROCEDURES

- A. Contractor to comply with the Submittal Procedures defined in each Trade Section.

1.18 CONSTRUCTION PROGRESS SCHEDULES

- A. Submit initial progress schedule in duplicate within 10 days after Notice to Proceed for the Engineer review.
- B. Submit revised schedules with each Application for Payment, identifying changes since previous version. Indicate estimated percentage of completion for each item of Work at each submission.

1.19 SHOP DRAWINGS

- A. Submit eight (6) opaque reproductions of which 2 will be retained by the Engineer and 4 will be returned to the Contractor.

1.20 SAMPLES

- A. Submit samples to illustrate functional and aesthetic characteristics of the Product.
- B. Submit samples of finishes from the full range of manufacturers' standard colors, textures, and patterns for Engineer's selection.

1.21 MANUFACTURERS' CERTIFICATES

- A. When specified in individual specification Sections, submit manufacturers' certificate to Engineer for review, in quantities specified for in Submittals.
- B. Indicate material or Product conforms to or exceeds specified requirements. Submit supporting reference data, affidavits, and certifications as appropriate.

1.22 CONSTRUCTION PHOTOGRAPHS: Not Required

1.23 QUALITY ASSURANCE/CONTROL OF INSTALLATION

- A. Monitor quality control over suppliers, manufacturers, Products, services, site conditions, and workmanship to produce Work of specified quality.
- B. Comply fully with manufacturers' instructions
- C. Comply with specified standards as a minimum quality for the Work except when more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

1.24 REFERENCES

- A. Conform to reference standards current as to the date of agreement between Owner and Contractor.
- B. Should specified reference standard conflict with Contract Documents, request clarification from Architect/Engineer before proceeding.

1.25 FIELD SAMPLES

- A. Construct field samples for review as required by individual specifications Sections. Acceptable samples represent a quality level for the Work.

1.26 INSPECTION AND TESTING LABORATORY SERVICES - Not Applicable

1.27 MANUFACTURERS' FIELD SERVICES AND REPORTS

- A. When specified in individual specifications Sections, require material or Product suppliers or manufacturers to provide qualified staff personnel to observe site conditions and to initiate instructions when necessary.
- B. Report observations and site decisions or instructions that are supplemental or contrary to manufactures written instructions.

1.28 TEMPORARY UTILITIES

- A. Under normal operating conditions, Electric power inside existing building will be furnished by the Owner at no cost to this Contractor unless otherwise indicated in the Construction Documents.
- B. During power outages, the new standby generator can be used to provide limited lighting and power, primarily for life safety considerations. Should the Contractor require electrical energy use in excess of that supplied by the new generator system, contractor shall provide this power at no additional cost to the owner. See paragraph 1.3 of this Section.

1.29 TEMPORARY SANITARY FACILITIES

- A. Workmen at the project may use the toilet facilities in the existing building. This Contractor will keep the toilets in a sanitary condition and upon completion of the construction shall repair and/or replace, at no expense to the Owner, any damage to the toilet facilities caused by such use.

1.30 BARRIERS AND FENCING

- A. Provide fencing and barriers to prevent unauthorized entry to construction areas and to protect the public from open trenches and manholes.
- B. Construction: Commercial grade plastic safety fence.

1.31 ENCLOSURES

- A. Provide temporary weather-tight closures to exterior openings to permit acceptable working conditions and protection of the Work.
- B. Provide temporary partitions as required to separate Work areas from owner occupied areas, to prevent penetration of dust and moisture into Owner occupied areas, and to prevent damage to existing materials and equipment.
- C. Paint surfaces exposed to view from Owner occupied areas.
- D. Prohibit traffic or storage upon waterproofed or roofed surfaces.

1.32 PROTECTION

- A. Contractor shall be responsible for the care and protection of the existing building and adjacent facilities and grounds on the site during progress of the work, and shall repair and make good any damage to same without additional cost to the Owner.
- B. The existing buildings contain furnishings, materials, and equipment used for various purposes. It shall be the responsibility of this Owner to remove, store, and protect such furnishings, materials and equipment found in areas where work required in this Contract is being executed. Notify the owner 24 hours in advance of requiring furnishings to be moved.

1.33 SECURITY

- A. Contractor shall erect temporary barriers in the construction areas. Barriers shall be of adequate design to prevent those not employed in the construction from entering the construction areas and to adequately protect all employees and members of the public from injury due to construction of the project. Locate barriers as required and coordinate location of the barriers with the Owner's Representative. Upon completion of the project, remove barriers from the site.

1.34 ACCESS ROADS AND PARKING

- A. Existing on-site roads may be used for construction traffic.
- B. Arrange for temporary parking areas to accommodate construction personnel.

1.35 PROGRESS CLEANING

- A. Contractor shall at all times keep the building free from rubbish and material that may constitute an obstruction to the progress of the work or a hazard to the safety of the persons employed in the work. Maintain site in a clean and orderly condition, removing all rubbish from the site.

1.36 PROJECT IDENTIFICATION - Not Applicable

1.37 FIELD OFFICES AND SHEDS - Not Applicable

1.38 REMOVAL OF UTILITIES, FACILITIES AND CONTROLS

- A. Remove temporary above grade or buried utilities, equipment, facilities, materials, prior to Substantial Completion inspection.
- B. Remove underground installations to a minimum depth of 2 ft.
- C. Clean and repair damage caused by installation or use of temporary work.
- D. Restore existing facilities used during construction to original condition. Restore permanent facilities used during construction to specified condition.

1.39 PRODUCTS

- A. Products: Means new material, machinery, components, equipment, fixtures, and systems forming the Work, but does not include machinery and equipment used for preparation, fabrication, conveying and erection of the Work. Products may also include existing materials or components specifically identified for reuse.
- B. Do not use materials and equipment removed from existing premises, except as specifically identified or allowed by the Contract Documents.
- C. Use interchangeable components of the same manufacture for similar components.

1.40 TRANSPORTATION, HANDLING, STORAGE AND PROTECTION

- A. Transport, handle, store and protect Products in accordance with manufacturer's instructions.

1.41 SUBSTITUTIONS

- A. Engineer will consider requests for Substitutions only at Submittal Review.
- B. Document each request with complete data substantiating compliance of proposed Substitution with Contract Documents.
- C. Submit 1 copy of request for Substitution for consideration.

1.42 STARTING SYSTEMS

- A. Provide seven days notification prior to start-up of each item.
- B. Ensure that each piece of equipment or system is ready for operation.
- C. Execute start-up under supervision of responsible persons in accordance with manufacturer's instructions.
- D. Submit a written report that equipment of system has been properly installed and is functioning correctly.

1.43 DEMONSTRATION AND INSTRUCTIONS

- A. Demonstrate operation and maintenance of Products to Owner's personnel two weeks prior to date of Substantial Completion.
- B. Submit sign-in sheet and meeting materials to Engineer.
- C. For equipment or systems requiring seasonal operation, perform demonstration for other season within six months.
- D. Demonstrate start-up, operation, control, adjustment, trouble-shooting, servicing, maintenance, and shutdown of each item or equipment at scheduled times, at equipment location.

1.44 TESTING, ADJUSTING AND BALANCING - Not Applicable

1.45 CONTRACT CLOSEOUT PROCEDURES

- A. Submit written certification that Contract Documents have been reviewed, Work has been inspected, and Work is complete in accordance with Contract Documents and ready for Architect/Engineer's inspection.
- B. Submit final Application for Payment identifying total adjusted Contract Sum/Price, previous payments, and amount remaining due.
- C. Contractor to comply with the Closeout Requirements and Procedures for Substantial Completion and Final Inspection for each Trade.

1.46 FINAL CLEANING

- A. Execute final cleaning prior to final inspection.
- B. Clean interior and exterior surfaces exposed to view. Vacuum carpeted and soft surfaces.
- C. Clean debris from site, roofs, gutters, downspouts, and drainage systems.
- D. Replace filters of operating equipment.

1.47 ADJUSTING

- A. Adjust operating Products and equipment to ensure smooth and unhindered operation.

1.48 PROJECT RECORD DOCUMENTS

- A. Maintain on site, one set of Contract Documents to be utilized for record documents.
- B. Record actual revisions to the Work. Record information concurrent with construction progress.

- C. Specifications: Legibly mark and record at each Product Section a description of actual Products installed.
- D. Record Documents and Shop Drawings: Legibly mark each item to record actual construction.
- E. Submit documents to Architect/Engineer with claim for final Application for Payment.

1.49 OPERATION AND MAINTENANCE DATA

- A. Submit 3 sets prior to final inspection, bound in 8 1/2 x 11 inch text pages, three D side ring binders with durable plastic covers.
- B. Prepare binder cover with printed title "OPERATION AND MAINTENANCE INSTRUCTIONS", and title of project.
- C. Internally subdivide the binder contents with permanent page dividers, logically organized, with tab titling clearly printed under reinforced laminated plastic tabs.
- D. Contents:
 - 1. Directory, listing names, addresses, and telephone numbers of Architect/Engineer, Contractor, Subcontractors, and major equipment suppliers.
 - 2. Operation and maintenance instructions, arranged by system.
 - 3. Project documents and certificates.

1.50 WARRANTIES

- A. The Contractor shall, as a part of his Contract, guarantee all materials and workmanship furnished under this Contract to meet the requirements of all local, state, and national codes. The Contractor shall also warranty the entire work to be free from defects in workmanship and material for a period of one year from the date of acceptance by the Owner. During this period, the Contractor shall furnish all labor and material to repair or replace all items or components which fail due to defects in material or installation workmanship. The contractor shall provide a complete inventory of factory recommended spare parts. Any parts used during the warranty period shall be replaced at the end of that period so that the Owner shall have a complete inventory at the end of the period.

1.51 SPARE PARTS AND MAINTENANCE MATERIALS

- A. Provide Product, spare parts, maintenance and extra materials in quantities specified in individual specifications Sections.
- B. Deliver to Project site and place in location.

2.0 PRODUCTS

Not Used

3.0 EXECUTION

Not Used

END OF SECTION

SECTION 16010

BASIC ELECTRICAL REQUIREMENTS

1.0 GENERAL

1.1 SECTION INCLUDES

- A. Basic Electrical Requirements specifically applicable to Division 16 Sections, in addition to Division 1 - General Requirements and the General Conditions of the Contract.

1.2 WORK BY OWNER - Not Applicable

1.3 OWNER FURNISHED PRODUCTS - Not Applicable

1.4 WORK SEQUENCE

- A. Install work in phases to accommodate Owner's occupancy requirements during the construction period. Coordinate electrical schedule and operations with Owner.

1.5 FUTURE WORK

- A. Provide for future work under requirements of Division 1.

1.6 ALLOWANCES – Not applicable

1.7 UNIT PRICES - Not Applicable

1.8 ALTERNATES

- A. Alternates quoted on Bid Forms will be reviewed and accepted or rejected at the Owner's option. Accepted Alternates will be identified in Owner-Contractor Agreement.
- B. Coordinate related work and modify surrounding work as required.
- C. Schedule of Alternates: See Division 1

1.9 REFERENCES

- A. ANSI/NFPA 70 - National Electrical Code.

1.10 SUBMITTALS

- A. Submit shop drawings and product data grouped to include complete submittals of related system, products, and accessories in a single submittals. Engineer will commence review only when all data has been received.
- B. Submittal form to identify Project, contractor, Subcontractor or supplier; and pertinent Contract Document references. Mark dimensions and values in units to match those specified.
- C. Apply Contractor's stamp, signed or initial, certifying that review, verification of Products required, field dimensions, adjacent construction Work and coordination of information is in accordance with the requirements of the Work and Contract Documents.
- D. The Contractor shall determine and verify field measurements and field construction criteria for conformance with Drawings and Specifications and for conflicts with other items of Construction past or present. He shall coordinate each submittal with the requirements of the Work and of the Contract Documents and notify the Engineer in writing, at the time of the submission, of any and all deviations in the submittals from requirements of the Work and Contract Documents.

No fabrication or work which requires submittals shall begin until submittals are returned with the Engineer's approval.

- E. Identify variations for Contract Documents and Product or system limitations which may be detrimental to successful performance of the completed Work.
- F. Engineer's review does not constitute acceptance or responsibility for accuracy or dimensions, nor shall it relieve the Contractor from meeting any requirements of the Work and Contract Documents, nor shall it constitute approval for any deviation from the Contract Documents unless such deviations are specifically stated as such on the submittal and specifically allowed by the Engineer by specific written notification for each such variation. The Engineer's review will not relieve the Contractor from responsibility for errors or omissions in the Shop Drawings.
- G. Revise and resubmit submittals as required; identify all changes made since previous submittal.

1.11 SUBSTITUTIONS

- A. Submit under provisions of Division 1.

1.12 REGULATORY REQUIREMENTS

- A. All electrical work shall be performed in strict accordance with the UBC, ANSI, NEC, NFPA, Model Energy Code, all applicable provisions of the Local Authorities having jurisdiction and the State of New Mexico. All materials and labor necessary to comply with rules, regulations, and ordinances shall be provided. Where the Drawings and/or specifications indicate material or construction in excess of code requirements or visa-versa, the more stringent application shall govern.
- B. Furnish products listed by Underwriters Laboratories, Inc. or other testing firm acceptable to authority having jurisdiction.
- C. Permits necessary for the performance of the work under this contract shall be secured and paid for by the Contractor. Final inspection by the Engineer will not be made or certificate of final payment issued until certificates of satisfactory inspection from the inspection authorities are delivered.

1.13 PROJECT/SITE CONDITIONS

- A. Install Work in locations shown on Drawings, unless prevented by Project conditions.
- B. Prepare drawings showing proposed rearrangement of Work to meet Project conditions, including changes to Work specified in other Sections. Obtain permission of Engineer before proceeding.

1.14 SEQUENCING AND SCHEDULING

- A. Construct Work in sequence under provisions of Division 1.

1.15 RECORD AS-BUILT DRAWINGS

- A. The Contractor shall modify original reproducible drawings and two sets of the Project Manual delineating recorded as-built conditions of the Project or record documents compiled from the job records. The Contractor may obtain reproducible drawings from the office of the Engineer. This set of documents shall show all changes in the Work including actual location of all Work.
- B. Completion of Record As-built Drawings is a condition of Final Inspection and consideration of Final Payment.

2.0 PRODUCTS

Not Used

3.0 EXECUTION

3.1 SUBSTANTIAL COMPLETION AND FINAL INSPECTION REQUIREMENTS

- A. Before substantial completion can be granted, the following items must be completed and/or submitted to the Owner/Engineer.
- Have all systems tested, adjusted and calibrated.
 - Have all electrical equipment properly labeled.
- B. Prior to the Final Inspection or consideration of Final Payment, the Contractor shall:
- Provide copies of permits and/or inspection certificates.
 - Provide a Check-out report.
 - Provide Operating and Maintenance Manual(s).
 - Provide Record as-built Drawings.
 - Return keys to the Owner.
 - Deliver all spare parts.
 - Touch up any damaged finishes.

END OF SECTION

SECTION 16060

MINOR ELECTRICAL DEMOLITION FOR REMODELING

1.0 GENERAL

1.1 SECTION INCLUDES

- A. Electrical demolition.

2.0 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Materials and equipment for patching and extending work: Match Existing.

3.0 EXECUTION

3.1 EXAMINATION

- A. Verify field measurements and circuiting arrangements are as shown on Drawings.
- B. Verify that abandoned wiring and equipment serve only abandoned facilities.
- C. Demolition Drawings are based on casual field observation. Report discrepancies to Engineer before disturbing existing installation.
- D. Beginning of demolition means installer accepts existing conditions.

3.2 PREPARATION

- A. Disconnect electrical systems scheduled for removal.
- B. Coordinate utility service outages with Utility Company and owner.
- C. When work must be performed on energized equipment or circuits, use personnel experienced in such operations.
- D. Existing Electrical Service and feeder circuits: Disable systems only to make switchovers and connections. Minimize outage duration. See Section 01001 for requirements.

3.3 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

- A. Demolish and extend existing electrical work under provisions of Division 1 and this Division.
- B. Remove, relocate, and extend existing installations to accommodate new construction.
- C. Remove abandoned wiring to source of supply.
- D. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.
- E. Disconnect and remove abandoned panelboards and distribution equipment.
- F. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.

- G. Maintain access to existing electrical installations which remain active. Modify installation or provide access panel as appropriate.
- H. Extend existing installations using materials and methods compatible with existing electrical installations, or as specified.

3.4 CLEANING AND REPAIR

- A. Clean and repair existing materials and equipment which remain or are to be reused.

3.5 INSTALLATION

- A. Install relocated materials and equipment under the provisions of Division 1.

END OF SECTION

SECTION 16111

CONDUIT

1.0 GENERAL

1.1 SECTION INCLUDES

- A. Metal conduit.
- B. Flexible metal conduit.
- C. Liquidtight flexible metal conduit.
- D. Electrical metallic tubing.
- E. Nonmetal conduit.
- F. Electrical nonmetallic conduit.
- G. Flexible nonmetallic conduit.
- H. Fittings and conduit bodies.

1.2 RELATED SECTIONS - NOT APPLICABLE

1.3 REFERENCES

- A. ANSI C80.1 - Rigid Steel Conduit, Zinc Coated.
- B. ANSI C80.3 - Electrical Metallic Tubing, Zinc Coated.
- C. ANSI C80.5 - Rigid Aluminum Conduit.
- D. ANSI/NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies.
- E. ANSI/NFPA 70 - National Electrical Code.
- F. NECA "Standard of Installation".
- G. NEMA RN 1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
- H. NEMA TC 2 - Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC - 80).
- I. NEMA TC 3 - PVC Fittings for use with Rigid PVC Conduit and Tubing.

1.4 DESIGN REQUIREMENTS

- A. Conduit Size: ANSI/NFPA 70.

1.5 SUBMITTALS

- A. Not Applicable

1.6 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Division 1.
- B. Accurately record actual routing of conduits larger than 2 inches.

1.7 REGULATORY REQUIREMENTS

- A. Conform to requirements of ANSI/NFPA 70.
- B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

1.8 FIELD SAMPLES

- A. Not Applicable

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect, and handle Products to site under provisions of Division 1.
- B. Accept conduit on site. Inspect for damage.
- C. Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering.
- D. Protect PVC conduit from sunlight.

1.10 PROJECT CONDITIONS

- A. Verify that field measurements are as shown on Drawings.
- B. Verify routing and termination locations of conduit prior to rough-in.
- C. Conduit routing is shown on Drawings in approximate locations unless dimensioned. Route as required to complete wiring system.

2.0 PRODUCTS

2.1 CONDUIT REQUIREMENTS

- A. Minimum Size: 1/2 inch unless otherwise specified.
- B. Underground Installations: Use thickwall nonmetallic conduit.
- C. Outdoor Locations, above Grade: Use rigid steel, intermediate metal conduit and electrical metallic tubing. Provide weathertight fittings.
- D. Wet and Damp Locations: Use rigid steel, intermediate metal conduit and electrical metallic tubing. Provide weathertight fittings.
- E. Dry Locations:
 - 1. Concealed: Use electrical metallic tubing.
 - 2. Exposed: Use rigid steel conduit, intermediate metal conduit, and electrical metallic tubing.

2.2 METAL CONDUIT

- A. Rigid Steel Conduit: ANSI C80.1.

- B. Rigid Steel Conduit: ANSI C80.1.
 - C. Intermediate Metal Conduit (IMC): Rigid steel.
 - D. Fittings and Conduit Bodies: ANSI/NEMA FB 1; all steel fittings.
- 2.3 PVC COATED METAL CONDUIT – Not Used
- 2.4 FLEXIBLE METAL CONDUIT
- A. Description: Interlocked steel construction.
 - B. Fittings: ANSI/NEMA FB 1.
- 2.5 LIQUIDTIGHT FLEXIBLE METAL CONDUIT
- A. Description: Interlocked steel construction with PVC jacket.
 - B. Fittings: ANSI/NEMA FB 1.
- 2.6 ELECTRICAL METALLIC TUBING (EMT)
- A. Description: ANSI C80.3; galvanized tubing.
 - B. Fittings and Conduit Bodies: ANSI/NEMA FB 1; steel set screw type.
- 2.7 NONMETALLIC CONDUIT
- A. Description: NEMA TC 2; Schedule 40 PVC.
 - B. Fittings and Conduit Bodies: NEMA TC 3.
- 2.8 NONMETALLIC TUBING
- A. Not Allowed
- 3.0 EXECUTION**
- 3.1 INSTALLATION
- A. Install conduit in accordance with NECA "Standard of Installation".
 - B. Install nonmetallic conduit in accordance with manufacturer's instructions.
 - C. Arrange supports to prevent misalignment during wiring installation.
 - D. Support conduit using coated steel or malleable iron straps, lay-in adjustable hangers, clevis hangers, and split hangers.
 - E. Group related conduits; support using conduit rack. Construct rack using steel channel ; provide space on each for 25 percent additional conduits.
 - F. Fasten conduit supports to building structure and surfaces.
 - G. Do not support conduit with wire or perforated pipe straps. Remove wire used for temporary supports.
 - H. Arrange conduit to maintain headroom and present neat appearance.
 - I. Route conduit parallel and perpendicular to walls.

- J. Maintain adequate clearance between conduit and piping.
- K. Maintain 12 inches clearance between conduit and surfaces with temperatures exceeding 104 degrees F (40 degrees C).
- L. Cut conduit square using saw or pipecutter; de-burr cut ends.
- M. Bring conduit to shoulder of fittings; fasten securely.
- N. Join nonmetallic conduit using cement as recommended by manufacturer. Wipe nonmetallic conduit dry and clean before joining. Apply full even coat of cement to entire area inserted in fitting. Allow joint to cure for 20 minutes, minimum.
- O. Use conduit hubs or sealing locknuts to fasten conduit to sheet metal boxes in damp and wet locations and to cast boxes.
- P. Install no more than equivalent of three 90-degree bends between boxes. Use conduit bodies to make sharp changes in direction, as around beams. Use factory elbows for bends in metal conduit larger than 2 inch size.
- Q. Avoid moisture traps; provide junction box with drain fitting at low points in conduit system.
- R. Provide suitable fittings to accommodate expansion and deflection where conduit crosses control and expansion joints.

3.2 INTERFACE WITH OTHER PRODUCTS

- A. Install conduit to preserve fire resistance rating of partitions and other elements, using approved materials and methods.

END OF SECTION

SECTION 16123
BUILDING WIRE AND CABLES

1.0 GENERAL

1.1 SECTION INCLUDES

- A. Building wire and cable.
- B. Wiring connectors and connections.

1.2 RELATED SECTIONS

- A. Section 16111 - Conduit.
- B. Section 16195 - Identification.

1.3 REFERENCES

- A. ANSI/NFPA 70 - National Electrical Code.

1.4 SUBMITTALS

- A. Not Applicable

1.5 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years documented experience.

1.6 REGULATORY REQUIREMENTS

- A. Conform to requirements of ANSI/NFPA 70.
- B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

1.7 FIELD SAMPLES

- A. Not Applicable

1.8 PROJECT CONDITIONS

- A. Verify that field measurements are as shown on Drawings.
- B. Conductor sizes are based on copper unless indicated as aluminum or "AL".
- C. Wire and cable routing shown on Drawings is approximate unless dimensioned. Route wire and cable as required to meet Project Conditions. Include wire and cable lengths within 10 feet of length shown.

1.9 COORDINATION

- A. Coordinate Work under provisions of Division 1.
- B. Determine required separation between cable and other work.

- C. Determine cable routing to avoid interference with other work.

2.0 PRODUCTS

2.1 BUILDING WIRE AND CABLE

- A. Description: Signal conductor insulated wire.
- B. Conductor: Copper
- C. Insulation Voltage Rating: 600 volts.
- D. Insulation: ANSI/NFPA 70, type THHN/THWN

3.0 EXECUTION

3.1 EXAMINATION

- A. Verify that mechanical work likely to damage wire has been completed.

3.2 PREPARATION

- A. Completely and thoroughly swab raceway before installing wire.

3.3 WIRING METHODS

- A. Use only building wire, Type THHN/THWN insulation, in raceway.

3.4 INSTALLATION

- A. Install products in accordance with manufacturers instructions.
- B. Use solid conductor for feeders and branch circuits 10 AWG and smaller.
- C. Use stranded conductors for control circuits.
- D. Use conductor not smaller than 12 AWG for power and lighting circuits.
- E. Use conductor not smaller than 14 AWG for control circuits.
- F. Use 10 AWG conductors for 20 ampere, 120 volt branch circuits longer than 75
- G. Pull all conductors into raceway at same time.
- H. Use suitable wire pulling lubricant for building wire 4 AWG and larger.
- I. Protect exposed cable from damage.
- J. Use suitable cable fittings and connectors.
- K. Neatly train and lace wiring inside boxes, equipment, and panelboards.
- L. Clean conductor surfaces before installing lugs and connectors.
- M. Make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.

- N. Use suitable reducing connectors or mechanical connector adaptors for connecting aluminum conductors to copper conductors.
- O. Use split bolt connectors for copper conductor splices and taps, 6 AWG and larger. Tape un-insulated conductors and connectors with electrical tape to 150 percent of insulation rating of conductor.
- P. Use solderless pressure connectors with insulating covers for copper conductor splices and taps, 8 AWG and smaller.
- Q. Use insulated spring wire connectors with plastic caps for copper conductor splices and taps, 10 AWG and smaller.

3.5 INTERFACE WITH OTHER PRODUCTS

- A. Identify wire and cable.
- B. Identify each conductor with its circuit number or other designation indicated on Drawings.

3.6 FIELD QUALITY CONTROL

- A. Perform field inspection and testing under provisions of Division 1.
- B. Inspect wire and cable for physical damage and proper connection.
- C. Measure tightness of bolted connections and compare torque measurements with manufacturer's recommended values.
- D. Verify continuity of each branch circuit conductor.

END OF SECTION

SECTION 16170

GROUNDING AND BONDING

1.0 GENERAL

1.1 SECTION INCLUDES

- A. Grounding electrodes and conductors.
- B. Equipment grounding conductors.
- C. Bonding.

1.2 RELATED SECTIONS

- A. Not Applicable

1.3 REFERENCES

- A. ANSI/NFPA 70 - National Electrical Code

1.4 GROUNDING ELECTRODE SYSTEM

- A. Metal underground water pipe.
- B. Metal frame of the building.
- C. Concrete-encased electrode.
- D. Buried Electrode
- E. Rod electrode.

1.5 PERFORMANCE REQUIREMENTS

- A. Grounding System Resistance: 10 ohms.

1.6 SUBMITTALS

- A. Submit under provisions of Section 16010.
- B. Product Data: Provide data for grounding electrodes and connections.
- C. Test Reports: Indicate overall resistance to ground and resistance of each electrode.

1.7 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Section 16010
- B. Accurately record actual locations of grounding electrodes.

1.8 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing Products specified in this Section with minimum three years experience.

1.9 REGULATORY REQUIREMENTS

- A. Conform to requires of ANSI/NFPA 70.
- B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

2.0 PRODUCTS

2.1 ROD ELECTRODE

- A. Material: Copper Copper-clad steel.
- B. Diameter: 5/8 inch.
- C. Length: 10 feet.

2.2 ACTIVE ELECTRODES - Not Used

2.3 MECHANICAL CONNECTORS

- A. Material: Bronze.

2.4 EXOTHERMIC CONNECTIONS

- A. CAD-WELD or Equal

2.5 WIRE

- A. Material: Stranded copper.
- B. Buried Electrode: 4/0 AWG
- C. Grounding Electrode Conductor: Size to meet NFPA 70 Requirements.

2.6 GROUNDING WELL COMPONENTS

- A. Well Pipe: 8 inch diameter by 24 inch long concrete pipe with belled end.
- B. Well Cover: Cast iron with legend "GROUND" embossed on cover.

3.0 EXECUTION

3.1 EXAMINATION

- A. Verify that final backfill and compaction has been completed before driving rod electrodes.

3.2 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install rod and buried electrodes on locations indicated. Install additional electrodes as required to achieve specified resistance to ground.
- C. Provide grounding well pipe with cover at each rod location. Install well pipe top flush with finished grade.
- D. Provide grounding electrode conductor and connect to buried electrodes.
- E. Provide bonding to meet Regulatory Requirements.

- F. Equipment Grounding Conductor: Provide separate, insulated conductor within each feeder and branch circuit raceway. Terminate each end on suitable lug, bus or bushing.

3.3 INTERFACE WITH OTHER PRODUCTS

- A. Not applicable.

3.4 FIELD QUALITY CONTROL

- A. Inspect grounding and bonding system conductors and connections for tightness and proper installation.
- B. Use suitable test instrument to measure resistance to ground of system. Perform testing in accordance with test instrument manufacturer's recommendations using the fall- of-potential method.

END OF SECTION

SECTION 16190
SUPPORTING DEVICES

1.0 GENERAL

1.1 SECTION INCLUDES

- A. Conduit and equipment supports.
- B. Anchors and fasteners.

1.2 REFERENCES

- A. NECA - National Contractors Association.
- B. ANSI/NFPA 70 - National Electrical Code.

1.3 SUBMITTALS

- A. Submit under provisions of Section 16010.
- B. Product Data: Provide manufacturer's catalog data for fastening systems.
- C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

1.4 REGULATORY REQUIREMENTS

- A. Conform to requirements of ANSI/NFPA 70.
- B. Furnish products listed and classified by Underwriters Laboratories, Inc as suitable for purpose specified and shown.

2.0 PRODUCTS

2.1 PRODUCT REQUIREMENTS

- A. Materials and Finishes: Provide adequate corrosion resistance.
- B. Provide materials, sizes, and types of anchors, fasteners and supports to carry the loads of equipment and conduit. Consider weight of wire in conduit when selecting products.
- C. Anchors and Fasteners:
 - 1. Concrete Structural Elements: Use expansion anchors.
 - 2. Steel Structural Elements: Use beam and welded fasteners.
 - 3. Concrete Surfaces: Use self-drilling anchors and expansion anchors.
 - 4. Hollow Masonry Plaster, and Gypsum Board Partitions: Use toggle bolts and hollow wall fasteners.
 - 5. Solid Masonry Walls: Use expansions anchors.
 - 6. Sheet Metal: Use sheet metal screws.
 - 7. Wood Elements: Use wood screws.

2.2 STEEL CHANNEL

- A. Description: Painted steel.

3.0 EXECUTION

3.1 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Provide anchors, fasteners, and supports in accordance with NECA "Standard of Installation".
- C. Do not fasten supports to pipes, ducts, mechanical equipment, and conduit.
- D. Do not use spring steel clips and clamps.
- E. Obtain permission from Architect/Engineer before using powder-actuated anchors.
- F. Do not drill or cut structural members.
- G. Fabricate supports from structural steel or steel channel. Rigidly weld members or use hexagon head bolts to present neat appearance with adequate strength and rigidity. Use spring lock washers under all nuts.
- H. Install surface-mounted cabinets and panelboards with minimum of four anchors.
- I. In wet and damp locations use steel channel supports to stand cabinets and panelboards one inch off wall.
- J. Use sheet metal channel to bridge studs above and below cabinets and panelboards recessed in hollow partitions.

END OF SECTION

SECTION 16195

ELECTRICAL IDENTIFICATION

1.0 GENERAL

1.1 SECTION INCLUDES

- A. Nameplates and labels.
- B. Wire and cable markers.
- C. Conduit markers.

1.2 RELATED SECTIONS

- A. Painting.

1.3 REFERENCES

- A. ANSI/NFPA 70 - National Electrical Code

1.4 SUBMITTALS

- A. Submit under provisions of Section 16010.
- B. Product Data: Provide catalog data for nameplates, labels, and markers.
- C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under regulatory requirements. Include instructions for storage, handling, protection, examination, preparations and installation of Product.

1.5 REGULATORY REQUIREMENTS

- A. Conform to requirements of ANSI/NFPA 70.
- B. Furnish products listed and classified by Underwriters Laboratories, Inc. testing firm acceptable to authority having jurisdiction as suitable for purpose specified and shown.

1.6 EXTRA MATERIALS Not Applicable

2.0 PRODUCTS

2.1 NAMEPLATES AND LABELS

- A. Name plates: Engraved three-layer laminated plastic, white letters on black background.
- B. Locations:
 - 1. Each electrical distribution and control equipment enclosure.
 - 2. Communication cabinets.
- C. Letter Size:
 - 1. Use 1/8 inch letters for identifying individual equipment and loads.
 - 2. Use 1/4 inch letters for identifying grouped equipment and loads.
- D. Labels: Embossed adhesive tape, with 3/16 inch white letters on black background. Use only for identification of individual wall switches and receptacles, control device stations.

2.2 WIRE MARKERS

- A. Manufacturers:
 - 1. Brady or Approved Equal
- B. Description: Cloth, Tape, split sleeve, or tubing type wire markers.
- C. Locations: Each conductor at panelboard gutters, pull boxes, outlet and junction boxes, and each load connection.
- D. Legend:
 - 1. Power and Lighting Circuits: Branch circuit or feeder number indicated on drawings.
 - 2. Control Circuits: Control wire number indicated on schematic and interconnection diagrams on shop drawings.

2.3 CONDUIT MARKERS

- A. Location: Furnish markers for each conduit longer than 6 feet.
- B. Spacing: 20 feet on center.
- C. Color:
 - 1. 480 Volt System: Orange.
 - 2. 208 Volt System: Blue.

2.4 UNDERGROUND WARNING TAPE

- A. Manufacturers:
 - 1. Brady or Approved Equal
- B. Description: 4 inch wide plastic tape, detectable type, colored red with suitable warning legend describing buried electrical lines;

3.0 EXECUTION

3.1 PREPARATION

- A. Degrease and clean surfaces to receive nameplates and labels.

3.2 APPLICATION

- A. Install nameplate and label parallel to equipment lines.
- B. Secure nameplate to equipment front using screws or rivets.
- C. Secure nameplate to inside surface of door on panelboard that is recessed in finished locations.
- D. Identify conduit using field painting.
- E. Paint colored band on each conduit longer than 6 feet.
- F. Paint bands 20 feet on center.
- G. Identify underground conduits using underground warning tape. Install one tape per trench at 3 inches below finished grade.

END OF SECTION

SECTION 16441
ENCLOSED SWITCHES

1.0 GENERAL

1.1 SECTION INCLUDES

- A. Fusible switches.
- B. Nonfusible switches.
- C. Fuses.

1.2 REFERENCES

- A. NEMA KS 1 - Enclosed Switches.
- B. NFPA 70 - National Electrical Code.
- C. UL 198C - High-Interrupting Capacity Fuses; Current Limiting Type.
- D. UL 198C - Class R Fuses.

1.3 SUBMITTALS

- A. Submit under provisions of Section 16010.
- B. Product Data: Provide switch ratings and enclosure dimensions.
- C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

1.4 QUALITY ASSURANCE

- A. Perform Work in accordance with NECA Standard of Installation.

1.5 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing Products specified in this Section with minimum three years experience.

1.6 REGULATORY REQUIREMENTS

- A. Conform to requirements of NFPA 70.
- B. Furnish products listed and classified by UL as suitable for purpose specified and shown.

1.7 EXTRA MATERIALS

- A. Furnish under provisions of Section 16010
- B. Provide three of each size and type fuse installed.

2.0 PRODUCTS

2.1 MANUFACTURERS

- A. Square D
- B. Siemens
- C. Cutler Hammer

2.2 ENCLOSED SWITCHES

- A. Fusible Switch Assemblies: NEMA KS 1, Type HD load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position. Fuse clips: Designed to accommodate Class R fuses.
- B. Nonfusible Switch Assemblies: NEMA KS 1, Type HD load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position.
- C. Enclosures: NEMA KS 1.
 - 1. Interior Dry Locations: Type 1.
 - 2. Exterior Locations: Type 3R.

2.3 FUSES

- A. Manufacturers:
 - 1. Bussman.
 - 2. Gould Shawmut
- B. Description: Dual element, current limiting, time delay, one-time fuse, Class RK 1.
- C. Interrupting Rating: 200,000 rms amperes.

3.0 EXECUTION

3.1 INSTALLATION

- A. Install disconnect switches where indicated.
- B. Install fuses in fusible disconnect switches.
- C. Provide adhesive label on inside door of each switch indicating UL fuse class and size for replacement.

END OF SECTION

SECTION 16470

PANELBOARDS

1.0 GENERAL

1.1 SECTION INCLUDES

- A. Distribution panelboards.
- B. Branch circuit panelboards.

1.2 RELATED WORK

- A. Supporting Devices.
- B. Electrical Identification: Engraved nameplates.

1.3 REFERENCES

- A. NECA (National Electrical Contractors Association: Standard of Installation".
- B. NEMA AB - 1 Molded Case Circuit Breakers.
- C. NEMA ICS 2 - Industrial Control Devices, Controllers, and Assemblies.
- D. NEMA KS 1 - Enclosed Switches.
- E. NEMA PB 1 - Panelboards.
- F. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
- G. NFPA 70 - National Electrical Code.

1.4 SUBMITTALS

- A. Submit under provisions of Section 16010.
- B. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, integrated short circuit ampere rating, circuit breaker, and fusible switch arrangement and sizes.
- C. Manufacturer's Installation Instructions: Indicated application conditions and limitations of use stipulated by Product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

1.5 PROJECT RECORD DOCUMENTS

- A. Submit under provisions of Division 1.
- B. Record actual locations of Products; indicate actual branch circuit arrangement.

1.6 OPERATION AND MAINTENANCE DATA

- A. Submit under provisions of Section 16010.
- B. Maintenance Data: Include spare parts data listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

1.7 QUALITY ASSURANCE

- A. Perform Work in accordance with NECA Standard of Installation.

1.8 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this Section with minimum three years experience.

1.9 REGULATORY REQUIREMENTS

- A. Conform to requirements of NFPA 70.
- B. Furnish products listed and classified by UL as suitable for purpose specified and indicated.

1.10 FIELD MEASUREMENTS

- A. Verify that field measurements are as indicated on shop drawings and instructed by manufacturer.

1.11 MAINTENANCE MATERIALS

- A. Provide maintenance materials under provisions of Section 16010.
- B. Provide two of each panelboard key.

1.12 EXTRA MATERIALS

- A. Furnish under provisions of Division 1.

2.0 PRODUCTS

2.1 MANUFACTURERS

- A. Square D
- B. Siemens
- C. Cutler Hammer

2.2 DISTRIBUTION PANELBOARDS

- A. Panelboards: NEMA PB 1, circuit breaker type.
- B. Service Conditions:
 - 1. Temperature: 90 degrees F.
 - 2. Altitude: 7200 feet.
- C. Panelboard Bus: Copper, ratings as indicated. Provide copper ground bus in each panelboard.
- D. Minimum integrated short circuit rating: As indicated on the drawings.
- E. Molded Case Circuit Breakers: NEMA AB1. Provide circuit breakers with integral thermal and instantaneous magnetic trip in each pole. Provide circuit breakers UL listed as Type HACR for air conditioning equipment branch circuits.
- F. Provide circuit breaker accessory trip units and auxiliary switches as indicated.
- G. Enclosure: As scheduled on the drawings.
- H. Cabinet Front: Surface type, fastened with concealed trim clamps or screw cover. Provide hinged door with flush lock. Finish in manufacturer's standard gray enamel.

2.3 BRANCH CIRCUIT PANELBOARDS

- A. Lighting and Appliance Branch Circuit Panelboards: NEMA PB 1, circuit breaker type.
- B. Panelboard Bus: Copper, ratings as indicated. Provide copper ground bus in each panelboard ;provide insulated ground bus where scheduled.
- C. Minimum Integrated Short Circuit Rating: 10,000 amperes rms symmetrical for 240 volt panelboards, 14,000 amperes rms symmetrical for 480 volt panelboards,;
- D. Molded Case Circuit Breakers: NEMA AB 1, bolt-on type thermal magnetic trip circuit breakers, with common trip handle for all poles. Provide circuit breakers UL listed as type SWD for lighting circuits. Provide UL Class A ground fault interrupter circuit breakers where scheduled. Do not use tandem circuit breakers.
- E. Enclosure: As indicated on the drawings.
- F. Cabinet box: 6 inches deep; width: 20 inches
- G. Cabinet Front: Cabinet front with concealed trim clamps, concealed hinge, and flush lock all keyed alike. Finish in manufacturer's standard gray enamel.

3.0 EXECUTION

3.1 INSTALLATION

- A. Install panelboards in accordance with NEMA PB 1.1.
- B. Install panelboards plumb. Install recessed panelboards flush with wall finishes. Provide supports as required.
- C. Height: 6 ft to top of panelboard; install panelboards taller than 6 ft with bottom no more than 4 inches above floor.
- D. Provide filler plates for unused spaces in panelboards.
- E. Provide typed circuit directory for each branch circuit panelboard. Adjust directory to reflect circuiting changes required to balance phase loads.
- F. Provide engraved plastic nameplates.
- G. Provide spare conduits out of each recessed panelboard to an accessible location above ceiling. Minimum spare conduits: 5 empty 1 inch. Identify each as SPARE.

3.2 FIELD QUALITY CONTROL

- A. Field inspection and testing will be performed under provisions of Division 1.
- B. Measure steady state load currents at each panelboard feeder; rearrange circuits in the panelboard to balance the phase loads to within 20 percent of each other. Maintain proper phasing for multi-wire branch circuits.
- C. Visual and Mechanical Inspection: Inspect for physical damage, proper alignment, anchorage, and grounding. Check proper installation and tightness of connections for circuit breakers, fusible switches, and fuses.

END OF SECTION

SECTION 16496

ENCLOSED TRANSFER SWITCH

1.0 GENERAL

1.1 SECTION INCLUDES

- A. Automatic transfer switch.

1.2 RELATED SECTIONS

- A. Section 16622 - Package Engine-Generator System

1.3 REFERENCES

- A. NFPA 70 - National Electrical Code.
- B. NEMA ICS 1 - General Standards for Industrial Control and Systems.
- C. NEMA ICS - Standards for Industrial Control Devices, Controllers, and Assemblies.
- D. NEMA ICS 6 - Enclosures for Industrial Controls and Systems.

1.4 SUBMITTALS

- A. Product Data: Provide catalog sheets showing voltage, switch size, ratings and size of switching and overcurrent protective devices, operating logic, short circuit ratings, dimensions, and enclosure details.
- B. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.

1.5 OPERATION AND MAINTENANCE DATA

- A. Operation Data: Include instructions for operating equipment. Include instructions for operating equipment under emergency conditions when engine generator is running.
- B. Maintenance Data: Include routine preventative maintenance and lubrication schedule. List special tools, maintenance materials, and replacement parts.

1.6 QUALIFICATIONS

- A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience, and with service facilities within 250 miles of Project.
- B. Supplier: Transfer Switch shall be supplied by the same company furnishing the engine generator specified under Section 16620 and shall be an Authorized distributor of specified manufacturer with minimum five years documented experience.

1.7 REGULATORY REQUIREMENTS

- A. Conform to requirements of NFPA 70.
- B. Furnish products listed and classified by UL as suitable for purpose specified and indicated.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Deliver, store, protect and handle products to site as recommended by manufacturer.
- B. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to internal components, enclosure and finish.

1.9 MAINTENANCE SERVICE

- A. Furnish service and maintenance of transfer switch for one year from Date of acceptance of final testing and start-up. Final acceptance and start-up may be postponed by owner up to 18 months from the date of this contract.

1.10 MAINTENANCE MATERIALS

- A. Provide two of each special tool required for maintenance.

2.0 PRODUCTS

2.1 MANUFACTURERS

- A. ONAN/Cummins
- B. Caterpillar

2.2 AUTOMATIC TRANSFER SWITCH

- A. Description: NEMA ICS , automatic transfer switch suitable for use as service equipment.
- B. Configuration: Electrically operated, mechanically held transfer switch.

2.3 SERVICE CONDITIONS

- A. Service Conditions: NEMA ICS 1.
- B. Temperature: 90 degrees F.
- C. Altitude: 7,500 feet.

2.4 RATINGS

- A. Voltage: 208/120 volts, three phase, four wire, 60 Hz.
- B. Switched Poles: 3.
- C. Load Inrush Rating: combination load.
- D. Continuous Rating: As indicated on the drawings
- E. Withstand Current Rating: 65,000 rms symmetrical amperes, when used with molded case circuit breaker.

2.5 PRODUCT OPTIONS AND FEATURES

- A. Indicating Lights: Mount in cover of enclosure to indicate NORMAL SOURCE AVAILABLE, ALTERNATE SOURCE AVAILABLE, SWITCH POSITION.
- B. Test Switch: Mount in cover of enclosure to simulate failure of normal source.
- C. Return to Normal Switch: Mount in cover of enclosure to initiate manual transfer from alternate to normal source.
- D. Transfer Switch Auxiliary Contacts: 1 normally open; 1 normally closed.
- E. Normal Source Monitor: Monitor each line of normal source voltage and frequency; initiate transfer when voltage drops below 85 percent or frequency varies more than 3 percent from rated nominal value.
- F. Alternate Source Monitor: Monitor alternate source voltage and frequency; inhibit transfer when voltage is below 85 percent or frequency varies more than 3 percent from rated nominal value.

2.6 AUTOMATIC SEQUENCE OF OPERATION

- A. Initiate Time Delay to Start Alternate Source Engine Generator: Upon initiation by normal source monitor.
- B. Time Delay to Start Alternate Source Engine Generator: 0 to 15 seconds, adjustable.
- C. Initiate Transfer Load to Alternate Source: Upon initiation by normal source monitor and permission by alternate source monitor.
- D. Time Delay Before Transfer to Alternate Power Source: 2 to 120 seconds, adjustable.
- E. Initiate Retransfer Load to Normal source: Upon permission by normal source monitor.
- F. Time Delay Before Transfer to Normal Power: 0 to 30 minutes, adjustable; bypass time delay in event of alternate source failure.
- G. Time Delay Before Engine Shutdown: 0 to 10 minutes, adjustable.
- H. Engine Exerciser: Start engine every 7 days; run for 30 minutes before shutting down. Bypass exerciser control if normal source fails during exercising period.
- I. Alternate System Exerciser: Provisions for Transfer of load to alternate source during engine exercising period.

2.7 ENCLOSURE

- A. Enclosure: ICS 6, NEMA 3R.
- B. Finish: Manufacturer's standard enamel Finish.

3.0 EXECUTION

3.1 INSTALLATION

- A. Install transfer switches in accordance with manufacturer's instructions.
- B. Provide engraved plastic nameplates under the provisions of Section 16195.

3.2 MANUFACTURER'S FIELD SERVICE

- A. Prepare and start systems under provisions of Division 1

3.3 DEMONSTRATION

- A. Provide systems demonstration under provisions of Division 1.
- B. Demonstrate operation of transfer switch in bypass, normal, and emergency modes.

END OF SECTION

Division 16622 – Electrical
Emergency/Standby Power System
Generator Set

Part 1. GENERAL

1.01 Scope

- A. Provide complete factory assembled generator set equipment with digital (microprocessor-based) electronic generator set controls, digital governor, and digital voltage regulator.
- B. Provide factory test, startup by a supplier authorized by the equipment manufacturer(s), and on-site testing of the system.
- C. The generator set manufacturer shall warrant all equipment provided under this section, whether or not is manufactured by the generator set manufacturer, so that there is one source for warranty and product service. Technicians specifically trained and certified by the manufacturer to support the product and employed by the generator set supplier shall service the generator sets.

1.02 Codes and Standards

- A. The generator set installation and on-site testing shall conform to the requirements of the following codes and standards, as applicable. The generator set shall include necessary features to meet the requirements of these standards.
 - 1. CSA 282, 1989 Emergency Electrical Power Supply for Buildings
 - 2. IEEE446 – Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
 - 3. NFPA37 –
 - 4. NFPA70 – National Electrical Code. Equipment shall be suitable for use in systems in compliance to Article 700, 701, and 702.
 - 5. NFPA99 – Essential Electrical Systems for Health Care Facilities
 - 6. NFPA110 – Emergency and Standby Power Systems. The generator set shall meet all requirements for Level 1 systems. Level 1 prototype tests required by this standard shall have been performed on a complete and functional unit, component level type tests will not substitute for this requirement.
- B. The generator set and supplied accessories shall meet the requirements of the following standards:
 - 1. NEMA MG1. Alternator shall comply with the requirements of the current version this standard as they apply to AC alternators.
 - 2. UL142 – Sub-base Tanks
 - 3. UL1236 – Battery Chargers
 - 4. UL2200. The generator set shall be listed to UL2200 or submit to an independent third party certification process to verify compliance as installed..
- C. The control system for the generator set shall comply with the following requirements.
 - 1. CSA C22.2, No. 14 – M91 Industrial Control Equipment.
 - 2. EN50082-2, Electromagnetic Compatibility – Generic Immunity Requirements, Part 2: Industrial.
 - 3. EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
 - 4. FCC Part 15, Subpart B.
 - 5. IEC8528 part 4. Control Systems for Generator Sets
 - 6. IEC Std 801.2, 801.3, and 801.5 for susceptibility, conducted, and radiated electromagnetic emissions.
 - 7. UL508. The entire control system of the generator set shall be UL508 listed and labeled.

8. UL1236 –Battery Chargers.

- D. The generator set manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.

1.03 Acceptable Manufacturers

Only approved bidders shall supply equipment provided under this contract. Equipment specifications for this project are based on generator sets manufactured by Cummins Power Generation with microprocessor-based controls. Equipment by other suppliers that meets the requirement of this specification are acceptable, if approved not less than 2 weeks before scheduled bid date. Proposals must include a line by line compliance statement based on this specification.

Part 2. PRODUCTS

2.01 Generator set

A. Ratings

1. The generator set shall operate at 1800 rpm and at a voltage of: 208Volts AC, Three phase, four-wire, 60 hertz.
2. The generator set shall be rated at 250kW, 312.5 kVA at 0.8 PF, standby rating.
3. Site conditions: Altitude 7,200ft, ambient temperatures up to 122 degrees F.
4. The generator set rating shall be based on standby service.

B. Performance

1. Voltage regulation shall be plus or minus 0.5 percent for any constant load between no load and rated load. Random voltage variation with any steady load from no load to full load shall not exceed plus or minus 0.5 percent.
2. Frequency regulation shall be isochronous from steady state no load to steady state rated load. Random frequency variation with any steady load from no load to full load shall not exceed plus or minus 0.5%.
3. The diesel engine-generator set shall accept a single step load of 100% nameplate kW and power factor, less applicable derating factors, with the engine-generator set at operating temperature.
4. Motor starting capability shall be a minimum of 231 kVA. The generator set shall be capable of recovering to a minimum of 90% of rated no load voltage following the application of the specified kVA load at near zero power factor applied to the generator set. Maximum voltage dip on application of this load, considering both alternator performance and engine speed changes shall not exceed 25%.
5. The alternator shall produce a clean AC voltage waveform, with not more than 5% total harmonic distortion at full linear load, when measured from line to neutral, and with not more than 3% in any single harmonic, and no 3rd order harmonics or their multiples. Telephone influence factor shall be less than 40.
6. The generator set shall be certified by the engine manufacturer to be suitable for use at the installed location and rating, and shall meet all applicable exhaust emission requirements at the time of commissioning.

C. Construction

1. The engine-generator set shall be mounted on a heavy-duty steel base to maintain alignment between components. The base shall incorporate a battery tray with hold-down clamps within the rails.
2. All switches, lamps, and meters in the control system shall be oil-tight and dust-tight. All active control components shall be installed within a UL/NEMA 3R enclosure. There shall be no exposed points in the control (with the door open) that operate in excess of 50 volts.

D. Connections

1. The generator set load connections shall be composed of silver or tin plated copper bus bars, drilled to accept mechanical or compression terminations of the number and type as shown on the drawings. Sufficient lug space shall be provided for use with cables of the number and size as shown on the drawings.
2. Power connections to auxiliary devices shall be made at the devices, with required protection located at a wall-mounted common distribution panel.
3. Generator set control interfaces to other system components shall be made on a permanently labeled terminal block assembly. Labels describing connection point functions shall be provided.

2.02 Engine and Engine Equipment

The engine shall be diesel, 4 cycle, radiator and fan cooled. Minimum displacement shall be 610 cubic inches, with six cylinders. The horsepower rating of the engine at its minimum tolerance level shall be sufficient to drive the alternator and all connected accessories. Two cycle engines are not acceptable. Engine accessories and features shall include:

- A. An electronic governor system shall provide automatic isochronous frequency regulation. The governing system dynamic capabilities shall be controlled as a function of engine coolant temperature to provide fast, stable operation at varying engine operating temperature conditions. The control system shall actively control the fuel rate and excitation as appropriate to the state of the generator set. Fuel rate shall be regulated as a function of starting, accelerating to start disconnect speed, accelerating to rated speed. The governing system shall include a programmable warm up at idle and cooldown at idle function. While operating in idle state, the control system shall disable the alternator excitation system.
- B. Skid-mounted radiator and cooling system rated for full load operation in 122 degrees F (50 degrees C) ambient as measured at the alternator air inlet. Radiator fan shall be suitable for use in a system with 0.5 in H₂O restriction. Radiator shall be sized based on a core temperature that is 20F higher than the rated operation temperature, or prototype tested to verify cooling performance of the engine/radiator/fan operation in a controlled environment. Radiator shall be provided with a duct adapter flange. The equipment manufacturer shall fill the cooling system with a 50/50-ethylene glycol/water mixture prior to shipping. Rotating parts shall be guarded against accidental contact.
- C. Electric starter(s) capable of three complete cranking cycles without overheating.
- D. Positive displacement, mechanical, full pressure, lubrication oil pump.
- E. Full flow lubrication oil filters with replaceable spin-on canister elements and dipstick oil level indicator.
- F. An engine driven, mechanical, positive displacement fuel pump. Fuel filter with replaceable spin-on canister element. Fuel cooler, suitable for operation of the generator set at full rated load in the ambient temperature specified shall be provided if required for operation due to the design of the engine and the installation.
- G. Replaceable dry element air cleaner with restriction indicator.
- H. Flexible supply and return fuel lines.
- I. Engine mounted battery charging alternator, 40-ampere minimum, and solid-state voltage regulator.
- J. Coolant heater
 - 1. Engine mounted, thermostatically controlled, coolant heater(s) for each engine. Heater voltage shall be as shown on the project drawings. The coolant heater shall be UL499 listed and labeled.
 - 2. The coolant heater shall be installed on the engine with silicone hose connections. Steel tubing shall be used for connections into the engine coolant system wherever the length of pipe run exceeds 12 inches. The coolant heater installation shall be specifically designed to provide proper venting of the system. The coolant heaters shall provisions to isolate the heater for replacement of the heater element without draining the coolant from the generator set. The quick disconnect/automatic sealing couplers shall allow the heater element to be replaced without draining the engine cooling system or significant coolant loss.
 - 3. The coolant heater shall be provided with a DC thermostat, installed at the engine thermostat housing. An AC power connection box shall be provided for a single AC power connection to the coolant heater system.
 - 4. The coolant heater(s) shall be sized as recommended by the engine manufacturer to warm the engine to a minimum of 104F (40C) in a 40F (4C) ambient, in compliance with NFPA110 requirements, or the temperature required for starting and load pickup requirements of this specification.
- K. Provide vibration isolators, spring/pad type, quantity as recommended by the generator set manufacturer. Isolators shall include seismic restraints if required by site location.
- L. Starting and Control Batteries shall be calcium/lead antimony type, 24 volt DC, sized as recommended by the engine manufacturer, complete with battery cables and connectors. The batteries shall be capable of a minimum of three complete 15-second cranking cycles at 40F ambient temperature when fully charged.
- M. Provide exhaust silencer(s) for each engine of size and type as recommended by the generator set manufacturer and approved by the engine manufacturer. The mufflers shall be critical grade. Exhaust system shall be installed according to the engine manufacturer's recommendations and applicable codes and standards.

- N. Provide a minimum 12 amp battery charger for each generator set battery bank. Generator sets incorporating two battery banks shall be provided with two chargers connected together and operating in parallel, with alarm output(s) connected in parallel. The charger(s) shall include the following capabilities:
1. Chargers shall be UL 1236-BBHH listed and CSA or CUL certified for use in emergency applications.
 2. The charger shall be compliant with UL991 requirements for vibration resistance.
 3. The charger shall comply with the requirements of EN61000-4-5 for voltage surge resistance; EN50082-2 for immunity; EN61000-4-2 for ESD; EN61000-4-3 for radiated immunity; ANSI/IEEE C62.41 category B and IN61000-4-4 for electrically fast transient; EN61000-4-6 for conducted emissions; and FCC Part 15 Class A for radiated emissions.
 4. The charger shall be capable of charging a fully discharged battery without damage to the charger. It shall be capable of returning a fully discharged battery to fully charged condition within 24 hours. The charger shall be UL-labeled with the maximum battery amp-hour rating that can be recharged within 24 hours. The label shall indicate that the charger is suitable for charging of 200AH batteries per NFPA requirements.
 5. The charger shall incorporate a 4-state charging algorithm, to provide trickle charge rate to restore fully discharged batteries, a bulk charge rate to provide fastest possible recharge after normal discharge, an absorption state to return the battery to 100 percent of charge, and a float stage to maintain a fully charge battery and supply battery loads when the generator set is not operating. In addition, the charger shall include an equalization timer. Charge rates shall be temperature compensated based on the temperature directly sensed at the battery.
 6. The DC output voltage regulation shall be within plus or minus 1%. The DC output ripple current shall not exceed 1 amp at rated output current level.
 7. The charger shall include the following features:
 - a) two line alphanumeric display with programming keys to allow display of DC output ammeter and voltmeters (5% accuracy or better), display alarm messages, and perform programming;
 - b) LED indicating lamp(s) to indicating normal charging condition (green), equalize charge state (amber), and fault condition (red);
 - c) AC input overcurrent, over voltage, and undervoltage protection;
 - d) DC output overcurrent protection;
 - e) Alarm output relay
 - f) Corrosion resistant aluminum enclosure

2.03 AC Generator

- A. The AC generator shall be; synchronous, four pole, 2/3 pitch, revolving field, drip-proof construction, single prelubricated sealed bearing, air cooled by a direct drive centrifugal blower fan, and directly connected to the engine with flexible drive disc. All insulation system components shall meet NEMA MG1 temperature limits for Class H insulation system and shall be UL1446 listed. Actual temperature rise measured by resistance method at full load shall not exceed 105 degrees Centigrade.
- B. The generator shall be capable of delivering rated output (kVA) at rated frequency and power factor, at any voltage not more than 5 percent above or below rated voltage.
- C. A permanent magnet generator (PMG) shall be included to provide a reliable source of excitation power for optimum motor starting and short circuit performance. The PMG and controls shall be capable of sustaining and regulating current supplied to a single phase or three phase fault at approximately 300% of rated current for not more than 10 seconds.
- D. The subtransient reactance of the alternator shall not exceed 15 percent, based on the standby rating of the generator set.

2.04 Generator set Control. The generator set shall be provided with a microprocessor-based control system that is designed to provide automatic starting, monitoring, and control functions for the generator set. The control system shall also be designed to allow local monitoring and control of the generator set, and remote monitoring and control as described in this specification.

The control shall be mounted on the generator set, or may be mounted in a free-standing panel next to the generator set if adequate space and accessibility is available. The control shall be vibration isolated and prototype tested to verify the durability of all components in the system under the vibration conditions encountered.

The generator set mounted control shall include the following features and functions:

- A. Control Switches

1. Mode Select Switch. The mode select switch shall initiate the following control modes. When in the RUN or MANUAL position the generator set shall start, and accelerate to rated speed and voltage as directed by the operator. A separate push-button to initiate starting is acceptable. In the OFF position the generator set shall immediately stop, bypassing all time delays. In the AUTO position the generator set shall be ready to accept a signal from a remote device to start and accelerate to rated speed and voltage.
 2. EMERGENCY STOP switch. Switch shall be Red "mushroom-head" push-button. Depressing the emergency stop switch shall cause the generator set to immediately shut down, and be locked out from automatic restarting.
 3. RESET switch. The RESET switch shall be used to clear a fault and allow restarting the generator set after it has shut down for any fault condition.
 4. PANEL LAMP switch. Depressing the panel lamp switch shall cause the entire panel to be lighted with DC control power. The panel lamps shall automatically be switched off 10 minutes after the switch is depressed, or after the switch is depressed a second time.
- B. Generator Set AC Output Metering. The generator set shall be provided with a metering set including the following features and functions:
1. Digital metering set, 1% accuracy, to indicate generator RMS voltage and current, frequency, output current, output KW, KW-hours, and power factor. Generator output voltage shall be available in line-to-line and line-to-neutral voltages, and shall display all three-phase voltages (line to neutral or line to line) simultaneously.
 2. Analog voltmeter, ammeter, frequency meter, power factor meter, and kilowatt (KW) meter. Voltmeter and ammeter shall display all three phases. Meter scales shall be color coded in the following fashion: green shall indicate normal operating condition, amber shall indicate operation in ranges that indicate potential failure, and red shall indicate failure impending. Metering accuracy shall be within 1% at rated output. Both analog and digital metering are required.
 3. The control system shall monitor the total load on the generator set, and maintain data logs of total operating hours at specific load levels ranging from 0 to 110% of rated load, in 10% increments. The control shall display hours of operation at less than 30% load and total hours of operation at more than 90% of rated load.
 4. The control system shall log total number of operating hours, total KWH, and total control on hours, as well as total values since reset.
- C. Generator Set Alarm and Status Display.
1. The generator set control shall include LED alarm and status indication lamps. The lamps shall be high-intensity LED type. The lamp condition shall be clearly apparent under bright room lighting conditions. Functions indicated by the lamps shall include:
 - The control shall include five configurable alarm-indicating lamps. The lamps shall be field adjustable for any status, warning, or shutdown function monitored by the genset. They shall also be configurable for color, and control action (status, warning, or shutdown).
 - The control shall include green lamps to indicate that the generator set is running at rated frequency and voltage, and that a remote start signal has been received at the generator set. The running signal shall be based on actual sensed voltage and frequency on the output terminals of the generator set.
 - The control shall include a flashing red lamp to indicate that the control is not in automatic state, and red common shutdown lamp.
 - The control shall include an amber common warning indication lamp.
 2. The generator set control shall indicate the existence of the warning and shutdown conditions on the control panel. All conditions indicated below for warning shall be field-configurable for shutdown. Conditions required to be annunciated shall include:
 - low oil pressure (warning)
 - low oil pressure (shutdown)
 - oil pressure sender failure (warning)
 - low coolant temperature (warning)
 - high coolant temperature (warning)
 - high coolant temperature (shutdown)
 - high oil temperature (warning)
 - engine temperature sender failure (warning)
 - low coolant level (warning)
 - fail to crank (shutdown)
 - fail to start/overcrank (shutdown)
 - overspeed (shutdown)
 - low DC voltage (warning)
 - high DC voltage (warning)
 - weak battery (warning)
 - low fuel-daytank (warning)

high AC voltage (shutdown)
low AC voltage (shutdown)
under frequency (shutdown)
over current (warning)
over current (shutdown)
short circuit (shutdown)
ground fault (warning)
over load (warning)
emergency stop (shutdown)
(4) configurable conditions

3. Provisions shall be made for indication of four customer-specified alarm or shutdown conditions. Labeling of the customer-specified alarm or shutdown conditions shall be of the same type and quality as the above-specified conditions. The non-automatic indicating lamp shall be red, and shall flash to indicate that the generator set is not able to automatically respond to a command to start from a remote location.

D. Engine Status Monitoring.

1. The following information shall be available from a digital status panel on the generator set control :
 - engine oil pressure (psi or kPA)
 - engine coolant temperature (degrees F or C)
 - engine oil temperature (degrees F or C)
 - engine speed (rpm)
 - number of hours of operation (hours)
 - number of start attempts
 - battery voltage (DC volts)
2. The control system shall also incorporate a data logging and display provision to allow logging of the last 10 warning or shutdown indications on the generator set, as well as total time of operation at various loads, as a percent of the standby rating of the generator set.

E. Engine Control Functions.

1. The control system provided shall include a cycle cranking system, which allows for user selected crank time, rest time, and # of cycles. Initial settings shall be for 3 cranking periods of 15 seconds each, with 15-second rest period between cranking periods.
2. The control system shall include an idle mode control, which allows the engine to run in idle mode in the RUN position only. In this mode, the alternator excitation system shall be disabled.
3. The control system shall include an engine governor control, which functions to provide steady state frequency regulation as noted elsewhere in this specification. The governor control shall include adjustments for gain, damping, and a ramping function to control engine speed and limit exhaust smoke while the unit is starting.
4. The control system shall include time delay start (adjustable 0-300 seconds) and time delay stop (adjustable 0-600 seconds) functions.
5. The control system shall include sender failure monitoring logic for speed sensing, oil pressure, and engine temperature which is capable of discriminating between failed sender or wiring components, and an actual failure conditions.

F. Alternator Control Functions:

1. The generator set shall include a full wave rectified automatic digital voltage regulation system that is matched and prototype tested by the engine manufacturer with the governing system provided. It shall be immune from misoperation due to load-induced voltage waveform distortion and provide a pulse width modulated output to the alternator exciter. The voltage regulation system shall be equipped with three-phase line to neutral RMS sensing and shall control buildup of AC generator voltage to provide a linear rise and limit overshoot. The system shall include a torque-matching characteristic, which shall reduce output voltage in proportion to frequency below an adjustable frequency threshold. Torque matching characteristic shall be adjustable for roll-off frequency and rate, and be capable of being curve-matched to the engine torque curve with adjustments in the field. The voltage regulator shall include adjustments for gain, damping, and frequency roll-off. Adjustments shall be broad range, and made via digital raise-lower switches, with an alphanumeric LED readout to indicate setting level. Rotary potentiometers for system adjustments are not acceptable.

2. A microprocessor-based protection device shall be provided to individually monitor all phases of the output current of the generator set and initiate an alarm (over current warning) when load current exceeds 110% of the rated current of the generator set on any phase for more than 60 seconds. The device shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (over current shutdown). The protective functions provided shall be in compliance to the requirements of NFPA70 article 445.
3. A microprocessor-based protection device shall be provided to monitor all phases of the output current for short circuit conditions. The control/protection system shall monitor the current level and voltage. The controls shall shut down and lock out the generator set when output current level approaches the thermal damage point of the alternator (short circuit shutdown). The protective functions provided shall be in compliance to the requirements of NFPA70 article 445.
4. Controls shall be provided to monitor the KW load on the generator set, and initiate an alarm condition (over load) when total load on the generator set exceeds the generator set rating for in excess of 5 seconds. Controls shall include a load shed control, to operate a set of dry contacts (for use in shedding customer load devices) when the generator set is overloaded.
5. A microprocessor-based AC over/under voltage monitoring system that responds only to true RMS voltage conditions shall be provided. The system shall initiate shutdown of the generator set when alternator output voltage exceeds 110% of the operator-set voltage level for more than 10 seconds, or with no intentional delay when voltage exceeds 130%. Under voltage shutdown shall occur when the output voltage of the alternator is less than 85% for more than 10 seconds. The system shall monitor individual phases and be connected line to neutral on 3-phase 4-wire generator sets, and for systems that are solidly grounded.
6. When required by National Electrical Code or indicated on project drawings, the control System shall include a ground fault monitoring relay. The relay shall be adjustable from 3.8-1200 amps, and include adjustable time delay of 0-10.0 seconds. The relay shall be for indication only, and not trip or shut down the generator set. Note bonding and grounding requirements for the generator set, and provide relay that will function correctly in system as installed.
7. The generator set control shall include a 120VAC-control heater.

G. Other Control Functions

1. The generator set shall be provided with a network communication module to allow LonMark compliant communication with the generator set control by remote devices. The control shall communicate all engine and alternator data, and allow starting and stopping of the generator set via the network in both test and emergency modes.
2. A battery monitoring system shall be provided which initiates alarms when the DC control and starting voltage is less than 25VDC or more than 32 VDC. During engine cranking (starter engaged), the low voltage limit shall be disabled, and DC voltage shall be monitored as load is applied to the battery, to detect impending battery failure or deteriorated battery condition.

H. Control Interfaces for Remote Monitoring:

1. The control system shall provide four programmable output relays. These relay outputs shall be configurable for any alarm, shutdown, or status condition monitored by the control. The relays shall be configured to indicate: (1) generator set operating at rated voltage and frequency, (2) common warning, (3) common shutdown, (4) load shed command.
2. A fused 10 amp switched 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit whenever the generator set is running.
3. A fused 10 amp 24VDC power supply circuit shall be provided for customer use. DC power shall be available from this circuit at all times from the engine starting/control batteries.
4. The control shall be provided with a direct serial communication link for the LonWorks communication network interface as described elsewhere in this specification and shown on the drawings.

2.05 Other equipment to be provided with the generator set

- A. Provide and install a 20-light LED type remote alarm annunciator with horn, located as shown on the drawings or in a location that can be conveniently monitored by facility personnel. The remote annunciator shall provide all the audible and visual alarms called for by NFPA Standard 110 for level 1 systems for the local generator control panel. Spare lamps shall be provided to allow future addition of other alarm and status functions to the annunciator. Provisions for labeling of the annunciator in a fashion consistent with the specified functions shall be provided. Alarm silence and lamp test switch(es) shall be provided. LED lamps shall be replaceable, and indicating lamp color shall be capable of changes needed for specific application requirements. Alarm horn shall be switchable for all annunciation points. Alarm horn (when switched on) shall sound for first fault, and all subsequent faults, regardless of whether first fault has

been cleared, in compliance with NFPA110 3-5.6.2. The interconnecting wiring between the annunciator and other system components shall be monitored and failure of the interconnection between components shall be displayed on the annunciator panel.

B. The annunciator shall include the following alarm labels, audible annunciation features, and lamp colors:

<u>Condition</u>	<u>Lamp Color</u>	<u>Audible Alarm</u>
Normal Power (to Loads)	Green	No
Genset Supplying Load	Amber	No
Genset Running	Green	No
Not in Auto	Red (Flashing)	Yes
High Battery Voltage	Red	Yes
Low Battery Voltage	Red	Yes
Charger AC Failure	Red	Yes
Fail to Start	Red	Yes
Low Engine Temperature	Amber	Yes
Pre-High Engine Temperature	Amber	Yes
High Engine Temperature	Red	Yes
Pre-Low Oil Pressure	Amber	Yes
Low Oil Pressure	Red	Yes
Overspeed	Red	Yes
Low Coolant Level	Amber	Yes
Low Fuel Level	Amber	Yes
Network OK	Green	Yes
(4) Spares	Configurable	Configurable

Low battery voltage lamp shall also be lighted for low cranking voltage or weak battery alarm.

C. The generator set shall be provided with a mounted main line circuit breaker rated for 200 amps, sized to carry the rated output current of the generator set. The circuit breaker shall incorporate an electronic trip unit that operates to protect the alternator under all overcurrent conditions, or a thermal-magnetic trip with other overcurrent protection devices that positively protect the alternator under overcurrent conditions. The supplier shall submit time overcurrent characteristic curves and thermal damage curve for the alternator, demonstrating the effectiveness of the protection provided.

D. Outdoor Weather-Protective Enclosure

1. The generator set shall be provided with an outdoor enclosure, with the entire package listed under UL2200. The package shall comply with the requirements of the National Electrical Code for all wiring materials and component spacing. The total assembly of generator set, enclosure, and sub-base fuel tank (when used) shall be designed to be lifted into place using spreader bars. Housing shall provide ample airflow for generator set operation at rated load in an ambient temperature of 100F. The housing shall have hinged access doors as required to maintain easy access for all operating and service functions. All doors shall be lockable, and include retainers to hold the door open during service. Enclosure roof shall be cambered to prevent rainwater accumulation. Openings shall be screened to limit access of rodents into the enclosure. All electrical power and control interconnections shall be made within the perimeter of the enclosure.

2. All sheet metal shall be primed for corrosion protection and finish painted with **OWNER SELECTED COLOR BEIGE TO MATCH SURROUNDING TERRAIN** using a two step electrocoating paint process, or equal meeting the performance requirements specified below. All surfaces of all metal parts shall be primed and painted. The painting process shall result in a coating that meets the following requirements:

Primer thickness, 0.5-2.0 mils. Top coat thickness, 0.8-1.2 mils.

Gloss, per ASTM D523-89, 80% plus or minus 5%. Gloss retention after one year shall exceed 50%.

Crosshatch adhesion, per ASTM D3359-93, 4B-5B.

Impact resistance, per ASTM D2794-93, 120-160 inch-pounds.

Salt Spray, per ASTM B117-90, 1000+ hours.

Humidity, per ASTM D2247-92, 1000+ hours.

Water Soak, per ASTM D2247-92, 1000+ hours.

3. Painting of hoses, clamps, wiring harnesses, and other non-metallic service parts shall not be acceptable. Fasteners used shall be corrosion resistant, and designed to minimize marring of the painted surface when removed for normal installation or service work.
 4. Enclosure shall be constructed of minimum 12 gauge steel for framework and 14 gauge steel for panels. All hardware and hinges shall be stainless steel.
 5. A factory-mounted exhaust silencer shall be installed inside the enclosure. The exhaust shall exit the enclosure through a rain collar and terminate with a rain cap. Exhaust connections to the generator set shall be through seamless flexible connections.
 6. The enclosure shall include the following maintenance provisions:
 - Flexible coolant and lubricating oil drain lines, that extend to the exterior of the enclosure, with internal drain valves
 - External radiator fill provision.
- E. Provide a sub-base fuel tank for the generator set, sized to allow for full load operation of the generator set for 24 hours, no exceptions. The sub-base fuel tank shall be UL142 listed and labeled. Installation shall be in compliance to NFPA37. The fuel tank shall be a double-walled, steel construction and include the following features:
1. Emergency tank and basin vents.
 2. Mechanical level gauge.
 3. Fuel supply and return lines, connected to generator set with flexible fuel lines as recommended by the engine manufacturer and in compliance to UL2200 and NFPA 37 requirements.
 4. Leak detection provisions, wired to the generator set control for local and remote alarm indication.
 5. High and low level float switches to indicate fuel level. Wire switches to generator control for local and remote indication of fuel level
 6. Basin drain.
 7. Integral lifting provisions.

Part 3. OPERATION

3.01 Sequence of Operation

- A. Generator set shall start on receipt of a start signal from remote equipment. The start signal shall be via hardwired connection to the generator set control and a redundant signal over the required network connection.
- B. The generator set shall complete a time delay start period as programmed into the control.
- C. The generator set control shall initiate the starting sequence for the generator set. The starting sequence shall include the following functions:
- D. The control system shall verify that the engine is rotating when the starter is signaled to operate. If the engine does not rotate after two attempts, the control system shall shut down and lock out the generator set, and indicate "fail to crank" shutdown.
- E. The engine shall fire and accelerate as quickly as practical to start disconnect speed. If the engine does not start, it shall complete a cycle cranking process as described elsewhere in this specification. If the engine has not started by the completion of the cycle cranking sequence, it shall be shut down and locked out, and the control system shall indicate "fail to start".
- F. The engine shall accelerate to rated speed and the alternator to rated voltage. Excitation shall be disabled until the engine has exceeded programmed idle speed, and regulated to prevent over voltage conditions and oscillation as the engine accelerates and the alternator builds to rated voltage.
- G. On reaching rated speed and voltage, the generator set shall operate as dictated by the control system in isochronous state.
- H. When all start signals have been removed from the generator set, it shall complete a time delay stop sequence. The duration of the time delay stop period shall be adjustable by the operator.
- I. On completion of the time delay stop period, the generator set control shall switch off the excitation system and shall shut down.
- J. Any start signal received after the time stop sequence has begun shall immediately terminate the stopping sequence and return the generator set to isochronous operation.

Part 4. OTHER REQUIREMENTS

4.01 Submittals.

- A. Within 10 days after award of contract, provide six sets of the following information for review:
 - Manufacturer's product literature and performance data, sufficient to verify compliance to specification requirements.
 - A paragraph by paragraph specification compliance statement, describing the differences between the specified and the proposed equipment.
 - Manufacturer's certification of prototype testing.
 - Manufacturer's published warranty documents.
 - Shop drawings showing plan and elevation views with certified overall dimensions, as well as wiring interconnection details.
 - Interconnection wiring diagrams showing all external connections required; with field wiring terminals marked in a consistent point-to-point manner.
 - Manufacturer's installation instructions.

4.02 Factory Testing.

- A. The generator set manufacturer shall perform a complete operational test on the generator set prior to shipping from the factory. A certified test report shall be provided. Equipment supplied shall be fully tested at the factory for function and performance.
- B. Factory testing may be witnessed by the owner and consulting engineer. Costs for travel expenses will be the responsibility of the owner and consulting engineer. Supplier is responsible to provide two weeks notice for testing.
- C. Generator set factory tests on the equipment shall be performed at rated load and rated power factor. Generator sets that have not been factory tested at rated power factor will not be acceptable. Tests shall include: run at full load, maximum power, voltage regulation, transient and steady-state governing, single step load pickup, and function of safety shutdowns.

4.03 Installation

- A. Equipment shall be installed by the contractor in accordance with final submittals and contract documents. Installation shall comply with applicable state and local codes as required by the authority having jurisdiction. Install equipment in accordance with manufacturer's instructions and instructions included in the listing or labeling of UL listed products.
- B. Installation of equipment shall include furnishing and installing all interconnecting wiring between all major equipment provided for the on-site power system. The contractor shall also perform interconnecting wiring between equipment sections (when required), under the supervision of the equipment supplier.
- C. Equipment shall be installed on concrete housekeeping pads. Equipment shall be permanently fastened to the pad in accordance with manufacturer's instructions and seismic requirements of the site.
- D. Equipment shall be initially started and operated by representatives of the manufacturer.
- E. All equipment shall be physically inspected for damage. Scratches and other installation damage shall be repaired prior to final system testing. Equipment shall be thoroughly cleaned to remove all dirt and construction debris prior to initial operation and final testing of the system.
- F. This is a critical path project for the County of Santa Fe. As such, all components for this project must be delivered complete and without short shipments, freight included, within four weeks of contract award.

4.04 On-Site Acceptance Test:

- A. The complete installation shall be tested for compliance with the specification following completion of all site work. Testing shall be conducted by representatives of the manufacturer, with required fuel supplied by Contractor. The Engineer shall be notified in advance and shall have the option to witness the tests.
- B. Installation acceptance tests to be conducted on-site shall include a "cold start" test, a two hour full load test, and a one step rated load pickup test in accordance with NFPA 110. Provide a resistive load bank and make temporary connections for full load test, if necessary.
- C. Perform a power failure test on the entire installed system. This test shall be conducted by opening the power supply from the utility service, and observing proper operation of the system for at least 2 hours. Coordinate timing and obtain approval for start of test with site personnel.

4.05 Training

- A. The equipment supplier shall provide training for the facility operating personnel covering operation and maintenance of the equipment provided. The training program shall be not less than 4 hours in duration and the class size shall be limited to 5 persons. Training date shall be coordinated with the facility owner.

4.06 Service and support

- A. The manufacturer of the generator set shall maintain service parts inventory at a central location which is accessible to the service location 24 hours per day, 365 days per year.
- B. The generator set shall be serviced by a local service organization that is trained and factory certified in generator set service. The supplier shall maintain an inventory of critical replacement parts at the local service organization, and in service vehicles. The service organization shall be on call 24 hours per day, 365 days per year.
- C. The manufacturer shall maintain model and serial number records of each generator set provided for at least 20 years.

4.07 Warranty

- A. The generator set and associated equipment shall be warranted for a period of not less than 5 years from the date of commissioning against defects in materials and workmanship.
- B. The warranty shall be comprehensive. No deductibles shall be allowed for travel time, service hours, repair parts cost, etc.