SECTION 01025 - MEASUREMENT AND PAYMENT

PART 1 - GENERAL

1.01 DESCRIPTION

A. Measurement and payment for bid items listed in the proposal shall be based upon use of a lump sum or unit price method. Extra work or changes in the Work shall be accomplished as provided in the Contract.

1.02 PAYMENT

A. Payment for Unit Price Items

Payment for a unit price bid item shall be based upon the amount shown in the bid schedule multiplied by the total quantity measurement of the item and shall be full compensation for furnishing all labor, transportation, materials, equipment, tools and appurtenances required for construction of the item complete in place in accordance with the Contract Documents.

B. Payment for Lump Sum Items

Payment for lump sum bid items shall be based upon the amount shown in the bid schedule and shall be full compensation for furnishing all labor, transportation, materials, equipment, tools and appurtenances required for construction of the unit complete in place in accordance with the Contract Documents.

C. Work Not Listed in the Bid Schedule

Costs for related work and appurtenances which are required and/or implied by the General Provisions, Technical Specifications, Special Provisions and Drawings, and are not listed as a separate bid item but are necessary to complete the project shall be included in the appropriate bid item or items within the proposal.

1.03 MEASUREMENT

A. General

Measurement for unit price quantities shall be based upon the appropriate bid item in the proposal. The actual quantity of measurement shall be as constructed by the Contractor in place in conformance with the Contract Documents.

B. Linear Measurements

Measurement for bid items involving linear units shall be based upon the linear measured in feet or as indicated in the bid item.

C. Area Measurements

Measurement for bid items involving area units shall be based upon the surface area measured in square yards, square feet or as indicated in the bid item.

D. Volume Measurements
Measurement for bid items involving volume units shall be based upon the volume measured in cubic yards, or as indicated in the bid item.

E. Unit Measurements
Measurement for bid items involving units of the item shall be based upon the number of units counted as indicated in the bid item.

F. Lump Sum Measurement
Measurement for a lump sum bid item shall be considered as a complete project or a portion of a project constituting a unit. The items to be included in the lump sum bid shall be as specified in the proposal bid item and/or the General or Special Conditions.

1.04 GENERAL DESCRIPTION OF BID ITEMS

A. General
This section covers methods of measurement and payment for items of Work under this Contract. The total Bid Price shall cover all Work required by the Contract Documents. All costs in connection with the proper and successful completion of the work, including furnishing all materials, equipment, supplies, and appurtenances; providing all construction plant, equipment, and tools; and performing all necessary labor and supervision to fully complete the Work, shall be included in the unit and lump sum prices bid. All Work not specifically set forth as a pay item in the Bid Form shall be considered a subsidiary obligation of Contractor and all costs in connection therewith shall be included in the prices bid. The descriptions of bid items provided hereafter apply to the Bid Schedule.

B. Estimated Quantities
All estimated quantities stipulated in the Bid Form or other Contract Documents are approximate and are to be used only (a) as a basis for estimation the probable cost of the Work and (b) for the purpose of comparing the bids submitted for the Work. The actual amounts of work done and materials furnished under unit price items may differ from the estimated quantities. The basis of payment for work and materials will be the actual amount of work done and materials furnished. Contractor agrees that he will make no claim for damages, anticipated profits, or otherwise on account of any difference between the amounts of work actually

C. Mobilization/Demobilization, Bid Item 01

1. Mobilization shall consist of preparatory work and operations, including but not be limited to, those necessary for the movement of personnel, equipment, supplies, and incidentals to the project site; for the establishment of all offices, buildings, construction yards, sanitary facilities, and any other facilities necessary for work on the project; and for all other work and operations which must be performed or costs incurred prior to beginning work on the various contract items on the project site, as well as the related demobilization costs anticipated at the
completion of the project. The cost of all bonds and insurance policies, including premiums and incidentals, shall be included in mobilization.

2. No additional compensation will be allowed for additional mobilizations required, including but not limited to, delays caused by the relocation of existing utility facilities shown on the plans or discovered during construction operations.

3. The deletion of work or the addition of extra work as provided for herein shall not affect the price paid for Mobilization.

4. The Contract lump sum price paid for Mobilization shall include the cost of all bonds and insurance policies and all costs incurred prior to beginning of work shall be considered to be included in and distributed proportionately through all the contract items of work, and no additional compensation will be allowed.

5. The contract lump sum price for mobilization/demobilization shall not exceed 3% of bid total.

D. Permit Fees Allowance, Bid Item 02

1. This item covers the direct cost of all the fees paid by the Contractor necessary to secure permits for project construction.

2. Contractor shall submit documentation of permit fees to the Owner, and the Owner shall reimburse the Contractor 100% of the permit fee at cost. There shall be no mark-up by the Contractor of permit fees. All other costs associated with acquisition of the permits shall be included under Bid Item 01.

3. Payment for Permit Fees Allowance will be made for all substantiated permit fees. Contractor shall submit documentation of permit fees to the Owner, and the Owner shall reimburse the Contractor 100% of the permit fee at cost. There shall be no mark-up by the Contractor of permit fees. All other costs associated with acquisition of the permits shall be included under Bid Item 01. If actual permit costs exceed the allowance of this bid item, a Change Order will be issued for all justified costs. The Contractor will only be reimbursed for costs incurred for payment of permits.

E. Physical Verification of Existing Utilities, Bid Item 03

1. Full compensation for work involved in potholing of existing utilities, including hiring a private utility locator to locate utilities prior to potholing, and documenting all found utilities on redlined as-built's provided to the owner, shall be considered as included in the LUMP SUM price paid for “Physical Verification of Existing Utilities” as required for construction shown on the plans, as specified in these Special Provisions, and as directed by the Engineer and no separate payment shall be made therefor.
F. Clearing, Grubbing, and Grading, Bid Item 04

1. Payment for site clearing and soil preparation will be made at the lump sum price named in the Bid Schedule under Item 03. The price for the bid shall constitute full compensation for providing all labor, materials, equipment, supplies, testing and appurtenant work necessary to the work complete in place, as identified herein and specified in the Contract Documents.

2. The price shall constitute full compensation for removal of vegetation, structures and trees, where shown, scarifying, and sterilizing existing soil, and preparation and compaction of subgrade beneath concrete structures in accordance with geotechnical report requirements, disposal of excess excavated material, localized pavement saw cutting, removal and replacement where shown, and any appurtenant work as shown on the Plans or called for in the Specifications.

G. Landscape and Rock Finish, Bid Item 05

1. Payment for landscape and rock will be made at the lump sum price named in the Bid Schedule under Item 05. The price for the bid shall constitute full compensation for providing all labor, materials, equipment, supplies, and appurtenant work necessary to the work complete in place, as identified herein and specified in the Contract Documents.

2. The price shall constitute full compensation for final finish grading, pre-emergent application, purchase and deliver of 1” diameter landscape rock, and placement of rock, final cleaning of the site, and other activities to provide a clean, neat, finished surface, including everything necessary or incidental thereto to complete the Work in accordance with the Contract Documents.

H. Construct Site Improvement, Bid Item 06

1. This item covers all the work necessary for the construction of the Site Improvements. The lump sum price shall include providing all labor, materials, equipment, supplies, testing and appurtenant work necessary or incidental to the construction of the project, complete in place and in accordance with the Contract Documents. Work under this bid item shall include, but not be limited to, the following:

   a. Installation of emergency backup generator, weatherproof sound attenuated enclosure, fuel tank and other appurtenant equipment.

   b. Installation of ATSSs, breakers, conduit and wiring, pull boxes, ground rod system and junction boxes.

   c. Installation of emergency backup generator and ATSSs concrete pads.

   d. Other miscellaneous work required for the construction of On-Site improvements that are not specifically addressed above.
e. Removal of existing backup generator & concrete pad, ATSs, conduit and wiring in accordance with the Contract Documents.

2. Payment for construction of the Site Improvements will be made at the lump sum price named in the Bid Schedule under Item 06. The price for the bid shall constitute full compensation for providing all labor, materials, equipment, supplies, testing and appurtenant work necessary to the work complete in place as shown and specified in the Contract Documents, and no additional compensation will be allowed.

END OF SECTION
PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. It is the intent of this section of the Specifications that the Contractor furnishes all labor, supervision, tools, equipment, and materials necessary for erecting complete and ready for continuous use, a tested and working electrical system, substantially as indicated on the Plans and hereinafter specified.

B. These Specifications are intended to provide a broad outline of the work and equipment required, but are not intended to include all the details of design and construction. The Owner reserves the right to make minor changes to the location of the equipment at no cost change in the contract.

C. The electrical plans are diagrammatic, approximately to scale. However, they shall not be used for exact locations. The Contractor shall verify all dimensions from the detailed drawings and approved shop drawings and shall coordinate these dimensions with the actual field conditions. Actual distances, locations, and elevations will be governed by field conditions.

D. Allowance has been made in the design for the number of conduits, cables and conductors that the Owner considers adequate for feeding various drives and equipment. These circuits and diagrams are based on available data pertaining to a particular design of equipment and portray the systems that the Owner has chosen to affect the required operation and level of control. Equipment provided by the Contractor (even though of the make and model specified) may differ in detail, arrangement, connections or form from that shown.

E. The plans do not, and are not intended to, show all equipment (including but not limited to pull boxes and junction boxes) required nor to indicate all mechanical or structural difficulties that may be encountered that would necessitate routing alteration, offsets, or fittings. Items not specifically mentioned in these Specifications or noted on the Plans or approved shop drawings, but which are obviously necessary to make a complete working installation, shall be deemed to be included herein.

F. Discrepancies shown on the different Plans, between the Plans and actual field conditions, or between the Plans and Specifications shall be promptly brought to the attention of the Owner for a decision.

G. All electrical equipment shall be capable of operating successfully at full-rated load, without failure, when the ambient temperature of the air is 40°C except where specified otherwise.

H. Electrical conductors including cable, bus bars, etc. shall be copper, except where specified otherwise.

I. Without limiting the generality of other requirements of these Specifications, arrange for the submittal, by the subcontractor, of a reproducible Mylar of the complete schematics and wiring diagrams or drawings to include all installed field
and panel conduit and piping/tubing runs and routing, tray systems, supports, mounting details, point to point diagrams with a cable, wire, tube and termination numbers. Drawings shall be a record of work as actually constructed and shall be labeled as "Record Drawings."

1.02 SCOPE OF WORK

A. General: The Contractor shall provide all the materials and equipment, and perform all the work necessary for the complete execution of the electrical work as shown on the electrical plans and as specified, including electrical work indicated on other Plans that is specifically included in the electrical work. The Contractor shall provide all labor and materials not specifically shown on the Plans or specified herein, yet required to ensure proper and complete operation of any system(s) or design intent inherent in the project except as specifically excluded.

B. In general, the electrical work shall consist of, but not be limited to, the items listed as follows:

1. Automatic transfer switch
2. Standby diesel generator
3. All electrical equipment, panels, conduits, wiring and connections for work specified elsewhere in these Specifications and as shown on the Drawings.

1.03 CODES AND STANDARDS

A. All the equipment and materials shall conform to the latest revision of the following standards:

1. State of California Administrative Code, Title 8, Electrical Safety Orders
2. American National Standards Institute (ANSI)
3. Institute of Electrical and Electronic Engineers (IEEE)
4. National Electrical Manufacturers Association (NEMA)
5. Underwriters’ Laboratories (UL)
6. Insulated Power Cable Engineers Association (IPCEA)
8. National Electrical Code (NEC)
9. California Building Code (CBC)

B. Responsibility for complying with all applicable government regulations shall be as required in the Special Conditions.
C. All electrical equipment and materials, and the design, construction, and installation thereof, shall comply with all applicable provisions of the Federal Occupational Safety and Health Act (OSHA), state building standards, and applicable local codes and regulations.

D. Where the Plans or these Specifications call for equipment and workmanship to be of better quality or higher standard than required by the above codes, standards, rules, and regulations, then said Plans and Specifications shall prevail. Nothing on the Plans or in these Specifications shall be construed to permit work in violation of the above codes, standards, rules, and regulations and the Contractor shall be held responsible for any work that is not acceptable.

E. In case of differences between the building codes, specifications, state law, local ordinances, industry standards, utility company regulations, fire insurance carrier's requirements, and the contract documents, the most stringent shall govern. The Contractor shall promptly notify the Owner in writing of such differences.

1.04 COORDINATION OF WORK AND TRADES

A. Electrical work shall conform to the construction schedule and progress of other trades. The electrical construction shall be performed in cooperation with all other trades so that a neat and orderly arrangement of the work as a whole shall be obtained.

B. Before any work is started, the Contractor shall verify with the equipment manufacturers that equipment dimensions and arrangements will allow for equipment installation in the spaces provided for on the Plans for automatic transfer switch, standby generator, and other major items of electrical equipment or apparatus and that the installation indicated will provide for all required ventilation, clearances, access, and work space.

C. Before installing any equipment, materials, or raceways, the Contractor shall examine the complete set of Plans and Specifications and approved shop drawings and verify all dimensions and space requirements. All equipment utilized as “approved equal” to the specified manufacturers’ reference shall be Contractor-coordinated in all aspects for the assurance of proper space, mounting, installation, testing and related operation.

1.05 COORDINATION OF THE ELECTRICAL SYSTEM

A. The Contractor shall verify all actual equipment ratings. The necessary minimum equipment, wire, and conduit sizes are shown on the Plans. If the Contractor furnishes equipment of different ratings, the Contractor shall coordinate the actual current rating of equipment furnished with the branch circuit conductor size, the controller size, and the branch circuit over-current protection. The branch circuit conductors shall have a carrying capacity of not less than 125 percent of the actual full-load current rating. The size of the branch circuit conductors shall be such that the voltage drop from the overcurrent protection devices up to the equipment shall not be greater than 2 percent when the equipment is running at full load and rated voltage.
1.06 UTILITY COMPANY REQUIREMENTS

A. All work for electrical power shall be performed in accordance with the requirements of the respective serving utility companies.

B. Within 30 days after the notice of contract award, the Contractor shall notify the serving utilities that the project is under construction and provide them with all pertinent information, including the dates on which the electrical service modification will be required. Construction of these facilities shall be installed to accommodate equipment and cable of the serving utility and shall conform to all requirements of the serving utility.

C. The Contractor shall coordinate details and timing of service entrance installation with the utility, provide all required temporary service, and include all utility connection fees for temporary service in his proposal. The Owner will pay for all permanent electrical services.

D. Electrical service is provided by Pacific Gas and Electric (PG&E)

1.07 PERMITS AND INSPECTIONS

A. The Contractor shall obtain all permits and inspections and he shall pay all fees, therefore, as indicated in the Special Provisions. At the conclusion of the work on the project, the Contractor shall furnish to the Owner, properly executed, all required certificates of final inspection and approval before the work will be accepted as complete. The Owner will inspect the daily construction progress for conformance with the Plans and Specifications.

1.08 EQUIPMENT, MATERIALS AND WORKMANSHIP

A. It is the intent of these Specifications and of the Plans to secure high quality in all equipment and materials, and to require first-class workmanship, in order to facilitate trouble-free operation and minimum maintenance of the electrical system.

B. All equipment and materials shall be new, listed by UL, and bear the UL label, unless exception to this requirement is inherent to an individual item specified herein, or an exception is otherwise granted by the Owner.

C. Equipment and materials shall be the products of reputable, experienced manufacturers. Similar items in the project shall be the products of the same manufacturer. All equipment and materials shall be of industrial grade and standard of construction, shall be of sturdy design and manufacture, and shall be capable of long, reliable, trouble-free service.

D. All work, including installation, connection, calibration, testing and adjustment, shall be done by qualified, experienced personnel who are technically skilled in their trades, are thoroughly instructed, and are competently supervised. The resulting complete installation shall reflect professional quality work, employing industrial standards and methods.
1.09 SEISMIC REQUIREMENTS

The equipment and major components including the automatic transfer switch and standby generator shall be suitable for and certified by actual seismic testing to meet all applicable seismic requirements of the California Building Code (CBC). Guidelines for the installation consistent with these requirements shall be provided by the equipment manufacturer and based upon testing of representative equipment. Equipment certification acceptance criteria shall be based upon the ability for the equipment to be returned to service immediately after a seismic event within the above requirements without the need for repairs. Seismic anchorage calculations shall be submitted for each major component. These calculations shall be signed and stamped by a structural engineer registered in the State of California.

1.10 AREA DESIGNATIONS

For purposes of defining electrical enclosure and electrical installation requirements of this project, certain areas have been classified on the Plans and in these Specifications as defined below. Electrical equipment and installations within these areas shall conform to the code requirements for the areas involved.

A. General Purpose Locations

Electrical work installed in areas that are not specifically classified shall be “general purpose.” Workmanship, materials, and enclosures in these locations shall comply with the general requirements of this Specification.

In all areas, raceway shall be PVC coated rigid steel conduit or galvanized rigid steel conduit; entrances shall be threaded; fittings shall have gasketed covers located at a low point to drain the fitting or conduit system. Threaded hardware shall be stainless steel. Mounting brackets shall be galvanized after fabrication. Enclosures shall be mounted with a 1/4-inch air space from walls unless otherwise noted on the plans.

1.11 SUBMITTALS

Shop drawings shall be submitted for the following items of major equipment in accordance with General Conditions and as indicated in Division 16 sections.

A. Automatic transfer switch, standby generator connection assembly, conduits, cable/wiring, and other major equipment or apparatus.

B. Seismic calculations.

C. The Contractor shall submit a detailed test procedure checklist to verify proper operation of the electrical system.

1.12 GROUNDING

A. A grounding system shall be installed in accordance with the National Electrical Code and all state and local codes and regulations. The grounding system shall bond together and effectively ground all exposed non-energized metal surfaces containing energized parts, devices or conductors, all building steel, all metallic electrical raceways and the neutrals of all transformers. An equipment grounding
1.13 WARNING SIGNS

A. Permanent warning signs shall be mounted at all mechanical equipment that may be started automatically or from remote locations. Signs shall be made in accordance with Porcelain Enamel Institute Specification S-103 and shall be suitable for exterior use. Mounting details shall be in accordance with manufacturer’s recommendation. Signs shall be located as approved by the Owner.

B. Warning signs shall be 7-inches high by 10-inches wide, colored yellow and black, on not less than 18-gauge vitreous enameling stock. Sign shall read:

CAUTION
THIS EQUIPMENT STARTS AUTOMATICALLY BY REMOTE CONTROL

1.14 QUALITY ASSURANCE

A. The plans indicate diagrammatically the desired location and arrangement of outlets, conduit runs, equipment, and other items. Exact locations shall be determined in the field based on the physical size and arrangement of equipment, finished elevations, and obstructions. Locations indicated on the Plans, however, shall be adhered to as closely as possible.

B. All conduit and equipment shall be installed in such a manner as to avoid all obstructions, preserving headroom, and keeping openings and passageways clear. Where these Plans do not indicate exact locations, such determined locations shall be approved by the Owner. Where equipment is installed without approval and must be moved, it shall be moved without additional cost.

C. The installation of all materials and equipment shall be accomplished by workmen skilled in this type of work and installation shall be coordinated in the field with other trades so that interferences are avoided.

D. The Contractor shall provide adequate means for and shall fully protect all finished parts of the materials and equipment against damage from any cause during the progress of the work and until accepted by the Owner.

E. All materials and equipment, both in storage and during construction, shall be covered in such a manner that no finished surfaces will be damaged, marred, or splattered with water, foam, plaster, or paint, and all moving parts shall be kept clean and dry.

F. The Contractor shall replace or have refinished by the manufacturer, all damaged materials or equipment, including face plates of panels and switchboard sections, at no additional expense.
1.15 TESTING

A. The Contractor shall perform and record the tests described hereinafter and any other tests that may be required by the Owner or other authorities having jurisdiction. The entire electrical installation shall be tested, adjustments made, and defects corrected as an obligation under the work of this section. The Contractor shall furnish all necessary replacement parts and labor necessary due to damage resulting from damaged equipment or from test and correction of faulty installation.

The following testing, as a minimum, shall be accomplished:

1. Insulation resistance tests
2. Continuity test of all wiring
3. Completely test the grounding system with a low ohm resistance meter under simulated service conditions to assure compliant operation of the wiring and the proper functioning of all equipment.
4. Test for short circuits in the system
5. Complete operational test on all equipment
6. Verify field performance and operation of electrical system utilizing the approved testing procedure.

B. The Contractor shall test all power and control feeder circuits in the presence of the Owner by means of a 1,000-volt megohmeter to ensure that they are free of open circuits and grounds before energizing.

C. The Contractor shall perform a functional checkout on control circuits. The checkout shall consist of energizing each control circuit and operating each control, alarm, or malfunction device, and each interlock in turn to verify that the specified action occurs.

D. After each electrical installation is complete, it shall be tested thoroughly to demonstrate that the entire system is in proper working order and in accordance with the Plans and Specifications. In no case shall the tests be less than those outlined hereinafter.

1.16 CLEANUP

A. All parts of the electrical materials and equipment shall be left in a clean condition. Exposed parts shall be clean of cement, plaster and other materials, and all oil and grease spots shall be removed with a non-flammable cleaning solvent. Such surfaces shall be carefully wiped and all cracks and corners scraped out.

B. During the progress of the work, the Contractor shall clean up after his men and shall leave the premises and all portions of the site in which he is working free from debris and surplus materials.
PART 2 - PRODUCTS

2.01 GENERAL

A. Equipment used for the same purpose shall be of the same make. Outdoor equipment and wiring devices shall be of approved weatherproof construction or shall be in a weatherproof enclosure.

PART 3 - EXECUTION (NOT USED)

END OF SECTION
SECTION 16050: BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

This section includes the following:

A. Grounding electrodes and conductors.
B. Equipment grounding conductors.
C. Bonding methods and materials.
D. Conduit and equipment supports.
E. Equipment and anchoring.
F. Anchors and fasteners.
G. Nameplates and labels.
H. Wire markers.
I. Raceway markers.

1.02 REFERENCES

A. NECA (National Electrical Contractors Association) - “Standard Practice of Good Workmanship in Electrical Construction.”
C. NFPA 99 (National Fire Protection Association) - Health Care Facilities.

1.03 SYSTEM DESCRIPTION

A. Grounding systems use the following elements as grounding electrodes:
   1. Rod electrode.
B. Anchor and fasten electrical products to building elements and finishes as follows:
   1. Conduit placed against concrete or masonry above ground shall be fastened to the concrete with pipe straps or one-hole conduit clamps attached to the concrete by means of expansions anchors and bolts.
   2. Factory-made pipe straps shall be one-hole malleable iron or two-hole galvanized clamps for rigid steel conduits. Straps shall be PVC-coated for PVC-coated rigid conduits.
3. Pipe hangers for individual conduits shall be factory made, consisting of a pipe ring and threaded suspension rod. The pipe ring shall be malleable iron, split and hinged, or shall be springable wrought steel. Rings shall be bolted to or interlocked with the suspension rod socket. Rods shall be 3/8 inch for 2-inch conduit hangers and smaller and shall be 2 inch for 2-1/2-inch conduit hangers and larger.

4. Hanger straps, rods, or pipe supports under concrete shall be attached to inserts set at the time the concrete is poured. Under wood, use bolts, lag bolts, or lag screws; under steel joints or trusses, use beam clamps.

5. Wire, perforated strap, or plumber's tape shall not be used in the support of conduit. Conduit shall not be secured to suspended ceiling hanger wires or to the suspended ceiling structure.

C. Identify electrical components as follows:

1. Nameplate for each electrical distribution and control equipment enclosure.

1.04 DESIGN REQUIREMENTS
A. Select materials, sizes, and types of anchors, fasteners, and supports to carry loads of equipment and raceway, including weight of wire and cable in raceway.

1.05 SUBMITTALS
A. Submittals shall be in accordance with the General Conditions.
B. Product Data: Submit grounding electrodes and connections, fastening components, and nameplates.
C. Test Reports: Indicate overall resistance to ground.

1.06 CLOSEOUT SUBMITTALS
A. Project Record Documents: Record actual locations of components and grounding electrodes.

1.07 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing products specified in this section with a minimum of 3-years documented experience.

1.08 FIELD MEASUREMENTS
A. Verify field measurements prior to fabrication.

PART 2 - PRODUCTS

2.01 ROD ELECTRODES
A. Material: Copper-clad steel.
B. Diameter: 3/4 inch

C. Length: 10 feet

2.02 MECHANICAL CONNECTORS

A. Description: Copper alloy connectors, suitable for grounding and bonding applications, in configurations required for particular installation.

2.03 EXOTHERMIC CONNECTIONS

A. Product Description: Exothermic materials, accessories, and tools for preparing and making permanent field connections between grounding system components.

2.04 GROUNDING WIRE

A. Material: Stranded copper.

B. Size: As indicated on the Drawings.

2.05 GROUNDING WELL COMPONENTS

A. Well Pipe: 12 inch NPS by 24-inch long concrete pipe with belled end.

B. Well Cover: Concrete with legend “GROUND” embossed on cover.

2.06 ANCHORS AND FASTENERS

A. Materials and Finishes: Corrosion resistant.

2.07 EQUIPMENT PADS AND ANCHORING

A. All floor-standing equipment shall be mounted on raised concrete pads. Pad size and height shall be as indicated on the Plans. Pads not indicated shall extend out 4 inches beyond enclosure and shall be 4 inches above finished grade.

B. All equipment shall be securely anchored to pads. Anchorage shall be in accordance with OSHA and other applicable standards for earthquake protection. All panels shall be designed, constructed and attached to resist stresses produced by seismic forces.

C. Earthquake Design Data

Submit with the shop drawings a complete set of detailed calculations or test results, details of constructions, and method of attachment for all panels showing compliance with earthquake design restraint. The calculations and details shall be signed by a professional engineer who has demonstrated proficiency in structural engineering or civil engineering and is registered in the state of California. The calculations shall be performed specifically for this job, during the time frame of the job and be dated by the Engineer performing them. No control panels shall be delivered and mounted at project without approved submittal data.
2.08 NAMEPLATES AND LABELS

A. Nameplates: Engraved three-layer laminated plastic, black letters on white background.

B. Letter Size: 1/4-inch letters.

C. Nameplate shall identify equipment and/or function.

D. Convenience receptacles shall be identified with originating panel and circuit number (for example, PNLA, Cir #3).

PART 3 - EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

A. Grounding and Bonding Installation:

1. Install electrodes at locations as indicated on the Plans.

2. Install grounding well pipe with cover as indicated on the Plans. Install the well pipe top flush with finished grade.

3. Grounding continuity for underground duct banks may be maintained by the installation of a bare copper conductor installed in the concrete envelope. Ground continuity shall be maintained through all manholes and pull boxes. All metal parts in manholes shall be connected to the grounding system.

4. Install bonding meeting regulatory requirements.

5. Metallic raceways shall be terminated with double lock nuts and bushings. Conduits terminating in switch boards and motor control centers shall be equipped with grounding bushing and connected to equipment ground bus.

6. All metallic raceway, non current-carrying parts of the electrical system shall be grounded.

7. Install separate, green insulated conductor within each feeder and branch circuit raceway. Terminate each end on suitable lug, bus, or bushing.

8. Locate and install anchors, fasteners, and supports in accordance with NECA “Standard Practice of Good Workmanship in Electrical Construction.”

9. Do not fasten supports to pipes, ducts, mechanical equipment, or conduit.
10. Do not use spring steel clips and clamps.

11. Do not use powder-actuated anchors.

12. Do not drill or cut structural members.

B. Supports:

1. Fabricate supports from structural steel or formed steel members. Rigidly weld members or install hexagon head bolts to present neat appearance with adequate strength and rigidity. Install spring lock washers under nuts.

2. Install surface mounted cabinets and panelboards with a minimum of four anchors.

3. In wet and damp locations, install steel channel supports to stand cabinets and panelboards 1-inch off the wall.

C. Identification Components:

1. Degrease and clean surfaces to receive nameplates.

2. Install nameplate parallel to equipment lines.

3. Secure nameplate to equipment front using adhesive.

4. Secure nameplate to inside surface of door on recessed panelboard in finished locations.

3.03 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Grounding and Bonding: Perform inspections and tests listed in NETA ATS, Section 7.13.

END OF SECTION
SECTION 16123:  WIRE AND CABLE

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

A. This section includes wire and cable; nonmetallic-sheathed cable, and wiring connectors and connections.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 16000 – General Electrical Requirements

1.03 REFERENCES

A. NECA 1-2010 “Standard Practice of Good Workmanship in Electrical Construction.”


1.04 SYSTEM DESCRIPTION

Product Requirements: Provide products as follows:

A. Stranded conductor for feeders and branch circuits 10 AWG and smaller.

B. Stranded conductors for control circuits.

C. Power conductors not smaller than 12 AWG.

D. Conductor not smaller than 14 AWG for control circuits.

1.05 DESIGN REQUIREMENTS

A. All conductors shall be copper.

1.06 SUBMITTALS

A. Submittals shall be in accordance with General Conditions.

B. Product Data: Submit for building wire and each cable assembly type.

C. Test Reports: Indicate procedures and values obtained.

D. Project Record Documents: Record actual locations of components and circuits.

1.07 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with a minimum of 3-years documented experience.
1.08 FIELD MEASUREMENTS
   A. Verify field measurements are as indicated on the drawings.

1.09 COORDINATION
   A. Where wire and cable destination is indicated and routing is not shown, determine routing and lengths required.
   B. Wire and cable routing indicated is approximate unless dimensioned.

PART 2 - PRODUCTS

2.01 WIRE
   A. Product Description: Single conductor insulated wire.
   B. Conductor: Copper.
   C. Insulation Voltage Rating: 600 volts.
   D. Insulation: NFPA 70; Type THHN/THWN/THWN2/XHHW2 insulation for feeders and branch circuits. Sizes 8 and larger shall be rated THWN2/XHHW2.
   E. Conductors shall have thermoplastic, solid color thermosetting, polyvinyl chloride insulation with nylon jacket. The insulated conductors shall conform to Underwriter's Laboratories standards for type THHN/THWN2/XHHW2. The overall jacket for a multi-conductor cable shall be polyvinyl chloride.
   F. Wire and cable designated "Shielded" on the Drawings and required for the instrumentation signal circuits shall be shielded cable. Signal voltage and current will be 24 volts DC and 4-20 milliamperes DC, respectively. The cables shall be 600 volt AC rated, with a laminated aluminum-polyester tape shield and a copper drain wire, with a plastic jacket over all, and shall be UL approved as type TC tray cable, 90°C in dry locations, and 75°C in wet locations. The conductors in the cable shall be stranded and twisted bare copper wires with a minimum of seven strands and insulated with a minimum thickness of 0.020 inch of flame retardant and moisture resistant, high quality, cross-linked, polyethylene insulation. The wires shall be color coded and covered with a minimum of 0.001/0.001 inches of laminated aluminum-polyester tape shield and a #20 AWG tinned and stranded copper drain wire, with a minimum of ten strands. Over the twisted and shielded cable assembly, there shall be a minimum thickness of 0.045-inches of moisture, flame, and sunlight resistant, polyvinyl chloride (PVC) outer jacket.
   G. All conductors shall be soft-drawn copper, 97 percent conductivity minimum.
   H. All conductors within fluorescent fixtures shall have type AVA or RHH 600 volt insulation except fixtures with approved wireways for 75°C wire.
   I. Instrumentation cable shall be single or multi-conductor shielded pairs as indicated. Conductors shall be No. 16 AWG coated copper.
PART 3 - EXECUTION

3.01 EXAMINATION
A. Verify mechanical work likely to damage wire and cable has been completed.
B. Verify raceway installation is complete and supported.

3.02 PREPARATION
A. Completely and thoroughly swab raceway before installing wire.

3.03 INSTALLATION
A. Route wire and cable to meet project conditions.
B. Install wire and cable in accordance with NECA “Standard Practice of Good Workmanship in Electrical Construction.”
C. Neatly train and lace wiring inside boxes, equipment, and panelboards.
D. Identify and color code wire and cable. Identify each power and control conductor with tube type wire markers, indicating the conductor's circuit designation and starting, ending, and splice locations.
E. Wire in Raceway:
   1. Pull conductors into raceway at same time.
   2. Install wire 4 AWG and larger with pulling equipment with tension monitored.
   3. Wire lubricants shall be UL approved.
F. Cable:
   1. Protect exposed cable from damage.
   2. Use suitable cable fittings and connectors.

G. Wiring Connections:
   1. Clean conductor surfaces before installing lugs and connectors.
   2. Make splices, taps, and terminations to carry full ampacity of conductors with no perceptible temperature rise.
   3. All low DC and AC (below 100V) voltages and signals shall be grounded separately from above power grounds. 600 volt conductors, No. 8 AWG and larger, shall be terminated spliced with compression type connectors and insulated with three layers of UL-approved vinyl insulating tape. 600 volt conductors, No. 10 AWG and smaller, shall be spliced with pre-insulated coil spring type connectors. Terminations and splices in all
motor connection boxes shall be made with compression type connectors.

4. Termination splices shall be insulated with varnished cambric tape, overlapped with three (3) layers of a high temperature, UL-approved, tape.

5. Control conductors shall be spliced with pre-insulation crimp type connectors and terminated with split tongue pre-insulated, crimp type connectors.

H. Splicing
1. Wires and cables for control and power circuits shall be continuous without splices between terminals, except where otherwise specifically approved by the Engineer. All splices shall be made in an approved manner. Mechanical connectors and terminal devices shall be the soldered-type, or the compression-type that is indented or crimped on to the conductor.

2. Splices and terminations of instrument cable shall be with pre-insulated crimp type connectors. Shields shall be electrically continuous at spliced joints with two layers of UL-approved electrical insulating tape over splices. Connectors for terminations shall be split tongue or ring type. Shields shall be grounded at the receiving end of cables.

3. Splices in manholes and underground pull boxes for 600-volt conductors and below shall be waterproofed using encapsulating epoxy resin splice kits.

3.04 WIRE COLOR
A. General
1. Wire and cable shall be factory color coded by integral pigmentation with a separate color for each phase and neutral. On conductors larger than 8 AWG, color tape or colored plastic bands will be permitted.

2. Each system shall be color coded and shall have it maintained throughout.

<table>
<thead>
<tr>
<th>Phase</th>
<th>120/240</th>
<th>120/208</th>
<th>277/480 Volts</th>
<th>Control Wires</th>
<th>DC Conductors</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Black</td>
<td>Black</td>
<td>Brown</td>
<td>Purple</td>
<td>Blue</td>
</tr>
<tr>
<td>B</td>
<td>Red</td>
<td>Red</td>
<td>Orange</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>N/A</td>
<td>Blue</td>
<td>Yellow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutral</td>
<td>White</td>
<td>White</td>
<td>Gray</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ground</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

B. Neutral Conductors: White. When two or more neutrals are located in one conduit, individually identify each with proper circuit number.
C. Branch Circuit Conductors: Install three or four wire home runs with each phase uniquely color coded.

D. Feeder Circuit Conductors: Uniquely color code each phase.

E. Ground Conductors:
   1. For 6 AWG and smaller: Green.
   2. For 4 AWG and larger: Identify with green tape at both ends and visible points including junction boxes.

3.05 FIELD QUALITY CONTROL

A. Inspect and test in accordance with NETA ATS, except Section 4.

B. Perform inspections and tests listed in NETA ATS, Section 7.3.1.

END OF SECTION
SECTION 16130: RACEWAY AND BOXES

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK
   A. This section includes conduit and tubing, surface raceways, wireways, outlet boxes, pull and junction boxes, and handholes.

1.02 REFERENCES
   A. ANSI C80.1 (American National Standards Institute) - Electrical Rigid Steel Conduit.
   B. NECA 1-2010 “Standard Practice of Good Workmanship in Electrical Construction.”
   C. NEMA FB 1 (National Electrical Manufacturers Association) - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies.
   D. NEMA OS 1 (National Electrical Manufacturers Association) - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
   E. NEMA OS 2 (National Electrical Manufacturers Association) - Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports.
   F. NEMA RN 1 (National Electrical Manufacturers Association) - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
   G. NEMA TC 2 (National Electrical Manufacturers Association) - Electrical Plastic Tubing (EPT) and Conduit (EPC-40 and EPC-80).
   H. NEMA TC 3 (National Electrical Manufacturers Association) - PVC Fittings for Use with Rigid PVC Conduit and Tubing.
   I. NEMA 250 (National Electrical Manufacturers Association) - Enclosures for Electrical Equipment (1000 Volts Maximum).

1.03 SYSTEM DESCRIPTION
   A. Raceway and boxes located as indicated on the Drawings, and at other locations required for splices, taps, wire pulling, equipment connections, and compliance with regulatory requirements. Raceway and boxes are shown in approximate locations unless dimensioned. Provide raceway to complete wiring system.

1.04 DESIGN REQUIREMENTS
   A. Minimum Raceway Size: 3/4 inch unless otherwise specified. Where conduit sizes are not shown, they shall be one size larger than required by NEC.
   B. All wiring, except as specifically noted, shall be in conduit.
C. All wiring runs in earth outside the building shall be installed in PVC coated rigid steel conduit or galvanized rigid steel conduit.

D. Unless specifically noted otherwise, all exposed raceway shall be rigid galvanized steel or PVC coated rigid galvanized steel.

1.05 SUBMITTALS
Product Data: Submit shop drawings for the following in accordance with General Conditions.

A. Liquid-tight flexible metal conduit.
B. Nonmetallic conduit.
C. Raceway fittings.
D. Conduit bodies.
E. Surface raceway.
F. Wireway.
G. Pull and junction boxes.
H. Handholes.

1.06 CLOSEOUT SUBMITTALS
Submit project record documents that:

A. Record actual routing of all conduits.
B. Record actual locations and mounting heights of outlet, pull, and junction boxes.

1.07 DELIVERY, STORAGE, AND HANDLING
A. Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering.

1.08 COORDINATION
A. Coordinate mounting heights, orientation and locations of outlets mounted above counters, benches, and backsplashes.

PART 2 - PRODUCTS

2.01 PVC COATED STEEL CONDUIT AND FITTINGS
A. Product Description: Rigid steel conduit with external PVC coating, 40 mils thick, shall comply with UL-6 and NEMA RN 1. Conduit and fittings shall be manufactured by Perma-Cote, Calbond, Thomas & Betts, or approved equal.
B. A two-part urethane chemically cured coating shall be applied at a nominal 2-mil thickness to the interior of all conduit and fittings. The coating shall be sufficiently flexible to permit field bending of the conduit without cracking or flaking of the coating.

C. PVC coated steel fittings and bodies shall comply with NEMA FB 1. Fittings with external PVC coating shall match the conduit.

2.02 RIGID GALVANIZED STEEL CONDUIT

A. Product Description: rigid steel conduit shall be mild steel, hot dip galvanized inside and out. Rigid steel conduit shall be manufactured in accordance with ANSI C80.1, UL-6, and Federal Specification WW-C-581E.

2.03 LIQUIDTIGHT FLEXIBLE METAL CONDUIT

A. Product Description: Interlocked galvanized construction with a smooth moisture and oil-proof abrasive-resistant reopened jacket.

B. Fittings: NEMA FB 1.

2.04 NONMETALLIC CONDUIT

A. Product Description: NEMA TC 2; Schedule 40 PVC rated for 90°C.

B. Fittings and Conduit Bodies: NEMA TC 3.

C. Install non-metallic conduit for electric utility services or as otherwise specifically indicated on the Plans. The plastic conduit shall be installed in accordance with the manufacturer’s printed recommendations. Bends, sweeps, end-bells, and other fittings, as required, shall be of the same material as the conduit.

2.05 OUTLET BOXES

A. Sheet Metal Outlet Boxes: NEMA OS 1 one-piece knockout type, galvanized steel.

1. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; furnish 1/2-inch male fixture studs where required.

2. Concrete Ceiling Boxes: Concrete type.

B. Weatherproof Outlet Boxes: Nonferrous metal with threaded conduit entry and gasketed covers.

C. Cast Boxes: NEMA FB 1, Type FD, cast ferroloy. Furnish gasketed cover by box manufacturer.

2.06 PULL AND JUNCTION BOXES

A. Sheet Metal Boxes: NEMA OS 1, galvanized steel.
B. Pull boxes shall be painted with two coats of primer and one finished coat of light gray enamel, ANSI No. 61.

C. Boxes shall be fabricated of structural quality flat rolled steel sheet free from irregularities, mill scale, surface corrosion, or other defects and shall be neatly and accurately formed with corners mitered and sides joined by continuous welding. After fabrication, each box and cover shall be galvanized.

D. Galvanizing shall be in accordance with the requirements of ASTM Standard A123. The galvanizing shall stand seven 1-minute immersions when tested in accordance with the methods set forth in ASTM Standard A239. Articles shall be straightened after galvanizing, if necessary, to remove wavy surfaces or distortion.

E. Cast-Type Boxes
Cast-type boxes shall be malleable iron with cadmium finish or copper-free aluminum with threaded hubs for installation on exposed conduit work outdoors, in vaults, and miscellaneous structures as shown on the Drawings. Cast-type boxes shall be Crouse-Hinds "Condulets," Appleton Electric Products "Unilets," or equal.

F. Underground Pull boxes
1. Pull boxes shall be precast type designed and manufactured for heavy traffic loading with heavy duty, hot dipped galvanized steel, traffic type covers.
2. All pull boxes shall have bolt-down covers complete with fiber gaskets for a weather-tight fit.
3. All joints between precast sections shall be sealed.
4. Box covers shall be permanently identified as follows:
   a. Electrical systems 600 volts and less - "E"

G. Pull boxes shall be code gauge steel with removable covers secured with machine screws. The pull box shall be painted with two coats of primer and one finished coat of light gray enamel, ANSI No. 61. Pull boxes shall meet all code requirements as to size for number and size of conduits terminating.

H. Weatherproof pull boxes shall be hot dip galvanized with two coats of primer paint and one coat of enamel, ANSI No. 61 gray. Covers shall be gasketed and made completely weathertight.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify outlet locations and routing and termination locations of raceway prior to rough-in.
3.02 INSTALLATION

A. Install work in accordance with state and municipality standards.
B. Install raceway and boxes in accordance with NECA 1-2010 “Standard Practice of Good Workmanship in Electrical Construction.”
C. Ground and bond raceway and boxes in accordance with Section 16050.
D. Fasten raceway and box supports to structure and finishes in accordance with Section 16050.
E. Identify raceway and boxes in accordance with Section 16050.
F. Arrange raceway and boxes to maintain headroom and present neat appearance.

3.03 INSTALLATION - RACEWAY

A. Raceway routing is shown in approximate locations unless dimensioned. The exact locations shall be determined by the Contractor to suit the structural details. Route raceways to complete wiring system.
B. Support raceway using coated steel or malleable iron straps, lay-in adjustable hangers, clevis hangers, and split hangers.
C. Do not support raceway with wire or perforated pipe straps. Remove wire used for temporary supports.
D. Do not attach raceway to ceiling support wires or other piping systems.
E. Route exposed raceway parallel and perpendicular to walls.
F. Route conduit in and under slab from point-to-point.
G. Maintain clearance between raceway and piping for maintenance purposes. Conduit shall be kept at least 6 inches from the covering on hot water pipes, 18 inches from the covering on flues and breechings, and 3/4 inch from all water-bearing walls, unless shown otherwise on the Plans. The open ends of all conduits shall be sealed during the construction of the facility. Use approved conduit unions where union joints are necessary. Running threads will not be permitted.
H. Exposed conduit, stubbing up through floor slab into bottom of exposed panels, cabinets, or equipment, shall be lined up, properly spaced, and shall be straight and plumb. Conduits shall be installed at sufficient depth below slab to eliminate any part of the bend above top of slab.
I. Cut conduit square using saw or pipe cutter; de-burr cut ends.
J. Join nonmetallic conduit using cement as recommended by the 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 a minimum of 20 minutes.

K. Install conduit hubs to fasten conduit to sheet metal boxes in damp and wet locations and to cast boxes.

L. Install no more than equivalent of three 90-degree bends between boxes. Install conduit bodies to make sharp changes in direction, as around beams. Install factory elbows for bends in metal conduit larger than 2-inch size.

M. Avoid moisture traps; install junction box with drain fitting at low points in conduit system.

N. Install suitable pull cord of 200-pound strength in each empty raceway except sleeves and nipples.

O. All spare conduits shall be stubbed up to a flush coupling and plugged. Conduit shall run continuously between outlets and shall be provided with conduit junction boxes where connections are made, except in special pull boxes where indicated on the Plans.

P. Flexible steel conduit may be used in runs from adjacent junction boxes to motors, benches, and in certain locations where, for structural or other reasons, it is impractical to use rigid conduit and where specific permission to do so has been granted by the Owner. Flexible conduit shall be used with PVC coated steel conduit fittings and bushings. All exposed conduits and all conduit stub-ups shall be PVC jacketed steel.

Q. Threading shall be done with dies with guide sleeves bored out to allow for increased diameter of conduit. Conduit bends shall be made with next larger size EMT bender or next larger sized shoe bushed for proper fit. Cuts or damaged areas shall be repaired with an approved paste material.

3.04 UNDERGROUND DUCT INSTALLATION

A. Ducts shall be installed minimum of 24 inches below finished grade. Ducts shall be installed on a minimum grade line of 2 inches fall per 100 feet, sloping toward manhole or pull box.

B. Changes in direction shall be made with long sweeps with minimum radius of 24 times duct diameter.

C. The installed ducts shall be cleaned by: (1) pulling a flexible mandrel through each duct; or (2) pulling a wire brush and swab through each duct. The mandrel shall be 1/4 inch less in diameter than the duct diameter. Spare ducts shall have a 200-pound strength nylon cord installed with at least 36 inches of slack on each end.

3.05 CONDUIT FITTINGS AND OUTLET BOXES

A. Cast, non-ferrous fittings shall be installed for all exposed conduits including fittings for switches and receptacles. Fittings installed in pipe and filter gallery or
exterior to buildings shall have a PVC coating bonded to the surface and a PVC sleeve extended from all hubs. Stainless-steel screws shall be used to attach the cover to the conduit fitting.

B. All outlet boxes that finish to an exposed concrete block surfaces shall have 2-1/8-inch deep tile rings and shall be set to allow concrete block facing over the ring to frame the opening. Tile rings shall not be grouted into exposed concrete block walls. Center outlet in course of concrete block.

C. Standard plaster rings will not be accepted.

D. Unless otherwise specified or noted on the Plans, boxes for the various outlets shall be as follows:

1. For light outlet boxes, use minimum of 4 inches square, 2-1/8 inches deep, equipped with plaster ring and fixture-supporting device as required by the unit installed.

2. For wall switch outlets, use 4-inch boxes with single or two-gang boxes with gang plaster rings for more than two switches, unless noted otherwise on the Plans.

3. For convenience outlets, use 4-inch boxes with single-gang plaster rings. All conduit fittings, sealing devices, junction boxes, and devices used in hazardous areas shall be UL approved and as manufactured by Crouse-Hinds or Appleton.

E. Locate flush mounting box in masonry wall to require cutting of masonry unit corner only. Coordinate masonry cutting to achieve neat opening.

F. Do not install flush mounting box back-to-back in walls; install with minimum 6 inches separation.

G. Secure flush mounting box to interior wall and partition studs. Accurately position to allow for surface finish thickness.

H. Install stamped steel bridges to fasten flush mounting outlet box between studs.

I. Install flush mounting box without damaging wall insulation or reducing its effectiveness.

J. Install adjustable steel channel fasteners for hung ceiling outlet box.

K. Do not fasten boxes to ceiling support wires or other piping systems.

L. Support boxes independently of conduit.

M. Install gang box where more than one device is mounted together. Do not use sectional box.

N. Install gang box with plaster ring for single device outlets.
3.06 INTERFACE WITH OTHER PRODUCTS
   A. Install conduit to preserve fire resistance rating of partitions and other elements, using materials and methods in accordance with Section 16050.
   B. Locate outlet boxes to allow luminaries positioned as indicated on the Drawings.
   C. Align adjacent wall mounted outlet boxes for switches, thermostats, and similar devices.

3.07 ADJUSTING
   A. Adjust flush-mounting outlets to make front flush with finished wall material.
   B. Install knockout closures in unused openings in boxes.

3.08 CLEANING
   A. Clean interior of boxes to remove dust, debris, and other material.
   B. Clean exposed surfaces and restore finish.

END OF SECTION
SECTION 16446: AUTOMATIC TRANSFER SWITCHES

PART 1 - GENERAL

1.01 SUMMARY

A. Furnish and install automatic transfer switches with number of poles, amperage, voltage, and withstand current ratings as shown on the Plans. Each ATS shall consist of a power transfer switch unit and a control panel interconnected to provide complete automatic operation.

1.02 REFERENCES

The delayed transition transfer switches and controls shall conform to the requirements of:

A. UL 1008 - Standard for Transfer Switch Equipment
B. NFPA 70 - National Electrical Code
C. NFPA 110 - Emergency and Standby Power Systems
D. IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications

1.03 SUBMITTALS

A. Product Data: Submit catalog sheets showing voltage, switch dimensions, ratings of switches, operating logic, wiring diagrams, short circuit ratings, dimensions, and enclosure details.

PART 2 - PRODUCTS

2.01 MECHANICALLY HELD TRANSFER SWITCH

A. Automatic transfer switches shall be ASCO 300 Series, Eaton contactor type transfer switch with ATC 300 plus controller or equal. Any alternate shall be submitted for approval at least 10 days prior to bid. Alternate bids must list any deviations from this specification.

B. The transfer switch unit shall be electrically operated and mechanically held. The electrical operator shall be a solenoid mechanism, momentarily energized. The transfer switch unit shall include both electrical and mechanical interlocks to prevent both sets of main contacts from being closed at the same time. Main operators that include overcurrent disconnect devices OR do not include electrical and mechanical interlocks will not be accepted.

C. All transfer switch sizes shall use only one type of main operator for ease of maintenance and commonality of parts.

D. The switch shall be positively locked and unaffected by momentary outages, so that contact pressure is maintained at a constant value and contact temperature rise is minimized for maximum reliability and operating life.
E. All main contacts shall be silver composition. Switches rated 600 amperes and above shall have segmented, blow-on construction for high withstand and close-on capability and be protected by separate arcing contacts.

F. Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. Switches rated 600 amps and higher shall have front removable and replaceable contacts. All stationary and moveable contacts shall be replaceable without removing power conductors and/or bus bars.

G. Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof, which are not intended for continuous duty, repetitive switching or transfer between two active power sources, are not acceptable.

H. Where neutral conductors are to be solidly connected as shown on the Plans, a neutral conductor plate with fully rated AL-CU pressure connectors shall be provided.

2.02 MICROPROCESSOR CONTROLLER

A. The controller's sensing and logic shall be provided by a single built-in microprocessor for maximum reliability, minimum maintenance, and the ability to communicate serially through an optional serial communication module.

B. A single controller shall provide selectable nominal voltages for maximum application flexibility and minimal spare part requirements. Voltage sensing shall be true RMS type and shall be accurate to ±1 percent of nominal voltage. Frequency sensing shall be accurate to ±0.2 percent. The panel shall be capable of operating over a temperature range of -20°C to +60°C and storage from -55°C to +85°C.

C. The controller shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the controller to be disconnected from the transfer switch for routine maintenance. Sensing and control logic shall be provided on multi-layer printed circuit boards. Interfacing relays shall be industrial grade plug-in type with dust covers. The panel shall be enclosed with a protective cover and be mounted separately from the transfer switch unit for safety and ease of maintenance. The protective cover shall include a built-in pocket for storage of the operator’s manuals.

D. All customer connections shall be wired to a common terminal block to simplify field-wiring connections.

2.03 ENCLOSURE

A. The ATS shall be furnished in a Type 1 enclosure.

B. All standard and optional door-mounted switches and pilot lights shall be 16-mm industrial grade type or equivalent for easy viewing and replacement. Door controls shall be provided on a separate removable plate, which can be supplied loose for open type units.
C. Maximum dimension of switch shall be as shown on the Drawings.

2.04 CONTROLLER DISPLAY AND KEYPAD

A. A four-line, 20-character LCD display and keypad shall be an integral part of the controller for viewing all available data and setting desired operational parameters. Operational parameters shall also be available for viewing and limited control through the serial communications input port. The following parameters shall only be adjustable via DIP switches on the controller:

1. Nominal line voltage and frequency
2. Single or three phase sensing
3. Operating parameter protection

All instructions and controller settings shall be easily accessible, readable and accomplished without the use of codes, calculations, or instruction manuals.

2.05 VOLTAGE, FREQUENCY AND PHASE ROTATION SENSING

A. Voltage and frequency on both the normal and emergency sources (as noted below) shall be continuously monitored, with the following pickup, dropout and trip setting capabilities (values shown as % of nominal unless otherwise specified):

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sources</th>
<th>Dropout/Trip</th>
<th>Pickup/Reset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undervoltage</td>
<td>N&amp;E,3f</td>
<td>70 to 98%</td>
<td>85 to 100%</td>
</tr>
<tr>
<td>Overvoltage</td>
<td>N&amp;E,3f</td>
<td>102 to 115%</td>
<td>2% below trip</td>
</tr>
<tr>
<td>Underfrequency</td>
<td>N&amp;E</td>
<td>85 to 98%</td>
<td>90 to 100%</td>
</tr>
<tr>
<td>Overfrequency</td>
<td>N&amp;E</td>
<td>102 to 110%</td>
<td>2% below trip</td>
</tr>
<tr>
<td>Voltage unbalance</td>
<td>N&amp;E</td>
<td>5 to 20%</td>
<td>1% below dropout</td>
</tr>
</tbody>
</table>

B. Repetitive accuracy of all settings shall be within ±0.5 percent over an operating temperature range of -20°C to 60°C.

C. Voltage and frequency settings shall be field adjustable in 1 percent increments either locally with the display and keypad or remotely via serial communications port access.

D. The controller shall be capable (when activated by the keypad or through the serial port) of sensing the phase rotation of both the normal and emergency sources. The source shall be considered unacceptable if the phase rotation is not the preferred rotation selected (ABC or CBA).

E. Source status screens shall be provided for normal and emergency to provide digital readout of voltage on all three phases, frequency, and phase rotation.

2.06 TIME DELAYS

A. An adjustable time delay of 0 to 6 seconds shall be provided to override momentary normal source outages and delay all transfer and engine starting
signals. Capability shall be provided to extend this time delay to 60 minutes by providing an external 24 VDC power supply.

B. A time delay shall be provided on transfer to emergency, adjustable from 0 to 60 minutes, for controlled timing of transfer of loads to emergency.

C. An adjustable time delay of 0 to 6 seconds to override momentary emergency source outage to delay all retransfer signals during initial loading of engine generator set.

D. Two time-delay modes (which are independently adjustable) shall be provided on re-transfer to normal. One time delay shall be for actual normal power failures and the other for the test mode function. The time delays shall be adjustable from 0 to 60 minutes. Time delay shall be automatically bypassed if the emergency source fails and the normal source is acceptable.

E. A time delay shall be provided on shut down of engine generator for cool down, adjustable from 0 to 60 minutes.

F. A time delay activated output signal shall also be provided to drive an external relay(s) for selective load disconnect control. The controller shall have the ability to activate an adjustable 0 to 5 minute time delay in any of the following modes:

1. Prior to transfer only.
2. Prior to and after transfer.
3. Normal to emergency only.
4. Emergency to normal only.
5. Normal to emergency and emergency to normal.
6. All transfer conditions or only when both sources are available.
7. The controller shall also include the following built-in time delay for Delayed/Transition operation:
   a. 0 to 5 minute time delay for the load disconnect position for delayed transition operation.
   b. All time delays shall be adjustable in 1-second increments, except the extended parallel time, which shall be adjustable in .01-second increments.
   c. All time delays shall be adjustable by using the LCD display and keypad or with a remote device connected to the serial communications port. The time delay value displayed on the LCD or remote device shall be the remaining time until the next event occurs.
PART 3 - EXECUTION

3.01 INSTALLATION
   A. Install housekeeping pads as shown on the Drawings.
   B. Install engraved plastic nameplates in accordance with Section 2.10.102.

3.02 FIELD QUALITY CONTROL
   B. Inspect and test in accordance with NETA ATS, except Section 4.
   C. Perform inspections and tests listed in NETA ATS, Section 7.22.3.

3.03 MANUFACTURER'S FIELD SERVICES
   A. Check out transfer switch connections and operations and place in service.

3.04 ADJUSTING
   A. Adjust control and sensing devices to achieve specified sequence of operation.

3.05 DEMONSTRATION AND TRAINING
   A. Demonstrate operation of transfer switch in normal and emergency modes.

END OF SECTION
SECTION 16620: STANDBY ENGINE GENERATORS

PART 1 - GENERAL

1.01 DESCRIPTION

A. This section describes materials, installation, testing, and delivery of the diesel engine generator set and associated equipment to be used for standby power in the event of a utility power failure.

B. The manufacturer shall provide supervision and verification of the installation and shall be present at the testing and start-up procedures as indicated herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 16000 - General Electrical Requirements.

B. Section 16446 - Automatic Transfer Switch

1.03 STANDARDS

Construct equipment in accordance with the applicable requirements of the following standards and regulations:

A. National Electrical Code (NEC).

B. American National Standards Institute (ANSI).

C. National Electrical Manufacturers Association (NEMA).

D. Institute of Electrical and Electronic Engineers (IEEE).

E. Insulated Cable Engineers Association (ICEA).


G. Underwriters' Laboratories, Inc. (UL).

H. Air Quality Management District (AQMD)

1.04 SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions and Section 01300.

B. Shop and installation drawings and catalog data for the following equipment will be submitted by manufacturer. Show applicable ratings, sizes, materials, manufacturers and part numbers, and overall dimensions and weights.

1. Itemized bill of material.

2. Engine-generator base with anchor bolt sizes and layout. Submit anchor bolt material listing. Submit catalog data for vibration isolators and calculations for size and number of anchor bolts. Calculations shall be
signed and stamped by a California-registered structural engineer or civil engineer.

3. Engine.

4. Generator.

5. Silencer


7. Control panel.

8. Battery charger.


11. Sound attenuated enclosure.

12. Generator sizing calculation to include the voltage dip under the condition stated in paragraph 2.02B of this specification.


C. Submit system schematic diagram showing all piping and wiring interconnections with sizes and quantities. Submit ladder-type schematic electrical diagrams with legend identifying all devices on diagrams.

D. Submit installation fact sheet giving fuel, coolant, lubricating oil, and exhaust and ventilation requirements.

E. Submit torsional vibration analysis.

F. Submit factory test report.

G. Submit a start-up inspection report signed by the engine manufacturer’s authorized field service representative.

H. Obtain construction and operating permits from the local Air Quality Management District on behalf of the Owner. Submit copy of application and original of permits to the Owner.

I. Provide an information copy of the standard engine inspection and maintenance service contract. The contract shall be for the complete system including all auxiliary support systems.

1.05 OWNER’S MANUAL

The following shall be included in the Owner’s Manual in compliance with Section 01330:
A. One set of operation, maintenance, and parts manuals shall be supplied with the generator set. The manuals shall cover all components, options, and accessories supplied.

B. Copies of all factory engine tests, in quintuplicate, certified by an officer of the manufacturing corporation.

C. Copies of generator test documentation, in quintuplicate, certified as above.

D. Point-to-point wiring diagrams for all controls

E. Details of starting systems, including electrical schematics.

1.06 MANUFACTURER’S SERVICES

A. Provide equipment manufacturer’s services at the jobsite for the minimum man-days listed below, travel time excluded:

1. Two man-days to check the installation and advise during start-up, testing, and adjustment of the equipment and to instruct the Owner’s personnel in the operation and maintenance of the equipment.

2. Submit operation and maintenance manuals prior to this instruction.

B. Written certification, in a form approved by the Owner, shall be provided by the equipment manufacturer or his authorized representative. This certification shall verify:

1. That the equipment and its installation has been inspected on the job by the manufacturer and that the equipment is in first-class condition throughout, has been installed in accordance with the manufacturer’s requirements and recommendations, and that the installation is approved by the manufacturer.

2. That the equipment is operating in a safe and satisfactory manner and is delivering capacities and performance not less than the capacities and performance specified and/or indicated on the drawings.

1.07 TOOLS AND ACCESSORIES

A. Furnish and deliver all special tools, instruments, accessories, and special lifting and handling devices shown in the approved instruction manuals. Unless otherwise specified or directed by the Owner, the items shall be delivered to the Owner, with the Contractor’s written transmittal accompanying each shipment, in the manufacturers’ original containers labeled to describe the contents and the equipment for which it is furnished. The Contractor shall deliver a copy of each transmittal to the Owner for record purposes.
1.08 WARRANTY
A. Equipment furnished under this section shall be guaranteed against defective parts or workmanship for a period of 24 months from date of field testing and acceptance by the Owner.

1.09 MEASUREMENT AND PAYMENT
A. Payment for the work in this section shall be included as part of the lump-sum bid amount stated in the Proposal.

1.10 AIR QUALITY REQUIREMENTS
A. The generator system provided shall meet all requirements of the local and state air quality regulatory agencies. The manufacturer shall provide all emissions data and shall process and obtain the permit to install the units.

PART 2 - MATERIALS

2.01 MANUFACTURERS
A. The engine, generator, generator control panel, and fuel tank unit shall be manufactured in the U.S. by manufacturers currently engaged in the production of such equipment. An authorized distributor maintaining a parts depot and service facility shall be located within a 75-mile radius of the job site.

B. The engine-generator shall be manufactured by Caterpillar Inc. Engine Division, Cummins-Onan, or pre-approved equal.

2.02 RATING
A. The rating of the standby engine-generator shall be as listed below as a minimum and based on operation of the set when equipped with all operating accessories, such as air cleaners, lubricating oil pump, fuel injection pump, radiator fan, and jacket water pump. The units shall meet all AQMD emission requirements. If a larger unit(s) is required, it shall fit into the space provided as indicated on the Plans to the satisfaction of the Owner. The specified standby KW shall be for continuous electrical service during interruption of the normal utility source.

1. Standby KW: As shown on the Drawings (minimum).
2. Engine Speed: 1,800 rpm (maximum).
3. Voltage: 480/277 volts, 3 phase, 4 wire.
4. Frequency: 60 hertz.
5. Power Factor: 0.8.
6. Altitude: 1,000 feet above sea level.
7. Ambient Air Temperature: 120°F maximum, 30°F minimum.
8. Humidity at Maximum Temperature: 95 percent.

9. The momentary rms voltage dip shall not be greater than 20 percent of rated voltage when full load at rated power factor is applied to the generator.

10. Maximum allowable frequency dip: 20 percent.

11. Alternator Temperature rise rating (80, 105, 130 degrees C).

B. The engine generator shall be capable of starting and running the following loads in the sequence listed. Maximum voltage dip per step shall be 20 percent. Provide oversized generator and/or engine-generator unit to comply with this requirement. If no starting method is listed for pumps, assume across the line starting.

<table>
<thead>
<tr>
<th>Load</th>
<th>hp or kw</th>
<th>Starting Method</th>
<th>Code Letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admin Building</td>
<td>88kW</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Paratransit Building</td>
<td>32kW</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Total Load</td>
<td>120kW</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

2.03 ENGINE

A. General: The engine shall be the standard product of the manufacturer, a current production model, and have the following features:

1. Full compression ignition diesel.
2. Two- or four-stroke cycle.
3. Water cooled.
4. Replaceable cylinder liners.
5. Replaceable valve seat inserts.
6. Turbocharged, aftercooled, retarded 4 degrees.
7. With or without aftercooler.
8. Capable of the rated output when operating on commercially available No. 2-D diesel fuel (ASTM D 975).

B. Provide the engine with the following accessories:

1. Fuel, lube oil, and intake air filters.
2. Intake air silencer, high frequency type or combination intake filter/silencer.
3. Lube oil cooler.
4. Fuel transfer pump with suction lift as required.
5. Flexible fuel lines.
7. Coolant and oil drain valves.

C. Starting System:

1. Provide a DC electric starting system with positive engagement drive. Minimum voltage shall be 24 volts.

2. Provide lead-acid storage batteries of the heavy-duty diesel-starting type. The batteries shall have sufficient capacity to provide for 1-1/2-minute total cranking time without recharging and shall be 20-hour rated no less than 200 amp-hours at 24 volts. Provide a freestanding corrosion-resistant fiberglass battery box. Provide battery cables and replaceable connectors.

3. Provide a UL-listed, two rate, current-limiting battery charger to automatically recharge batteries. Charger shall float at 2.17 volts per cell and equalize at 2.33 volts per cell. It shall include overload protection, silicon diode full wave rectifiers, voltage surge suppressors, DC ammeter, and fused AC input. AC input voltage shall be 120 volts. Amperage output shall be no less than 10 amperes for units smaller than 500 kw and 20 for units larger than 500 kw. Charger output shall be at least 25 percent greater than the auxiliary equipment power demand.

D. Governing System:

1. Provide an adjustable isochronous governor of the electrical-hydraulic or all electric type with electrical speed sensing. Governor shall provide adjustable speed setting from 58- to 62-hertz adjustable speed regulation, adjustable load limit from 100 percent to 110 percent of unit rating, and shall also control the engine at recommended idle speed. The governor shall be capable of maintaining the frequency constant within ±0.25 percent for any constant load from no load to full generator rating. After a sudden load change of 25 percent of rated load, the governor shall reestablish stable operating conditions in not less than 1-1/2 seconds. Stable operation is defined as operation at a frequency that is constant within ±0.25 percent of rated frequency. The maximum change of frequency during the 1-1/2 second surging period shall not exceed 1.5 hertz.

2. Install the electronic control portion of the governor in the generator control panel. Governor shall be Woodward 2301, Barber Colman DYN1-10004, or equal.

E. Lubrication System:
1. Fix a pressure-type lubricating system with gear-type oil pump and full flow oil filter to the engine. Filters shall be threaded spin-on type, conveniently located for servicing. Provide filters with a spring-loaded bypass valve to ensure oil circulation if filters are clogged.

2. Provide an oil drain with readily accessible manual valve with piping extended for easy access and proper capture of waste oil.

F. Engine-Mounted Fuel System:

1. Provide an engine-mounted fuel filter with spin-on type replaceable elements, fuel pressure gauge, accessible manual shutoff valve, and engine-driven positive displacement pump.

2. Provide a water separator on the engine just ahead of the fuel filters to prevent condensation, or other water, present in the fuel from reaching the engine filters, pumps, or injectors. Construct of heat-resistant Lexan, with an aluminum-perforated baffle, for easy viewing of the amount of water contained.

G. Jacket Water Heater: Provide a UL-listed, unit-mounted thermal circulation-type water heater incorporating a self-contained thermostatic switch, controlled by the exit coolant temperature from the heater to maintain engine jacket coolant to 90°F in an ambient temperature of 30°F. The dual heater unit shall be single phase, 60 hertz, 208 volts, 2.0 kw. Heater shall be Chromalox or equal. Provide hand valves in the heater hoses to facilitate changing heating elements without draining the entire cooling system.

H. Safety Switches: Provide devices for indication and control of the following conditions at the generator control panel.

1. Low oil pressure (pre-alarm).

2. Low oil pressure (shutdown).

3. High water temperature (prealarm).

4. High water temperature (shutdown).

5. Overspeed (shutdown).

Overspeed trip and cranking termination shall be by a dual element electronic-type speed switch that operates on magnetic impulses from the flywheel ring gear or other engine-timed gear. Overspeed trip setting shall be 118 percent of synchronous speed. The low setting shall be used to automatically ensure continued engine cranking until the engine has reached 600 rpm, even if the oil pressure is up to an acceptable level at a lower speed.

I. Emissions: Provide the engine with emission control equipment to ensure that gaseous exhaust emissions (for NOx, HC, and CO) do not exceed the maximum levels established by the local Air Quality Management District. These maximum levels shall be at the manufacturer’s rated speed and load as measured by SAE-
J177 and SAE-J215 recommended practices. Verification of the ability to meet these emission specifications shall be submitted.

2.04 GENERATOR

A. General:

1. The generator shall be a 3-phase, 60-hertz, single-bearing, drip proof, rotating field, synchronous type, with 3-phase rotating armature brushless exciter. Provide Class F insulation on the stator and rotor. Further protect both with 100 percent epoxy varnish impregnation and an overcoat of resilient epoxy asphalt insulating material to increase resistance to abrasive dust or sand, high humidity, and light acidic, oil, or salt-laden atmospheres, as well as prevent fungus growth.

2. The wave form deviation factor of the line-to-line voltage at no load and balanced rated load at 0.80 power factor shall not exceed 5 percent. The rms of all harmonics shall be less than 3 percent and that of any one harmonic less than 2 percent at full rated load.

3. Conform to the applicable NEMA standards for motors and generators, MG-1. Base rating of generator on continuous operation at 0.80 power factor.

B. Regulator: The voltage regulator shall be a solid-state, volts per hertz type with 3-phase sensing and shall maintain a constant and stable generator output voltage within ±1 percent of nominal for all steady-state loads from no load to full load with isochronous speed control and ±2 percent with speed droop operation. A 5 percent variation in frequency and the effects of field heating shall not affect the unit’s regulation performance. Provide stability and voltage range adjustments.

2.05 STRUCTURAL STEEL BASE

A. Mount the engine-generator on a heavy-duty structural steel base. Provide holes for mounting bolts. Provide the structural steel base with means for lifting the unit for shipment and installation. Clearly identify lift points and total weight and permanently mark on the base.

B. Anchor the steel base to the foundation with an anchorage system designed to withstand seismic forces per the California Code of Regulations, Title 24, Part 2, Section 2312, Seismic Zone 4, with Z = 0.4, Cp = 0.67, and Ip = 1.5. The manufacturer shall submit calculations stamped and signed by a California-registered structural engineer or civil engineer.

C. Isolate the engine-generator from the structural steel base with rubber-in-shear isolators for units 225 kw and smaller. Isolate the engine-generator from the structural steel base with steel spring isolators for units 230 kw and larger.

D. The Contractor shall install vibration isolators between the unit base and the concrete foundation that are per the Plans and spring-type isolators with neoprene-jacketed precompressed molded fiberglass noise isolation pads, steel
load plate, built-in leveling bolt, welded steel or cast housing, and high deflection steel springs. Isolators shall be Peabody Noise Control, Inc.; Kinetics brand, Type SM; or equal.

2.06  COOLING SYSTEM

A. Provide an engine-mounted radiator with blower-type fan sized to maintain full load operation continuously at the specified maximum ambient temperature. Equip the radiator with a 1-inch-wide duct adapter flange and low coolant level switch gauge. The radiator shall be able to produce the airflow required for proper cooling of the engine at full rated load with up to 1.0 inch of water resistance. Provide ductwork with flexible connection section between radiator duct flange and exhaust louver. Provide fan guard for protection of maintenance personnel as required by Cal/OSHA.

B. Ductwork shall be galvanized iron or steel sheets or aluminum sheets. Anchor ducts securely to the building and install so as to be completely free from vibration during engine operation. Brace and reinforce ducts with angles or other structural members. Internal ends of slip joints shall be installed in the direction of flow.

C. Flexible connection shall be wire-reinforced glass fabric. The connection shall be rendered practically airtight.

D. Fill the engine-cooling system with distilled water and a solution of 30 percent by volume ethylene glycol for freeze protection and 5 percent by volume of a borate-nitrite solution (NALCO 2000 or equal) to prevent rust and corrosion.

E. Provide a coolant drain with readily accessible manual valve with piping extended for easy access and proper capture of waste coolant.

2.07  EXHAUST SYSTEM

A. Exhaust system shall consist of a silencer, flexible exhaust fitting, exhaust piping, insulation, and mounting hardware.

B. Provide a chamber-type supercritical hospital grade silencer constructed of Type 304 stainless steel with a baked on silicon-based coating rated for 1100°F minimum. Silencer shall provide an average noise attenuation of 33 to 40 dBA. Provide brackets, companion flanges, gaskets, and fasteners for mounting silencer. Silencer shall be as manufactured by Universal, Nelson, Riley-Beard, or equal.

C. Silencer and exhaust pipe size shall be sufficient to ensure that measured exhaust back pressure does not exceed the maximum limitations specified by the generator set manufacturer.

D. Provide a seamless Type 316 stainless steel bellows-type flexible exhaust fitting at least 18-inches long.
E. Exhaust piping shall be carbon steel. Provide flanged or welded type fittings. Provide sufficient flanged fittings to permit the system to be entirely dismantled in sections. Use sweep elbows with a radius at least three times the pipe diameter.

F. Provide vertical discharge tailpipe. Cap with a counterbalanced raincap.

G. Cover the exhaust manifolds with an expanded metal guard for personnel protection.

H. Cover the silencer and interior exhaust piping with lagging to maintain a surface temperature not to exceed 150°F. Lagging shall be calcium silicate insulation with banded aluminum jacket.

2.08 FUEL STORAGE SYSTEM

A. Provide a sub-base fuel tank for the generator set, sized to allow full load operation of the generator set for 24 hours. The fuel tank shall be UL 142 listed and labeled. Installation shall be in compliance with NFPA 37.

B. The fuel tank shall be 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 the generator set with flexible fuel lines as recommended by the engine manufacturer and in compliance with UL 2200 and NFPA 37 requirements.
4. Leak detection provisions, wired to the generator set control for local and remote alarm indication.
5. High and low fuel level float switches to indicate fuel level. Wire switches to generator control for local and remote indication of fuel level.
6. Minimum 5-gallon capacity spill container at fuel fill point.
8. Integral lifting provisions.

2.09 GENERATOR CONTROL PANEL

A. Provide a NEMA 1, vibration isolated, dead front, 16-gauge steel control panel with lockable hinged cover. Mount and wire the control panel to the engine-generator set. The panel shall include the following equipment:

1. Voltmeter, 3-1/2 inches, 2 percent accuracy with 3-phase fuse protection. Digital meters are acceptable.
2. Ammeter, 3-1/2 inches, 2 percent accuracy. Digital meters are acceptable.
3. Ammeter-voltmeter phase selector switch. Digital meters are acceptable.
4. Frequency meter, 3-1/2 inches, dial type. Digital meters are acceptable.
5. Kilowatt meter.
6. Oil pressure gauge.
7. Water temperature gauge.
8. Oil temperature gauge.
9. Running time meter.
10. Instrument transformers.
11. Automatic starting controls.
12. Voltage level adjustment rheostat.
13. Dry contacts for remote alarms wired to terminal strips from the following alarms:
   a. Fault indicator lights with press to test feature for low oil pressure.
   b. High coolant temperature.
   c. Low coolant level.
   d. Overspeed.
   e. Overcrank.
   f. Run dry contact.
   g. Generator common fail.
   h. In auto.
   i. Breaker position (not closed).
14. Visual alarm indicators for impending shutdown from low oil pressure and high coolant temperature.
15. 80-dB alarm horn with silence switch.
16. Three-position function switch marked “manual,” “off/reset,” and “auto.”
17. Panel illumination lights and switch.
18. Electric governor control unit.
19. Generator voltage regulator as previously specified.
20. Low battery voltage alarm light.

21. 4 to 20mA signal outputs for oil pressure, coolant temperature, and battery voltage.

22. Emergency stop button on control panel and an additional emergency stop button on the side of the engine-generator mounted approximately 48 inches above finished floor.

B. Meters, circuit breakers, control switches, and current transformers shall be General Electric, Cutler-Hammer, or equal. Pilot lights and push buttons shall be oil tight type. An annunciator panel may be provided in lieu of oil tight pilot lights. Digital instrumentation is acceptable in lieu of meters and lamps.

C. Provide relays and timing devices with clear polycarbonate dust covers. Devices shall be plug-in type with holddown spring retainers. Output contacts shall be rated 10 amperes at 24-volts DC.

D. Provide engraved or etched nameplates to show position of switches and function of pilot lights, push buttons, and meters. Do not provide embossed tape.

E. Provide fully automatic generator set start-stop controls in the generator panel. Controls shall operate as follows:

1. When the function switch is in automatic position and upon closure of a set of external contacts or when the switch is in manual position, the engine shall automatically crank. An adjustable cranking limiter shall allow from 2 to 5 cycles of 10 seconds’ crank followed by 10 seconds’ rest. If the engine fails to start after this time, the starting circuit shall be locked out and the overcrank shutdown light initiated.

2. When operating in the automatic mode and the remote engine run contact opens, the engine shall shut down.

3. Initiation of any safety shutdown shall immediately stop the engine and light the appropriate light. Upon correction of the fault, the shutoff system shall be made operable by moving the function switch to off/reset and then back to the “auto” position.

2.10 GENERATOR CIRCUIT BREAKER

A. Provide a molded case circuit breakers sized and quantity as shown on the Drawings and in accordance with the NEC. Install generator breakers in a NEMA 1 enclosure as a load circuit interrupting and protection device. It shall operate both manually for normal and automatically during overload and short-circuit conditions. Circuit breaker shall trip free of the handle. The handle position, or a luminescent flag, shall indicate “off,” “on,” or “triped” breaker positions. The trip unit for each pole shall have elements providing inverse time delay during overload conditions and instantaneous magnetic tripping for short-circuit protection. Insulated neutral terminals and a ground terminal shall be provided and marked. The circuit breaker shall meet standards established by UL, NEMA,
and NEC. Do not use generator exciter field circuit breakers in lieu of a main line circuit breaker.

B. Circuit breaker shall be equipped with an auxiliary contact to provide “Generator Circuit Breaker Not Closed” input to future monitoring.

2.11 TORSIONAL VIBRATION ANALYSIS

A. Submit a torsional vibration analysis of the engine-generator combination, showing it free of harmful torsional vibration stresses within ±10 percent of its normal operating speed range, the natural frequency, critical speeds, relative amplitudes of angular displacement, and approximate nodal locations of the complete elastic system of the engine and driven equipment.

2.12 SOUND ATTENUATING ENCLOSURE

A. Provide weatherproof (NEMA 3R) Level II, Stage 2 sound attenuating enclosure that allows the generator set to operate at full rated load in an ambient temperature of up to 100°F. Enclosure shall be 14-gauge steel construction with corrosion resistant hardware and hinged, lockable doors. Enclosure shall include internally mounted muffler, sound insulating panels and rodent barriers. Insulation shall be non-hydroscopic material. All electrical and fuel stub-ups shall be within enclosure. Enclosure shall comply with all applicable NEC and UL 2200 requirements.

B. The sound enclosure shall produce sound pressure levels at the indicated measured distances from the enclosure not to exceed those listed below.

<table>
<thead>
<tr>
<th>Sound Pressure Levels (dBA) at…</th>
<th>1 m (3.3 ft)</th>
<th>7 m (23 ft)</th>
<th>15 m (50 ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>89.1</td>
<td>76.1</td>
<td>70.1</td>
</tr>
</tbody>
</table>

PART 3 - EXECUTION

3.01 FACTORY TESTING

A. Perform factory tests in the presence of the Owner's Representative prior to shipment. Provide 7-days’ advance notice of test date. Include the following tests.

B. Demonstrate proper operation of all safety devices, shutdown features, and alarms. Conduct load tests utilizing resistive load banks as follows:

<table>
<thead>
<tr>
<th>Load</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>½</td>
<td>1</td>
</tr>
<tr>
<td>¾</td>
<td>1</td>
</tr>
<tr>
<td>Full</td>
<td>4</td>
</tr>
</tbody>
</table>

C. Record current, voltage, frequency, water temperature, and lube oil pressure every 15 minutes.
D. Verify fuel consumption rate at 1/2, 3/4, and full loads. Note fuel consumption rates on a label located at fueling point.

E. The manufacturer shall pay reasonable food, transportation and lodging expenses for up to three Owner personnel to witness testing.

3.02 INSTALLATION

A. Installation will be done by the installation contractor. The manufacturer shall provide written installation instructions with shop drawings. The manufacturer shall coordinate with the installation contractor regarding installation of the engine-generator set foundations and fuel and piping systems and shall verify that all components specified herein are installed in accordance with the generator set manufacturer’s written requirements. Foundation blocks, anchor bolt layouts, and piping may have to be modified from those shown on the Plans. Such work shall be at the Contractor’s expense.

B. Anchor bolts for the engine-generator set bases shall be cast-in-place. The engine manufacturer shall provide anchor bolts and select anchor bolt material.

C. Fill the tanks with No. 2-D diesel fuel meeting ASTM D 975-60T. After field testing is complete, refill the tanks.

3.03 PIPING

A. Pitch horizontal runs of exhaust pipe away from the engine. Provide condensate traps with petcocks or valves at low spots in the exhaust system.

3.04 PAINTING AND COATING

A. Coat non-insulated exhaust pipes and silencers with a baked silicon-based coating rated for 1100°F minimum.

3.05 START-UP

A. On completion of the installation, the initial start-up shall be performed by a factory-trained service representative of the engine supplier, who shall thoroughly inspect, operate, test, and adjust the equipment. The inspection shall include the soundness of all parts, completeness of all details, proper operation of all components with special emphasis on safety devices, correctness of the settings, proper alignments, and correct phase rotation to match other sources.

B. Field tests shall include the following:

1. Simulate power failure by tripping the main breaker and demonstrate complete manual and automatic start, load, unload, and stop sequence of the engine-generator.

2. Conduct a 2-hour run, utilizing maximum available load. If available load is less than 75 percent of the generators’ rating, provide load bank loads to obtain 75 percent generator loading (minimum).
3. Retest all alarms and shutdown features.

3.06 SCHEDULED OIL SAMPLING

A. In order to forecast and minimize engine failure, the supplier of the equipment shall provide a quarterly (every 3 months) oil sampling analysis for a period of 2 years from date of acceptance. This scheduled oil sampling shall be of the atomic absorption spectrophotometry method as opposed to the spectographic analysis method and shall be accurate to within ±1 ppm for the following elements: lead, iron, chromium, copper, aluminum, and silicon. In addition, test the sample for the presence of water, fuel, dilution, and antifreeze.

B. Provide equipment needed to take oil samples in a kit at the time of acceptance. Include a sample gun kit, bottles, mailers, and written instructions.

C. Provide immediate notification by telephone or fax to the Owner when analysis results show any critical reading. If readings are normal, provide a report by mail showing that the oil quality is within established requirements.

D. This scheduled oil sampling program shall be available to the Owner at the supplier’s normal rate, after the mandatory 2 years, and shall be continued thereafter at the Owner’s option.

3.07 DELIVERY, STORAGE AND HANDLING

A. The manufacturer shall deliver the assembly to the field just prior to installation as determined by the installation contractor and as approved in writing by the Owner.

B. The manufacturer shall store the assembly within a building protected from the elements for a period up to 365 calendar days.

C. The installation contractor shall accept the delivery of the assembly and will take responsibility for them from that point on and will coordinate with the manufacturer to ensure proper installation of the system. The manufacturer shall coordinate with the installation contractor as needed to provide a complete and functional installation that is covered by the manufacturer’s warranty.

END OF SECTION